Using Interactive Games to Improve Math Achievement Among Middle School Students in Need of Remediation

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Dedication

This dissertation is dedicated to my three fathers: my heavenly father, my earthly father, and my father-in-law. It is my prayer that I will be as much of an influence on my children as my fathers have been on me.

Acknowledgments

I want to start by praising God for giving me the gifts and blessings to reach this goal. I would next like to thank my wife, Cheryl King, for pushing me to start this program and then demonstrating limitless patience throughout its completion, especially the writing of my dissertation. I firmly believe that this would not have been possible without her unwavering support. I will next thank my committee members, Dr. James Tucker (dissertation chairperson), Dr. Susan Swayze, and Dr. James Davis. You three performed as a well-tuned machine so that I always received what I needed when I needed it. Thank you, Dr. Carolyn Graham for providing me with easy to understand explanations during our statistics classes. I owe a great debt of thanks to my first dissertation chairperson, Dr. Mary English, for getting me off to a great start. I need to thank Darren Reed, Regina Ganett-Spruill, and Chacko Abraham of Cohort 7, who each played a critical role in helping me overcome significant obstacles. I want to thank Dr. Virginia Roach for helping me to set the priorities that carried me throughout the program. You all played a critical role in this process. My final thank you goes to Dr. Keith Stephenson, who mentored me through this dissertation. Keith, your timely and expert advice has saved me from countless hours of “pain and suffering.”

We can never accomplish difficult goals without the support and encouragement of others. My mother (Gertrude Vance), mother-in-law (Thelma Hill), sister-in-law (Yvonne Brown), and my daughters (Chevonne and Jasmine) led the village of people providing that support to me. A heartfelt thank you to everyone that I did not mention but who provided me with a well-timed word of encouragement or “kick in the pants” to help me persevere, stay focused, and complete the task.

Abstract of Dissertation

"Using Interactive Games to Improve Math Achievement Among Middle School Students in Need of Remediation"

Many parents and educators ask, "Can electronic games help students learn math?" That question was the focus of this empirical investigation, which was designed to determine the extent to which interactive electronic educational games have a positive impact on the math achievement of middle school students. This project was completed during the second and third marking periods of school year 2010-2011.

This study was focused on the following research question: To what extent are there significant differences in math game intervention posttest scores (when controlling for pretest scores) among three groups of seventh-grade math students at a suburban public school in the mid-Atlantic region of the United States? To answer the research question, a quasi-experimental study was conducted, which involved 128 students in three groups. One group of 30 students received an electronic game as an intervention as part of its remedial instruction. A second group of 32 students received remedial instruction but not the intervention. The third group of 66 students received neither remedial instruction nor the intervention. The research period was 18 weeks. A pretest and a posttest were given to all students in the sample. Data were analyzed using analysis of covariance (ANCOVA).

Based on the data analysis, it was concluded that (a) receiving an interactive game intervention combined with remediation training (the experimental group) was superior to remediation training alone (the comparison group) or no intervention (the control group) and that (b) remediation training alone (the comparison group) was superior to no

intervention (the control group). All three groups achieved posttest scores that were roughly the same. The experimental group had the lowest pretest scores; the comparison group had higher pretest scores than the experimental group; the control group had the highest pretest scores. The results from the ANCOVA indicated a statistically significant difference between the pretest and posttest math achievement scores. When controlling for pretest differences between the three groups, the estimated marginal means for the control group improved by 23.60 points, by 28.21 points for the comparison group, and by 35.20 points for the experimental group.

Table of Contents

List of Figures

List of Tables

Acronyms

Table 1. *Acronyms*

Acronym	Full title
NAEP	National Assessment of Educational Progress
NCTM	National Council of Teachers of Mathematics
NCLB	No Child Left Behind Act of 2001
SPSS	Statistical Package for the Social Sciences
EAI	Enhanced Anchored Instruction

Chapter 1: Introduction

Overview

Many parents and educators ask, “Can electronic games help students learn math?” That question was the focus of this empirical investigation that was designed to determine the extent to which interactive electronic educational games have a positive impact on selected middle school math student outcomes. This study was completed during a math remediation activity conducted during the second and third marking periods of school year 2010-2011.

The relationship between interactive electronic gaming and educational achievement continues to be debated (Williams, Hemstreet, Liu, & Smith, 1998). Many types of electronic games are available to middle school students. The electronic game in this study was limited to an interactive game that combines middle school math content with interactive technology: vMathlive™. The vMathlive™ instructional game utilizes the latest innovations in interactive technology, including 3-D animation, customizable avatars, and engaging interactive functionality.

Students with poor math skills are especially vulnerable in the current education system. These students are often called “at risk” because they are more likely to drop out of school (Education, 2008). Authenticity, consistent academic failure, low expectations, and low self-esteem are reasons typically cited for student dropout ("Anchored Instruction and Situated Cognition Revisited," 1993). Authenticity in K-12 education refers to how well classroom activities reflect the everyday and occupational mathematical practices of adults (Gainsburg, 2006). This concept was echoed in a study by (Purcell-Gates, Duke, & Martineau, 2007), which found that many African-American students "opt out" of the existing education system because they see no relevancy between the classroom instruction and their current or future lives; thus, some students attend class but do not apply themselves because they do not deem the subject matter to be beneficial. Dorr (2006), Hutchison (2007), and Zyda (Zyda, 2007) suggested that curriculum that is authentic and that uses technology can help at-risk students engage in the classroom. Hutchison further suggested that video games built on existing course content can be developed using avatars (electronic images representing humans) simulating real world situations. As such, video games can be designed so that students can see parallels between their world and the computer simulation. These elements of realism create the element of authenticity that is necessary to obtain the active engagement of the student. Researchers have noted that such educational innovations can be applied specifically to the math curriculum (Hutchison, 2007; (Bottge, Rueda, LaRoque, Serlin, & Kwon, 2007). This study examined the extent to which interactive educational games have a positive impact on selected middle school math student outcomes.

"Disruptive education," as coined by Clayton, Horn, and Johnson (2008), provided the theoretical base for this study. The core elements of disruptive education include restructuring the interaction between teacher and student, implementing effective psychological interventions, involving students in active learning, and actively engaging students through authentic course material. The theory suggests that students can gain significant benefits from a student-centered classroom. Those benefits are designed to elicit elements that are known to foster student achievement, such as independent inquiry and motivation to learn. A class of interactive gaming called problem-based gaming is a resource that enhances authenticity. Moreover, three studies conducted in the 1990s by the Cognition and Technology Group at Vanderbilt demonstrated the effectiveness of using interactive video-based gaming to increase learning in diverse communities: ("Anchored Instruction and Its Relationship to Situated Cognition," 1990; "The Jasper Experiment: Using Video to Furnish Real-World Problem-Solving Contexts," 1993). Gaming is disruptive because it has the potential to help automate the process of creating the student-centered classroom.

Research Question

The following research question was the focus of this study: To what extent are there significant differences in math game intervention posttest scores (when controlling for pretest scores) among three groups of seventh-grade math students at a suburban public school in the mid-Atlantic region of the United States?

Summary of Methodology and Research Design

This research involved a quantitative study that used a quasi-experimental design to determine whether math-centric interactive games can be used to increase the math achievement of remedial students. The study was conducted in a suburban, mid-Atlantic public school. The population comprised 128 students who were enrolled in the school’s seventh-grade regular math classes. The students were instructed by two math teachers who taught in accordance with the school district’s existing curriculum and recommended practices. A subset of these students were enrolled in two after-school math remediation programs operated by the school. The students in one of the math remediation programs were provided access to the interactive game with the math content. The students in the other remediation program received the standard remedial instruction. One of the teachers taught both of the remediation classes. The entire population sample took a pretest and a posttest that were administered by the school. Achievement levels of those enrolled in the interactive game remediation program (experimental group), those enrolled in the game-less remediation math program (comparison group), and those not enrolled in the remediation math program (control group) were compared. Inferential statistics were used to test for significant differences in math achievement for the experimental group, the comparison group, and the control group. ANCOVA was used to determine if there were significant differences in math achievement levels. Chi-square statistics were used to determine that the groups were not statistically different despite differences in the demographic make-up of the groups.

The students were taught by math teachers recognized as being highly qualified under the standards of No Child Left Behind (NCLB). Additionally, the math teachers had successfully taught the content material to previous classes. Prior to the commencement of the research, the teacher of the game-based remediation program was given training in the use of the interactive game and the technology platform on which it operates.

The following topics were taught: (a) integer operations, (b) probability, (c) solving linear equations and linear inequalities in one variable, and (d) proportional reasoning.

The school-day classes at the middle school were taught as usual; the topics of instruction were the same for all students. Students in each classroom were given the same number of school days to master the units. Students were given an assessment test at the beginning of the research period (pretest) and a similar test at the end of the research period (posttest). The test results were used to determine the amount of gain in math achievement. The treatment occurred over approximately 18 weeks—the amount of time for the second and third marking periods.

Recommendations for Policymakers

The intervention tool in this study has proven to be effective when used in a remedial classroom. For that reason, the researcher recommends that all K-12 policymakers begin planning for the integration of this intervention tool into their school environments. One component of that planning is the adjustment of their budgets to accommodate the costs associated with the acquisition of products appropriate for their school environment. The second component of the planning is the professional development that will be necessary to gain teacher buy-in of the pedagogical changes required to successfully integrate this intervention instrument into their existing courses. The third component is the messaging required to make the public, especially parents, aware of the instructional advantages of this type of instructional tool and intervention instrument.

These steps are necessary if the implementation of the tool is to be effective. These departures from the status quo are difficult, however, and in many cases they are uncomfortable for educators who are entrenched in 20^{th}-century strategies or manual processes. To overcome these obstacles, all K-12 educational leaders and administrators will need to demonstrate true leadership on the issue and establish an atmosphere that demands migration to the implementation and integration of 21^{st}-century technology. Such leadership is demanded to ensure that our students are the beneficiaries of the most advanced, research-based instructional strategies available.

Statement of Need

Instructional technology holds promise as a tool for meeting the instructional needs of students. Within the context of instructional technology, the combination of math-content lessons delivered through interactive video is typically called a video game. Studies have shown that a video game that incorporates problem-based learning can be effective in developing math skills in K-12 students (Edwards, 1994; Van Haneghan & Stofflett, 1995). Studies also have shown that interactive technology can be effective in helping students master course content (Harrell, 2000; Langone, Clees, Rieber, & Matzko, 2003). The literature review in this study is focused on problem-based gaming, problem-based learning, interactive technology, differentiation, and current math pedagogy. These topics are all integral to educators who wish to implement a student-centered classroom.

The pedagogical platform of a student-centered classroom holds promise for students. There are a number of techniques for developing a student-centered classroom. The purpose of this study was to analyze the pedagogical benefit of one of those techniques. Implementation of a course designed on a platform that uses a computer-based interactive game requires fundamental adjustments when transitioning from the current system of directed instruction (Brown, 2004). Integration of interactive technology into a math course requires that the teacher be comfortable with technology, the course content, and a system of differentiated instruction (Williams et al., 1998). This combination results in a math classroom that is student centered.

Creating a student-centered classroom increases the student's confidence in his or her ability to learn (Harrell, 2000). Integrating interactive games as an active learning technique is a powerful tool for developing the student-centered classroom. For this reason, it is likely that the pedagogical changes associated with the integration of interactive games benefit all students regardless of skill level by improving student self-efficacy related to math. Self-efficacy is also an important piece to the puzzle of addressing the needs of students (Koszalka, Grabowski, & Kim, 2002). Student efficacy can be positively affected by student mastery of course content (Parkison, 2004). Students' efficacy is positively affected by their experiencing improvements in grades and results on high-stakes tests. Therefore, math achievement resulting from the implementation of interactive games should have a positive influence on self-efficacy. For these reasons, it is important to understand the effect of interactive games.

Statement of Significance

This study has a number of significant applications. The greatest significance of this study is in its application as an intervention tool that can improve math achievement. There is a national commitment to improve results in math and science. If it can be demonstrated that the medium of gaming is also a tool that can be used to advance learning, gaming will gain its place within education pedagogy. A tool that enhances the national effort to improve math achievement automatically becomes a tool of great promise.

Instruction differentiation within the classroom may be improved with interactive gaming. Gaming enables a student to work at his or her individual pace. Interactive gaming also enables teachers to focus their attention on the specific questions or difficulties that each student is having (Clayton, Horn, & Johnson, 2008). The instructional differentiation enabled by interactive gaming can be a cornerstone of a student-centered classroom.

Although this intervention tool was applied to instruction for math remediation students, it can be used with any student in any course. It can be integrated into regular classrooms of heterogeneous students. In this case, a classroom of heterogeneous students would be a classroom of students with a wide range of abilities, from talented-and-gifted to special-needs students. The intervention tool also should be very effective for special-needs students enrolled in pull-out programs; it should be very effective for limited English proficient (LEP) students. Versions of electronic games are available for social studies, language arts, science, algebra, and history. This wide range of applicability makes the tool one with enormous potential for use in student-centric classrooms.

Theoretical Framework

Situated cognition theory (SCT) provided the theoretical framework for this study. It was used to guide the study as well as provide a context for interpreting the results of the study. SCT is based on research into cognition that demonstrates that learning is most effective when teaching is provided in the environment in which the information being taught will be used. According to the theory, knowledge is situated, meaning it is a product of the activity, context, and culture in which it is developed and used (Black & Schell, 1995). This study used the platform of SCT as applied to the context of the virtual environment of games. This platform is designed to demonstrate that games built on a requirement of math content knowledge represent a viable intervention strategy for the improvement of math skills and math self-efficacy among middle school students.

Conceptual Framework

Enhanced anchored instruction (EAI) theory was be the conceptual framework for this study. EAI is built on a platform of problem-based learning and depends on the application of interactive video-based problems, called anchors, to improve the student's math problem-solving skills. The anchors are embedded within the video-based lessons. The math problems are not explicitly stated; each is embedded in a story or objective. The student must identify the relevant problem(s) and then find an appropriate solution to determine an appropriate ending to the story. To generate a proper solution, the student must collect and keep track of pertinent information that is contained within the story. Students must also (a) identify the questions that are necessary for solving the problem, (b) identify the sources that are available for assistance, and (c) decide how best to apply the data that are collected (Bottge, Rueda, Serlin, Hung, & Kwon, 2007).

EAI was chosen to be the lens through which the study was viewed because the theory is consistent with problem-based gaming. In this study, the student was asked to successfully navigate the many aspects of the instructional game. To be successful, students needed to use the help files to select the appropriate math technique, listen to instructions for how to navigate obstacles, combine the two to determine an appropriate solution, and collaborate with classmates to develop game mastery. These tasks are fundamental to a properly designed EAI.

Delimitations

The delimitations of this study included the following: (a) sample of seventh-grade students only, (b) site selection—one suburban, mid-Atlantic public school, (c) sample size of 128 students, and (d) duration of 18 weeks.

The study was limited to seventh-grade students because the seventh-grade curriculum most closely matched the learning objectives of the units. A suburban school was selected because the demographics of the specific suburban school had many similarities to both the urban areas and suburban areas located within the state. The sample size of 128 students was based on the number of seventh-grade students enrolled in regular math classes with the participating teachers during the second and third marking periods of the 2010-2011 school year. The delimiter of 18 weeks was established because the second and third marking periods lasted for 18 weeks.

Limitations

Controlling for grade level, while increasing the study's internal validity, also decreased the study's external validity. The maturity levels and socialization activities of the students in sixth, seventh, and eighth grades are very different. For that reason, educators have long held that instructional strategies that are effective for one grade level are not necessarily effective with other grade levels. After considering these facts, the researcher limited the study to seventh-grade students because the seventh-grade curriculum most closely matched the learning objectives of the units. Thus, the findings are generalizable only to seventh-grade students.

The effect of using a suburban school represents another limitation to the study. Students in rural areas, suburban areas, and urban areas have challenges and resources that may differ from each other. Limiting participation to suburban students limited the generalizability of the study.

The duration of 18 weeks is a limiting factor as well; 18 weeks may not be long enough to effect change in math achievement. Additionally, the external validity of the study is limited to experiments of similar duration.

The effect of collaboration and interactive gaming in a multiuser, Web-based environment was not explicitly analyzed as part of this study. Recent studies (Dorr, 2006; Sharritt, 2008; Watson, 2007) have shown that the online, multiuser gaming environment has positive influences on student achievement. In this age of ubiquitous computing, the potential of the multiuser, online gaming environment is of increasing interest. It was expected that collaboration would have an effect on the achievement of the students in the remedial math program. The analysis conducted as part of this study took into account that such an effect existed but did not attempt to measure the extent of that effect. Not including an analysis of the effect of multiuser, online gaming limited the generalizability of the findings.

Definitions

Table 2 presents definitions for the key terms used in this research study. Some of these terms have multiple meanings; thus, these definitions are provided to enhance the external reliability of this study.

Table 2. *Definition of Terms*

Term	Definition
Achievement gap	Observed disparity among the performance levels of groups of students (especially groups defined by gender, race, or ethnicity) (Olszewski-Kubilius, Lee, Ngoi, & Ngoi, 2004)
Authenticity	Indicator of how well classroom activities reflect everyday and occupational mathematical practices (Gainsburg, 2006)
Avatar	Graphic representation of the user, which is manipulated by the computer user in the electronic environment (Annetta, Murray, Laird, Bohr, & Park, 2006)
Differentiation	Instructional technique focused on ensuring that what a student learns, how the student learns it, and how the student demonstrates what is learned match the student's readiness level, interests, and preferred mode of learning (Tomlinson, 2004)
Education gaming	Video gaming that comprises the following three elements: (a) includes not only text, but also image and screen literacy; (b) involves navigating information and assembling knowledge from fragments; and (c) is user-friendly interactive technology, integrated effectively into a learning environment to help students with the active process of learning (Annetta, Murray, Laird, Bohr, & Park, 2006)
Enhanced anchored instruction (EAI)	Application of situated learning theory in which a learning environment or curriculum is created via video materials and taught by structuring the materials in such a way that knowledge is applied to solve problems (Langone et al., 2003)
Interactive technology	Technology in which users are reacting to what they see; the user is in control of what is viewed (Marion & Thomson, 2001)
Problem-based learning (PBL)	Focused, experiential learning organized around the investigation and resolution of real-world problems (Development, 2008)

Chapter 2: Literature Review

Introduction

This chapter presents a review of literature describing the logic and educational basis for the study. Figure 1 is a graphical representation of the study's focus.

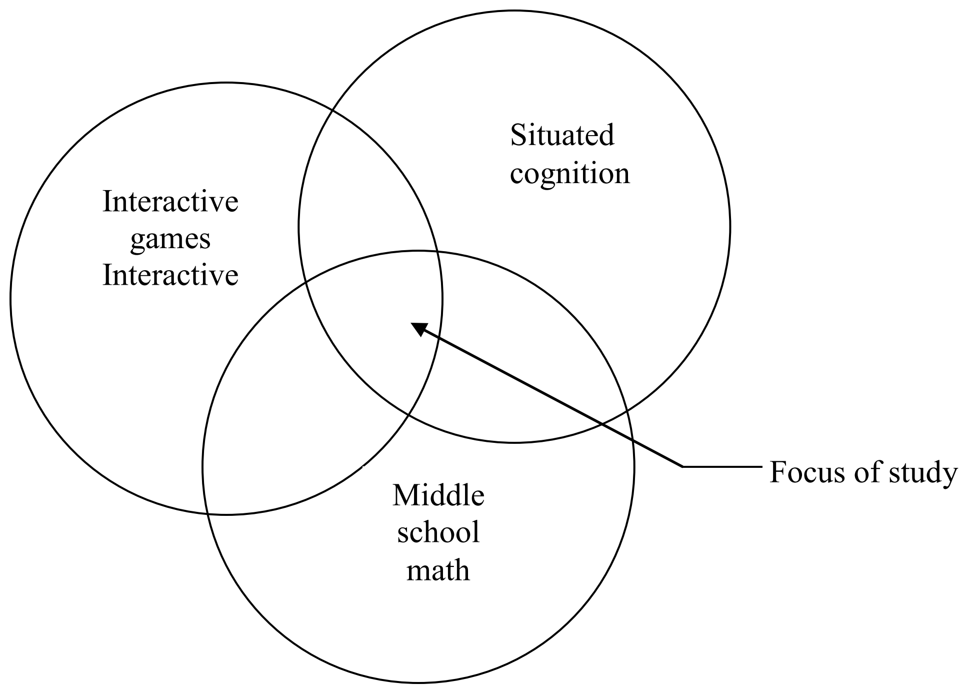

Figure 1. Focus of study.

There are bodies of literature regarding situated cognition, interactive games, and middle school math. The intersection of these three bodies of literature represents the growing body of literature regarding educational gaming. This literature review targets the educational benefits and implementation requirements for educational gaming. In the review, problem-based learning is referred to most often because it is the most sophisticated form of interactive educational gaming. Both this literature review and the research study investigated the potential benefits of integrating interactive gaming with existing education pedagogy.

Search

This literature review encompassed sources from 1980 to 2009. Within the context of problem-based learning and interactive video, literature has been included to address issues relating to math pedagogy, teacher efficacy, and student efficacy. The literature relative to technology was restricted to the years 2000 to 2008. References to "Jasper" were the exception to this rule. This exception was made because of the foundational role of the Jasper experiments for subsequent research. Studies related to problem-based learning were limited to the period of 1992 to 2009. Nonempirical literature related to problem-based learning was limited to the period of 2000 to 2009. The following key terms were used to find sources: (a) problem-based learning, (b) interactive technology, (c) instructional technology, (d) educational technology, (e) activity-based learning, (f) active learning, (g) math, and (h) middle school. Databases used included (a) Academic Search Primer, (b) ERIC (education), (c) JSTOR, (d) Dissertations and Theses, (e) Google Scholar, and (f) EdRes. The searches were completed between June 2007 and December 2009.

Purpose

The purpose of this literature review was to examine the potential benefit of using interactive gaming as a tool to raise the math achievement level of middle school students. Chapter 2 presents first a review of theories serving as the basis for the dissertation; the chapter 2 continues with a review of literature that provides a description of interactive and problem-based gaming. The next section of the paper presents a description of how interactive and problem-based gaming are used. The final section of the literature review describes the effects of interactive gaming relative to education. These sections were viewed through the lens of the enhanced anchored instruction theory and the situated cognition theory. Each of the four sections includes research about improving scores through (a) improved relevancy, (b) improved motivation and interest, and (c) improved differentiation. These three conditions are central tenets associated with interactive gaming.

Education Theory

This research used a lens that was built using two educational theories. The first theory is situated cognition theory, which states that students learn best when the learning is accomplished in the environment in which it will be used. The second theory is enhanced anchored instruction, which states that using video segments, called anchors, increases learning and the ability of students to transfer that learning to new situations. The third theory relative to this study is self-efficacy, which states that students achieve more when they believe they have the skills, talent, and support necessary to be successful (Middleton & Midgley, 2002). The theory of self-efficacy was included to provide additional context. Research describing these three theories is found in the following sections. The importance of self-efficacy to the instructional process is briefly described, but it is not a specific element of this study.

Situated cognition. A 1994 qualitative study by Evanciew explored the effect of integrating learned knowledge with the context in which the learning is to be used. This type of applied education is the core of vocational programs. The study by Evanciew was completed in the environment of an apprenticeship program. The apprenticeship program operated in a small, rural, southeastern United States community. Data for this study were collected through the use of observations and interviews. The researcher used observations to view the behaviors and results as they occurred and to avoid relying on accounts by the participants to describe the behavior or results. In addition to the observations, two types of interviews were conducted. One interview format was highly structured. The other interview format was conversational. The conversational format asked each participant the same questions but varied the order of the questions. A tape recorder was used in both interview formats to ensure accuracy and completeness. The interviews were transcribed and analyzed through the lens of situated cognition theory and with the objective of answering the following questions:

1. What learning and teaching experiences occur between mentors and apprentices in workplaces participating in youth apprenticeship programs?
2. What teaching methods and behaviors do mentors use when working with youth apprentices?
3. How do the apprentices experience these methods and behaviors?
4. Do participants believe a more relevant and useful education is possible by participating in the workplace component of youth apprenticeships?

Evanciew (1994) found that the mentors used many of the same techniques found in K-12 education, specifically the techniques of modeling, coaching, and scaffolding. The researcher also found that the mentors used a variety of strategies that employed problem-based learning. Those strategies included providing the apprentice with experiences that required the apprentice to "figure out the answer" and creating an error and requiring the apprentice to troubleshoot the condition. The mentor led the apprentice through the learning situation by explaining, asking instructive questions, and answering specific questions asked by the apprentice. As a result of these techniques, the apprentices perceived that (a) they could solve problems, (b) mentors were available to help them when necessary, (c) their work was interesting and challenging, (d) work was more fun than school, (e) work was more important than school, and (f) work was related to the topics they were learning in school. These findings suggest that a difference in attitudes between school students and apprentices more likely occurred because of instructional delivery than because of course content. Educators that seek to reach students to improve student motivation and achievement should explore options that include elements of the apprenticeship model.

Enhanced anchored instruction. A 2004 study by Bottge, Heinrichs, Mehta, Rueda, Hung, and Danneker compared the results of instruction delivered through enhanced anchored instruction (EAI) with instruction delivered by text-based instruction (TBI). The primary purpose of the study was to compare the learning accomplished through EAI with the learning accomplished through TBI. In addition to measuring the learning gains, the researchers also wanted to identify whether there were differences between the two groups in their ability to apply the learning in situations that require the student to apply the knowledge to a problem-solving condition. The study participants were 93 sixth-grade students in four math classes in a middle school in the midwestern United States.

Two math teachers in the middle school participated in the study. Each teacher taught one EAI class and one TBI class. Classes were randomly assigned to the teachers as individual students could not be assigned. One effect of this system of selection was that the population of Whites and non-Whites were equal within the EAI and TBI groups but were not equally distributed between the teachers. The study was completed in two phases. The first phase measured learning by using the differences in scores between a pretest and a posttest. The second phase was conducted at intervals of 6 weeks, 13 weeks, and 22 weeks after the posttest. This phase measured how well the students were able to apply the lessons learned during the first phase. The gains were measured by using practical problems involving the skills gained during phase one. The required skills included reading diagrams, reading a materials list, calculating costs, and adding and subtracting fractions. Students completed projects that required them to write documents as well as construct models. The documents and models were evaluated by raters that had been given specific instructions on how to evaluate the projects. Interrater agreement was calculated to be 99%.

Bottge et al. (2004) found that for phase one, there was no significant difference in results between the experimental group (EAI) and the control group (TBI). The researchers found that for phase two, the EAI group performed better and that the difference was significant. They also found that providing refresher instruction to the TBI group brought their phase two results to the same level as the EAI group. The study demonstrates that EAI is a legitimate tool for middle school education. Additionally, EAI is better than traditional pedagogy for producing transferable skills that are maintained for extended periods. The methodology used by the researchers, including their steps for establishing content validity and test reliability, created strong credibility for the study's results.

Self-efficacy. Self-efficacy is an important component for producing transferable skills because it is important for the subject to believe he or she can be successful in a new environment. Self-efficacy is also important for the subject to feel capable of meeting new challenges in a familiar environment. For that reason, when math is taught in a way that produces gains in self-efficacy, one of the additional long-term benefits is that the individual is more likely to feel that previously acquired skills can be adapted and applied to new challenges. If one accepts the premise that one of the purposes of education is to prepare the student for life outside school, transferable skills help to demonstrate to the student the authenticity of the curriculum.

A 2009 quantitative study by Usher and Pajares (2009) identified specific questions that could be used to measure the self-efficacy of middle school mathematics students. The researchers were also able to validate relevant elements of Bandura's (1997) social cognition theory as related to self-efficacy.

Bandura (1997) had hypothesized that self-efficacy beliefs are developed from four sources: (a) mastery experiences, (b) vicarious experiences, (c) social persuasions, and (d) emotional and physiological states. The study by Usher and Pajares (2009) was a three-phase study with each of the phases having a specific purpose, the results of which would be used in the subsequent phase. Phase one used a sample of 1,111 students; phase two had a sample size of 824 students; phase three had a sample size of 803 students. The students involved in each phase were demographically diverse. Students were in grades six, seven, and eight. The purpose of phase one was to establish a list of questions that could be used with a sample population as a tool to screen data to be collected during phases two and three. Phase one was accomplished by giving a questionnaire to a diverse group of students, analyzing the results, editing questions, and analyzing the student responses for construct validity and convergent validity. The 84 questions in the questionnaire were refined as necessary in preparation for phase two.

Phase two was used to refine the questionnaire to the point that it was suitable for data collection, measurement, and analysis of the sources defined by Bandura's (1997) self-efficacy model. A total of 824 students responded to the questionnaire. Usher and Pajares (2009) used the analysis of the questions during phase two to reduce the questionnaire to 39 questions that were both more focused and more informative. Input solicited by the researchers from experts in social cognitive theory added 34 questions to the questionnaire. Phase three was designed to create a reliable model to measure self-efficacy. The 73 questions were submitted to 803 students. The 803 responses were analyzed to develop a final model that was parsimonious, practical, and psychometrically strong. This resultant model contained 24 questions that were broken into four groups. Each group of questions provided information regarding one of Bandura's sources of efficacy.

Usher and Pajares (2009) were able to demonstrate through this study that the sources of self-efficacy in middle school math students were those defined by Bandura (1997). Additionally, they were able to demonstrate a strong correlation between the sources. These results were not surprising but had not been proven prior to their study. More importantly, prior to their research there was no definitive scale for measuring the effect of mastery experiences, vicarious experiences, social persuasions, and emotional or physiological states on the self-efficacy of the target population. The thorough design and implementation of the results of the study culminated in a final questionnaire containing 24 questions. This questionnaire is a tool that can be used as a starting point for researchers completing studies on the topic of self-efficacy of math students.

What is Problem-Based Gaming?

Problem-based gaming is computer software or hardware that is different from other current technologies because of the degree of its (a) interactivity and (b) the functional requirements of its design. This section describes these two discriminators.

Problem-based gaming is computer technology that uses video games to implement a system of instructional games that are founded on a platform of problem-based learning (Torp & Sage, 2002).   Problem-based learning is a process of learning in which a case problem is presented to students who are asked to apply reasoning, questioning, researching, and critical thinking to find a solution to the problem. It is "focused, experiential learning (minds-on, hands-on) organized around the investigation and resolution of messy, real-world problems" (Torp & Sage, 2002). Problem-based learning emphasizes not the outcome but the process, with a focus on students' learning to become self-reliant and eventually independent.   Boud and Feletti (Boud & Feletti, 1991) developed a more complete definition of PBL:

> A way of constructing and teaching courses using problems as the stimulus and focus for student activity. It is not simply the addition of problem-solving activities to otherwise discipline centered curricula, but a way of conceiving of the curriculum which is centered around key problems in professional practice. . . problem-based courses start with problems rather than with the exposition of disciplinary knowledge. They [the problems] move students towards the acquisition of knowledge and skills through a staged sequence of problems

> presented in context, together with associated learning materials and support from teachers. (p.37)

One of the questions frequently asked by middle school and high school math students is "When will we use this?" Problem-based learning (PBL) answers this question in a way that establishes authenticity (Cerezo, 2004). Students are then motivated to master the course content because relevancy has been established. Mastering the course material is key to improving performance on high-stakes testing. For this reason, properly implemented PBL holds promise for improving test scores of all students.

Interactive technology. Students in 2010 are familiar with many forms of interactive technology. Entertainment-based video games, cell phones, and computers are a few of the technological devices that are familiar to these students. There is no consensus definition for interactive technology. For the purpose of this review, the following definition was used:

> Interactive technology is technology where users are reacting to, not reacting with, what they see. The user is hands-on, controlling what is viewed. Computers with social interfaces present information in such a way that it is customized for the particular user. Different learning rates are accommodated, because computers are able to pay individual attention to independent learners. Regardless of ability or disability, each user will be able to work at an individual pace. Interactive technology allows learners to quiz themselves anytime in a risk-free environment. (Marion & Thomson, 2001)

There is a wide spectrum of technology that can be described as "interactive." The lower end of the spectrum includes technology such as Microsoft Excel in which a user enters a value and the computer returns a different yet corresponding value. At the opposite end of the spectrum is technology described as "virtual reality," in which the user enters an artificial environment that simulates every aspect of a corresponding physical environment. With this technology it is impossible for the user to tell the difference between the physical environment and the artificial environment. Interactive technology found in the K-12 classroom is closer to the Excel end of the spectrum. Interactive technology used for training aircraft pilots, military personnel, doctors, and architects is toward the virtual reality end of the spectrum.

Functional requirements of problem-based gaming. When designing a problem-based gaming system that is appropriate for middle school students, the following elements must be addressed: (a) motivation, (b) gender neutrality, (c) feedback and scaffolding, (d) verbal and written reflection, (e) the game genre, (f) balance between the content and the game, and (g) visual effect and usability (Kebritchi, 2008).

Motivation is a key design element. Sedighian and Sedighian (1996) concluded that motivation can be enhanced by (a) situating mathematics learning in the games, (b) providing a set of goals to achieve, (c) providing enough of a challenge to be exciting but not overwhelming, (d) making games cognitive artifacts by incorporating the factors of interactivity and communication, (e) associating learning to a pleasant memory, (f) providing a learning environment that allows students to experience the joy of learning, and (g) providing sensory stimuli by using high-quality graphics and animation.

When creating technology for middle school students, it is important that the system be age appropriate and designed for the needs of the user. Much of the currently installed technology is designed merely to be effective in communicating the course content. The effect of that type of design is that academic weaknesses in portions of the targeted student population are discounted. Students with poor basic skills have weaknesses in math, reading, and science. With regard to use by African American students, elements that are culturally relevant or focused on addressing weaknesses in reading skills are typically not designed into the technology (Hawthorn, 2005)s. Properly designed problem-based gaming systems have the ability to take these design features into account. High-quality gaming systems include facilities for overcoming weaknesses in core subjects.

A second element in the design of the interactive technology for middle school students with poor basic skills is that it should be problem based and allow for the student to take a wrong path as well as the correct path (Hathorn, 2005). Associated with this requirement is the notion that the technology should allow for multiple paths to the correct answer (Langone et al., 2003).

One benefit to students of these two elements is the provision for mastery of course content. The other benefit is that it also provides a means for the students to transfer that mastery both to real-world situations and to other academic pursuits (Griesser, 2001).

The U.S. Department of Education funded a research project, completed in 2003 by Langone et al., related to the salient design features of interactive multimedia instructional technology. The goal of the project was "to provide design standards for computer technology that would provide students with disabilities more effective and efficient simulated instructional activities in the area of transition skills" (Langone et al., 2003). The research used a grant project called Project Shop as its evaluation model. Project Shop's dual purposes were to determine the elements of the instructional design for multimedia and to develop simulation technology to help users transfer learned skills to real-world situations. The 20 research subjects were evaluated during a 3-week period. More than 100 students, teachers, parents, and school faculty reviewed the video and provided feedback. The researchers found that to make the interactive video most effective for its intended purpose of generalization, the video should use (a) common physical stimuli, (b) common social stimuli, (c) many examples of common stimuli, and (d) many examples of correct answers. These elements are not typically found in the middle school math curriculum. In comparison, these elements are typically designed into problem-based gaming. The research provided a clear and very useful blueprint for using problem-based gaming to make math instruction relevant while developing skills that are transferable to situations outside the classroom.

Interactive technology provides "strong hooks" for grabbing the attention of math students today. These hooks help students to learn more and enjoy learning more. It is not clear whether or not lessons learned using the technology can be transferred to other problem-solving situations. Research does provide criteria for the elements of age-appropriate and effective gaming systems (Fanning, 2008). Researchers have continued to develop criteria that can be used to build systems that can both increase classroom learning and make the learning transferable to problem-solving environments outside the classroom (Kebritchi, 2008).

How Is Problem-Based Gaming Used?

There are two key ways to use problem-based gaming. One is to improve the effectiveness of instruction. A second way is to improve student motivation to learn. This section presents literature on both of these topics as well as a general description of current applications of the technology.

Applications of Problem-Based Gaming

Problem-based learning (PBL) using interactive technology is also called problem-based gaming. Video gaming can be used to implement new instructional strategies that target students with poor basic skills. These strategies include (a) making changes to instruction, (b) delivering content using methodologies that overcome specific academic weaknesses, (c) increasing the effectiveness of course delivery, (d) providing professional development targeted toward the student's 21st-century environment, (e) increasing student motivation, and (f) bringing authenticity to the curriculum.

Problem-based gaming is used to address foundational causes of the achievement gap. Various reports published between 2001 and 2004 indicated that the key to addressing the achievement gap may be found in changing classroom instruction (Delmore, 2005; DiGisi & Fleming, 2005). In other words, the root of the achievement gap may be a failure in instruction. The "Pygmalion effect" also may be a factor in the failure of instruction (Parkison, 2004). This factor is manifested both in the student's belief regarding his or her ability to succeed and the teacher's belief regarding the student's ability to master the material. Teachers often develop a belief that a student is a poor learner based on that student's previous grades or test scores. Some teachers also are predisposed to believe that a student will have difficulty learning based on that student's ethnicity, gender, or economic disadvantages. Addressing psychological and social factors is a strategy for reducing the Pygmalion effect (Cohen, Garcia, Apfel, & Master, 2006). Making changes to pedagogy is a cornerstone for addressing the failures in instruction (Malcolm, 2007). Problem-based gaming addresses these factors by making instruction more student-centric and less teacher-centric.

Problem-based gaming presents a strategy for providing students of lower socioeconomic status (SES) with the same learning opportunity as higher SES students. Previous studies have found that students in lower SES schools were three times as likely to be using computers for drill and practice as those in higher SES schools, whereas students in higher SES schools were three times as likely to be learning higher order skills (Clarke & Moore, 2007). Reducing or eliminating this disproportionality would have an influence on the achievement gap. Integration of problem-based gaming instructional technology is a weapon in the war against the achievement gap.

Problem-based gaming can be used to address systemic differences in instruction as well as differences localized in the classroom. A 2002 research study by Lubienski examined reasons for the disparity in test scores between African American students and their White counterparts. The study reviewed differences in results by race with the desire to separate the factor of SES. The researcher analyzed data from the National Assessment of Educational Progress (NAEP). Assessment results of 4th graders, 8th graders, and 12th graders were compared to determine trends and patterns. In addition to the NAEP data, survey questionnaires were completed by students and teachers. The researcher was particularly interested in determining whether differences in assessment results were based on differences in instruction. After analyzing the NAEP data and the survey questionnaires, the researcher determined that the gap was based on differences in (a) the math courses taken by the students, (b) the beliefs of the students about how to arrive at the proper answer, and (c) the instructional practices at the schools attended. The researcher found that the education background of the teacher and the elements of the course that received high emphasis from the teacher were not significant contributors to the gap in results. All students need to be taught to use high-order thinking skills with the understanding that there is more than one way to arrive at the correct answer. Problem-based gaming can be a tool for addressing all of Lubienski's findings.

Problem-based gaming is a tool that can be used to reach students with poor basic skills. There are many interrelated factors that contribute to the achievement gap (Lubienski, 2002). One of the factors that all the poorly performing groups have in common is poor basic skills. It has not been determined yet whether the fact of poor basic skills is rooted in environmental differences associated with gender or ethnicity or the differences are solely a result of factors identified with instruction. Researchers have completed studies that try to isolate these factors (Harris, Marcus, McLaren, & Fey, 2001). In other words, research has not determined yet whether the sources of the disparity are located outside the classroom or inside the classroom (Hill & Hounshell, 2002). Education researchers typically have focused on factors inside the classroom. Problem-based gaming is a tool that can be customized to overcome whatever is found to be the source of the disparity between the affected demographic groups.

Improving instruction effectiveness through instructional gaming. Video gaming, in the form of building interactive technology systems on a foundation of problem-based learning, has been studied to a limited degree. The effectiveness of the integration of problem-based gaming into a middle school math course is based on a few key factors: (a) the teacher must believe that the technology is useful, (b) the organization leadership must be fully committed to the integration, and (c) it is important to develop a group dynamic for completing the integration.

A qualitative study by K. D. Clark in 2000 found that teachers believed instructional technology was an integral part of the process of effective education for middle school students. A total of 66 teachers were surveyed at one Texas middle school with 28 surveys returned. The survey results included information about the usefulness of instructional technology, the respondent's skill with instructional technology, and information about technology training. The researcher found that specific technology had been identified as useful to the educational process. The researchers also found that instructional technology should be tied to the state's high-stakes testing. The study is useful for the issues raised and points to requirements for developing effective technology-based instruction.

The 2004 qualitative study by Spitzer and Stansberry attempted to find the influences that determine the degree to which instructional technology is integrated into school curriculum. To answer questions posed by the researchers, two schools with different school cultures and climates were chosen. All the teachers in each of the schools were given the opportunity to answer anonymous survey questions, participate in interviews, and complete questionnaires, all of which were designed to determine the factors that affect the effective integration of instructional technology. The researchers used the Mary Douglas grid and group theory to frame their study. The Spitzer and Stansberry research found that organization leadership and group dynamics are the key components in determining the degree of instructional technology integration. The researchers demonstrated that despite obvious differences in context, the factors for successful integration were the same.

Instructional gaming and student motivation. Technology, curriculum, and professional development are useless unless students are motivated to learn. For that reason, actions that generate interest in course material and that motivate students with poor basic skills to learn have an important place in improving student achievement (Hidi & Harackiewicz, 2000).

A research project partially funded by a grant from the Social Sciences and Humanities Council of Canada and completed by Hidi and Harackiewicz in 2000 addressed the issue of motivating students in an education setting. The project focused on research in the area of interests and goals. The researchers were particularly interested in identified connections between interests and goals. The researchers used previously completed studies to examine the relationships between (a) interest and motivation, (b) individual interest and situational interest, (c) situational interest as a motivator for school learning, (d) interest and intrinsic motivation, (e) goal orientation and academic motivation, (f) factors affecting the setting of performance goals, (g) content mastery and performance goals, and (h) interests and goals. The researchers also reviewed politics and education policy. The theme of the researchers' findings was grounded in the factors identified by Mitchell (1993), grouped into categories of "catch" and "hold." The catch category includes those intrinsic or extrinsic motivators and interests that gain the student's short-term focus and assist in setting short-term performance goals. The hold category includes those intrinsic or extrinsic motivators and interests that gain the student's long-term focus and assist in setting long-term performance goals. Hidi and Harackiewicz found that extrinsic rewards can be powerful tools for gaining the interests of students and motivating students to gain mastery of course content. Additionally, interests and motivators can play a significant role in the cognitive capabilities of students within their education setting. The study offered solid suggestions for re-forming student interests and student motivation to the benefit of the student. The study presented a legitimate rationale for integrating extrinsic rewards and motivators into the modern classroom. Externally triggered situational interests and extrinsic motivators such as those associated with problem-based gaming should be added to the instructional arsenal used in the teacher's classroom.

Change to Pedagogy

Adding problem-based gaming to current instructional practice requires necessary changes to current pedagogy. More importantly, problem-based gaming provides a vehicle for integrating authenticity into curricula. Authenticity has been found to be a value-added element to instruction that both engages and motivates students. This section describes benefits of (a) adding authenticity to content, (b) adding authenticity to instruction, and (c) adjustments to instruction that are required to integrate problem-based gaming into the existing curriculum.

Combining interactive technology with course content built on a problem-based learning platform (Bottge, Rueda, Serlin et al., 2007) has provided the framework for dramatic change in pedagogy. This combination has proven to be encouraging. The most significant aspect of this combination is the change from a teacher-centric classroom to a student-centric classroom. This change is fraught with difficulty as well as potential.

Giving teachers ownership of the process as well as the necessary supports helps them become motivated to make the necessary changes (Wetzel, 2001). To effectively add technology in the form of problem-based gaming as a means of changing the classroom from being teacher-centric to being student-centric, teachers must feel that they are still in control.

An empirical multicase study by Wetzel in 2001 focused on pedagogical and curricula changes generated by the integration of instructional technology. Five science teachers at a middle school in suburban Virginia were included in the research. Nine science teachers from the school were invited to participate. The researcher sought to identify the factors for successfully implementing and integrating instructional technology into existing pedagogy and curriculum. The researcher found that when changes were properly and systematically implemented, there was a decrease in teacher concerns. The researcher also found that when teachers were given ownership and support they were willing to change previous strategies and techniques. A final finding of the researcher was that successful implementation included giving teachers ownership of the process by allowing them to select the times and curriculum points for technology integration, fostering collaboration among participants, providing relevant staff development, and providing ongoing technical support. The study is useful for identifying success factors for pedagogical change when implementing instructional technology. Although the sample size was small, study results were strengthened because the findings were consistent with results from previous studies such as the 1990 study by Silva, Moses, Rivers, and Johnson.

Research results consistently have demonstrated that teachers are the key to improving test scores (Balfanz & Mac Iver, 2000; Harris et al., 2001; O'Neill, 1995; Senese, 1984). Problem-based, gaming-based course delivery changes the classroom from a teacher-centered environment to one that is student centered. For that reason, motivating teachers to "give up control" is an important part of the pedagogical change. Equally important to this change in pedagogy is motivating students (Berk, 2003; K. D. Clark, 2000; Gullatt & Lofton, 1998; Linn et al., 2000; Petty, 1990; Tomlinson, 1995). Instructional technology has the potential to be the most powerful tool in the teacher's toolkit. To achieve this goal, selecting the proper technology is a critical first step. Once selected, fully integrating the technology into the course is another requirement. The effectiveness of the selected technology is dependent on the environment in which the teacher serves (Yoho, 2006). The properly constituted environment includes fully integrated technology, a school climate conducive for learning, a rigorous curriculum that stresses high-order thinking, and supportive school leadership (Hoon, 2006).

Researchers have reviewed education systems that are technology based, especially systems that involve the use of interactive video technology to teach mathematics in middle schools (Flener, 2000). Research in this area is encouraging.

Flener completed a qualitative study in 2000 that reviewed the effectiveness of interactive video to teach math to middle school students. The study involved 17 teachers at eight schools in the Chicago (IL) Public Schools. The researcher sought to determine (a) the teacher's level of performance when using the system, (b) the teacher's comfort while using the materials, (c) the student's level of achievement when taught by teachers using the system, (d) the student's comfort level in the system, and (e) the student's perception of his or her learning. For the study, the researcher used a system named Jasper that contained interactive video that was built on a problem-based learning (PBL) foundation. The system included all necessary teaching resources. Teachers were properly trained and familiar with both the instruction materials and teaching using the problem-based learning technique. The study results were that (a) the teacher's level of performance increased, (b) teachers felt comfortable using the materials, (c) student level of achievement increased, (d) students felt comfortable being taught using the Jasper system, and (e) students perceived that they mastered the material. The 2000 research used an interactive system that was developed in the early 1990s and upgraded over time. This fact demonstrates that the principles should have an extended "shelf life." The findings also indicate the potential for using this type of system as a new approach to deal with student populations that are currently underperforming.

Students with poor math skills benefit from a change in pedagogy that includes more problem-based gaming. One existing reform model combines technology with course content built on a problem-based learning platform (Bottge, Rueda, Serlin et al., 2007). This combination has proven to be encouraging.

Brian Bottge led a team of researchers that completed a qualitative study in 2007 (Bottge, Rueda, Serlin et al., 2007); the study was designed to determine if problem-based learning coupled with multimedia technology could positively impact student achievement in math. The study used a reform model called enhanced anchored instruction (EAI). The researchers were particularly interested in students with learning disabilities (LD). The study population included 128 middle school math students. Six classrooms used the EAI model for instruction for a 7-month period; all instruction was conducted in a regular education classroom. The EAI model affects both curriculum and instruction. In this use of the EAI model, students were asked to solve a problem presented to them using a multimedia format. After solving the initial problem, the students were then asked to apply the lesson to a related hands-on problem. For that reason, the researchers designed the study to determine how the learning trajectories of students changed as a result of implementing the EAI model. Researchers found that high achievers, average achievers, and low achievers all benefited from the EAI model. Results for students without LD and those with LD were analyzed and found to show statistically significant improvement. Student achievement was reported in relation to the student's pre-EAI performance level. The researchers determined specific circumstances in which low achievers outperformed high achievers. The research is another demonstration of the power and flexibility of problem-based learning using interactive technology. This study demonstrated that EAI can be used to address the instructional needs of a variety of students. Based on the results of this study, as the education environment continues to become more complex, this type of reform model holds promise for meeting the instructional needs of students from every demographic group.

Video gaming-based pedagogy. In 2004, Haneghan, Pruet, and Bamberger (Haneghan, Pruet, & Bamberger, 2004) conducted a mixed-methods study regarding mathematics reform to improve academic achievement for an urban population consisting of predominantly low-income African American students. The key objective of the study was to determine the effect of high-quality professional development and support for teachers. Researchers analyzed test scores and results from a survey instrument to determine the study's results. The research covered 3 years and involved four project schools and two control schools. All schools had similar demographics. Study participants were randomly selected: 350-400 students per school, 150-200 students per grade level. There was variability in the cohort population. Teachers were given extensive professional development; additionally, ongoing access to math resource teachers was available. Specifically, the teachers were trained to (a) build on students' prior knowledge, (b) provide opportunities for students to listen to each other, (c) focus on students' thinking and problem-solving strategies, (d) engage students in justifying their responses, and (e) use problem solving as the emphasis of instruction. The researchers found that a rigorous curriculum, combined with structured professional development, integration of manipulatives, and instruction founded in authenticity could achieve increased scores on standardized tests. The study demonstrated that the key component for improved student achievement was relevant professional development.

Authenticity is an important element of the professional development reforms to current pedagogy. This change is easily incorporated in problem-based gaming. In 2004, a case study by Cerezo examined the effectiveness of PBL in middle school math. The study involved 14 at-risk female students; at-risk status was determined by socioeconomic status rather than race or ethnicity. The students attended various schools in a city in the southeastern part of the United States. The students were carefully selected for participation. The teachers performing the instruction were trained in PBL and had classroom experience with its implementation. The students were taught a unit using the PBL method. At the end of the unit they completed a questionnaire and they were interviewed. One of the study results was that the students felt positive about the learning experience. They attributed their positive experience to the authenticity of the problem, the social interaction demanded as part of the problem's solution, and the freedom to think differently during the process of finding a solution. A second result of the study was the participant's report of improved self-efficacy and its effect of self-regulated learning. The study is important for the findings obtained regarding the reaction of at-risk students to instruction using PBL. This study contains information that may explain why other groups have demonstrated increased performance when taught using a PBL method (Williams et al., 1998).

In a quantitative study similar to Cerezo's (2004) research, Williams et al. had completed a quantitative study in 1998 that examined how middle school students used and interacted with computers in a PBL environment. The study involved 115 students in a middle school located in a city in the southwestern United States. Of the 115 participants, 76 were Hispanic, 14 African American, and 25 White. There were two treatment groups and one control group. One treatment group received computer-based PBL instruction; the other treatment group received paper-based PBL instruction. The control group received traditional lecture-based instruction. A pretest and a posttest were used to determine content mastery. The study found that there was a statistically significant gain for both of the treatment groups. The researcher also found no significant difference in the gain of the computer-based group versus the paper-based treatment group. There was no statistically significant gain in the scores of the control group. The study is a strong affirmation of the benefit of problem-based learning. An interesting finding by the researcher that was reported but not part of the study is that the computer-based group reported greater satisfaction with the learning process than either of the other groups. This finding of satisfaction with computer-based PBL is consistent with other studies on the topic. The study demonstrated that districts that do not have the technology infrastructure to automate PBL can begin with a paper-based system and still improve test results.

Establishing content authenticity through instructional gaming. Researchers have shown that one effective strategy for engaging students is to establish subject matter authenticity (Griesser, 2001). The ability to apply mathematics to problem-solving environments is an important aspect of math instruction. Students need to know how they will use course material in real life (Griesser, 2001). The attractiveness of authenticity is that it communicates to the student how the course material can be used in real life. When course material can be linked to actual events in the student's past or present, or when course material is linked to an expected event in the student's future, the student is more likely to be motivated to master the course material. Presenting an academic setting that builds on this behavior can have the effect of changing other aspects of the student's in-class performance (Cerezo, 2004).

Researchers have examined the potential use of interactive video technology to teach mathematics in middle schools. One of the important characteristics of the program used by one of those researchers was the program's effort to achieve authenticity with its target audience.

Griesser (2001) was one of these researchers. He completed a quantitative study in 2001 that used the Jasper Woodbury series to evaluate the difference in problem-solving ability for students taught using interactive video versus students taught with traditional instructional methods (Griesser, 2001). Of special interest to the researcher was the ability of students to transfer classroom instruction to unrelated novel situations. The study involved 72 students from a population of 150 students. The researcher gave the same pretest and posttest to the experimental group and the control group. The experimental group was taught using the Jasper interactive video series. The control group was taught using traditional methods. The test results were tested at the .05 significance level. The researcher found no statistical difference between the two groups in problem-formulation ability or problem-solving transferability. There was a statistically significant difference in the problem-solving ability of the experimental group for the material taught. This study provided additional certification of the viability of using interactive video for math instruction. The study also raised the additional question about transferability to other academic or real world situations. As this study focused on one course unit, it would be interesting to determine if using the problem-based instruction with an interactive video system for multiple course units or for multiple courses would increase transferability to other situations.

Authentic problems in video games. Authenticity has been shown to be important to students at many education levels (Griesser, 2001). When a student perceives that the content has real relevance to the student's future, the student invests more of himself or herself in content mastery (Scheepers & Nulden, 2000). This notion has important ramifications for the goal of improving the achievement of students with poor basic skills.

Scheepers and Nulden completed a qualitative study in 2000 exploring the use of information technology to facilitate problem-based learning in educational activities. The problem that was presented was designed to represent a situation that would be found to be authentic to the students taking the class. The study involved two groups of college students. One group of students was in South Africa, the other in Sweden. The South African group consisted of 21 students in their 4^{th} year of college-level computer science. The Swedish group comprised 28 2^{nd}- and 3^{rd}-year students of college-level computer science. The PBL case dealt with "project escalation," a situation in which a project requires resources beyond the project's original budget. This condition is generated through either a change in project scope or through some form of project mismanagement. In both cases the ultimate result is a loss to the company or to the company's customer. In this study, students were presented a case with factual information that could be analyzed to make the determination that the project would escalate and be doomed for failure. The students were given freedom and direction so that they could complete the analysis and recommend the necessary actions to minimize the loss. The researchers found that the interactive technology in a course using PBL helped college students better understand course content and apply that understanding to similar situations outside the classroom. A survey questionnaire was given to all students taking the class; those results were analyzed. The researchers provided a model for establishing positive results when using the PBL model. The researchers also demonstrated that using technology to introduce the problem vignette had a positive effect on the PBL model. The model presented in the study provides a framework for getting students to feel positive about the process. The researchers also demonstrated a method for getting the students to be more focused and engaged in the problem solution. They provided a model for assisting students in transferring abstract classroom lessons to real-world situations. This fact is a key for establishing authenticity and is a significant teacher-student communication bridge.

Summary. Video gaming contains all the elements associated with reaching and motivating modern-day students. Elements that are particularly important are interactive technology and problem-based learning. Problem-based learning holds promise for addressing the concerns of at-risk students. One trait that many at-risk students share is poor basic skills. Whether computer-based PBL or paper-based PBL is used, students have been shown to improve scores, enjoy instruction, and display increased motivation. The key is to use real-world problems that are relevant to the students. This capability is one of the features of problem-based gaming.

What is the Effect of Video Gaming?

Researchers have demonstrated that video gaming can have positive effects on instruction. This section describes two views of the change. One view shows how video gaming can be used to create a student-centered classroom. The second view shows how properly implemented gaming can motivate teachers to change how instruction is delivered and to test the advantages of a student-centered classroom over a teacher-centric classroom.

Student-centered classroom. Changing pedagogy to eliminate the achievement gap is a strategy that has been advanced as having merit. An element of one of the new reform models is to change classroom instruction from being teacher centered to being student centered (Sheppard, 2006). A significant effect of designing problem-based gaming for classroom instruction is the reorientation of instruction from being teacher-centric to being student-centric. Instruction in a "self-paced environment" may be useful for students trying to use the student-centered model.

In 2006 Sheppard completed a qualitative study that focused on the key elements for developing successful math students in schools that had been identified as failing. The study involved 11 students, 2 principals, and 2 math teachers. Data were gathered through survey questionnaires and taped interviews. The study population was carefully chosen; eligible student participants were successful students in a failing school. For this study, "successful" was defined as scoring at the advanced or mastery level on the Graduate Exit Exam for the 21st Century. A failing school was a school defined as academically unacceptable by the Louisiana Department of Education. The study found that the students believed the teacher's ability to communicate the content material to be a key to students' success. The study also found that the teacher's contribution to student self-efficacy was a significant factor in the student's success. The researcher demonstrated similarity with studies of nonfailing schools regarding the effect of the teacher, building leadership, and parental influence on student success (Bottge, Rueda, Serlin et al., 2007; Bussey, 2007; Newlin, 2006; Ouellette, 2006). The study results demonstrated that a student-centered classroom is an important element of teaching. Regardless of whether or not a school is failing, successful integration of problem-based gaming requires that the teacher adopt a student-centered approach to communicating course content.

Creating a student-centered classroom is at the heart of reaching students with poor basic skills through problem-based gaming. As part of the process of motivating teachers to make their classroom student centered by adding problem-based gaming, three conditions must be met: (a) the teachers must see a practical benefit to using the technology, (b) the teachers must believe they have the proper training, and (c) the teachers must be provided an adequate support structure to bring the technology into their classes (Levin & Wadmany, 2006).

A qualitative study by Levin and Wadmany (2006) examined the instructional beliefs and practices of middle school teachers when integrating technology into their classrooms. The study involved a sample of six teachers in one school in central Israel. The researchers collected data through interviews, questionnaires, surveys, and observations. The data collected were analyzed with results generated for the individual teacher and for the complete sample population. The building leadership and researchers prepared technology-rich classrooms for the teachers. The technology-rich environment included hardware, software, and interactive multimedia lessons that complemented the course material. The teachers also were given training on using all the tools and resources that had been prepared. Technical support was available on demand. The study found that teacher comfort with the supplied technology and available support shifted instruction toward student-centered teaching rather than curriculum-centered teaching. More importantly, the researchers found improvements in student learning. The study is very important for demonstrating requirements for building a technology-rich classroom in which the teacher can work comfortably.

Positive effect of gaming on instruction. As is the case with most professionals, teachers are reluctant to make changes to processes and procedures that have been proven effective for them. Threats or force directed at the teacher is likely to prove counterproductive. Teachers are willing to make the change if the change is presented in a positive way (Wetzel, 2001). Therefore, to address the pedagogical changes fostered by integrating problem-based gaming, teachers must be convinced that the change is in their best interest and the best interest of their students.

A study to test a model for integrating technology with the associated pedagogical and curriculum change was conducted by Wetzel in 2001. The study was a multiple-case study using a dominant–less dominant, qualitative–quantitative design. Five teachers from a single middle school that were invited to participate in the survey made up the survey sample. One purpose of the study was to determine teachers' concerns about integrating technology into their curriculum. A second purpose of the study was to determine how successful implementation of technology altered the teachers' strategies and techniques. The study results were based on their project experiences. Four of the five teachers experienced a meaningful decrease in their concerns regarding integration of technology. Four of the five teachers shifted their strategies based on the successful integration of technology, with their attitudes toward technology changing from nonsupport to support. These teachers also changed their teaching style to make it more student centered. This study established its usefulness in three ways. First, it demonstrated the effectiveness of properly implemented technology. Second, it identified a system of mechanics for successful integration of technology into an existing course. Most importantly, it demonstrated the willingness of teachers to apply creativity for the purpose of making their instruction student-centered.

Summary. The integration of technology into a classroom requires planning, commitment, and the willingness to change (Hoon, 2006). The classroom teacher must believe in the technology as well as the pedagogy (V. Clark, 2003). The integration can work in environments that have been identified as failing (Sheppard, 2006). Successful integration requires that the teacher be comfortable with the technical environment, that the teacher be committed to innovation, and that the innovation be directed toward a student-centered classroom. Student success is the predicted reward for making the financial and pedagogical commitment to the process.

There are many issues related to both PBL and technology that must be overcome to successfully implement a course that is built on problem-based gaming. Three categories can be used to summarize these issues. One category of issues is described as "comfort with technology"; a second category is described as a "willingness to change their teaching style"; and a third category is the "student-centered teacher." These three categories of issues must be properly addressed to successfully integrate problem-based gaming into the classroom.

Intervention Instrument

VmathLive is a Web-based technology program that uses interactive games as one of its cornerstones for success; it is the online technology component of the Vmath intervention program. VmathLive and Vmath are products of Cambium Learning, Inc. One of the program's goals is to create an interactive and stimulating online learning environment for students in Grades 3-8. Game play is one of the tools used to create this environment. VmathLive focuses on interactive practice, self-paced instruction of math concepts and skills, and game play. The program has been used extensively by teachers as a tool in both preparation for high-stakes assessments and regular reinforcement of directed instruction conducted in a classroom setting. Additionally, the program has a reputation for being effective in a remedial classroom setting as an intervention instrument.

Although VmathLive has been specifically designed to support, complement, and reinforce the math intervention program Vmath, it can be used in cooperation with any core math program for seventh-grade students in a regular math setting. The effectiveness of VmathLive is largely dependent on consistent and continued use of the practice activities included in the program. The practice activities include problems that are generated randomly. One advantage of this approach is that students cannot memorize answers. Another advantage is that students sitting near each other do not complete the same practice problems. The company believes that game play can be used to motivate students to practice math concepts.

Students have the ability to compete against themselves, against the computer, or against students located anywhere in the world who are online and looking for a game. The company therefore uses VmathLive interactive game play to meet the following goals: (a) motivating students to continue to learn and improve, (b) increasing time on task with meaningful and rewarding practice, (c) providing instant feedback and analysis of errors, (d) instructing students with step-by-step animated visual representations of math concepts and skills, (e) rewarding student achievement, and (f) reporting student results to guide instructional decisions.

The game has been designed to meet the following functional requirements: (a) motivation, (b) gender neutrality, (c) feedback and scaffolding, (d) verbal and written reflection, (e) the game genre, (f) balance between the content and the game, (g) visual effect and usability (h) situating mathematics learning in the games, (i) providing a set of goals to achieve, (j) providing enough of a challenge to be exciting but not overwhelming, (k) making games cognitive artifacts by incorporating the factors of interactivity and communication, (l) associating learning to a pleasant memory, (m) providing a learning environment that allows students to experience the joy of learning, and (n) providing sensory stimuli by using high-quality graphics and animation.

Balance between the math content and game playing is maintained by providing a challenging game environment in which the mathematics content is of primary importance to the game player.

Basis for Instruction

The game is built on the educational theory of experiential learning. In this theory, educators purposefully engage with learners in a direct experience and focused reflection to increase knowledge, develop skills, and clarify values (Scheepers & Nulden, 2000). Experiential learning places the emphasis on active participation, as well as interactive and applied learning in a real situation. PBL places the emphasis on a real-world problem that is presented as the starting point for the learning experience (Scheepers & Nulden, 2000). For that reason, the game's maker provides both types of resources to help teachers integrate the games into the school curriculum. The game uses interactive video as the platform for providing the vehicle for the teacher to actively engage the student.

The VmathLive instructional environment has key resources to assist in integrating the game into the classroom environment. The instructional environment includes available teaching modules that can assist in the teaching of the game's mathematics content. Customizable lesson plans are also available. The lesson plans are designed to help with teacher-directed instruction as well as inquiry-based instruction. In addition to these resources, practice tests and quizzes are available to assist the teacher. All of these resources are aligned with the NCTM standards for the relevant mathematic content.

Conclusion

This chapter discusses the key elements for developing instructional practices that integrate problem-based gaming for the purpose of improving test scores for students with poor basic skills. This approach can be used for all students, but holds promise as an especially powerful platform for overcoming many aspects of instruction identified as ineffective for students with poor basic skills. The explanations and tactics described in this chapter provide a path for targeted assistance for a large population of students that have underachieved within the existing educational bureaucracy.

The literature in this review states that improving student achievement is more a factor of instruction than it is a function of student interventions. Selecting and integrating the proper technology with its associated requirements to change pedagogy is a strategy that has been proven in nonacademic settings. Limited research in the K-12 environment demonstrates that instruction based in high-end technology can be successful in the K-12 environment as well. Students of color represent 40% of public school students (Irvine, 2003). By focusing on the needs of this currently underperforming group, we also address the needs of all students. This “rising tide” of achievement for all is both the road to eliminating the existing gap in performance between Whites and Asians compared to Blacks and Hispanics and the path to addressing the instructional needs of all students with poor basic skills.

The researcher asserts that video gaming technology can be used to meet the needs of students with poor basic skills. The researcher also believes that video gaming can be a strategy for addressing the achievement gap problem. Current strategies for helping students with poor basic skills as well as addressing the achievement gap include additional remediation, psychological intervention, and technological interventions. Although there are manifold variations for each of these strategies, each one typically includes some form of the following three elements: (a) more time on task, (b) better teaching, and (c) motivating the students. Problem-based learning using interactive technology can be added to any of the strategies and be used to accomplish any of the elements of the strategies. The reviews conducted by the researcher support that position.

Adding problem-based gaming to courses does not require changes to existing curricula or standards. The approach can be used for any course and at any grade level. The combination can be used in regular education or special education classes. It should be viewed as an enhancement, not as a replacement for those systems that are already in place.

Video gaming represents an option for improving the communication of course content to students with poor basic skills. Problem-based learning can be especially useful for engaging at-risk students (Ryan, 1997). Whether computer based or paper based, the problem vignettes that introduce the unit are the key to establishing authenticity and relevance with the students (Williams et al., 1998). Authenticity and relevance are valuable assets for bridging the communication gap and overcoming motivation challenges associated with the at-risk student (Griesser, 2001). Interactive technology plays an important role because it provides a tool for teachers to deliver on the promise of differentiated instruction (Tomlinson, 1995) and gives the students the ability to spend course more time on task while working at their own speed (Langone et al., 2003).

Integrating a system of instruction using problem-based gaming requires three things. First, the teacher must be comfortable with technology (Levin & Wadmany, 2006) because the teacher cannot guide the student if the teacher is not knowledgeable and comfortable. Second, the teacher must be committed to instruction innovation (Wetzel, 2001). This requirement exists because providing students with content-appropriate, culturally relevant problems requires creativity. Third, the teacher must adopt a student-centered approach. Most classrooms are teacher-centric or content-centric (Sheppard, 2006).

Interactive technology provides a practical path for differentiated instruction. Although literature in the field confirms that differentiated instruction can be successful, differentiated instruction can be extremely difficult to implement in a typical regular education classroom (Berk, 2003). Integrating problem-based gaming into K-12 instruction creates a system of instruction that is parallel to that used by military personnel, doctors, engineers, and pilots. The academic benefit of the approach for students with poor basic skills is that the system can be used to (a) increase motivation to master the material, (b) build interest in the subject, (c) establish the authenticity of the subject, and (d) deliver on the promise of differentiation.

Gaps in literature. The literature regarding video gaming, interactive technology, differentiation, and problem-based learning is informative. Despite this fact, there continue to be gaps within the information pool. Regarding this literature, the following gaps have been identified:

1. How has instruction contributed to the achievement difficulties of students with poor basic skills?
2. Does problem-based gaming help with transferring classroom knowledge to problems in nonclassroom settings?
3. How can problem-based gaming be used to overcome the Pygmalion effect?
4. Can problem-based gaming help to teach middle school math in a way that is culturally relevant for students with poor basic skills?
5. How sophisticated does problem-based gaming need to be to be effective?

Research question. There is much that is not known about how to improve math achievement for middle school students. The question researched in this study was the following: To what extent are there significant differences in math game intervention posttest scores (when controlling for pretest scores) among three groups of seventh-grade math students at a suburban public school in the mid-Atlantic region of the United States?

Chapter 3: Methods

Introduction

Many parents and educators ask, "Can electronic games help students learn math?" That question was the focus of this empirical investigation designed to determine the extent to which interactive electronic video games have a positive impact on selected middle school math student outcomes.

Structure of the Study

This study involved seventh-grade students at one suburban public middle school in the mid-Atlantic area of the United States. All the students took the same pretest and posttest; two teachers provided all instruction. One teacher taught three classes, and the other teacher taught one class; a total of 128 students were instructed by the two teachers. The 128 students represented the entire population of regular seventh-grade students taught by the two teachers. A subset of the seventh-grade students were enrolled in an after-school math remediation program. All the remediation students were taught by the same teacher during the regular school day. Remediation was recommended to these students either because they had failed the previous year's high-stakes test or because they were earning a grade of D or F at the time the remediation program started. Students then self-selected to be part of the remediation program; 62 students enrolled in the remediation program. Some of these remediation students had an interactive math game added to their instruction; these students represented the experimental group. The rest of the remediation students did not have the interactive video game added to their remediation instruction; these students constituted the comparison group. The remaining students were not enrolled in remedial math and did not have access to the interactive video game; these students made up the control group. The control group consisted of 37 students taught by Teacher 1 and 29 students taught by Teacher 2. All students in the control group were either performing at a level that did not require remedial instruction or they decided not to self-select into one of the remediation groups.–Figure 2 depicts the structure of the study.

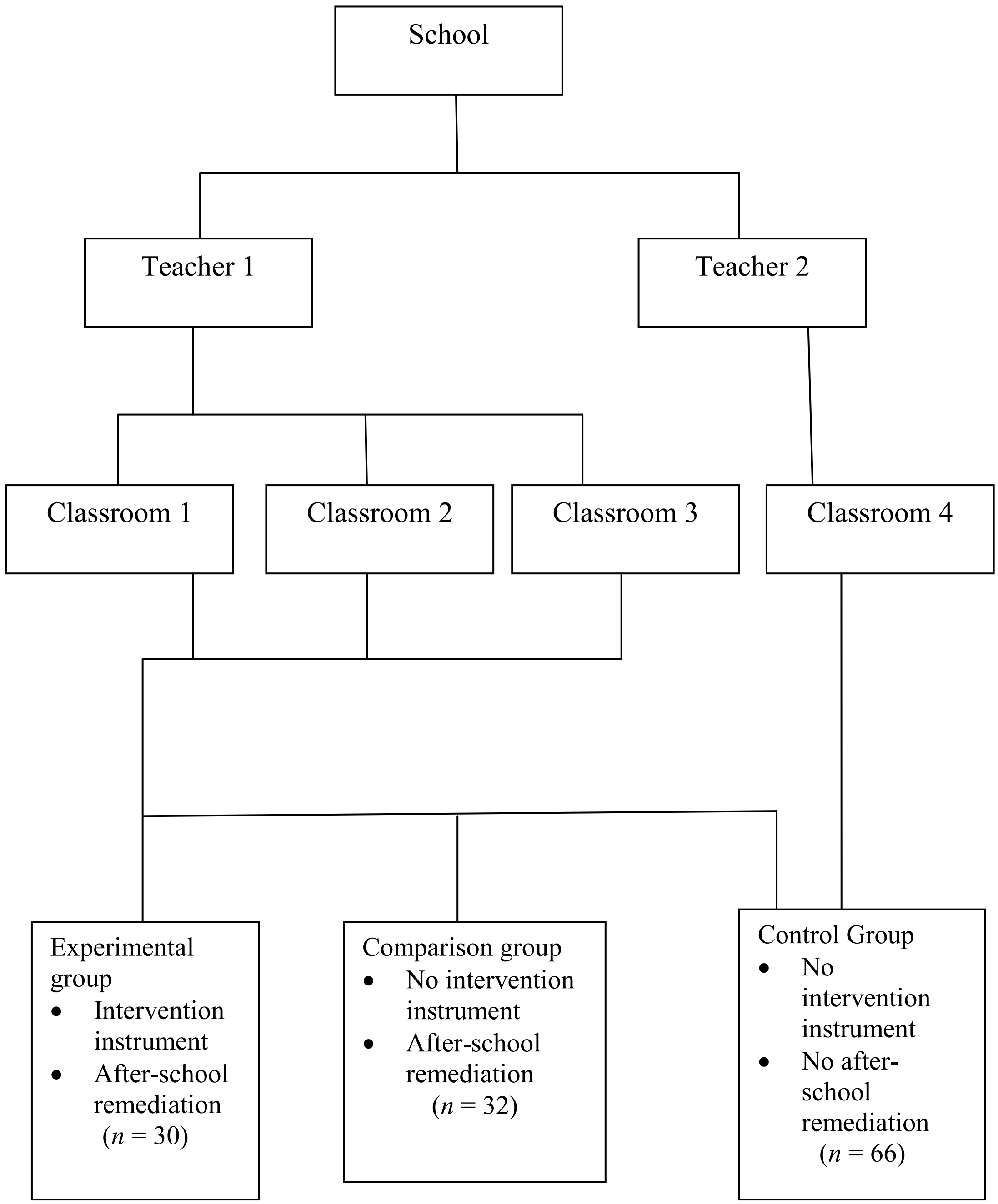

Figure 2. Structure of study.

Overview of Methodology

This study focused on the objective of determining whether or not interactive games positively affect the math achievement of middle school students at a suburban public school in the mid-Atlantic region of the United States. The quantitative study employed a pretest-posttest design and compared the end-of-marking period math posttest scores (statistically adjusted by controlling for pretest scores) of the experimental group (those that received the interactive games intervention and remedial instruction) with those of the comparison group (those that did not receive the interactive games intervention but did receive remedial instruction) and the control group (those that did not receive remedial instruction and did not have access to the interactive game) after controlling for the students' pretest scores. ANCOVA was used to analyze the data from this research regarding math achievement using one independent variable (introduction to an interactive educational game) and one dependent variable (posttest score). The pretest score was used as a covariate. The posttest scores for the two remediation groups were compared to each other as well as to the posttest scores of the control group.

To understand the rationale for the implementation of this intervention in the setting of a remediation classroom, one should be cognizant of the concept of disruptive education as coined by Clayton et al. (2008). The core elements of disruptive education include restructuring the interaction between teacher and student, implementing effective psychological interventions, involving students in active learning, and actively engaging students through authentic course material. The theory suggests that students, especially at-risk students, can benefit from student-centered classrooms. Interactive games constitute a resource that facilitates the student-centered classroom. Three studies conducted by the Cognition and Technology Group at Vanderbilt in the 1990s demonstrated the effectiveness of using interactive video-based gaming to increase learning in diverse communities through student-centric activities: ("Anchored

Instruction and Its Relationship to Situated Cognition," 1990; "The Jasper Experiment: Using Video to Furnish Real-World Problem-Solving Contexts," 1993), and ("The Jasper Experiment: An Exploration of Issues in Learning and Instructional Design," 1992).

The relationship between electronic gaming and educational achievement has continued to be debated (Williams et al., 1998). There are many types of electronic games available to middle school students. The game used in this study, vMathlive™, is an electronic game that combines seventh-grade math content with interactive game technology. The vMathlive™ instructional game utilizes the latest innovations in interactive technology, including 3-D animation, customizable avatars, and engaging interactive functionality.

This research study imitated the school district's typical instructional programs. All regular policies and procedures were maintained. For that reason, other than the intervention instrument, there were minimal differences between the activities examined through this research study and the normal and customary operation of the school district's instructional program. Those minimal differences were all necessary to collect data in a way that allowed for a publishable study while protecting the anonymity of the students. All data were obtained and protected in accordance with existing school district procedures. It is not unusual for the school to have its students complete a pretest and a posttest. This study replicated the type of circumstance in which the school typically determined that a pretest and a posttest would be informative. The researcher used those test scores as part of this study.

Research Question

The question researched in this study was the following: To what extent are there significant differences in math game intervention posttest scores (when controlling for pretest scores) among three groups of seventh-grade math students at a suburban public school in the mid-Atlantic region of the United States?

Research Procedures

Design. This research was a quasi-experimental study. A quasi-experimental design was required because study participants could not be randomly assigned. ANCOVA was used to analyze the data. The data regarding math achievement was analyzed using one independent variable (introduction to an interactive educational game) and one dependent variable (posttest score). The pretest score was used as a covariate. The study participants were enrolled in seventh-grade regular math at a suburban school. The remedial classes were located in classrooms within the school building. The students in the remedial math classes self-selected for a remedial class, based upon recommendations from their classroom teachers or guidance counselors. The recommendations generally were based on the fact that the students had failed the previous year's high-stakes test; some of the recommendations were made because students received a math grade of D or F for the previous year or were receiving a D or F for the current school year. The instruction covered topics selected by the school district to be taught during the second- and third-marking periods of the school year: (a) integer operations, (b) probability, (c) the fundamental counting principle, (d) solving linear equations in one variable, (e) proportional reasoning, and (f) solving and graphing linear inequalities in one variable.

Data were collected using a pretest and a posttest, which had been previously designed by the teachers. Questions were selected from a database of questions, which had been created by a vendor approved by the school district. The questions were rigorous and paralleled the questions included in the state's high-stakes test. The questions had been shown to be reliable indicators of the progress the students were making toward mastery of the topics included in the seventh-grade math curriculum. A description of the specific skills is included in Appendix C. The pretest was used to indicate the student's baseline content knowledge; the posttest was used to determine the amount of change following the introduction of the interactive game to the curriculum in a remedial setting.

Data were analyzed using an ANCOVA test. A quantitative method was selected for three reasons. First, the researcher was attempting to review a complex situation and identify a key factor that might contribute to positive change. Second, this method lends itself to comparison studies using other grade levels, geographic locations, or subjects. The third reason was to establish a reliable gauge for the size of the change. The researcher recognized that other factors might influence the data: teacher competence, teacher expectations, family income, school climate, and the number of student absences from class. It was the expectation of the researcher that the study design would control these additional influences so that the researcher would have confidence that the intervention tool was responsible for the differences in test scores.

Sampling. The study involved the use of one school district, one school, two remedial math programs, four classes, two teachers, and 128 students. The school district was located in a suburban area found in a mid-Atlantic state of the United States. The school was a public middle school located within the geographic boundaries of the school district. There was one experimental group, one comparison group, and one control group. There were 62 students in the two remediation groups combined and 66 students in the nonremedial group.

All teachers involved in the study were considered highly qualified according to NCLB standards. The teacher of the remediation groups had developed a track record of success in having students meet standards on the state's high-stakes test. He had had previous experience with interactive electronic games but no previous experience with vMathlive. The second teacher participating in the study also had a history of success in having students meet standards on the state's high-stakes test.

There were unequal samples among the three groups because the researcher had to use the classes as they existed. In addition to the sample size, demographic factors such as ethnicity, gender, and economic status, which were provided by the school district for each student, were documented to compare the three groups. This information was needed so that the researcher could identify any significant demographic differences between the groups. All students in the study attended Math 7 classes regularly. In this context, "regularly" means that students in the program were scheduled to attend math class Monday through Friday, for 85 minutes each day.

The study participants were considered to be a cohort. To be a member of the cohort, a student had to be enrolled continuously in school and assigned to the teacher for the duration of the research period. Students also had to complete both the pretest and the posttest. Absences were not considered in determining cohort membership. These conditions were meant to represent some of the real-life issues associated with the math achievement of students in the school district.

Selection. The following information was considered in the development of the study:

1. The school was selected for two reasons. First, the student population had a demographic mixture that was similar to that found in the statewide student population. Second, it had the technology infrastructure to support the technological needs of the experimental group.
2. Math 7 was chosen because it was the first class to introduce all the content areas covered in the pre-algebra curriculum.
3. A subset of students was included in the remedial groups. All students that enrolled in the after-school math remediation class were included in one of the remedial groups. The determination of which remedial group served as the experimental group and which as the first comparison group was achieved through a roll of a die. The researcher used a fair six-sided cube to make the determination. The group with the highest number on the cube became the experimental group; the other was assigned as the comparison group.
4. All students enrolled in the seventh-grade math classes of the two teachers but not enrolled in the after-school remediation program were included in the control group.

Remedial class enrollment. Students were enrolled in the remedial class through the normal and customary procedures of the school. The only difference was the addition of a consent form that was signed by the parent and a separate assent form that was signed by the student for a student to be included in the experimental group (Appendix F). As part of this procedure, parents and students were informed about the purpose of the study as well as the fact that participation in the remedial group was voluntary. They were also informed that even after initial consent they could terminate participation in the experimental group without affecting their eligibility to receive tutoring services. Students that chose not to participate in the experimental group received remedial assistance as part of the comparison group. When this occurred, another student was selected at random and asked to participate in the experimental group.

Once the consent form was signed, the researcher was given the form with the original signature; this form was filed and maintained by the researcher in accordance with the school district's policies and procedures for management of confidential information. The school also maintained a copy in their files, which are managed in accordance with the policies and procedures of the school district.

Intervention–treatment. The intervention treatment of vMathlive™ was used with the experimental group. The intervention instrument is an interactive, math-based educational game that uses a video-game delivery style. Academic content is based on the National Council of Teachers of Mathematics (NCTM) standards. Multiplayer vMathlive teaches pre-algebra by involving players in completing mathematics problems in an interactive environment. The student's success at the first stage of the environment allows the student to enter into a game environment in which the player competes against the computer. The third stage of the vMathlive environment allows the student to compete against players from around the world in a real-time, interactive, competitive setting. The elements of game design as identified in Chapter 2, include the following:

(a) motivation, (b) gender neutrality, (c) feedback and scaffolding, (d) verbal and written reflection, (e) the game genre, (f) balance between the content and the game, and (g) visual effect and usability (Kebritchi, 2008). These elements are all present in the vMathlive interactive game.

In the regular daytime classrooms, the teachers did not make any modifications to the system currently used to teach seventh-grade math in a regular classroom. In the remediation classrooms, the teacher used the same textbook to introduce concepts used in the daytime classrooms. Students also were instructed on how to use the textbook as a reference source. Students in the experimental group were encouraged to answer their questions by finding the answers within the game's resources and to collaborate with other students that were in the experimental class. Students were allowed to move at their own pace through the content areas and to access the Internet for assistance. Students in the experimental class could ask other students for assistance in mastering game play or the games' math content. Students in the comparison group also were encouraged to collaborate with other students in their remediation class and to obtain assistance from the classroom teacher for any topic that was difficult.

Data storage. The data associated with this research were managed in accordance with school district policies. Identifying information had been removed from the data, which included information from the entire sample population. This means that information from the experimental group, comparison group, and control group were included in the data file provided by the school district but any information that could be used to identify an individual student was excluded. The researcher was provided with an electronic file that contained the following information for each student: (a) student ID (project specific, not the school ID for the student), (b) gender, (c) ethnicity, (d) participation in free and reduced-price meal (FARM) program, (e) group, (f) pretest result, and (g) posttest result.

The purpose of these fields was to allow the researcher to complete comparisons designed to determine that the three groups (experimental, comparison, and control) were comparable. The group field was used to identify the group to which the student belonged. A value of 2 meant that the student was a remediation student receiving the intervention treatment. A value of 1 meant that the student received remediation instruction but not the intervention. A value of 0 meant that the student did not receive any remediation instruction. The student ID field was a project-specific field used to associate an individual student with the associated data. The number was different from the student ID used by the school district as part of the maintenance of the school's student information system. The FARM acronym was used to identify a subject as economically disadvantaged.

The researcher agreed not to share or publish the data or findings associated with the data without the permission of the school district. The data file was to be kept for 6 months after the completion of the dissertation defense. All other aspects of the management of the collected data were implemented based on the school district policies as they existed at the time.

The researcher recognized the possibility of risk with regard to privacy. For that reason, the researcher took strong steps to protect the privacy of the student data. These steps began with the removal of identifying information from the data file name. In other words, the data file name had no link to the school district, school district administrators, school district buildings, school district personnel, or any school district student included in the research. The file was also password protected. Password confidentiality was maintained in accordance with school district best practices.

The data file was transferred on a flash drive from the school district to the researcher. After the flash drive was given to the researcher, the data were immediately transferred to the researcher's computer. The data file on the flash drive was then deleted.

The researcher agreed to maintain the data on his personal computer for 6 months after the researcher's dissertation defense, at which time, the file was to be destroyed. The 6-month time period was selected to allow the researcher to conduct additional analyses if necessitated. The researcher's personal computer was a password-protected desktop computer located in his home. There was no risk that the computer would be accidentally left in a public area.

Intervention Procedure

The research period was 18 weeks, which started at the beginning of the second marking period and ended at the end of the third marking period. The instructional period for the daytime instruction for all students was 85 minutes. In addition to the daytime instruction, the experimental group used the interactive game of vMathlive™ during their after-school remediation. The after-school remediation instructional period was 60 minutes for two after-school sessions per week. The entire sample group experienced standard classroom instruction, including directed instruction, active learning exercises, or any other strategy the teacher considered to be in the best interest of the class and in line with school district guidance. For the two remediation groups (experimental and comparison), there were necessary difference in the management of the after-school instructional period. The list below describes the procedures that were followed for sample selection and teacher training as well as the activities for each group during the instruction period.

Teacher training. The following steps were taken to provide training for teacher participants:

1. The teacher of the experimental group was given one day of professional development with four objectives. The first objective was to provide explanations and demonstrations of how the game's content related to the state's curriculum objectives as well as how the game's activities developed content skills. The second objective of the training was to help develop teacher competence in assisting students to find answers within the game to any questions they might have. The third objective of the session dealt with how to navigate through the game's obstacles and level structure by providing a hands-on introduction to each of the game's activities. The fourth objective of the training was to develop competence in managing the instructional environment and accessing the reports generated by the students' activities.
2. The teacher was provided an overview of research-based issues related to student-centered instruction, which was designed to be applied to the experimental group's after-school remediation. This introduction included strategies for assisting students in locating answers to questions within the game as well as the proper protocol for collaborating with other students in the classroom. To facilitate collaboration, the teacher was encouraged not to

provide assistance with questions about how to play the game; the teacher was instructed to encourage students with questions to seek answers from other students in the class.

3. The teacher was provided guidance on topics such a handling those students that did not have as much game access as they desired. This guidance was provided as part of the ongoing question-and-answer interface between the researcher and the teacher.

Experimental group instruction. The after-school instructional period proceeded in a manner similar to the following sequence; the teacher was expected to apply professional judgment to meet the spirit and intent of the research. The instructional period was 60 minutes long.

1. The students started the remedial period in a classroom in which the computers were located. There was one computer for each student.
2. The teacher started the class by completing normal administrative tasks such as announcements, taking attendance, and answering student questions about their homework.
3. The teacher continued the class by presenting a short explanation of concepts to be encountered within the game, targeting those topics that the teacher knew to be especially problematic to students.
4. The teacher then proceeded by allowing students to begin playing the game.
5. "Game rooms" identified by the teacher were given to the students. Students were asked to play any of the games they desired; they were encouraged to collaborate on math problems as well as game strategy. Students were

permitted to go to any unlocked game they desired, whether or not it had been selected by the teacher.

6. During the next phase of the instructional period, the students logged out of the game. The teacher then allowed the students to collaborate with each other about challenges they faced related to either math content or game playing.
7. The final phase of the remediation instruction for the experimental group was to ask students for feedback about problems encountered during the period or topics the students would like to have discussed during the next day's regular school-day class.

During the conclusion of the remediation period, students were encouraged to find opportunities to play the game outside the supervision of the teacher. These opportunities might include time at home, time with a friend, time at the library, or time at a recreation center. Opportunities to play required only that the student have access to the Internet and that the owner of the computer give permission to access the game.

The game used in this research includes a teacher administration feature that allows the teacher to monitor the days, times, and duration of the student's involvement with the game. This monitoring is done through the student's log-in to the game. Whenever the student logs into the game, the timer starts. The timer continues to update the time for as long as the student is accessing the game's activities. The experimental group's teacher accessed this information to obtain anecdotal information regarding student access to the game outside the remedial period. The teacher noted that he learned that some of the experimental group students accessed the game outside the school remediation period. For the purpose of this research, these times were neither collected nor analyzed.

Comparison group instruction. The after-school instructional period proceeded in a manner similar to the following sequence; the teacher was expected to apply professional judgment to meet the spirit and intent of the research. The instructional period was 60 minutes long.

1. The teacher started the class by completing normal administrative tasks such as announcements and taking attendance.
2. The next phase included a discussion of topics covered during that day's school-day instruction. This phase often included a discussion of concepts that were previously taught but not yet mastered by the class. A third area for discussion included assistance with that day's homework assignment.
3. Based on determinations made during the previous phase, the teacher began the after-school remediation. Any activity the teacher believed to be appropriate for that topic's instruction was acceptable. In addition to directed instruction, activities included board games, projects, Web sites, hands-on activities, and so forth.
4. After this phase, the teacher engaged the students in activities that determined how well the lesson was understood.

School-day instruction. The teachers were instructed to make no changes to the way they were currently teaching the topics. The sequence below is provided as an example of a typical sequence followed by the teachers. It should be noted that the actual sequence of instruction was often different from the sequence below. The instructional period was 85 minutes long.

1. The teacher started the class by completing normal administrative tasks such as announcements and taking attendance.
2. The next phase was some type of warm-up activity, which often involved a concept previously taught but not yet mastered by the class. It also could be an activity to access existing student knowledge about an upcoming topic.
3. The next phase was actual directed instruction by the teacher. Any activity the teacher considered to be appropriate for that topic's instruction was acceptable. In addition to directed instruction, activities included board games, projects, interactive Web sites, hands-on activities, and so forth.
4. After this phase, the teacher engaged the students in activities to determine how well the lesson was understood.
5. The final phase of the daily instruction was the assignment of homework. This activity included identification of problems as well as necessary explanations for completing the assignment.

Data collection instrument. The table below shows the instruments used for data collection as well as their respective dates of administration.

Table 3. *List of Instruments*

	Instrument name	Date of administration
1.	Pretest	Start of research period
2.	Posttest	End of research period

Data for math achievement were collected by using a pretest and a posttest. The tests were administered by the classroom teacher. The instruments, which were tests used by the school to measure student progress, were given using computer-based software. The student ID was used as part of the log-in to the testing software; no hard-copy document was provided. The student's name was not printed. The software was responsible for associating the student ID data with the test scores. The teacher maintained a confidential hard-copy roster that associated the students' names and the student IDs used to access the testing software. This information was maintained in accordance with the school district's policy for management of confidential information.

The pretest and posttest each included 30 questions. A copy of the tests is included in Appendix A. The questions, which presented multiple-choice answers, were based on state standards for the unit being taught. The test questions had been used previously by the school to determine the amount of progress the students were making toward mastery of seventh-grade math topics. These tests were being used by the school because mastery of the questions represented mastery of the required content. The same questions were used on both the pretest and the posttest. One of the reasons for this decision was that the researcher wanted to stay as true to the normal and customary procedures of the school as possible. The school's normal procedure called for using the same test questions on both pretest and posttest. The building administration believed this was a true indicator of the student's growth in that topic area. As an additional control for the accuracy of the test scores, the test was given on a computer. The computer system scrambled the test questions and the options for each question in such a way that every student saw a different version of the test. The final test for the validity of the test results was the 18-week interval between the pretest and the posttest. Even if a student was able to memorize the answers on the pretest, it was believed that the student would not remember the test answers for 18 weeks.

The pretests were given to all students during one of the first 3 days of the marking period. The research period began as soon as the pretest was given. The pretest was given to every student on the same day; students that were absent on the day of the test were given the test the first day they returned to school. The posttest also was given to all students on the same day; students that were absent on the day of the posttest were given the test the first day they returned to school. The research period was completed when the last student had completed the posttest. No student names were used in this study. Student test results were tracked according to student IDs that were generated by the researcher. This information was managed electronically in a password-protected file. The researcher and the teacher had access to the test results. Only the researcher had access to the data analysis results.

Data analysis. Data were input into SPSS; ANCOVA was used to test the study hypotheses. A single independent variable and a single dependent variable were used. Figure 3 depicts the relationship between the variables.

Independent Variable ⟶ **Dependent Variable**
Use of an Interactive Educational Games ⟶ Math Achievement

Figure 3. Variables.

The ANCOVA. ANCOVA was selected over analysis of variance (ANOVA) because posttest scores can reflect both preexisting exposure to the topic as well as the effect of an intervention. The ANCOVA statistic can increase the precision of comparisons between tested groups by reducing within-group error variance. This statistic also increases precision by adjusting comparisons between groups through the elimination of confounding variables, thereby increasing the accuracy of intergroup comparisons. These two factors increase the internal validity of the research. Selecting ANCOVA allowed the researcher to include the pretest score as a covariate, which increased the accuracy of the result. This same degree of accuracy would have been much more difficult if the ANOVA statistic had been selected. By using ANCOVA, the preexisting knowledge was controlled, thereby providing a more precise prediction of the dependent variable. Selecting ANCOVA therefore increased the study's reliability.

The purpose of the research was to determine the degree of math achievement that occurred when electronic gaming was integrated with traditional instruction. Prior to the start of the research, there was no way to determine which of the three instructional systems was most effective. For that reason, the research compared the achievement results of students that were subject to each of the instructional methods to determine which was most effective. The alpha was set at the .05 level; this means that the researcher would know with 95% accuracy that a significant difference in the achievement results of the experimental group was caused by electronic gaming. The null hypothesis and its alternative are stated below:

Ho: $\mu_1 = \mu_2 = \mu_3$

Ha: $\mu_1 \neq \mu_2 \neq \mu_3$

This hypothesis was tested by comparing the mean of the control group (M_a) with the mean of the experimental group (M_b) and the mean of the comparison group (M_c). If the means were equal, there was no difference. If the mean score for the control group was higher than that for the two remedial groups, traditional instruction was more effective. If the mean score for the experimental group was higher, adding the intervention tool of interactive games was the more effective instructional strategy. If the mean score for the first comparison group was higher, simply adding additional instructional time was the most effective strategy. The researcher assumed that the sample population had a normal distribution.

For an ANCOVA to be valid, four key assumptions associated with the data must be met:

1. The observations are random and independent from the population.
2. The distributions of the population from which the samples are drawn are normal.
3. There is homogeneity of variance (variances in the distribution within the populations are equal).
4. The relationship between the dependent variable and the covariate is linear.

The data in this study were analyzed using the pretest as a covariate. The pretest score was chosen because there were a number of factors that might have affected the pretest score. Among those factors was the student's teacher during the school year, the student's attitude toward attendance in math class, and how comfortable the student was taking the pretest on the computer. These factors cannot be controlled through experimental control or research design. The factors affecting the pretest scores could be statistically controlled by identifying the pretest as the covariate while using ANCOVA for analyzing the data.

In addition to the pretest score, the other factors that were considered were ethnicity, gender, and FARM. It was possible that one or more of these factors could have had an effect on math achievement. For that reason, a chi-square analysis was completed to determine whether or not the differences in group demographics were statistically significant. These factors were selected to minimize bias in the posttest scores in favor of any of the groups. Without identifying these factors, the researcher could not be sure that the analysis results were based on the intervention instrument.

Validity

For the research results to be useful, the research design and methodology must be conducted following established scientific guidelines such that the results can be certified as valid. This section describes the procedures that were followed to establish the internal and external validity of the research study.

Internal validity. A study's degree of internal validity is determined by the extent to which it can be shown that the result of the change in the dependent variable is attributable to the change in the independent variable (Huitt, Hummel, & Kaeck, 2009). To meet this burden, the following study attributes were managed carefully: (a) research design, (b) operational definitions, (c) research methodology, and (d) measurement of variables. Each of the threats was controlled by the study attributes. A detailed description of these threats as identified by Campbell and Stanley (Yu, 2009) is found in Appendix D.

External validity. A study's degree of external validity is determined by the extent to which it can be applied to similar environments (Siegle, 2009). This research was a quasi-experimental study using a control group, a comparison group, and an experimental group. When carried out correctly, this type of design carries a high degree of external validity. Campbell and Stanley (Yu, 2009) identified four factors that adversely affect a study's external validity: (a) interaction, (b) pretesting, (c) setting, and (d) multiple treatments. In this study, these threats were controlled through research design and study implementation. A detailed description of these threats is found in Appendix D.

Human Participants

Risk. No physical or emotional risk to the students or teachers was generated on the basis of participating in this study. The educational risk to students was that the time spent participating in the study might adversely affect the degree of content mastery obtained by the students.

Ethical Issues

There were a few issues that could be considered to be ethical challenges. One of the ethical issues was whether or not students were "injured" by the game. Such injury would come in the form of a dearth of traditional instruction. Because the traditional model had known results, if the lack of that exposure caused students in the experimental group to achieve less than the control group, the students in the experimental group that satisfactorily completed remediation would be at a disadvantage when the research period ended.

Another ethical issue that arose was whether or not "playing" could legitimately be called instruction. Even in a circumstance in which math achievement improves, it is difficult to determine that the intervention of gaming is contributing to the instructional goals of the school district. Some educators argue that instructional goals go beyond simply mastering topics in the content area and include skills such as collaboration with peers, citizenship, and personal responsibility. These educators assert that gaming does not support these objectives and can negatively affect the acquisition of these skills. It is this argument that creates an ethical issue.

Chapter 4: Results

The purpose of this study was to determine the degree of math achievement that occurs when electronic gaming is integrated with traditional instruction. The research question of this study was the following: To what extent are there significant differences in math game intervention posttest scores (when controlling for pretest scores) among three groups of seventh-grade math students at a suburban public school in the mid-Atlantic region of the United States?

This chapter presents the results of the analyses performed to answer the research question. The study used a quasi-experimental design. Data were analyzed through ANCOVA. The ANCOVA was completed using the group membership (interactive game) as the independent variable, the posttest score as the dependent variable, and the pretest score as the covariate. Three groups were compared in this study: a control group that received no remediation training and no interactive games intervention, a comparison group that received remediation training but no interactive games intervention, and an experimental group that received remediation training and the interactive games intervention. The chapter begins with an explanation of the study's hypothesis. The study's design is then described. The third section of the chapter includes a description of the process used to develop the population sample. The fourth section of the chapter includes descriptive statistics for all study variables. The chapter then continues with an explanation of the effect of interactive games on math achievement. The chapter concludes with a summary.

Hypothesis

The purpose of the research was to determine the degree of math achievement that occurs when electronic gaming is integrated with traditional instruction. Prior to the start of the research, there was no way to determine which of the three instructional systems is most effective. For that reason, the research compared the achievement results of students that were subject to each of the instructional methods to determine which is most effective. The alpha was set at the .05 level: A significant difference in the achievement results of the experimental group indicates with 95% accuracy that the difference is caused by interactive gaming. The hypothesis and its alternate are stated below:

Ho: $\mu_1 = \mu_2 = \mu_3$

Ha: $\mu_1 \neq \mu_2 \neq \mu_3$

This hypothesis was tested by comparing the mean of the control group (M_a) with the mean of the experimental group (M_b) and the mean of the comparison group (M_c). Equal means indicate no difference. A higher mean score for the control group compared to the two remedial groups indicates that traditional instruction is more effective. A higher mean score for the experimental group indicates that adding the intervention tool of interactive games is the more effective instructional strategy. A higher mean score for the comparison group indicates that simply adding additional instructional time is the most effective strategy. The research assumes that the sample population has a normal distribution.

Design

This study was completed with seventh-grade math students at a suburban public middle school in the mid-Atlantic area of the United States. Figure 2 depicts the structure of the study. The study involved one school district, one school, two remedial math programs, four classes, two teachers, and 128 students. The school district was located in a suburban area in a mid-Atlantic state of the United States. A total of 62 students constituted the two remedial groups, and 66 students made up the nonremedial group. There was one comparison group, one control group, and one experimental group. A detailed description of the study's structure can be found in Chapter 3.

The study participants were considered to be a cohort. To be a member of the cohort, a student had to be continuously enrolled in school and assigned to the teacher for the duration of the research period. Students also had to complete both the pretest and the posttest. Absences were not used to determine cohort membership. These conditions were meant to imitate some of the real-life issues associated with the math achievement of students in the school district.

The students self-selected for a remedial math class. The remedial classes were located in classrooms within the school building. Students self-selected because a remedial class was recommended by their classroom teachers or guidance counselors. These recommendations often were based on the fact that the students had failed the previous year's high-stakes test; some of the recommendations were made because students received a math grade of D or F for the previous year or were receiving a D or F for the current school year.

Data

The researcher was provided with an electronic file that contained the following information for each student: (a) student ID (project specific, not the school ID for the student), (b) gender, (c) ethnicity, (d) participation in free and reduced-price meal (FARM) program, (e) group, (f) pretest result, and (g) posttest result.

The purpose of these fields was to allow the researcher to complete comparisons designed to determine that the three groups (experimental, comparison, and control) were comparable. The group field was used to identify the group to which the student belonged. A value of 2 meant that the student was a remediation student receiving the intervention treatment. A value of 1 meant that the student received remediation instruction but not the intervention. A value of 0 meant that the student did not receive any remediation instruction. The student ID field was a project-specific field used to associate an individual student with the associated data. The number was different from the student ID used by the school district as part of the maintenance of the school's student information system. The FARM acronym was used to identify a subject as economically disadvantaged.

Descriptive Statistics

A total of 128 students participated in this study, including 66 in the control group (51.6%), 32 in the comparison group (25.0%), and 30 in the experimental group (23.4%). Table 4 depicts the demographic characteristics (gender, race, and socioeconomic status) for the complete sample and for each group. Overall, 46.9% of the sample were females and 53.1% were males. There were more males than females in the control group (51.5% males and 48.5% females) and the comparison group (62.5% males and 37.5% females), but there were more females than males in the experimental group (53.3% females and 46.7% males). A χ^2 test was performed to determine if gender was related to group membership, and the result was not statistically significant, $\chi^2(2) = 1.70$, $p = .427$. Most of the students in this study were Hispanic (53.9%), with 35.2% African American and 10.9% Caucasian. Hispanics were the majority racial group in both the comparison group (59.4%) and the experimental group (66.7%) but not the control group (45.5%). A χ^2 test revealed that there was no statistically significant difference in the ethnic distribution across the three treatment groups, $\chi^2(4) = 4.46$, $p = .347$.

In terms of socioeconomic status, most of the students received a free or reduced-price lunch (71.9%); this was true for the control group (69.7%), the comparison group (75.0%), and the experimental group (73.3%). There was no relationship between socioeconomic status and group membership, $\chi^2(2) = .34$, $p = .843$. The demographic analysis presented here revealed that (a) there was an approximately equal distribution of males and females; (b) the majority of the students in this study were Hispanic or African American; (c) most of the students were of low socioeconomic status; and (d) the gender, ethnic, and socioeconomic characteristics of the control, comparison, and experimental groups were similar. Therefore, the analyses presented to test the null hypothesis of this study do not include gender, ethnicity, or socioeconomic status as control variables.

The chi-square test results are important to the analysis of the data. This research involved a quasi-experimental study. One reason the study needed to be quasi-experimental was that the researcher was required to take the groups as they existed. If one or more of the differences in the group demographics had been found to be statistically significant, the researcher would have been required to control for those differences while analyzing the test scores. Because each of the chi-square tests (gender, ethnicity, and socioeconomic status) indicated no statistically significant difference in the groups for the respective demographic variables, the researcher was able to complete the ANCOVA analysis using pretest scores as the lone covariate.

Table 4. *Descriptive Statistics for Sample Demographic Characteristics as a Function of Group* (N = 128)

Variable	Control group (n = 66)		Comparison group (n = 32)		Experimental group (n = 30)		Total sample (N = 128)	
	n	%	*n*	%	*n*	%	*n*	%
Gender								
Female	32	48.5	12	37.5	16	53.3	60	46.9
Male	34	51.5	20	62.5	14	46.7	68	53.1
Race								
African American	28	42.4	10	31.3	7	23.3	45	35.2
Caucasian	8	12.1	3	9.4	3	10.0	14	10.9
Hispanic	30	45.5	19	59.4	20	66.7	69	53.9
Socioeconomic status								
No free or reduced-price lunch	20	30.3	8	25.0	8	26.7	36	28.1
Free or reduced price-lunch	46	69.7	24	75.0	22	73.3	92	71.9

Note. The control group received no remediation training and no intervention; the comparison group received remediation training but not intervention; the experimental group received remediation training and the intervention.

Descriptive statistics for the pretest and posttest math achievement scores are shown in Table 5. These statistics are provided for both the total sample and for the control, comparison, and experimental groups separately. The control group had the highest average scores on the pretest (M = 65.11, SD = 13.97), and scores increased by an average of 19.06 points, thereby resulting in a posttest average of 84.17 (SD = 12.25). Comparison group scores averaged 48.94 (SD = 11.04) for the pretest and increased by 31.65 points, resulting in a posttest mean of 80.59 (SD = 10.97). For the experimental group, scores averaged 43.17 (SD = 7.76) for the pretest and increased by 41.50 points, resulting in a posttest average of 84.67 (SD = 8.55). Thus, the posttest math achievement scores for the experimental group were the largest, and although the experimental group had the lowest pretest mean, they had the highest posttest mean.

Table 5. *Descriptive Statistics for Math Achievement Scores as a Function of Group* (N = 128)

	Control group (n = 66)		Comparison group (n = 32)		Experimental group (n = 30)		Total sample (N = 128)	
Time	M	SD	M	SD	M	SD	M	SD
Pretest	65.11	13.97	48.94	11.04	43.17	7.76	55.92	15.43
Posttest	84.17	12.25	80.59	10.97	84.67	8.55	83.39	11.20

Note. The control group received no remediation training and no intervention; the comparison group received remediation training but not intervention; the experimental group received remediation training and the intervention.

Inferential Statistics

The research question for this study was the following: To what extent are there significant differences in math game intervention posttest scores (when controlling for pretest scores) among three groups of seventh-grade math students at a suburban public school in the mid-Atlantic region of the United States? To answer this research question, an ANCOVA was performed. The independent variable in the ANCOVA was group membership (control, comparison, or experimental), and the dependent variable was posttest math achievement scores. The students' pretest math achievement scores were used as a covariate in the ANCOVA to control for group differences in pretest scores given the nonexperimental nature of this study.

Prior to conducting the ANCOVA, the assumptions of normality for the dependent variable and homogeneity across groups were examined. Figure 4 shows the histogram of posttest mathematics achievement scores. From this figure it can be seen that the distribution of scores on the dependent variable for the ANCOVA was approximately normal. To test the assumption of homogeneity of variances across treatment groups, Levene's test of the equality of variances was conducted. The result was not statistically significant, $F(2, 125) = .59$, $p = .558$. This finding indicated that the variances of the three treatment groups were not significantly different. Based on these analyses, it was concluded that the assumptions of normality for the dependent variable and homogeneity of variances were met.

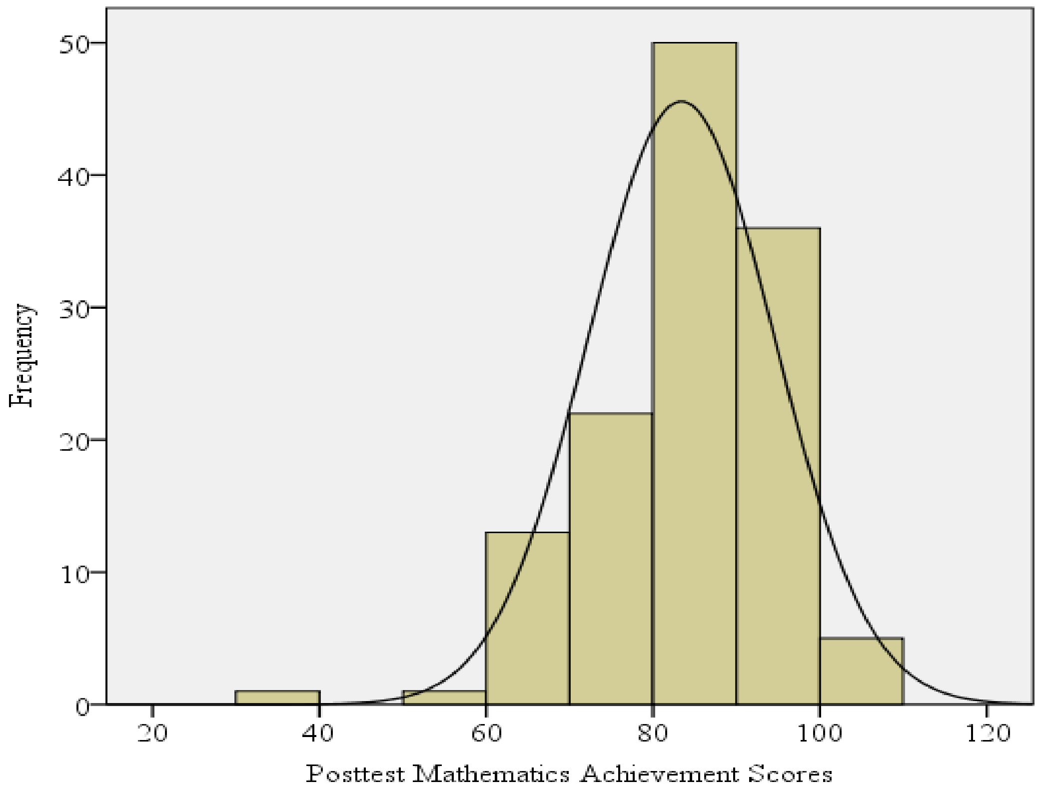

Figure 4. Histogram of posttest mathematics achievement scores.

Table 6 shows the results from the ANCOVA. Pretest scores were statistically significant, $F(1, 124) = 52.88$, $p < .001$. This finding indicated that participants with higher pretest scores also tended to have higher posttest scores ($r = .45$, $p < .001$). Group membership was statistically significant in the ANCOVA model, $F(2, 124) = 10.26$, $p < .001$. This finding indicated that there was a difference between the mean posttest scores for the three groups even when controlling for pretest scores. Post hoc tests were performed to determine which of the three treatment groups differed from which others. A Bonferroni adjustment to the alpha level was used so that each pair of groups was compared using an alpha level of .05/3 = .017. These analyses indicated that the experimental group had higher posttest scores than the control group ($p = <.001$) and higher than the comparison group (p = .005). The comparison group did not differ from the control group in terms of posttest math scores using the Bonferroni-adjusted alpha level (p = .049).

Table 6. *Results from the ANCOVA With Group Membership as the Independent Variable, Posttest Math Scores as the Dependent Variable, and Pretest Math Scores as a Covariate (N = 128)*

Effect	Sum of squares	df	Mean squares	F	p
Pretest scores	4664.80	1	4664.80	52.88	<.001
Group membership	1810.08	2	905.04	10.26	<.001
Error	10938.76	124	88.22		
Total	15942.47	127			

Figure 5 shows the mean math achievement scores as a function of group membership and time. From this figure it can be seen that the scores for all three groups improved from the pretest to the posttest, but that the scores for the experimental group improved more than the scores for the other two groups. Scores for the control group improved less than the scores for the other two groups.

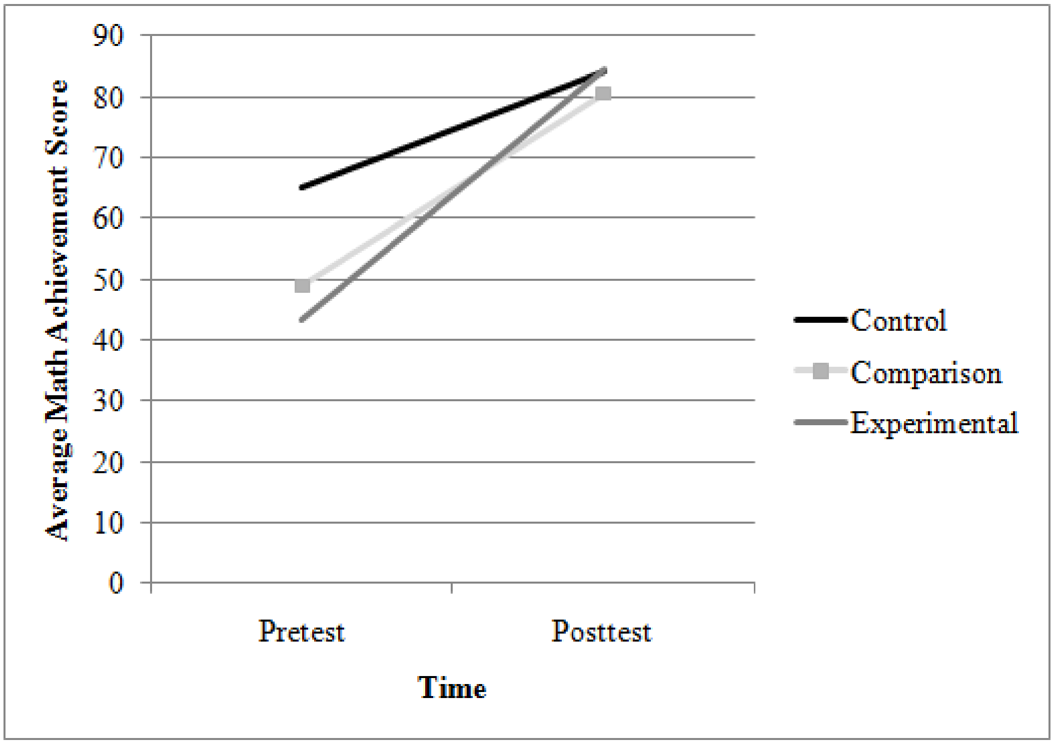

Figure 5. Average math achievement scores as a function of group and time.

The ANCOVA procedure also provides estimated marginal means and standard errors for posttest math scores when controlling for pretest scores. Figure 6 is a graph of the estimated marginal means for this ANCOVA. The estimated marginal means are estimates of what the posttest means would be if the three groups had been equivalent on pretest scores. Descriptive analyses described previously indicated that the three groups were not equivalent on pretest scores, with the control group's having the highest mean (M = 65.11), followed by the comparison group (M = 48.94), and the experimental group's having the lowest pretest mean (M = 43.17). The estimated marginal means for posttest scores while controlling for these pretest differences were the following: control group, M = 79.52, SE = 1.32; comparison group, M = 84.13, SE = 1.73; experimental group, M = 91.12, SE = 1.93.

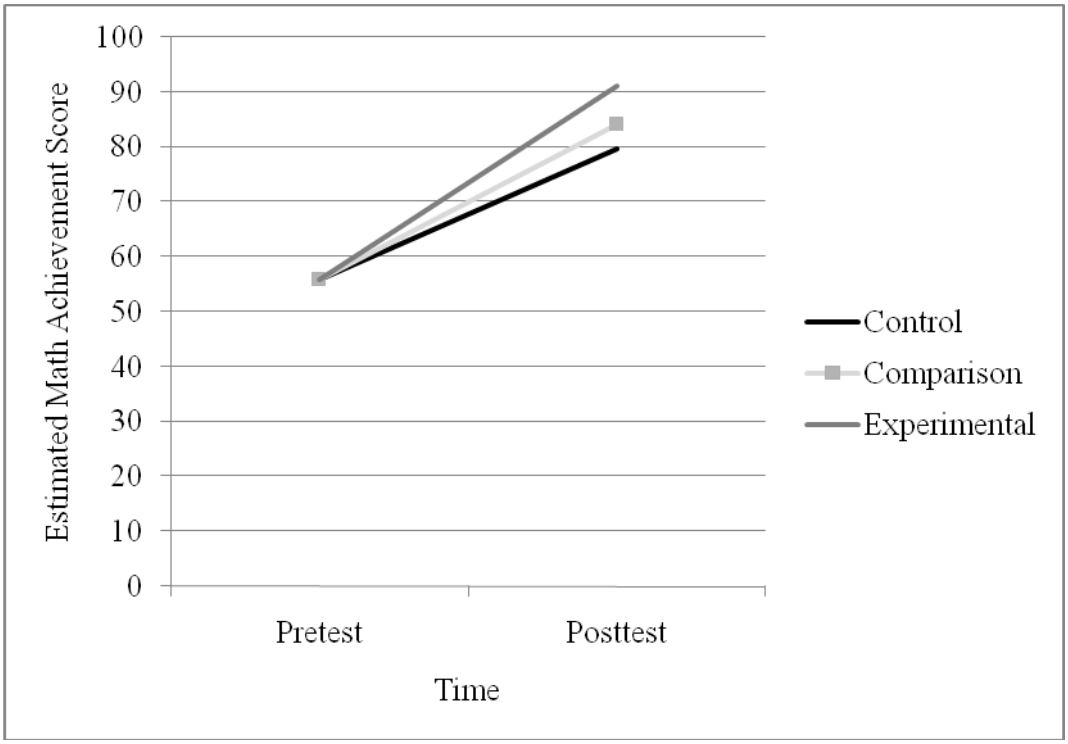

Figure 6. Estimated math achievement posttest means controlling for pretest mean differences as a function of group and time

Summary of Findings

The research question of this study was the following: To what extent are there significant differences in math game intervention posttest scores (when controlling for pretest scores) among three groups of seventh-grade math students at a suburban public school in the mid-Atlantic region of the United States? This chapter has presented the results from the analyses performed to answer the research question of this study. Preliminary results indicated that the three groups (control, comparison, and experimental) did not differ in terms of the distribution of gender, race, or socioeconomic status; therefore, these three demographic variables were not included as covariates in the ANCOVA. Pretest math achievement scores were used as a covariate.

The results from the ANCOVA indicated that pretest math achievement scores were related to posttest math achievement scores as expected. There were differences between the three groups on posttest scores when controlling for pretest scores, with students in the experimental group having larger gains than those in the control or comparison groups, and no difference observed between the control and comparison groups when using the Bonferroni-adjusted alpha level. Based on these results, the null hypothesis was rejected. When controlling for pretest differences between the three groups, it was estimated that the control group improved by 23.60 points (based on an estimated marginal mean of 79.52 compared to the overall pretest mean of 55.92), that the comparison group improved by 28.21 points (based on an estimated marginal mean of 84.13 compared to the overall pretest mean of 55.92), and that the experimental group improved by 35.20 points (based on an estimated marginal mean of 91.12 compared to the overall pretest mean of 55.92).

Therefore, it was concluded that receiving an interactive game intervention combined with remediation training (the experimental group) was superior to remediation training alone (the comparison group) or no intervention (the control group), and that remediation training alone (the comparison group) did not differ from no intervention (the control group). The next chapter presents a discussion of these findings in the context of past research in this area, as well as recommendations for future research and educational practice.

Chapter 5: Discussion

The purpose of this study was to determine the degree of math achievement that occurs when electronic gaming is integrated with traditional instruction. The research question was the following: To what extent are there significant differences in math game intervention posttest scores (when controlling for pretest scores) among three groups of seventh-grade math students at a suburban public school in the mid-Atlantic region of the United States? The previous chapter presented the results of the analyses performed to answer this research question, and the current chapter provides a discussion of those results. Initially, an overview of the research is presented including the problem addressed in this study, the conclusions from the literature review, and an overview of the methodology employed to achieve the purpose of this study. Next, the primary conclusions from this study are presented and integrated with past research on problem-based learning, instructional technology, student-centered learning, authentic instruction, and student motivation. Recommendations are offered in the next section for both proposed changes to educational practice and future research in the areas of instructional technology and the implementation and use of problem-based gaming instruction programs. The chapter ends with a summary of the key points from this chapter.

Overview of Study

This study was developed to explore the effect of electronic gaming on math achievement to support a national commitment to improve educational results and student achievement in the area of mathematics. As was discussed in Chapter 1, a demonstration that gaming is a viable tool to improve student learning could lead to more widespread use of gaming in schools and could ultimately improve student learning and achievement.

The use of gaming is consistent with a student-centered approach to learning and has received some past support (Harrell, 2000; Langone et al., 2003).

Problem-based instructional learning has been recommended to increase the level of educational engagement for at-risk learners (Bottge et al., 2007; (Hutchison, 2007) Hutchison,). This study was based on the theoretical concepts of disruptive education, in which students are more actively engaged in education (Clayton et al., 2008), situated cognition theory in which learning occurs within a specific context (Black & Schell, 1995), and enhanced anchored instruction, in which problem-based learning is emphasized (Bottge et al., 2007). In addition, current research on student-centered learning, instructional technology, authentic instruction, and student motivation has indicated that problem-based gaming instruction programs may be an effective way to increase student achievement.

Several conclusions were drawn from the literature review presented in Chapter 2 of this dissertation. First, it was concluded that gaming as a problem-based learning strategy is appropriate for at-risk students and those with a poor basic skill level, but that it can be beneficial for students of all achievement levels. Second, it was concluded that video gaming represents an option for improving the communication of course content to students with poor basic skills by focusing on problem-based learning, authenticity, and relevancy (Ryan, 1997; Williams et al., 1998).

Third, it was concluded that the use of gaming as a problem-based learning strategy requires teachers that are comfortable with technology (Levin & Wadmany, 2006), committed to instructional innovation (Wetzel, 2001), and intent upon using a student-centered learning approach (Sheppard, 2006). Finally, interactive technologies such as gaming provide a practical path for the differentiated instruction that is required in a student-centered approach to education (Berk, 2003). Despite the efforts of past researchers to address the viability of gaming in instruction, several gaps in the literature exist, including research on the effects of gaming on low-achieving students, the transfer of classroom knowledge to nonclassroom settings, the use of gaming to overcome the Pygmalion effect, the cultural relevance of gaming in education, and the required level of sophistication for educational gaming.

Chapter 3 of this dissertation presented the methodology employed to achieve the purpose of the study. A quantitative, quasi-experimental study was performed to determine whether math-centric interactive games could be used to increase the math achievement of remedial students. This study was conducted in a small, mid-Atlantic public school with 128 students enrolled in seventh-grade regular math classes. These students received (a) no remedial instruction, (b) the standard remedial mathematics instruction, or (c) the standard remedial mathematics instruction plus access to the interactive games with math content. A pretest–posttest design was employed in which students were assessed prior to remedial instruction and 9 weeks later, after remedial instruction.

After obtaining the results from descriptive statistical analyses and preliminary analyses of the achievement test data, an ANCOVA was performed to determine the effect of the three treatments on changes in math achievement scores (i.e., the difference between pretest math achievement scores and posttest math achievement scores), and the results from this analysis were presented in Chapter 4. In addition to controlling for pretest scores, gender, race, and socioeconomic status were also included in this analysis. The results from this analysis indicated that

1. Participants with higher pretest scores also tended to have higher posttest scores.
2. Differences between the three treatment groups were statistically significant when controlling for pretest scores. The group exposed to the standard remedial mathematics instruction and the interactive games achieved significantly higher posttest scores than either of the other two groups; the group receiving only the standard remedial mathematics instruction improved more than the control group participants who received no additional instruction.

Based on these results, the answer to the research question of this study was that interactive games had a positive effect on math achievement among seventh-grade math students in a suburban, mid-Atlantic public school who were in need of math remediation. Not only did these students perform better than the group that received no remediation (the control group), but they also performed better than the students who received only the standard remedial mathematics program but not problem-based gaming instruction (the comparison group). Receiving an interactive game intervention combined with remediation training was superior to the standard remediation training alone and superior to no intervention for the seventh-grade students who participated in this study.

The score improvements in this study were very dramatic. Teachers reported that the results for the comparison group were higher than normal. Although the comparative results would be the same in a different study, the researcher believes it is possible that the amount of improvement may be unusual. The reason for this is that the students knew they were being studied. They knew this because the students in the experimental group were required to sign consent forms that explained their participation in the study. It is easily possible that the students shared this information with their friends that were in the other groups. Although there was no reported discussion between students and teachers about the study, it is likely that students discussed the study and developed a higher level of motivation than would ordinarily be present. It would be useful to conduct a similar study that did not require the use of a consent form detailing the study and the participant's role.

Conclusions

The primary conclusion from this study was that when problem-based gaming instruction was added to the standard remedial math program, students performed better than when they received only the standard remedial math program and better than students who received neither the problem-based gaming instruction nor the standard remedial math program. This finding is consistent with past research that addressed the effectiveness of various instructional strategies. That is, the problem-based gaming instruction program examined in the current study is consistent with instructional methodologies that have been shown to be effective.

Current research has indicated that for instruction to be effective, it should be student centered rather than teacher centered (Sheppard, 2006); the problem-based gaming instruction approach in this study was based on a student-centered platform. According to Hawthorn (Hawthorn, 2005), instructional technology for middle school students must be designed for the needs of the individual user. Some instructional technologies consist only of attempts to efficiently deliver course content without taking into account the academic strengths and weaknesses of individual students. In the problem-based gaming instruction program in the current study, individual student learning preferences, speed, and ability were taken into account as the student engaged the instructional game.

Instruction must be authentic so that real-world problems are included in instruction (Scheepers & Nulden, 2000). Griesser (2001) noted that authenticity in instruction is important at all educational levels and that it is necessary for student motivation to be high. The problem-based gaming instruction in this study (discussed in detail in Chapter 3) was developed to provide access to authentic, real-world problems. Problem-based learning addresses the issue of authenticity through the very nature of the activities (Cerezo, 2004), which are guided by the presentation of real-world problems to be solved by the students throughout the program.

Finally, student motivation has been linked to instructional effectiveness (Hidi & Harackiewicz, 2000). According to Fanning (2008), instructional technology has the potential to increase the attention of students. The problem-based gaming instruction program in this study was developed to increase students' motivation to learn, and increased motivation is likely to be one reason for the effectiveness of the program in this study. In summary, the effectiveness of the problem-based gaming instruction program in the current study is grounded in its consistency with the demonstrated effectiveness of student-centered learning, authentic instruction, and student motivation.

The conclusion that the problem-based gaming instruction examined in the current study was more effective than the standard remedial mathematics instruction alone may provide assistance in reducing the achievement gap (Delmore, 2005; DiGisi & Fleming, 2005). These authors focused on low student self-efficacy, low teacher expectations, and poor instructional practices as the factors that cause achievement gaps between minority and Caucasian students, and between students from low socioeconomic backgrounds and those from higher socioeconomic backgrounds. For example, K. Clark and Moore (2007) found that students from low socioeconomic backgrounds typically focused on drill-and-practice activities whereas those from higher socioeconomic backgrounds focused on higher order skills. By providing a more student-centered approach to instruction, the problem-based gaming instruction program has the potential to improve student achievement among those groups of students who are most at risk for academic failure.

External Validity

A study's degree of external validity is determined by the extent to which it can be applied to similar environments (Siegle, 2009). This research was a quasi-experimental study using a control group, a comparison group, and an experimental group. When implemented correctly, this type of design carries a high degree of external validity. The researcher believes that this study can be repeated in any similar environment. There are a number of middle schools configured in a manner similar to the school used in this study. Any of these middle schools with the same level of technological infrastructure would be suitable for a similar study. A similar study using the heterogeneous classroom found during the regular school day would be a variation of this design that would provide valuable information on the viability of the intervention in a mainstream environment. Another variation to test the external validity of this study would be a study population composed exclusively of LEP students. In short, this study has a high degree of external validity and should be able to withstand the scrutiny of being repeated.

Recommendations

Recommendations for policymakers. Based on the results of this research, it is recommended that policymakers write requirements and implement procedures that integrate instructional gaming into the current instructional system. There seems to be a great deal of generational resistance to integrating gaming into the current educational bureaucracy mainstream. Students are advocates of including gaming in their instructional environments. Nevertheless, many parents, school administrators and teachers do not see how electronic games can play a positive role in serious academic improvements. Their lack of understanding therefore stands in the way of much needed aggressive integration of electronic gaming into the K-12 environment. This hesitancy is in spite of the fact that these adults are usually well aware of the serious applications of simulations and virtual environments in the worlds of military science, architecture, medicine, and construction. The adult decision makers have a difficult time making the leap from serious professional applications to the academic environments of their children. This difficulty is often directly linked to the fact that the adults have seen only the games and virtual environments used for play and the recreational benefits of their children; they have not seen the games used for serious academic purposes. As part of this implementation, school administration policymakers should create opportunities for educators and parents to view gaming programs with academic content in school-based instructional circumstances.

Recommendations for educational practice. Based on the results from this study, it is recommended that school administrators consider the implementation of problem-based gaming instruction combined with standard remedial mathematics programs in their schools. Prior to implementation, however, school administrators must ensure that the gaming instruction program that is implemented adheres to certain criteria. According to the guidelines offered by Kebritchi (2008), the problem-based gaming instruction programs should address motivation, provide gender neutrality, use feedback and scaffolding, include verbal and written reflection, ensure that the game genre is appropriate, achieve balance between the mathematics content and the game, and provide visual effect and usability.

Despite the fact that teachers believe educational technology is an integral part of the process of effective education for middle school students (K. D. Clark, 2000), instructional technology is not effectively integrated into instruction in many cases (Spitzer & Stansberry, 2004). For technology to be successfully integrated in the classroom, a variety of conditions must be met. Planning, commitment, and the willingness to change must be present (Hoon, 2006), and classroom teachers must believe in the technology as well as the pedagogy (V. Clark, 2003). School administrators must ensure that these conditions are addressed prior to the implementation of a problem-based gaming instruction program. Nevertheless, the results from the current study, along with the results from other studies that have demonstrated the effectiveness of instructional technology, should provide school administrators with the empirical evidence required to further the integration of instructional technology in the classroom.

School administrators are risk averse. For that reason, projects that are built on the educational theory and benefits of disruptive education have great difficulty gaining approval for research. This aversion to risk is sourced in the pressure to achieve the pass rates that are required under the No Child Left Behind Act. The aversion to risk and the pressure to achieve high pass rates based on traditional models of instruction combine to thwart aggressive implementation of new methods and instructional strategies.

Recommendations for future research. Based on the results from this study, four recommendations are offered for future research in this area. First, it is recommended that the interactive games intervention examined in the current study be examined with students at different grade levels. The sample for the current study consisted of seventh-grade students, and the positive findings regarding the use of the interactive game intervention among these students may not apply to students at other grade levels.

A second recommendation for future research is that studies should be performed in which the long-term effects of problem-based gaming instruction are examined. The duration of the gaming program in the current study was 18 weeks, and this was sufficient to demonstrate the effectiveness of the problem-based gaming instruction over standard remedial instruction and no remedial instruction. Nevertheless, it is possible that the achievement improvements observed through problem-based gaming instruction may deteriorate over time. Follow-up examinations of mathematics achievement at regular intervals over a period of years would be helpful to determine if the gaming intervention produces long-term effects or only short-term improvement.

A third recommendation for future research is that additional control variables be examined to determine the generality of these findings for various groups of students. In the current study, gender, race, and socioeconomic status were not analyzed. For the purpose of this study, none of these variables reached a level of statistical significance when controlling for pretest scores, indicating that the problem-based gaming instruction was equally effective for males and females, for students of various races, and for students of low and high socioeconomic levels. Nevertheless, taking a different view of these variables that could have an impact on the viability of the problem-based gaming instruction program could be helpful. For example, the differences in achievement results of males and females were not compared. It is possible that males and females respond differently to the interactive gaming intervention. It is also possible that the type of interactive game intervention have different effects for males and females. Therefore, it is recommended that future studies include such variables as control variables in the statistical analyses.

A fourth recommendation for future research is that this study be replicated in other geographic areas. In the currents study, all student participants were from one suburban school district. The effects of problem-based gaming instruction in rural or urban school districts may not be the same as the effects observed in the current study in a suburban area. Rural, suburban, and urban students may differ in ways that impact the success of the program, such as access to computers in childhood. Further replications in other geographic areas would therefore aid in understanding the generalizability of the current study's findings that the problem-based gaming instruction was effective.

The fifth and final recommendation for future research is that researchers should attempt to develop true experimental designs when performing research in this area. In the current study, intact classrooms were used, with all students in a particular classroom in the same group (i.e., the group that received no intervention, or only the standard mathematics remediation intervention, or the standard mathematics remediation intervention plus the problem-based gaming instruction), resulting in a quasi-experimental research design. The conclusions from the current study have validity because pretest differences in math achievement were used as a control variable. Additionally, demographic differences between the groups were analyzed and found to be not statistically different. This finding means that differences between classrooms in terms of pretest math ability, gender, race, and socioeconomic status did not confound the results. A variety of other variables, however, could have confounded the results, such as experience with computers or reading ability. These variables also could be controlled in a quasi-experimental design, but a true experiment in which students were randomly assigned to the three treatment groups would provide stronger control over not only the known confounding variables but any unknown confounding variables as well.

Summary

This chapter has presented a discussion of the findings from this study. Initially, an overview of this study was provided. The results from this study may be used to support the national commitment to improve educational results in mathematics. The effectiveness of problem-based gaming instruction provides a valuable tool to improve student learning. The program examined in this study is consistent with the student-centered learning approach, with the development of authentic instructional practices, and with attempts to increase student motivation.

It was concluded based on the results from this study that when problem-based gaming instruction was added to the standard remedial math program, students performed better than those who received only the standard remedial math program and better than students who received neither the problem-based gaming instruction nor the standard remedial math program. This conclusion provides teachers with a tool that has the potential to play a role in the reduction of the achievement gaps between minority and Caucasian students, and between students from low socioeconomic backgrounds and those from higher socioeconomic backgrounds. The primary recommendation for educational practice offered as a result of the findings from the current study is that school administrators consider the implementation of problem-based gaming instruction combined with standard remedial mathematics programs in their schools. Finally, five recommendations for future research are offered:

1. The interactive games intervention examined in the current study should be examined with students at different grade levels.
2. Future studies should be performed in which the long-term effects of problem-based gaming instruction are examined.
3. Additional control variables such as experience with computers or reading ability should be examined to determine the generality of these findings for various groups of students.

4. This study should be replicated in other geographic areas including rural and urban school districts.
5. Future researchers should attempt to develop true experimental designs when performing research in this area to control for other potentially confounding variables.

Educational gaming has the potential to help the education community on two fronts. First, there seems to be little doubt that because of the current fiscal crisis in the United States and the associated frontal attacks on the current education bureaucracy, there will be cuts to every level of education. Educational gaming is a tool that can be used to lower the total cost of delivering education. Second, educational gaming is a tool of great promise as educators look for methods to implement the student-centered classroom. This may include developing new models for achieving instruction differentiation in the classroom setting, seeking tools to eliminate the "seat-time" requirements for students while moving to "performance-based" student accountability, and investigating ways to improve delivery of online lessons.

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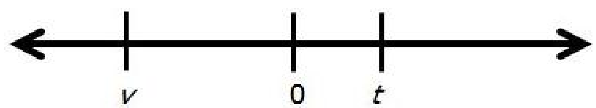
Appendix A

Appendix A: Assessment Instrument

Pre-Test: 2nd Marking Period

Multiple Choice
Identify the choice that best completes the statement or answers the question.

____ 1. If v and t are two integers, which statement would *always* be true?



a. The sum of v and t would be negative
b. The product of v and t would be positive
c. The sum of v and t would be positive
d. The quotient of v and t would be positive

____ 2. What is the value of: $-16 \div 8 = ?$

a. -2
b. 2
c. -0.5
d. 0.5

____ 3. $(3+2)^2 - \left(4^2 + 4\right)^2 =$

a. 1,025
b. -25
c. -375
d. 425

____ 4. A ray moves 80 feet below the surface of the ocean. It rises 43 feet and dives further into the water 12 feet. It finally rises 18 feet. The location of the ray is

a. 31 feet below the surface
b. 93 feet above the surface
c. 93 feet below the surface
d. 31 feet above the surface

____ 5. The table lists the results of 5 consecutive plays by a football team.

Play	**Yardage Gained/Lost**
Play 1	+ 10 yards
Play 2	+ 10 yards
Play 3	+ 10 yards
Play 4	- 18 yards
Play 5	- 18 yards

How many yards did the team gain or lose from their original position after the 5 plays?

a. Lost 6 yards c. Gained 6 yards

b. Gained 8 yards d. Lost 8 yards

____ 6. Jeff is working on shooting free throws. Of the 72 shots he has tried, he has made 54. What is the probability Jeff's next shot will go in based on his rate so far?

a. $\frac{1}{2}$ c. $\frac{2}{3}$

b. $\frac{1}{4}$ d. $\frac{3}{4}$

____ 7. A regular card deck contains 52 cards, 2 of which are black eights. Assuming the cards are dealt randomly, what is the probability that the first card dealt will be a black eight?

a. $\frac{2}{13}$ c. $\frac{1}{26}$

b. $\frac{1}{52}$ d. $\frac{1}{13}$

____ 8. Ben has a basket of 5 red balls, 3 yellow balls, and 2 green balls. He will pick one ball at random. What is the probability that the next ball he randomly chooses will be red?

a. $\frac{5}{8}$ c. $\frac{1}{2}$

b. $\frac{1}{10}$ d. $\frac{1}{5}$

____ 9. In Mr. Brown's classroom, 40% of the students are boys. If Mr. Brown chooses a student to answer a question in his classroom, what is the probability that the student he chooses is a boy?

a. $\frac{1}{2}$ c. $\frac{3}{5}$
b. $\frac{2}{3}$ d. $\frac{2}{5}$

____ 10. A bag of marbles contains 9 red, 7 purple, 6 blue, and 3 yellow marbles. If pulling one marble out of the bag, what is the probability of choosing a purple marble?

a. $\frac{9}{25}$ c. $\frac{3}{25}$
b. $\frac{7}{25}$ d. $\frac{6}{25}$

____ 11. The sandwich shop allows the choice of white or wheat bread, ham, turkey, or bologna and Swiss or American cheese. How many sandwich combinations are possible?

a. 48 c. 9
b. 12 d. 24

____ 12. Nicholas is 7 years older than Travis. If Nicholas is 10 years old, what is Travis' age?

a. 3 c. 4
b. 17 d. 20

____ 13. Jean has 4 types of lunch meat, 3 types of cheese and 2 types of bread. How many different sandwiches can Jean make?

a. 14 c. 9
b. 24 d. 12

____ 14. Amy has 12 shirts, 8 pairs of pants and 3 pairs of shoes. How many outfits can Amy make?

a. 288 c. 828
b. 23 d. 230

____ 15. Which represents all the values for *b* that make the following true?

$4b > 24$

a. $b < 6$
b. $b > -6$
c. $b < -6$
d. $b > 6$

____ 16. 6 pounds of apples cost $6.00. Tina only wants to buy 2 pounds. What would her cost be for that amount?

a. $12.00
b. $2.00
c. $1.00
d. $3.00

____ 17. Ryan bought a CD for $17, a pair of shoes for $30 and a pair of jeans for $25. The tax rate was 6%. What was the total cost of Ryan's purchases?

a. $72.00
b. $76.32
c. $4.32
d. $74.32

____ 18. What is a value of p that makes the following true?

$-8p \geq 16$

a. -1
b. 3
c. -3
d. 1

____ 19. Which represents all the values for *d* that make the following true?

$d \div -3 > 6$

a. $d < -2$
b. $d > -2$
c. $d > -18$
d. $d < -18$

____ 20. Which represents all the values for *x* that make the following true?

$-3x > 21$

a. $x > -7$
b. $x < -7$
c. $x < 63$
d. $x > -63$

____ 21. A restaurant serves 7 appetizers, 10 entrees and 6 desserts. What are the possible meal combinations?

a. 23
b. 42
c. 420
d. 230

____ 22. According to the table below, which expression is equivalent to the total numbers of outfits made by 1 shirt, 1 pair of pants and 1 pair of shoes?

SHIRT	**PANTS**	**SHOES**
polo	jeans	sneakers
tee	khakis	sandals
long-shoes	sweat	dress

a. $3 \times 3 \times 3$
b. $3 + 3 + 3$
c. $3 \times (3 + 3)$
d. $3^2 + 3$

____ 23. What value of *g* makes the following true?

$$-45 = g - 12$$

a. -33
b. 33
c. -57
d. 57

____ 24. Which value of n makes the following true?

$$40n = 80$$

a. .2
b. 2
c. $\frac{1}{2}$
d. 20

____ 25. What is the value of *r* that makes the following true?

$$r \div -3 = 12$$

a. -36
b. 36
c. 4
d. -4

____ 26. What is the value of *x* that makes the following true?

$$\frac{x}{2} = 12$$

a. 24
b. -24
c. 6
d. -6

____ 27. Which is a value for ***a*** that makes the following true?

$$\frac{a}{-3} > 4$$

a. -7 c. 13
b. 7 d. -13

____ 28. What value of *n* makes the following true?

$$\frac{15}{60} = \frac{n}{100}$$

a. 400 c. 25
b. 30 d. 9

____ 29. John earns $7.50 an hour. How many hours will John have to work to earn $600.

a. 85 hours c. 80 hours
b. 90 hours d. 75

____ 30. If it takes 2 cups of sugar for 24 cookies, how many cups of sugar will it take for 72 cookies?

a. 4 cups c. 3 cups
b. 5 cups d. 6 cups

Appendix B: Sample Activity

Activity – Similar shapes (ratio)

1. Students draw a rectangle on grid paper

2. Students label the dimensions (length and width) of the rectangle

3. Students draws a second shape with one side a few increments larger than the corresponding side on the first rectangle

4. Students next calculate how many increments to make the remaining side on the second rectangle.

5. Students draw the second side of the second rectangle according to the calculated dimension.

6. Students draw the remaining two sides of the second rectangle.

7. Students compare the two rectangles to see if they are similar.

8. If necessary, students make corrections to the second rectangle so that it is similar to the first rectangle.

9. After the two rectangles are drawn to be similar, students compare the actual dimensions with their calculated dimensions.

10. Students write a short paragraph about their “lessons learned” as part of the activity.

Appendix C: Specific Skills Taught

Integer Operations

a) Model addition, subtraction, multiplication and division of integers using pictorial representations of concrete manipulatives.
b) Formulate rules for addition, subtraction, multiplication, and division of integers.
c) Identify the absolute value of an integer and locate the absolute value on a number line.
d) Add, subtract, multiply and divide integers.
e) Simplify numerical expressions involving addition, subtraction, multiplication and division of integers using order of operations.
f) Solve practical problems involving addition, subtraction, multiplication, and division with integers.

Proportional Reasoning

a) Write proportions that represent equivalent relationships between two sets.
b) Solve a proportion to find a missing term.
c) Apply proportions to convert units of measurement between the U.S. Customary System and the metric system.
d) Apply proportions to solve problems that involve percents.
e) Apply proportions to solve practical problems, including scale drawings. Scale factors shall have denominators no greater than 12 and decimals no less than tenths.
f) Determine solutions to everyday problems involving whole numbers, decimals, fractions, and percents.

Probability

a) Determine the theoretical probability of an event.
b) Determine the experimental probability of an event.
c) Describe changes in the experimental probability as the number of trials increases.
d) Investigate and describe the difference between the probability of an event found through experiment or simulation versus the theoretical

probability of that same event.

Fundamental Counting Principle

a) Describe the number of possible arrangements of no more than three types of objects, using a tree diagram.
b) Compute the number of possible outcomes by using the Fundamental (Basic) Counting
c) Principle.
d) Determine the probability of a compound event containing no more than 2 events.

Linear Equations

a) Represent and demonstrate steps for solving one- and two-step equations in one variable using concrete materials, pictorial representations, and algebraic sentences.
b) Translate word problems and practical problems into algebraic equations and solve them.
c) Solve one- and two-step linear equations in one variable.
d) Solve practical problems that require the solution of a one- or two-step linear equation.

Linear Inequalities

a) Represent and demonstrate steps in solving inequalities in one variable, using concrete materials, pictorial representations, and algebraic sentences.
b) Graph solutions to inequalities on the number line.
c) Identify a numerical value that satisfies the inequality.

Appendix D: Validity

Internal Validity

Description of threats to internal validity	
Threat type	Description
History	These are the unique experiences subjects have between the various measurements done in an experiment. Because this study was completed in a relatively short period of time and because there were two measurements, this threat is small.
Maturation	These are natural changes that occur as a result of the normal passage of time. For example, subjects may perform better or worse on a dependent variable not as a result of the independent variable but because they are older. Because this study was completed in a relatively short period of time this threat is small.
Testing	This study involved the pretest of subjects to establish a baseline. A consequence of pretesting is that it can change the subjects' performance on later tests beyond any effects caused by the treatment itself. The study attributes listed above were drafted in such as way to control this threat.
Instrumentation	This threat is realized when the researcher changes the measurement methods during the study. In instances when human observers are used to report on events, it may be their judgment and reporting that changes over time instead of the subjects' performance. In this study, the instrumentation threat should have been minimal as human observers were not used. Additionally, the objective instrumentation of a pretest and a posttest were measured.
Statistical regression	This threat is realized when subjects in a study are selected as participants because they scored either extremely high or extremely low on a performance measure. When the study subjects or subject grouping are selected in this way, retesting of the subjects produces a distribution of scores that is closer to the overall population's (Huitt et al., 2009). In this study, this threat was controlled through the research design as well as the research methodology.
Selection	This threat is realized when the composition of the comparison groups at the beginning of the study is functionally different among the groups (Huitt et al., 2009). When this happens, the study results are likely to be biased. This researcher controlled this threat by making the control group and experimental group as functionally equivalent as possible.

Description of threats to internal validity	
Threat type	Description
Experimental mortality	This threat is realized when more subjects from one of the comparison groups drop out of the study than from the other groups. This threat is also realized when dropout rates are high for each group, even though they are similar. Because this study was completed in a relatively short period of time, this threat is small.

External Validity

Description of threats to external validity	
Threat type	Description
Interaction	This threat occurs when the subjects in the sample group are not randomly selected from the general population. The result is that subject bias by individual subjects can be compounded throughout the entire sample population to the point that the study's result is not transferable to the general population. This threat was controlled by the design element designating that within the quasi-experimental parameters of the research design, subjects were selected with as much randomness as possible
Pretesting	This threat occurs when the subjects react to the pretest. With this threat, the subjects in the study react more or less strongly to the treatment than they would have had they not experienced the pretest. This reaction is most poisonous when one of the comparison groups is pretested and the other is not. This threat was controlled by the design element designating that both the comparison groups take the same pretest.
Setting	This threat occurs when subjects who know they are participants in a study react differently to the treatment than subjects who experience the treatment but are not aware of being observed. This threat was controlled by the design element designating that none of the students be observed.
Multiple treatments	This threat occurs when the subjects in the experimental group are sequentially subjected to more than one treatment (Huitt et al., 2009). This threat results in limited generalizability because the early treatments may have a cumulative effect on the subjects' performance. This threat was controlled in this study by the design element designating that only one intervention be used.

Appendix E: School District Application for Research

Application to Conduct Research in Prince William County Public Schools

Submitted By

Arik King

1 Appling Rd

Stafford, VA 22554

Submitted To

Prince William County Public Schools

Department of Accountability

March 31, 2010

Prince William County
PUBLIC SCHOOLS
Providing A World-Class Education

March 24, 2011

Arik King
1 Appling Rd
Stafford, VA 22554

Dear Mr. King:

I am writing to let you know that your request to conduct your study, "Using Interactive Games to Improve Math Achievement Among Middle School Students in Need of Remediation," at Godwin Middle School, has been approved by the principal and by Prince William County Public Schools leadership. The principal, Jehovanni Mitchell, should serve as your point of contact at the school. PWCS requires a copy of the final IRB approval from your university for our records. Of course, participation of individual students is completely voluntary. As you stated, no individual, school, or district information can be identified in any report of the findings. PWCS requests a copy of the study findings when the study is complete. We do wish you the best of luck with the study.

Sincerely,

Jennifer Coyne Cassata

Jennifer Coyne Cassata, Ph.D.
Director, Office of Accountability

DR. JENNIFER COYNE CASSATA
Director, Office of Accountability

P.O. BOX 389, MANASSAS, VA 20108 • WWW.PWCS.EDU • 703.791.7277, FAX 703.791.7366

Appendix F: Teacher Consent Letter

March 31, 2010

Dear Educator,

My name is Arik King. I am a doctoral student at The George Washington University in Washington, DC. I am conducting a research study on educational gaming for middle schools students. I am asking that you participate in the study. There are no anticipated risks to you or your students as a result of participating in this study.

The purpose of the study is to determine whether or not students' math scores increase when educational gaming is added to regular instruction. The study will also develop anecdotal information about changes in student self-efficacy that result in response to gains in math achievement.

With your consent, students in your math class will be asked to volunteer for the study. Parents of those students will also be asked to allow their children to participate. Informed consent forms will be signed by all the parents of the students that are participating. Each participating student will receive an identification number. Within the study, this number will be used in place of his or her name. All study participants, including you, will remain anonymous outside the study. I will maintain an internal record of all names.

The units to be taught are "ratios" and "solving equations." These units will be taught according to existing state standards and using the methods that you currently use for instruction. The two units are the units being studied. Participating students will be asked to complete a survey at the beginning of the study. The students will be asked to complete the same survey at the end of the study. The students will also be asked to complete a pretest and a posttest as part of the study. The tests will be provided to you. At the end of the study, you will be given the results of the surveys and the tests.

Research at The George Washington University involving human participants is conducted under the oversight of the school's Internal Review Board (IRB). Your name, the names of your students, and the name of the school will be kept confidential. The names are kept as part of the study's internal validity. They will not be used in any report, analysis, or publication. When communicating with external entities, all identifying information will be replaced by the identification number that is assigned by the researcher for the individual participant. No names or identification numbers will be included in the study's reports.

Please sign this letter and return it to me. A second copy is also provided so that you may keep it for your records. By signing this letter, you give me permission to report the information about your students' mathematics achievement and changes to their self-efficacy as a result of those improvements. If you have any questions or concerns about this research project, please contact me at 703-498-0064 or by e-mail at kingae@pwcs.edu

Sincerely,

Arik King
Doctoral Student, Education Administration and Policy
The George Washington University

________ I have read the procedures described above for the research study

________ I voluntarily agree to participate in the study

______________________________ ____________________
Participant Signature Date

______________________________ ____________________
Participant Name (printed)

______________________________ ____________________
Principal Investigator Signature Date

______________________________ ____________________
Principal Investigator Name (printed)

Appendix G: Parent Consent Letter

March 31, 2010

Dear Parent,

Your child's math class is participating in a study that is being conducted by a doctoral student at The George Washington University's School of Education Administration and Policy. Your child's class was chosen because it meets the criteria for the study. I am asking that you allow your child to participate in the study.

The purpose of the study is to determine whether or not your child's math scores increase when educational gaming is added to regular instruction. Educational gaming is interactive computer software that uses a video game to teach the same course content as the classroom teacher. The study will also collect information about changes in student self-efficacy that result in response to gains in math achievement. Self-efficacy is the student's belief that he or she can actually do the required math. The study results will help the school district make informed decisions about using the games.

Each participating student will receive an identification number. Within the study, this number will be used in place of the student's name. All students will remain anonymous outside the study; however, the researcher will maintain an internal record of all names.

The units to be taught are "ratios" and "solving equations." These units will be taught according to existing state standards and using the methods that the teacher currently uses for instruction. Participating students will be asked to complete a survey at the beginning of the study. The students will be asked to complete the same survey at the end of the study. The students will also be asked to complete a pretest and a posttest as part of the study. Your child's academic progress will not be endangered in any way. It is anticipated that the study will last approximately 3 weeks.

Research at The George Washington University involving human participants is conducted under the oversight of the school's Internal Review Board (IRB). Your name, the name of your child, and the name of the school will be kept confidential. The names are kept as part of the study's internal validity. They will not be used in any report, analysis, or publication. When communicating with external entities, all identifying information will be replaced by the identification number that is assigned by the researcher for the individual participant. No names or identification numbers will be included in the study's reports.

If you have any questions about this research project, please contact me at 703-498-0064 or by email at arik@educationsys.com. Questions or concerns may be directed to the project's primary researcher. The primary researcher is Dr. James Tucker. He can be reached at 757-269-2217. His email is jrtucker@gwu.edu

If you do not want your child to participate in the study, please sign this letter and return it to me. A second copy is provided so that you may keep it for your records. If you do not return this letter, you give me permission to report the information about your child's mathematics achievement as part of the study. If your child has permission to be included in the research, no further action from you is necessary.

Sincerely,

Arik King
Doctoral Student, Education Administration and Policy
The George Washington University

________ I have read the procedures described above for the research study

________ I do not give permission for my child to participate in the study

______________________________ ____________________
Parent Signature Date

______________________________ ____________________
Parent Name (printed)

______________________________ ____________________
Principal Investigator Signature Date

______________________________ ____________________
Principal Investigator Name (printed)

Appendix H: Data

STUDENT ID	GENDER	ETHNICITY	FARM	Group	Pretest	Posttest
315	Male	Hispanic	TRUE	2	37	94
418	Female	Hispanic	FALSE	2	37	94
306	Female	Hispanic	TRUE	2	40	97
323	Male	Hispanic	FALSE	0	30	87
113	Female	Hispanic	FALSE	1	37	90
313	Female	Hispanic	TRUE	2	27	77
420	Female	Hispanic	TRUE	2	37	87
122	Female	Hispanic	TRUE	2	40	90
413	Male	Hispanic	TRUE	1	44	94
111	Female	Hispanic	FALSE	2	40	87
131	Female	Caucasian	FALSE	2	40	87
319	Female	Hispanic	TRUE	2	40	87
421	Male	African American	TRUE	2	44	90
426	Male	African American	TRUE	1	44	90
125	Female	Hispanic	TRUE	2	33	77
330	Male	African American	FALSE	2	33	77
324	Male	Hispanic	TRUE	2	40	84
103	Male	Hispanic	TRUE	1	50	94
407	Male	Hispanic	TRUE	1	40	84
117	Female	Hispanic	TRUE	2	44	87
404	Male	African American	TRUE	2	44	87
121	Female	Caucasian	TRUE	2	54	97
130	Male	Hispanic	TRUE	2	54	97
307	Male	Hispanic	TRUE	2	47	90
109	Male	Caucasian	FALSE	1	47	90
432	Female	African American	TRUE	1	30	73
502	Female	Hispanic	TRUE	0	30	73
318	Male	African American	FALSE	2	44	84
321	Female	Hispanic	TRUE	2	44	84
429	Male	Hispanic	TRUE	1	47	87
416	Female	Hispanic	FALSE	1	57	97

STUDENT ID	GENDER	ETHNICITY	FARM	Group	Pretest	Posttest
504	Female	African American	TRUE	0	40	80
102	Female	Hispanic	TRUE	1	40	77
326	Female	Caucasian	FALSE	2	37	73
305	Male	African American	FALSE	1	44	80
417	Female	Hispanic	TRUE	2	50	84
119	Male	Hispanic	TRUE	1	20	54
406	Male	African American	FALSE	1	60	94
507	Male	African American	TRUE	0	30	64
133	Male	African American	FALSE	0	50	84
124	Male	African American	FALSE	2	54	87
127	Male	Hispanic	TRUE	2	57	90
310	Male	Hispanic	TRUE	1	54	87
402	Male	Hispanic	TRUE	1	54	87
128	Female	African American	FALSE	1	44	77
506	Female	Hispanic	TRUE	0	47	80
517	Female	Hispanic	TRUE	0	54	87
312	Male	Hispanic	TRUE	0	64	97
304	Male	Hispanic	FALSE	0	67	100
431	Female	African American	TRUE	0	64	97
405	Male	Hispanic	TRUE	2	37	67
328	Male	African American	TRUE	2	40	70
327	Female	Hispanic	FALSE	2	47	77
409	Male	African American	TRUE	2	57	87
104	Male	Hispanic	TRUE	2	57	87
403	Male	Hispanic	TRUE	1	34	64
118	Male	Hispanic	TRUE	1	54	84
415	Female	African American	TRUE	1	64	94
509	Female	Hispanic	TRUE	0	40	70
505	Female	African American	FALSE	0	50	80

STUDENT ID	GENDER	ETHNICITY	FARM	Group	Pretest	Posttest
530	Male	Hispanic	TRUE	0	50	80
320	Male	African American	TRUE	0	70	100
114	Female	Hispanic	TRUE	0	64	94
522	Female	African American	TRUE	0	54	83
123	Male	Hispanic	TRUE	1	60	87
423	Female	Hispanic	TRUE	1	37	64
422	Male	Hispanic	TRUE	1	57	84
115	Female	Hispanic	TRUE	1	37	64
428	Male	African American	FALSE	1	50	77
120	Male	African American	FALSE	0	67	94
309	Female	African American	TRUE	1	54	80
513	Male	African American	TRUE	0	44	70
523	Male	African American	TRUE	0	67	93
532	Female	African American	TRUE	0	74	100
301	Female	Hispanic	TRUE	2	40	64
314	Female	African American	FALSE	1	44	67
511	Male	African American	TRUE	0	57	80
410	Female	Hispanic	TRUE	0	74	97
414	Male	Hispanic	TRUE	0	54	77
311	Female	African American	FALSE	0	77	100
110	Female	Hispanic	TRUE	0	64	87
308	Female	Hispanic	TRUE	1	57	77
116	Male	Caucasian	TRUE	1	64	84
411	Male	Hispanic	TRUE	1	67	87
501	Female	Hispanic	TRUE	0	40	60
419	Female	Hispanic	TRUE	0	74	94
112	Female	Hispanic	FALSE	0	80	100
514	Female	African American	FALSE	0	64	83
526	Female	Caucasian	FALSE	0	74	93

STUDENT ID	GENDER	ETHNICITY	FARM	Group	Pretest	Posttest
510	Male	Hispanic	TRUE	0	60	77
524	Male	Hispanic	TRUE	0	60	77
132	Female	Caucasian	FALSE	0	67	84
424	Male	African American	FALSE	0	67	84
302	Female	Hispanic	TRUE	0	67	84
325	Male	Hispanic	TRUE	0	70	87
126	Female	Hispanic	TRUE	0	77	94
107	Female	Hispanic	TRUE	0	80	97
108	Female	African American	TRUE	0	80	97
412	Male	Hispanic	TRUE	0	77	94
529	Male	Hispanic	FALSE	0	80	97
129	Female	African American	FALSE	0	64	80
533	Male	Caucasian	TRUE	0	64	80
521	Male	Hispanic	TRUE	0	77	93
520	Male	African American	TRUE	0	70	84
316	Male	Hispanic	TRUE	0	80	94
401	Male	Caucasian	FALSE	0	80	94
427	Male	Hispanic	TRUE	0	80	94
303	Female	African American	TRUE	0	80	94
322	Female	Caucasian	TRUE	1	57	70
430	Male	Hispanic	TRUE	1	64	77
518	Female	Hispanic	FALSE	0	54	67
105	Male	African American	TRUE	0	74	87
329	Male	African American	FALSE	0	54	67
515	Male	African American	TRUE	0	67	80
317	Male	African American	TRUE	1	54	64
106	Male	Caucasian	FALSE	0	77	87
525	Male	African American	TRUE	0	77	87
519	Female	African American	TRUE	0	77	87

STUDENT ID	GENDER	ETHNICITY	FARM	Group	Pretest	Posttest
531	Male	Caucasian	TRUE	0	80	87
516	Male	Hispanic	TRUE	0	67	73
425	Male	African American	TRUE	0	84	90
527	Male	African American	TRUE	0	64	67
512	Female	Caucasian	FALSE	0	77	80
528	Female	African American	TRUE	0	80	83
508	Female	African American	FALSE	0	67	67
408	Male	Caucasian	FALSE	0	77	74
101	Female	Hispanic	TRUE	0	80	73
503	Female	Hispanic	TRUE	0	47	30

Appendix I: University Approval for Research

THE GEORGE WASHINGTON UNIVERSITY MEDICAL CENTER
WASHINGTON DC

Date:	May 12, 2011
To:	James Tucker, Ed.D
From:	The George Washington University Committee on Human Research, Institutional Review Board (IRB), FWA00005945
Re:	Correspondence dated 06/04/2010
Subject:	**IRB#030922** -- *Using Interactive Games to Improve Math Achievement Among Middle School Students in Needs of Remediation*
Sponsor:	None
Risk Level:	**Minimal** **Status: Active** **Expiration date: 03/15/2012**

This is to certify that the Institutional Review Board has **fully approved** the above referenced protocol via expedited review procedure under category # **5 and 7** of 45 CFR 46.110.

The expiration date of this project is **03/15/2012**. HHS regulations at 45 CFR 46.109(e) require that **continuing review of research be conducted by the IRB at intervals appropriate to the degree of risk and not less than once per year**. The regulations make **no provision for any grace period extending the conduct of the research beyond the expiration date of IRB approval. When your protocol expires all research activities must stop.** Please mark your calendar now to insure that the IRB receives a renewal request 30 days before the anniversary date of the project, if this study is expected to extend beyond one year.

This protocol has been approved for a **maximum number of 130 subjects** to be enrolled under the auspices of George Washington University. If you wish to increase enrollment beyond this number, you must submit a modification request to the IRB and obtain approval before exceeding this number.

Please note that the IRB must be notified if the project is altered in any way (change in location, personnel, number of subjects, age of subjects, or any change in research protocol). If you have any questions, please do not hesitate to contact the Office of Human Research either by email at ohrirb@gwumc.edu or via phone at 202-994-2715.

SJS / mrc

Page 1 of 1

Informed Consent Form

Project Title:
Using Interactive Gaming to Improve Math Achievement Among Middle School Students in Need of Remediation
IRB #030922
George Washington University
Principal Investigator: James Tucker, Ed.D. TEL: 757-269-2217

Dear Parent,

Your child's math tutoring is being designed by a doctoral student enrolled in The George Washington University's School of Education Administration and Policy. The student is also a licensed teacher. He has taught in Stafford County and currently teaches in Prince William County. He designed this class as part of his doctoral program. Your child's participation will help develop new strategies for teaching math. This form is a request that you allow your child to participate in a research study.

The purpose of the study is to determine whether or not your child's math scores increase when educational gaming is added to regular instruction. Educational gaming is interactive computer software that uses a video game to teach the same course content as the classroom teacher. The study will also collect information about changes in student self-efficacy that result in response to gains in math achievement. Self-efficacy is the student's believe that they can actually do the required math. The study results will help parents and professional educators make informed decisions about using the games. It is also hoped that this research project will jump start your child's mastery of the topics he/she will study during this school year.

Each participating student will receive an identification number. Within the study, this number will be used in place of the student's name. All students will remain anonymous outside of the study. However, the researcher will maintain an internal record of all names.

The units to be taught are "Measurement and Geometry" and "Numbers and Number Sense". These units will be taught according to existing state standards and using the methods that the teacher currently uses for instruction. The students will be asked to complete a pre-test and a post-test as part of the study. The pre-test and post-test will be given at Walker-Grant Middle school as part of your child's regular school day activity. Your child's academic progress will not be endangered in any way. It is anticipated that the study will last the entire first marking period, approximately nine weeks.

Research at The George Washington University involving human participants is conducted under the oversight of the school's Internal Review Board (IRB). Your name, the names of your students, and the name of the school will be kept confidential. The names are kept as part of the study's internal validity. They will not be used in any report, analysis, or publication. When communicating with external entities, all identifying information will be replaced by the identification number that is assigned by the researcher for the individual participant. No names or identification numbers will be included in the study's reports.

Informed Consent Form - Student

Project Title:
Using Problem-Based Gaming to Improve Math Achievement Among Middle School Students in Need of Remediation
IRB #030922
George Washington University
Principal Investigator: James Tucker, Ed.D. TEL: 757 269 2217

Dear Student,

You are being asked to participate in a research study. As part of the study, you will be asked to regularly play a video game that we have selected for you. The video game has a lot of math, but should be a lot of fun. The purpose of the study is to help you do better in math while you are having fun.

If you agree to be in the study, please sign below. If you do not want to be in the study, you will still receive tutoring. No one will think anything bad about you whether or not you are in the study. Also, if you start out in the study but later decide you want to change your mind, you can stop being in the study and there will be no problem. If you desire, the Office of Human Research of George Washington University, at telephone number (202) 994-2715, can provide further information about your rights as part of this research project.

Sincerely,

Arik King
Doctoral Student, Education Administration and Policy
The George Washington University

_______ I agree to participate in the study

_______ I will not participate in the study

____
Student's Name (printed)

______________________ ______________
Student Signature Date