Student Achievement and the Use of the Program *Study Island*

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DEDICATION

This dissertation is dedicated to all people who work in schools to help students. You have the best job in the world, enjoy it.

ABSTRACT

Computer Aided Instruction (CAI) has been used for many years in an attempt to increase student achievement. Districts have spent millions of dollars implementing different forms of CAI that may or may not be working. This study was an attempt to describe one such district and its CAI implementation.

The study sought to complete three tasks. The first task was to create a description of the student use of a specific CAI, *Study Island*. Second, it examined grade level and graduation year data to see if there were correlations between using *Study Island* and achievement levels on the Minnesota Comprehensive Assessment (MCA). Lastly, the study examined correlations between the proficiency levels that students achieved on *Study Island* and their proficiency levels on the MCA.

The results of the study found several areas of significant results. First, students' scores on the MCA were significantly higher after the year that *Study Island* was included as a supplement to their curriculum. It is important to remember that this is not proving causation. This study was observational and not scientific in nature. Because of this, confounding variables do exist that could be causing the observed differences. Second, significant correlations between the use of *Study Island* and increased achievement levels on the MCA were found. The students' proficiency levels on *Study Island* were highly correlated with their proficiency levels on the MCA. Using regression analysis, the researcher determined the percent of questions that a student should answer correctly on *Study Island* to predict that she/he will achieve proficiency on the MCA.

Table of Contents

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE – INTRODUCTION

It is well-documented in the media that the United States lags behind other countries in mathematics achievement. Many indicators are used to determine this lack of achievement. These indicators include international tests, national tests, state tests, college entrance exam scores, and college remediation rates. Taking these measures into account, Schmidt (2012) says that the state of math education in the United States can be seen as “mediocre.” A system of mediocre math education in a country has consequences that reach farther than just its rankings on international measures of achievement.

There is an increased need in today’s society to become more educated and data literate. This need is not limited to people’s occupations, but to the decisions that people make in their daily lives. Schmidt (2012) also asserts that from medical decisions to retirement planning, people are faced with making decisions that require the analysis of more and more complex data. The need for education should not only be looked at in regard to the level of the individual person. The country as a whole is influenced by the sum of its parts. This influence can be seen in a country’s economy, which can be affected by all of the country’s people and their education levels (Hanushek & Woessmann, 2012).

There is no consensus on the exact cause of the United States falling behind other countries in mathematics achievement measures. One key difference between the United States and the other higher achieving countries, as stated by Wei and Eisenhart (2011), is the students’ mathematical learning environment. Students in the nations that lead the world in mathematics achievement scores spend more time out of every day working on their education. Most participate in after school tutoring that can extend the school day to

15 hours, even on the weekends (Wei & Eisenhart, 2011). With this amount of access to content, how can the students in the United States hope to compete? One theory is to have more competent teachers instructing the students in every classroom.

Rockoff (2004) points to teacher quality as one of the main factors that can increase student achievement. He says that if the measure of teacher quality were increased by one standard deviation, student achievement will be increased by 0.1 standard deviations on standardized scales. For this to happen, teachers need a model from which to work that has shown success in increasing student achievement. A large body of research has shown that students taught within the Bloom's mastery learning model will display an increase in achievement. This research shows that the students who were taught under a mastery learning framework consistently reach higher levels of achievement when compared to their peers who were not taught under this framework (Bangert-Drowns, Kulik, & Kulik, 1991; Guskey, 2010). In addition to having a highly skilled teacher in each classroom, adding "computer aided instruction" (CAI) to the curriculum has also shown positive results in increasing student achievement (Hannafin & Foshay, 2008).

The focus of this study is to examine one school that is adding CAI as a supplement to the classroom teacher's curriculum. A description of the school, its students, and its implementation of CAI follows.

This study examined existing 5th grade through 8th grade student data from a small rural school in Minnesota. There are approximately 1,000 students attending the school from kindergarten to twelfth grade. The data collected were from the school years of 2005-2006 to 2010-2011. During these school years, 463 total students moved in cohorts through the examined grades (Table 1).

Two types of datasets were downloaded and analyzed: “Minnesota Comprehensive Assessment” (MCA) scores downloaded from the “Total Information for Educational Systems” (TIES) data warehouse, and “Computer Aided Instruction” (CAI) data statistics from the program *Study Island*. The first dataset contained students’ standardized scores and proficiency levels that they earned on the MCA. The second dataset consisted of the usage statistics for cohort students on a CAI that was integrated into the classroom curriculum and delivered through an “Integrated Learning System” (ILS). CAI is teaching with the integration of technology into the curriculum which can

Table 1. Cohort by School Year Displaying Graduation Years, Number of Students per Grade

	12-13	13-14	14-15	15-16	16-17	17-18	18-19
	Cohort A	Cohort B	Cohort C	Cohort D	Cohort E	Cohort F	Cohort G
School Year	n = 63	n = 56	n = 38	n = 89	n = 80	n = 62	n = 75
05-06	5	4	3	2	1	k	PK
06-07	6	5	4	3	2	1	k
07-08	7	6	5	4	3	2	1
08-09	8	7	6	5	4	3	2
09-10	9	8	7	6	5	4	3
10-11	10	9	8	7	6	5	4
11-12	11	10	9	8	7	6	5

Note: Student grade levels that are highlighted in grey are the years that were included in the study.

deliver content to students. This content can vary in form from text-only based questions to fully interactive educational games. CAI can be delivered by a standalone, non-networked computer with software installed on it. However, most modern versions of CAI are part of an “Integrated Learning System,” or ILS. An ILS is a system of networked servers and computers that delivers the content and tracks the students’ responses to questions on that content so that the students’ actions using the CAI can be followed.

This particular school implemented CAI through an ILS in the 7th and 8th grades' curriculum at the beginning of the 2008-2009 school year. In the previous years, no CAI was integrated or used in classroom instruction. Within the data, two natural breaks were found. These breaks can be seen as before and after the implementation of the CAI program for the students. When the students were in 5th and 6th grade, or "elementary school," they did not receive CAI. When those students moved into 7th and 8th grades, or "middle school," they did receive CAI after the 2008-09 school year. The changes in the students' MCA scores can be examined because of this. The second natural break in the data was within the grades that implemented CAI. The 7th and 8th grade MCA scores can be examined for differences before and after the implementation year of 2008-09. The specific ILS program that was used to try to increase achievement in the area of mathematics is *Study Island* (Edmentum, 2013b). This program was the focus of study in this research. Key elements of *Study Island* are described in the next section.

Description of the Program

Case studies that are located on the *Study Island* website (Edmentum, 2013a) document growth of MCA achievement levels for those students who used the *Study Island* program. One such case study states, "Since implementing *Study Island* in 2006, the percentage of students meeting or exceeding standards on the MCAs has increased in math and reading, and the school has made Adequate Yearly Progress (AYP) each year." Also located on the *Study Island* website are independent research reports that document the key elements of *Study Island* (Edmentum, 2013a). The key features of *Study Island* that are identified in these reports are summarized in Table 2. These key features have been shown to have positive correlations to students' increased achievement levels (Watts, 2008b). There is a basic theme for all of these features, which is delivering content that is individualized to the learner.

In the district that is being studied, teachers set student goals for minimum proficiency levels in *Study Island.* This is done to create competition in the weeks before the MCA. At the end of the competition, a small tangible reward is given to the students who reach the achievement level. This reward is given in an attempt to motivate the

Table 2. Features offered and promoted by CAI (*Study Island*).

Study Island Feature	Explanation
Content aligned to state standards.	The content is aligned with the state standards and strands. Students or teachers can choose what strand to work on and measure their progress on the strand.
Feedback	
Diagnostic	Teachers can use the information to see where the students are having difficulties.
Formative	Teachers can use the data to change their lesson plans to adjust to student performance.
Summative	Teachers can assign summative assessments that are automatically scored.
Re-teaching	Students had 24/7 access to content and questions.
Drill and Practice	Students can be set up to compete against themselves, or other students.
Motivation	
Games	In game mode students can play a mini-game if they answer the question correctly.
Rewards	When students reach a predefined proficiency level they receive a "blue ribbon" on topic or stand.
Differentiated Instruction	Teachers can assign or students can choose from a variety of instructional formats ranging from text to video lessons.
Dynamic Questioning	Students will be automatically accelerated or remediated depending on how they answered the previous question.
Online Access	Students have access through any device that has a web browser and can access the internet.
Parental Involvement	The program can be accessed at home and parents can be involved the use of *Study island.*

students to review more content before the date of the MCA. Various measures of proficiency have been used by the teachers as goals. They have set proficiency goals for time used, amount of logins, and number of “blue ribbons.” In *Study Island*, “blue ribbons” are virtual awards that the students receive when they answer questions correctly at a pre-defined percentage. The number of questions and percent correct are set by the teacher. These features of *Study Island* are integrated into every session that the student uses the program. Teachers can modify all features and give students access to change the features as they see fit. Brief descriptions of the features follow.

Content aligned to state standards.

The content that the students receive through *Study Island* is aligned to the Minnesota state mathematics standards. These standards are the guidelines by which schools in Minnesota align their curriculum. To access specific content, teachers can create assignments for specific standards that they feel students need to work on, or allow the students to choose their own paths of study.

Feedback

Skinner (1965) said that students will learn when they are told if they have answered correctly or not. Further research has added that students' learning will increase if they are also given explanations of why their answer is correct or incorrect, not only that their answer was right or wrong (Marzano, Pickering, & Pollock, 2001). *Study Island* can score the questions and give explanations to the students in real time. These questions and answers are then stored in a database that can be accessed by the student or teacher through the web interface. This data can be valuable to a student's learning and for teachers' formative assessments of their students. Teachers can also assign questions to students for use as a summative assessment. One added benefit in using a computer to score the questions is that this alleviates some of the mundane and tedious correction work that can take time away from other, more important, teacher tasks.

Re-teaching and Dynamic Questioning

An ILS can automate the re-teaching (remediation and acceleration) that the student receives. This is described by Watts (2008a, p. 13): "Automatic item generation technology uses algorithms to create assessment items generatively that are of similar difficulty or that vary in difficulty." In other words, an ILS controls a web page so that it will react in different ways, depending on different user actions, to deliver the appropriate content to the student. An example of this is diagrammed in Figure 1.

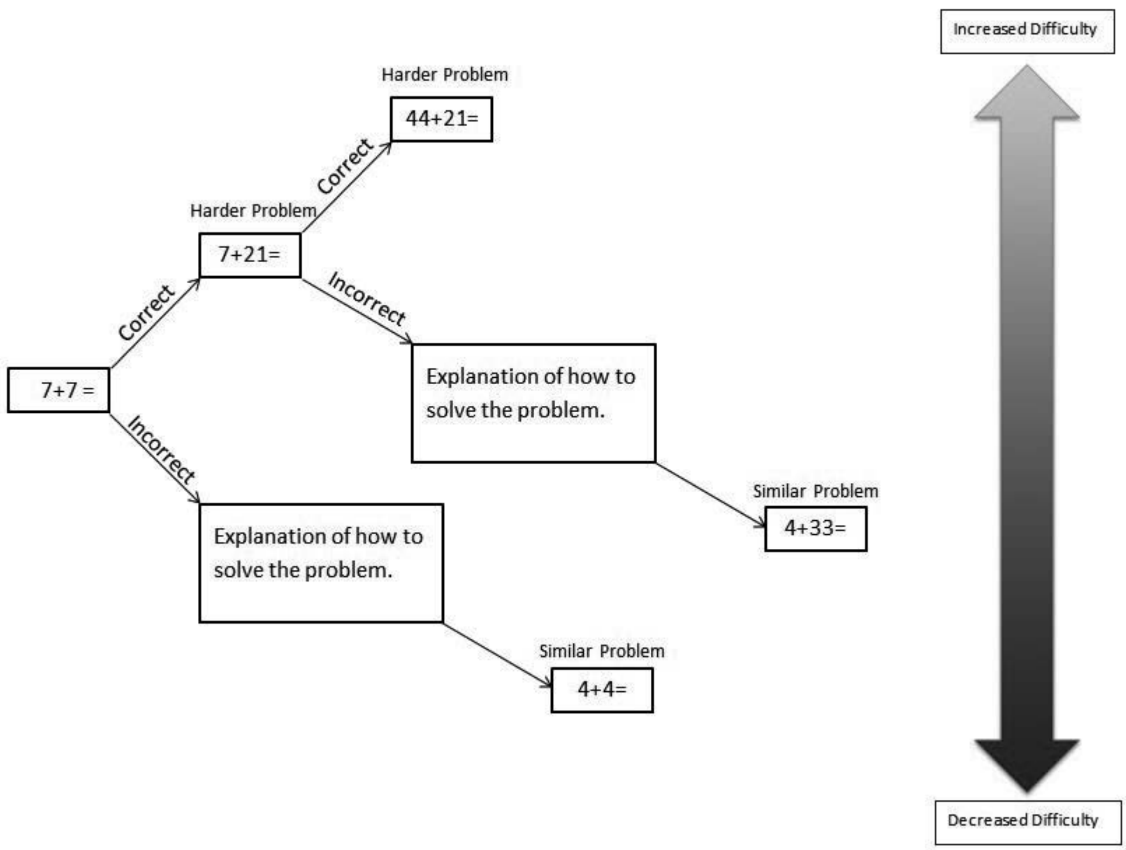

Figure 1. Examples of Dynamic Questioning as Used in CAI.

For example, poor results on a set of questions can lead to remediated instruction, or the scaling down of difficulty for the level of future practice within the program. Scoring well on a set of questions can conversely lead to questions with increased rigor. This change in difficulty levels for the questions is also calculated in real time by the ILS. In addition to changing difficulty levels, the ILS also changes the content of the questions from session to session to increase the variability of the questions that the students see. The ability to change types and difficulty levels of questioning is very closely matched to Bloom's Mastery Learning Framework, where students are remediated and accelerated based on their previous work. Bloom's theory will be discussed in more depth later in this paper.

Drill and Practice

The ILS can deliver problems to the student with or without the aid of the teacher. Because of dynamic questioning, the student can access a nearly unlimited bank of questions, according to *Study Island* (Edmentum, 2013b).

Motivation

If there is no variation to help with alleviation of monotony, drill and practice can become tedious for the student. One possible way to alleviate monotony is to introduce a game component to the problem. Alleviation of monotony does not have to come at the expense of learning. Studies have shown that the mastery of facts can be accomplished through games (Tüzün, YIlmaz-Soylu, Karakus, Inal, & KizIlkaya, 2009). Many ILS are adding game components to their programs or "gamifying" them. Smith-Robbins (2011) defined "gamification" as the process of setting goals, having an obstacle to overcome, and then having competition. By adding a game component to the program, you are challenging the students to compete against each other. This can also have an impact on the type of motivation for the students. Having a game component included in an ILS can switch the motivation of the students from extrinsic to intrinsic (Renaud & Wagoner, 2011).

Study Island can be used in either practice or game mode. In practice mode the students are exposed to content in a text-based manner (Figure 2). In the game mode they are exposed to similar text-based questions, but if the user answers the question correctly, they get to play a "mini" game (Figure 3).

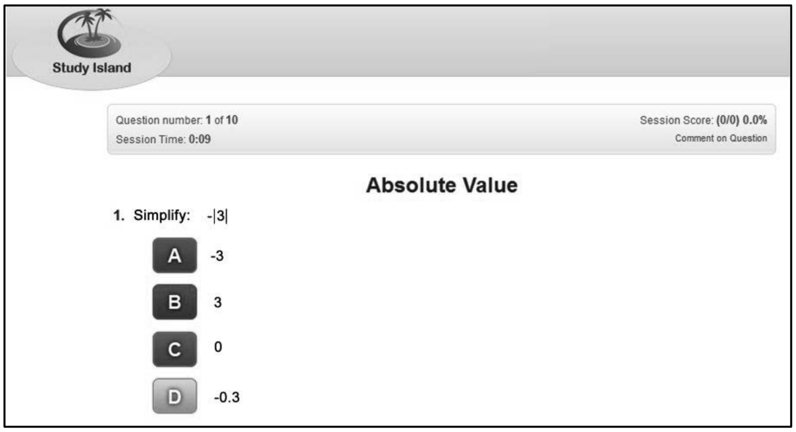

Figure 2. A *Study Island* Question in Practice Mode.

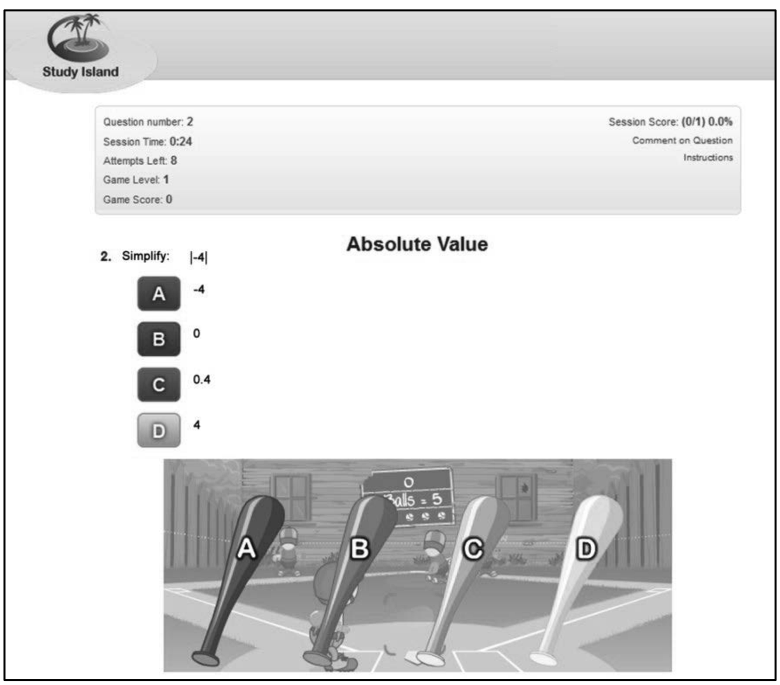

Figure 3. A *Study Island* Question in Game Mode.

Differentiated Instruction

The *Study Island* website states that it can differentiate for the students in the following way: "The *Study Island* program records statistics for each user session in a real-time report card. These statistics measure progress, streamline the learning process and can be customized by student, subject, class, grade and school" (*Study Island*, 2013a, p. 1). In this system, both the teacher and the student can vary the learning style in which the questions are delivered. If the teachers use formalized assessments, the learning becomes more personalized (ETS, 2012).

Online Access

Access to the technology can be examined in two areas: student's access inside of the school building and access outside of the school building. For access in both locations, the CAI must not be tied to a specific workstation or device. For this study, a device will be defined as something that can access the internet, and therefore the CAI can be accessed through it. *Study Island* can be accessed at any time through the internet by any device that has a web browser.

Parental Involvement

The amount of parental involvement in the schooling of their child is one of the predicting factors for academic achievement (Moreira, Dias, Vaz, & Vaz, 2013). Because *Study Island* is online and can be accessed by virtually any device that has an internet connected web browser, parents can be more involved in their students' education at home. With access to the program, parents can monitor student progress or participate in the learning by helping students work though questions.

Problem Statement

"Computer Aided Instruction" (CAI) has been used for many years to try to increase student achievement in mathematics. The general definition of CAI is the use of technology either to review or to deliver content to learners. Substantial amounts of research have shown a positive correlation between CAI and increased achievement on standardized testing (Clariana, 1996; Hannafin & Foshay, 2008; Kulik & Kulik, 1991; Platko, 2011a). Each of these study's central question was, "Does student use of CAI result in achievement increases on standardized tests?" The predominant answer to this question has been "yes," at moderate levels. One of the stated benefits of using CAI is its ability to collect and present data to the teacher that influences instruction for the student (Estep, 1997). Examples of some of the data available to teachers are amount of time that the program has been used, numbers of questions answered, and the percentage of the questions answered correctly.

There is a need to ask deeper questions about the overall use of CAI and its relationship to increased student achievement. We need to look at the individual components of the CAI and how they can help increase student achievement. The available literature is thin in terms of drawing conclusions about what aspects of CAI use are most highly correlated with increased standardized test scores. The real power in using these programs is the ability to help predict which students will and will not be proficient on the standardized tests. If teachers could predict this earlier in the school year, they will be better able to differentiate instruction for students before the state proficiency tests. Greater understanding about such correlations can guide teachers and districts in their implementation of a successful CAI programs. Based on these areas that were identified as needing further study, three research questions were determined. A discussion of the research questions follows in the next section.

Research Questions

The effectiveness of CAI's ability to increase student achievement depends on how it is implemented in the schools (Perciful, 1992). To be implemented effectively, teachers need to know the components of the CAI that are the best predictors of students' future success on specific standardized tests. This study aims to identify correlations between students' use of statistics on a specific CAI, *Study Island*, and achievement levels as measured by the "Minnesota Comprehensive Assessment" (MCA).

- Question #1: Is there a significant difference between the MCA scores of students who use *Study Island* and those who do not Use *Study Island*?
    - Sub Question #1a: Is there a significant difference in the average MCA proficiency between the students when they receive *Study Island* and when they do not?
    - Sub Question #1b: Is there a significant difference in the average MCA proficiency levels, for the grades that implemented *Study Island*, before and after the implementation?
- Question #2: Is there a correlation between achieving proficiency as measured by *Study Island* and achieving proficiency as measured by the MCA?
- Question #3: Is there a difference in students' usage and proficiency levels between game and practice mode when they use *Study Island?*

Rationale for Study

The purpose of this study is to contribute to the scholarly knowledge on the use of CAI, specifically *Study Island*, to increase student educational achievement in mathematics. As described previously, many studies have shown that the proper use of

CAI can increase the students' achievement levels in mathematics achievement (Kulik, 2003). Further research has also shown that gaming components in CAI can increase the motivation level of students to use the program and therefore increase student achievement levels (Burrus, 2012). Where this study specifically aims to add to the literature is to examine the correlations between student use of CAI and student achievement levels on a specific standardized test, the “Minnesota Comprehensive Assessment” (MCA). Recommendations will be made for administrators and teachers on program implementation.

Methodology

Data analysis.

The data were analyzed to see if there were differences in the students’ MCA scores when they did and did not use *study Island*. Correlations were also sought between the different usage and proficiency levels of the students as measured by *Study Island* and their proficiency levels as measured by the MCA. These different usage measures were separated out by the two different types of question modes in *Study Island*: game mode and test (practice) mode.

This method of analysis was appropriate because there is no attempt to determine causation from this data. This study attempts to add to the literature by describing a particular subgroup of students who participated in CAI by trying to find correlations between their MCA scores and their use of *Study Island*. The hope is that, with a picture of how students use *Study Island* and what parts of it correlate positively with increased student achievement as measured by the MCA, districts can better design their CAI implementation. With knowledge of these correlations, teachers can change their instructional methods to better fit teaching with CAI as a supplement to their curriculum.

Limitations and Assumptions

Limitations to this study can be divided into three different categories: instruction, participants, and data collection. First, changes in instruction and instructors can greatly change the educational success in the classroom. In fact, Rice (2003) says that the instructor is the most important factor that the school can control in influencing student success. In this study there was a different teacher at each grade level, but only one teacher per grade level. This will eliminate teacher influence within grade level, but not between grade levels.

Another factor between grades is that the implementation level of *Study Island* varied by instructor. *Study Island* was not used by the 5th and 6th grade teachers in their classrooms. It was implemented by the 7th and 8th grade teachers, starting in the 2008-09 school year, and has continued to be used by the teachers as a supplement to the curriculum.

The participants (Table 3) in the study might not all have had equal access to the program *Study Island,* which can be accessed, at any time, through nearly any device that has internet. This might put students who do not have access to the internet outside of the school day at a disadvantage.

Table 3: Students who received *Study Island* Treatments (grey).

	Students by Grade				
School Year	5	6	7	8	Total
05-06	63	52	70	63	248
06-07	56	63	52	70	241
07-08	38	56	63	52	209
08-09	89	38	56	63	246
09-10	80	89	38	56	263
10-11	62	80	89	38	269
11-12	75	62	80	89	306

To help combat this, the school designated time for the students to access the program. This designated time started during the 2010-11 school year, and the students received 25 minutes of computer access time every other day, on top of their normal classes. This time is designated as *Study Island* time.

The third limitation comes in the form of data collection. This study is not a true experimental design with a control and experimental group, but the before and after effects could be examined because of natural breaks in treatments. A pseudo-before and after test was created because *Study Island* was used in 7th and 8th grades and not 5th and 6th grades. The researcher used this break to try to examine a before and after treatment effect.

Another limitation is that during the 2010-2011 school year, there was some level of data loss. This loss was caused by a teacher re-setting the students' usage statistics to zero, so that the students could be measured in a competition centered upon the time of the MCAs. These data are not backed up on the *Study Island* servers and cannot be recovered in any other way. To compensate for this, the usage statistics were calculated by finding the ratio of the category by student per day (Appendix B). An example of this would be the time that the students used *Study Island*. The following formula was used to calculate this: the time in seconds that the students in the cohort used *Study Island* for one year, divided by the number of students in the cohort, and divided by the number of possible days that the students could use *Study Island* during the school year. The above assumptions and limitations are discussed in more detail in Chapter Three.

Definition of Terms

Computer Aided Instruction (CAI). Any form of instruction that has components that are taught or reinforced through or by technology.

Integrated Learning System (ILS). A system of networked hardware and software that delivers CAI to the user's computer or device. This consists of a server that connects to the internet to distribute content and record user responses, and a device that can access the internet to receive content and send responses back to the server.

Device. Any form of technology that can access the internet to deliver content from an ILS so that a user can participate in CAI. Examples of this could be a computer, tablet, or phone.

Minnesota Comprehensive Assessment (MCA). A yearly assessment administered to students in Minnesota schools. Only data from the mathematics MCA was looked at for this study. From the state of Minnesota website:

> The purpose of the MCA is to measure Minnesota students' achievement on the Minnesota Academic standards. The MCA results inform curriculum decisions at the district level; inform instruction at the classroom level; and, in reading and mathematics, demonstrate student academic progress from year to year (MDE, 2012a).

Raw Score: The score that the student obtains from the MCA test without consideration to the difficulty of the test.

Scale Score: Raw scores that are converted to scale scores by taking into account the difficulty level of the current and previous years of the test. This is done so that the scores can be compared from year to year for a given grade and subject (MDE, 2012a). The Scale Score has a one or two digit prefix that corresponds to the grade level that the student was in. For this study the grade prefix was removed.

Proficiency. There are four classifications of ranges of student scale sores:

Exceeds the Standards (E), Meets the Standards (M), Partially Meets the Standards (P), and Does Not Meet the Standards (D). Though students do not “pass” the MCA, they will meet the graduation requirement with an “E” or “M” on the MCA. The state of Minnesota determines proficiency levels by determining the percentage of students who exceed and meet the standards. Each of these correlates to a scale score with the grade level prefix removed. E = 99-63, M=62-50, P=49-40, D=39-1. Proficient means that the students met or exceeded the standards set by the MCA.

Elementary. The elementary grades included in this study were the 5th and 6th grades. These students did not use *Study Island* as a supplement to their curriculum. They can be looked at as a pseudo-before grouping for the *Study Island* data.

Middle School. The middle school grades included in this study were the 7th and 8th grades. These students did use *Study Island* as a supplement to their curriculum, starting in the 2008-09 school year. During these years they can be looked at as a pseudo-after grouping for the *Study Island* data.

CHAPTER TWO – LITERATURE REVIEW

This chapter describes the findings from a comprehensive review of literature that was conducted to explore the current measurement practices of mathematics achievement testing in the United States, the achievement levels of students on those measures, possible causes of some of these levels of student achievement, and the history of "Computer Aided Instruction" (CAI) use in mathematics instruction.

Specific sources were located by searching Proquest Dissertations & Theses and the Education Full Text database. Approximately 324 sources were reviewed with a total of 105 cited here. The majority of the sources are citing empirical data. Some sources that are not based on empirical data are added for context and are noted appropriately.

Measures of Lack of Student Achievement in Mathematics

Achievement in mathematics is measured in many ways. Some of these measures of accountability in mathematics achievement are: international tests, national tests, state tests, college entrance examination scores, and college remediation rates. At a national and international level, there are three major assessments that are looked at as measures of mathematics achievement for students in and outside of the United States. These assessments are summarized in Appendix A. The two major international assessments that deal with mathematics are the "Trends in Mathematics and Science Study" (TIMSS) and the "Program for International Student Assessment" (PISA). In the United States, the main measure of national mathematics achievement is the "National Assessment of Educational Progress" (NAEP). Schmidt (2012) summarizes the findings of all three assessments by saying that most of the students educated in American schools "lack the ability to understand and apply mathematics principles." Detailed explanations and results of the three assessments follow.

Program for International Student Assessment.

The PISA is administered, on a three year cycle, to students in the following countries: Australia, Austria, Belgium, Canada, Chile, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The last year that it was administered was 2009. The exam focuses on what the students can do as a result of their learning, and not the memorization of facts (SciMathMN, 2008).

The sponsor for the administration of the PISA is the "Organization for Economic Cooperation and Development" (OECD). Its mission statement is as follows:

> The mission of the Organization for Economic Co-operation and Development (OECD) is to promote policies that will improve the economic and social well-being of people around the world. The OECD provides a forum in which governments can work together to share experiences and seek solutions to common problems. We work with governments to understand what drives economic, social and environmental change. We measure productivity and global flows of trade and investment. We analyze and compare data to predict future trends. We set international standards on a wide range of things, from agriculture and tax to the safety of chemicals (OECD, 2012).

This mission statement describes an organization that is interested in driving change for the better worldwide. The member countries are doing this through working together to try to address the economic, social and environmental challenges of globalization, which includes improving student achievement.

The PISA has a different focus than the other two major assessments. It is an assessment of the student's "literacy" of the subject matter rather than his or her content knowledge. Literacy is defined by the OECD as the ability to access and process information (OECD, 2010). The examination does not try to assess just the students' knowledge that they have acquired in school, but how well students can apply that knowledge to tasks. Examination of the 2009 results of the PISA does not show the state of U.S. mathematics achievement in a favorable light. First, across all OECD countries, the overall performance in mathematics remained unchanged between 2003 and 2009 (OECD, 2010). The United States' overall performance increased from a score of 474 to 487, but our ranking was still 25th among the 34 OECD countries (Schmidt, 2012).

Trends in Mathematics and Science Study.

Another international measure, the TIMSS, measures achievement in a different way. It measures the content knowledge of the student, or "What did the student learn?" (SciMathMN, 2008). It was administered in 2011, with the last assessment data published in 2009. Gonzalez et al. (2008, p. 1) describe the purpose of the TIMSS in more detail: "TIMSS is used to measure, over time, the mathematics and science knowledge and skills of fourth- and eighth- graders. The TIMSS is designed to align broadly with mathematics and science curricula in the participating countries."

The United States' scores on the TIMSS are somewhat more encouraging than scores on the PISA. United States' students performed above the international mean of 500 in both the fourth (529) and eighth grade (508). The United States also ranked above

23 of the 36 nations in grade four, and above 37 of 48 nations in grade eight (Schmidt, 2012). The United States rates higher internationally on the TIMSS than the PISA, but for a nation that set goals to be the number one-ranked country in mathematics achievement by the year 2000 (National Education Goals Panel, 1998), ranking 13th and 11th in the world in 2007 has to be considered a failure.

The TIMSS is unique in that it allows states to participate in the study as "mini-nations." This is when the scores for a state's students are entered into the study in the same way that the scores would be included for a country. Two states, Minnesota and Massachusetts, participated in the study as mini-nations. In 2007 both scored significantly higher than the national average on both the fourth and eighth grade measures. On the fourth grade exam, Massachusetts and Minnesota scored 572 and 554 respectively. On the eighth grade assessments, Massachusetts scored 547 and Minnesota scored 532. SciMathMN provides a more in-depth analysis of the scores and also tells us that the score gains by the Minnesota students are significant (2009).

In 2007, as with the United States' overall performance, Minnesota's scores at both grades four and eight improved from 1995. The gain from the 1995 scores for the Minnesota fourth graders was among the largest of any of the 16 countries that participated in both the 1995 and the 2007 TIMSS. This gain was one third of a standard deviation, which is more than three times the gain of the United States as a whole. At eighth grade, Minnesota students performed about one-third of a standard deviation above the TIMSS Scale Average (500), but substantially below the top five achieving countries (SciMathMN, 2008).

The report also offers some explanations for how these improvements and higher scores could have been attained. First, the TIMSS testing framework is closely aligned to the Minnesota state standards for which the MCAs are written. Second, in these years, Minnesota's eighth grade curriculum shifted in the focus so that the students were exposed to more algebra. This shift in curriculum has caused a change in the time that students are exposed to algebraic concepts. In 1995, teachers reported that they allotted 10% of their curricular time to algebra, but increased this time to 50% by 2007 (SciMathMN, 2008). This allocation of time for algebraic content more closely aligns with the international standards of the high achieving countries.

National Assessment of Educational Progress.

The final measure, the NAEP, is an internal measure of academic achievement administered by the United States government. It has a similar framework to the TIMSS, and therefore has shown similar patterns of improvement in the scores of the United States' students through its last administration in 2011. There are two versions of the NAEP: the main NAEP that is administered every two years, and the long-term NAEP, administered every four years. Like the TIMSS, the NAEP measures the achievement of the students based on their content knowledge. While the main NAEP measures the achievement of students in multiple subjects, the long-term NAEP measures only the students' achievement in mathematics and reading (Appendix 1). The NAEP shows that the United States has grown significantly in mathematics achievement from the first year that it was used as a measure (1990) to the most recent measure (2011). The scores increased by 16 points in fourth grade (from 224 to 240) and 12 points in eighth grade (from 271 to 283) (Schmidt, 2012). Students scoring at a proficient level in mathematics increased from 19% to 33% in grade four, and from 20% to 26% in grade eight. These are both rates of growth that are considered to be statistically significant. Students in the twelfth grade are also assessed on a national level, but they are tested less frequently, and display much less impressive results than the eighth and fourth graders. Twelfth grade scores have increased minimally from 150 to 153 since 2005, and the percentage that performed at a proficient level has risen from 21% to 23% (2012).

College Entrance Exam.

College entrance exams are supposed to measure the college readiness of the students who are applying to college. Average scores on college entrance exams have varied minimally for the last ten years, with the mean score on the SAT mathematics test varying between a minimum of 514 and a maximum of 520 in 2005 (Figure 4). The ACT mathematics scores have also increased minimally during the same ten year span, increasing from 20.7 to 21.1 (Figure 5).

If the nation was improving in math achievement as a whole, one would hope that

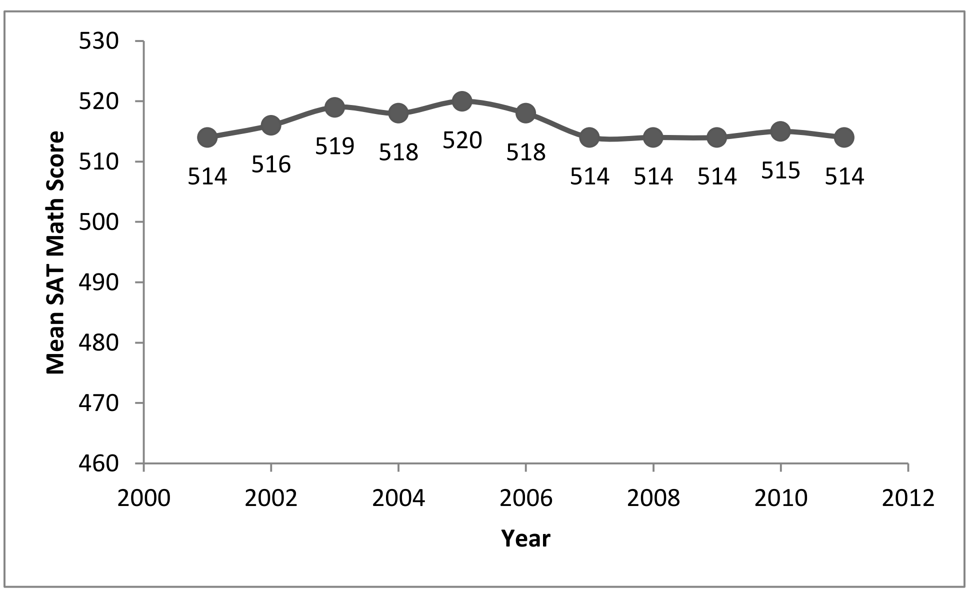

Figure 4: Mean Score Earned by Students on the SAT Math Exam From 2001 to 2011.

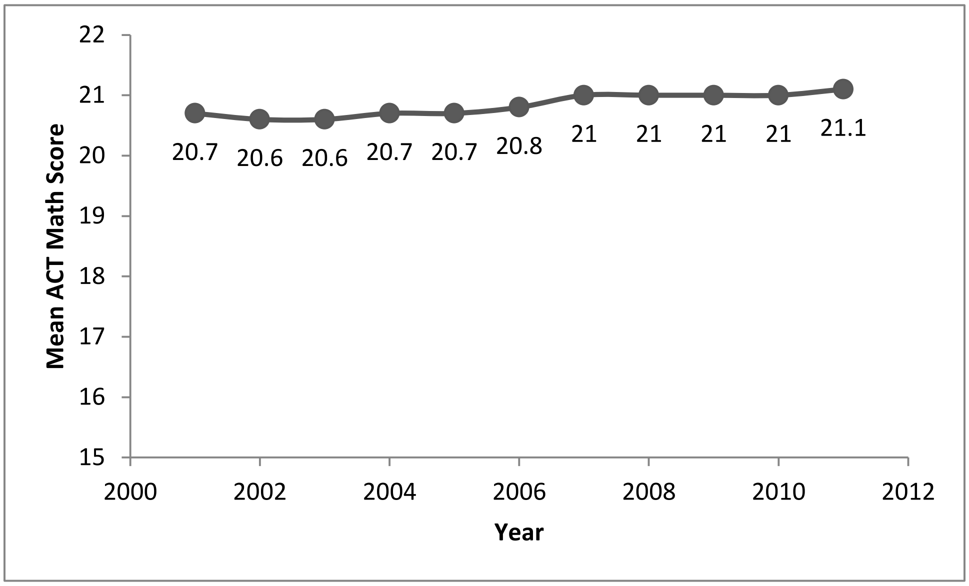

Figure 5. Mean Score Earned by Students on the ACT Math Exam From 2001 to 2011.

there would be a much steeper upward trend in both of these measures' scores. One problem with using college entrance exams as measures of national achievement is that they do not measure the students who do not take the test. In general, the students who do not take this test will be entering the workforce and should not be ignored when looking at national achievement levels.

Remediation Levels.

Students required to take remediated courses at the college level are the students who do not have the basic skills to complete entry level mathematics courses successfully. Minnesota State Colleges and Universities define remediation as follows: "'Remedial Education,' the term used in Minnesota Statutes 13.32, can imply courses which repeat material taught earlier that the student did not learn adequately the first time. For many educators, 'developmental education' is a broader term that encompasses pre-college-level education and other academic support services that the student may benefit from for any reason" (MNSCU, 2011, p. 2).

At some schools, students who are assessed as needing remediation will be required to take a course that does not count for college credit. Even though the students do not receive college credit for the classes, they are still required to pay for those classes. Nationally, statistics are published from 1995 and 2000 on remediation rates (Table 4). This table shows that schools have remediation rates that are either staying

Table 4. Remediation Levels for College Freshmen in 1995 and 2000.

		Percent of Entering Freshmen Enrolled in Remedial Courses.			
2000	Number of entering freshmen	Reading Writing or Mathematics	Reading	Writing	Mathematics
All institutions	2396	28	11	14	22
Public 2 year	992	42	20	23	35
Private 2 year	58	24	9	17	18
Public 4 year	849	20	6	9	16
Private 4 year	497	12	5	7	8
1995					
All institutions	2100	28	12	16	22
Public 2 year	936	40	19	24	32
Private 2 year	53	26	11	19	23
Public 4 year	721	21	8	11	17
Private 4 year	389	12	5	7	8

stable or increasing. As seen in the table, it is not just one type of institution that has to remediate students, but that this is a problem across all institution types.

In Minnesota, a more positive trend in reducing college remediation rates in mathematics can be seen (MNSCU, 2011). The percentage of remediated students has fallen from 58% in 2005 to 46% in 2009 (Figure 6).

Even with the above gains demonstrated by the TIMSS and the NAEP, the assessments' results still paint a grim picture of the United States as a whole when examining mathematics achievement. Underachieving is the only term that could be used

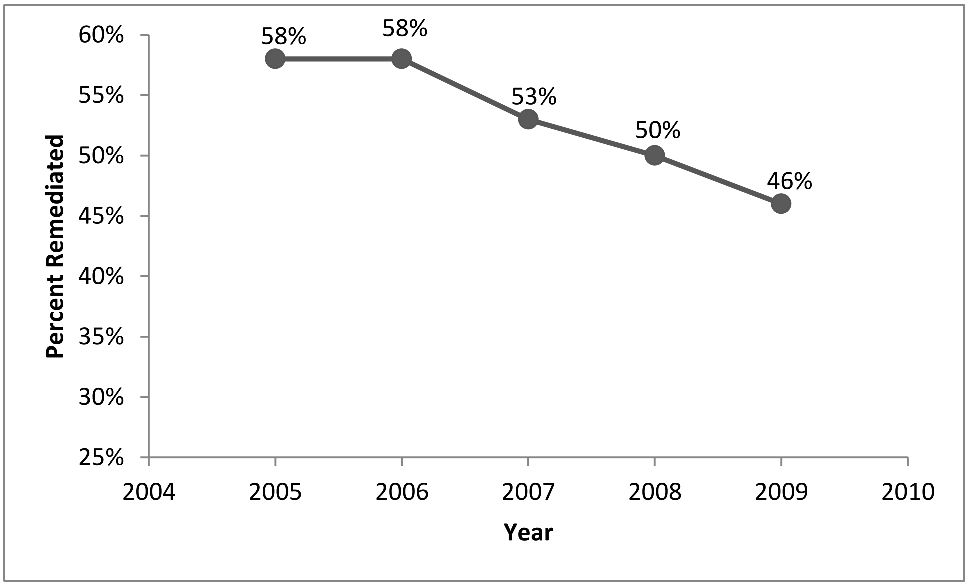

Figure 6. Percent of Student Remediation at Minnesota Colleges and Universities.

to describe a country that has set standards for proficiency, yet its students only achieve levels for that proficiency at 33%, 26%, and 23% in fourth, eighth, and twelfth grades respectively.

Why is This Important?

Why should people care that U.S. students' scores rank lower than many of the countries of the world in mathematics achievement? Easterly (2002, p. 20) doesn't think that we should. He points out that educating people just for the sake of education is frivolous. "Creating people with high skill in countries where the only profitable activity is lobbying the government for favors, is not a formula for success." In other words, creating skills where there exists no technology to use those skills is not going to foster economic growth, and therefore will not increase the person's earning potential. Parents in these countries are understandably unwilling to invest as much in their children's education as people in more developed parts of the world think that they should. For the people to invest in education, there needs to be incentives that can be seen in the future.

Easterly is talking about underdeveloped countries in the previous quote, but his point cannot be dismissed for an individual person, even in the Unites States. Depending on the person's intelligence level, she/he may or may not be able to be educated to a particular skill level. Individuals are different and have different capacities for learning. With this in mind, different people may not benefit in the same ways from the same level of education. Where education can benefit everyone is that it can maximize a person's individual earning potential, no matter what their capacity for learning is. Hanushek and Woessmann (2012) write that the economy is not only influenced by people with high levels of education, but also by individuals performing at average and lower levels.

Here we should ask a couple of questions. Are the test scores a measure of something that we should care about? Do we need to look at other measures of achievement besides scores on standardized tests? Even though the Taiwanese score higher than the United States in international measures of mathematics achievement, they fall behind the United States in more prestigious awards, such as the number of Nobel Prizes awarded (Wei & Eisenhart, 2011). Is this an indicator showing that many nations do well on the tests because they teach the students to be good at taking these tests? Schmidt, Wang, and McKnight (2005) asked the same question. They asked if the tests predicted success on the tests or in the student's career. For people to care, they need to make connections between achievement and problems that they have in everyday life. This has been shown to be true in studies that show correlation between an individual's earning potential, making sound personal decisions about her/his own future, entering college with subpar skill levels, and higher levels of educational achievement (Schmidt, 2012).

These factors all have one thing in common: money. An individual's wages are influenced by the number of skills that he/she has. Generally, the lower the skill level a job requires, the lower the wages that are paid. The ability of a person to be a lifelong learner also indicates what a person's earning potential can be (Carnoy, Rabling, Castaño-Muñoz, Montoliu, & Sancho-Vinuesa, 2012; Dorsett, Lui, & Weale, 2010; Schmidt, 2012). High correlations between earning potential and increased skill levels are increasingly prevalent in the fields of mathematics and computers. Having a level of quantitative literacy has a very large impact on future earning and securing long term employment (Schmidt, 2012). Skills in these fields are at a premium in the world economy and will be compensated as such. Mathematics and science content skills are not only correlated to individual income growth, but are also correlated to the growth of the economy and the per capita Gross Domestic Product (Hanushek & Kim, 1995). Students who enter colleges or the workforce with a skill deficit in mathematics will find it increasingly harder to compete with the students who have that skill base. Not being able to compete will affect their potential earning power and quality of life in the future. If the United States is to grow stronger in a world economy, quality education must be provided to all.

The increased need for data literacy does not only extend to people's earnings, but to their personal life decisions. It is increasingly more important to understand data in making medical decisions, retirement planning, and becoming an informed democratic citizen (Schmidt, 2012).

A lack of data literacy does not only affect the population on an individual level, it can also affect an entire country's economy. When trying to make predictions on long term trends for countries, or groups of people in those countries, educational experts try to correlate this educational data with other factors. Many times, these factors are economic in nature. Cheung and Chan (2008) assert that countries that want to be competitive in economies based on knowledge must make sure that their students possess strong mathematics, science, and reading skills. This is so the students can enter and stay in careers that will enhance the economic growth of the countries. The international tests that were mentioned before are rated highly as measures of students' skill levels, but are also used as economic indicators. It has also been shown that the scores on the international tests are significantly related to the economic well-being of the country and the different economic activities across countries. (Cheung & Chan, 2008; Hanushek & Kimko, 2000; Johansson, Karlsson, & Stough, 2000).

An example of this is the PISA mathematics scores. They have been shown to positively predict the people employed in the field of research and development but also negatively predict the number of male and female employees in the agriculture sector (Cheung & Chan, 2008). This tells us that countries that do well on the PISA mathematics test are more likely to have an advanced economy that is based on innovation. Conversely, countries that do poorly on the PISA are more likely to have an agrarian-based economy that needs workers with skills not necessarily measured by standardized tests. Cheung and Chan (2008) go on to say that if a country wants to compete in a global economy, it is important to have an education that cultivates innovation and produces students who are information literate, because the global economy values a knowledge-based environment.

Not everybody agrees with the theory that educational achievement is a good predictor of economic success. Some think that because some countries have solid economic structures in place that the education moves with the economy, and that the scores in themselves are not a determining factor (Bracey, 2007). To give evidence to his point, Bracey (2007) references the current Competitive Index (WEF, 2012a). He says that we should not worry about the TIMSS scores from 2007 because we have high Competitive Index Ranking. Bracey maintains that instead of pointing to one factor that is causal in the economic or educational quality of the United States, it is better to look at many factors. The World Economic Forum defines its competitive index as follows:

> The Global Competitiveness Report 2011-2012 continues to stand out as one of the world's most comprehensive and respected assessment of countries' competitiveness. Produced in collaboration with leading academics and a global network of research institutes, The Report provides users with a comprehensive assessment of their strengths and weaknesses related to national competitiveness using the Global Competitiveness Index as the main methodology. In addition to statistical data the index also features data from the Executive Opinion Survey carried out by the World Economic Forum. The 2011 Survey captures the perceptions of over 13,000 business leaders from the featured 142 economies (WEF, 2012b).

There are other researchers who cite the possibility of other factors masking the effects of a deficient educational system. Hanushek (2002, p. 17) lists a few of these factors when he cites the "higher quantity of education in the United States, greater college attendance, retention of our scientists and engineers (while attracting foreign immigrants), and greater innovative capacity." He maintains that a combination of these factors has been the buffer to the United States' "Competitive Index" falling. Since Bracey's statement, there have been more years of "Competitive Index" rankings. In each subsequent year, the U.S. has fallen in those rankings. The most current three years of data show the United States falling from second in the rankings in 2009-10 to fifth in 2011-12 (WEF, 2012a). This would indicate that the buffers, as pointed out by Hanushek, to our competitiveness may be failing. This is illustrated in the 2012-13 Global Competitive Index Country Profile. It points to the following as the main reasons for the fall in the ranking:

> The business community continues to be critical toward public and private institutions (41st). In particular, its trust in politicians is not strong (54th), perhaps not surprising in light of recent political disputes that threaten to push the country back into recession through automatic spending cuts. Business leaders also remain concerned about the government's ability to maintain arms-length relationships with the private sector (59th), and consider that the government spends its resources relatively wastefully (76th). A lack of macroeconomic stability continues to be the country's greatest area of weakness (111th, down from 90th last year) (World Economic Forum, 2012, p. 3).

Even with our Competitive Index falling, the United States still displays characteristics that usually don't appear together within a country. We have had lackluster mathematics and science scores, yet we are one of the leading superpowers of this time (Hanushek, 2002). This further solidifies that not just one factor is the cause of changes in economics or in educational achievement.

What is the Cause of the United States Falling Behind?

If we accept that by multiple measures we are lagging behind other countries in the world, and that these measures matter, the next question of academic achievement is, "What could be causes for us falling behind?"

Many of the Asian countries score better than the rest of the world on international assessments. Hong Kong, Singapore, Chinese Taipei, and Japan are in the top five of the latest TIMSS assessment and in the top eight of the most recent PISA administration. Children from these countries beat American children in both measures. Why don't American children perform as well as the children from these countries? Three factors come out of the literature as strong possibilities as to why Asian students score better as a whole on international tests compared to United States students: effort by the student, time spent on the curriculum, and the curriculum itself (Hanushek, 2002).

To look at a direct country comparison, Taiwanese children perform very well on the international mathematics assessments. There is no scientific evidence that Taiwanese children are more intelligent than American children. Nisbett et al. (2012, p. 130) recently supported this with the following findings: "Almost no genetic polymorphisms have been discovered that are consistently associated with variation in IQ in the normal range." Wei and Eisenhart state that a key difference must be the mathematical learning environment. Most Taiwanese parents believe effort is more important than inherent ability in mathematics and force participation in after school tutoring for their students. This can extend the school day to 15 hours, even on weekends. Much of this extended learning time is spent on mathematics (Wei & Eisenhart, 2011). With more time, the students can receive more repetition on the skills that are measured by these exams.

Another key piece to improving academic achievement is the curriculum that is delivered to the students. This is reinforced by Schmidt and Cogan's (2009) research. They tell us that curriculum is a key piece in improving student achievement. The United States has had a different theory on curriculum than the higher achieving countries. The curriculum in the United states is a "mile wide and an inch deep."(Schmidt, McKnight, & Raizen, 1997, p. 1). This can be rectified. As explained earlier, when the state of Minnesota realigned its standards to more closely align with the international standards, its ranking as a mini-nation greatly improved on the TIMSS.

Much research has focused on trying to find one issue that is the cause of the United States' deficiencies in mathematics achievement. One study by McEwan and Marshall (2004) that could possibly be globally applied to learning, introduces categories that are potentially responsible for the raising and lowering of academic achievement. They examined the differences between students in Cuba and Mexico. The Cuban students scored considerably higher on the TIMSS than the Mexican students. Lower frequency of classroom disruptions, increased parent education, the number of books in the house, characteristics of peer groups, socioeconomic status, presence of textbooks in the classroom, and presence of other instructional materials all were found to correlate positively with increased achievement when comparing the two countries. Schools can control only so many of the factors on this list, but the one thing that can be controlled by schools is the access to the school curriculum. Surprisingly, they found that the school and teachers' influences were unable to explain the observed differences. This is directly refuted by Orem (2012, p. 18), in the statement: "The research revealed that student achievement correlates to their efforts to recruit, prepare, develop, and retain a strong educator workforce." This is quantified in one study by saying that if the measure of teacher quality increases by one standard deviation, then it will increase student achievement by 0.1 standard deviations on standardized scales (Rockoff, 2004). Again, we have discrepancies in the research as to what method will increase student achievement. This points to not only one factor as a cause, but to multiple problems with multiple contributing factors.

What Can be Possible Cures for This?

To increase academic achievement in mathematics, there needs to be a framework within which to work. One of the guiding themes to the framework in this study will be "Opportunity to Learn" (OTL). For student achievement to improve, we need to increase the student's OTL. Research indicates that OTL is a critical issue related to achievement, but that it is difficult to measure. OTL was originally defined as the overlap between the information students were taught and the information on which they were tested (Banicky, 2000). It was expanded to other factors that also need to be addressed. These factors are summarized in Table 5. If students can receive improved quality in each of

Table 5. Factors in Opportunity to Learn

Curriculum	Instructional Quality	Time	Resources	School Conditions
Aligns with content standards	Teaching Experience	For lesson planning and collaboration	Adequate physical space	Instructional leadership on the part of the administration
Integrated across content areas	Teacher Certification	For uninterrupted periods of instruction	Access to textbook, technology and support materials	Policies promoting collegiality of school staff (PLC)
Relevant to students and reflecting real life problems	Teacher turnover		School and community partnerships designed to address student health and social service needs	High expectations for student learning
Aligned with assessments for monitoring student progress	Teacher Attendance		Parental Involvement	Student attendance initiatives
	Teacher Commitment		Quality Professional Development	Safe and orderly learning environment
	Use of appropriate and varied teaching strategies		Equitable finance formulas within and between schools/districts	Teacher involvement in decision making

these areas, then we should expect to see gains in their achievement.

When looking to improve the quality of teaching, a large body of research has shown that Bloom's mastery learning model will produce results. This research shows that when compared to students in traditionally taught classes, the students in the mastery learning classes consistently reach higher levels of achievement (Bangert-Drowns et al., 1991; Guskey, 2010). Mastery learning is a process (Figure 7) that starts with initial instruction on a topic. Students are then given a formative assessment to determine if they have achieved mastery of the material. If they have, they move on to enrichment

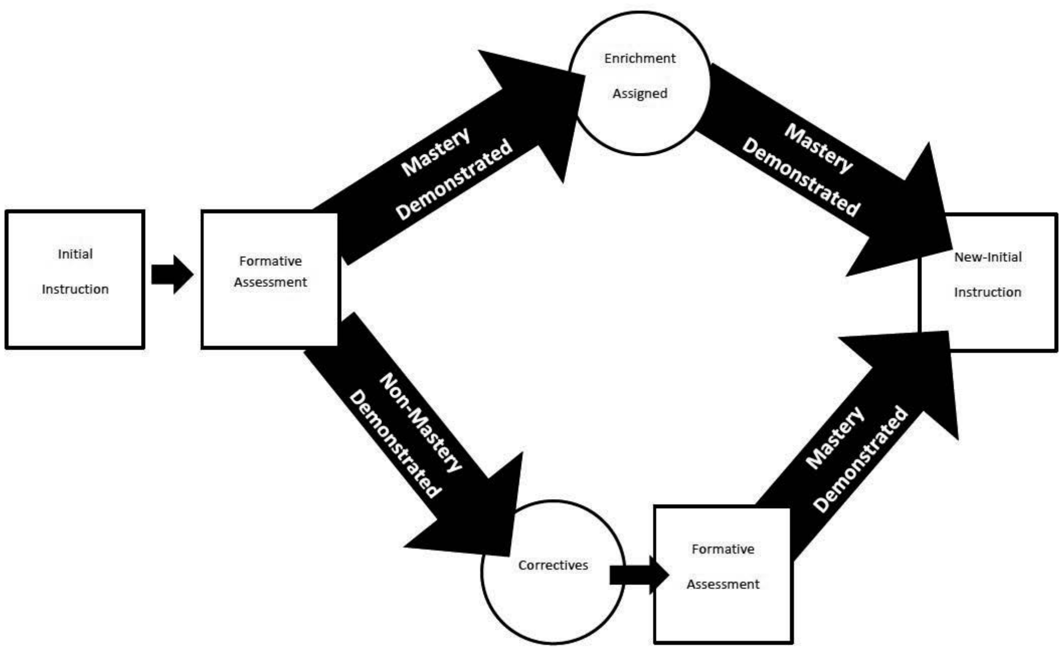

Figure 7. Diagram of Bloom's Mastery Learning Framework

activities on the same material. When enrichment is completed, the student moves to initial instruction on another topic. If students do not demonstrate mastery on the initial material, they move into the "correctives" phase. In the correctives phase, re-teaching of the material takes place. This can be focused on small areas of need or on more in-depth remediation. It is during this time when differentiation takes place. Cobb (2010) stated that this differentiating of the instruction for each student can be one of the most powerful teaching tools for improving achievement.

After the corrections are administered, another formative assessment is given to determine mastery. If the student has not gained mastery of the material, more correctives and formative assessments can be given until mastery is reached. Once mastery of the material has been reached, the student will move on to new initial instruction. Both students and teachers should be aware of the data from the formative assessment. If students don't know what they did wrong, then they cannot improve. Stiggins (2005) tells us that formative assessments are critical if you are to move to assessment "for" learning instead of assessment "of" learning.

In this type of model it can be seen, in some cases very quickly, that students will be at different places in the curriculum. This can lead to students not being engaged in their learning. Time on task, rather than time in class, is an important factor in increasing achievement (Bloom, 1980). This is one of the problems with this model; managing many students in many different locations in the curriculum is difficult for one instructor.

Some teachers may worry about how much time the correctives will take, and that it will cause them to cut down on the breadth of the curriculum (Bangert-Drowns et al., 1991). Guskey (2005, p. 9) states that the correctives "take relatively little time and effort, especially if tasks are shared among teaching colleagues." For many years, teachers have utilized ability groups, physical structures in their classrooms that minimize down-time, and team teaching as techniques for improving achievement. Team teaching is a technique in which one teacher works with the enrichment group and one teacher works the correctives group. This is a compromise from the ideal model, which is one-on-one tutoring, but it correlates much more highly to increased achievement levels than traditional lecture-test teaching (Bloom, 1971).

In an attempt to combine the frameworks of OTL and Bloom's Mastery Learning, the necessary OTL supports were overlaid on a diagram of Bloom's Mastery Learning to create Figure 8. This figure maps out the areas that administrators need to be cognizant of so that they can provide support for the people implementing Bloom's model.

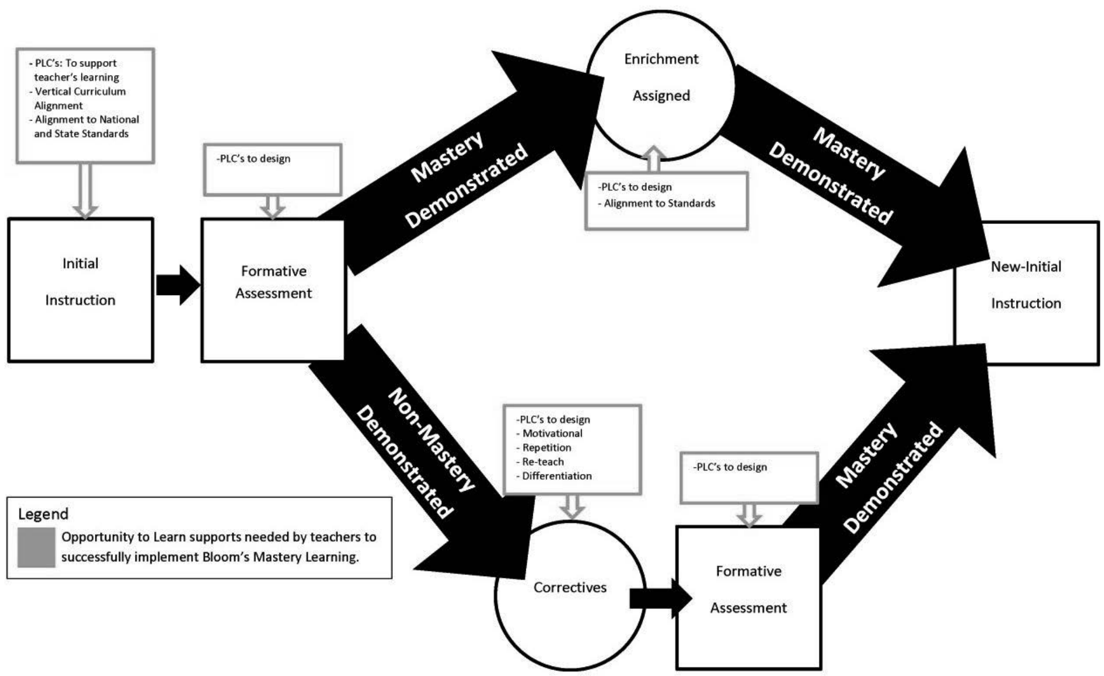

Figure 8. Diagram of Bloom's Mastery Learning Framework with OTL Teacher Supports Added.

By examining the framework an ILS uses to determine types of questions to deliver to the student through CAI, it was determined that it looks very similar to the Bloom model. The types of assistance that an ILS can give to the educational process were added to Figure 9. Adding CAI into this model gives the teachers another tool that will help with the gathering of information and differentiation of the instruction that is vital to the Bloom model. With all three levels of support (Bloom's, school's, and computer's) in place for the teachers, this is an appropriate framework to increase student achievement.

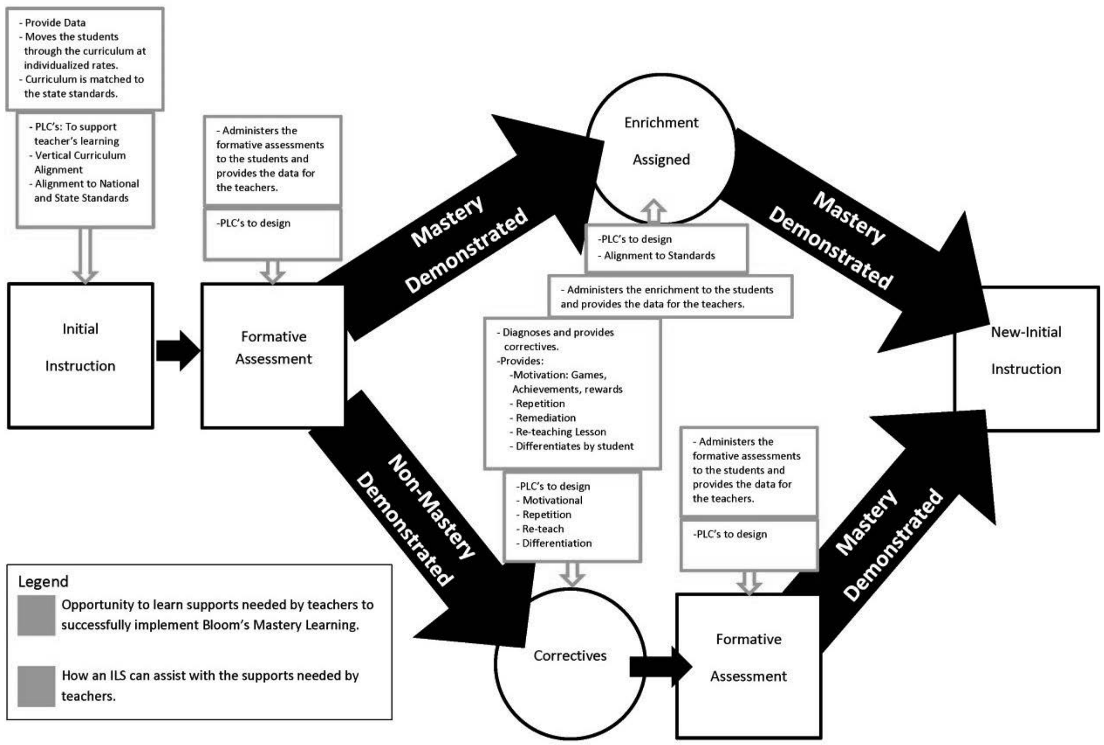

Figure 9. Diagram of Bloom's Mastery Learning Framework with OTL and Teacher Supports Added

How Can CAI Help?

CAI can be a tool that teachers use to administer formative assessments and correctives, and to gather data on student's performance. Of the five topics in the table describing OTL, CAI can be a benefit to four of them (curriculum, instructional quality, time, and resources). A CAI's curriculum is usually aligned to state and national standards that are tested on the state test; differentiation is built into the CAI programs, and they can be utilized whether the teacher is present or not. Students and teachers can control the lessons that the CAI delivers, which can be pre-programmed or created from scratch. The CAI can be accessed on or off school grounds, at any time of the day, and parents can participate in the learning with their students at home. These systems will deliver personalized instruction that is more closely related to Bloom's ideal model of one-on-one instruction. The more modern systems will be data providers and assistants more than they are hindrances. A more detailed discussion of what CAI is, and how it can help to increase academic achievement in the mathematics classroom follows.

A Brief History of Technology Use in Education

Using a computer for educational purposes is not a new phenomenon. Teaching with computers can be traced back to the early 1920s with Sydney Pressey's invention of the teaching machine. Figure 10 shows an example of one of Pressey's first teaching machines.

Pressey made the assertion that a student will learn when he/she is told when his/her answer is correct or incorrect. He also stated that because of this, a self-scoring machine could teach (Skinner, 1965). Building on these assertions, Skinner (1965, p. 428) says, "Machines also have the energy and patience needed for simple exercise or drill. Many language laboratories take the student over the same material again and again,

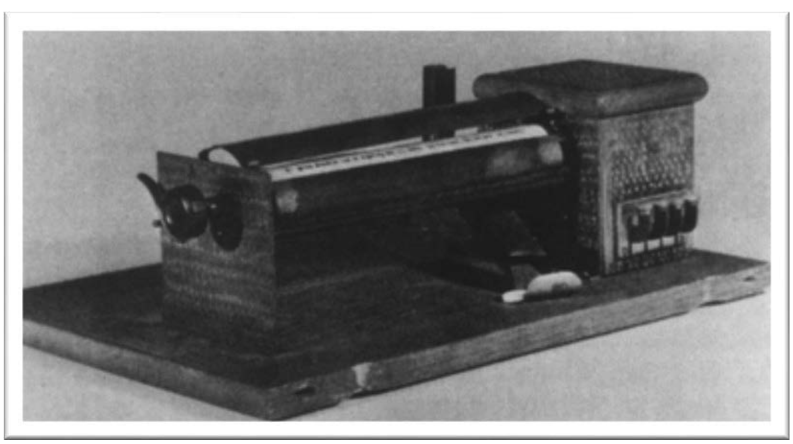

Figure 10. One of Pressy's First Teaching Machines.

as only a dedicated private tutor could do, on some theory of ‘automaticity.' These are all functions which should never have been served by teachers in the first place, and mechanizing them is small gain.” What Skinner and Pressey are saying is not that the teacher should be discouraging the student to study with repetition, but that the repetition can, and should be handled by a machine.

As was stated before, the private tutor, though impractical, was the ideal situation for learning according to Bloom (1980). The computer, with proper software and setup from the classroom teacher, can be the next best thing to having another teacher in the classroom. This virtual teacher would be in charge of the formative assessments and data collection for the actual classroom teacher. In this model the teacher sets the lessons, and then the computer becomes the tutor by administering the practice questions. This need for repetition to gain mastery of a task has long been known. If the machine can successfully handle the formative assessments and the skill practice, the teacher can be freed to help students in other ways, such as planning lessons or differentiating their instruction methods.

The early “teaching machines” of the 1920’s developed into the “Integrated Learning Systems” (ILS) of the 1960’s and 70’s. “International Business Machines” (IBM) created mainframe computers that were housed in their own rooms. The computer processing technology was at a level where students would take a test and wait until the next day for the machine to process the results. The IBM 1500 could network 32 student stations together in one room, and process their information simultaneously (“IBM Archives,” 2012).

There is a need to clarify what terms will be used in this study in reference to the computer systems. In the research, many different acronyms are used to describe different computer systems that have some or all of the above-named characteristics. These acronyms include “Computer Aided Instruction” (CAI), “Computer Based Education” (CBE), “Computer Based Instruction” (CBI), and “Integrated Learning System” (ILS), to name a few. Each one of these has been used, at different times, as terms for educational learning through technology. In more recent literature, the term ILS has been reserved for descriptions of the “system” of networked hardware and software that is used by teachers to deliver the CAI, which is the actual delivery of the content to the user. This study will refer to all systems that have integrated server side hardware, software and are networked, as an ILS(s). CAI will be used when discussing the use of an ILS that is integrated into instruction.

For an ILS to evolve from a machine that only guides students through repetitive tasks to one that can differentiate and evaluate, many improvements in technology were needed. Four technologies needed to be invented and or improved: access to computers, processing speed of the computers, connectivity, and internet connection speed.

The first major step in this process was the personal computer being introduced in 1976 (“The History of Instructional Design,” 2012). The United States government subsidized these computers so that schools could purchase them. Also with the price of personal computers falling, students have had increased access to computer technology in their homes (Figure 11).

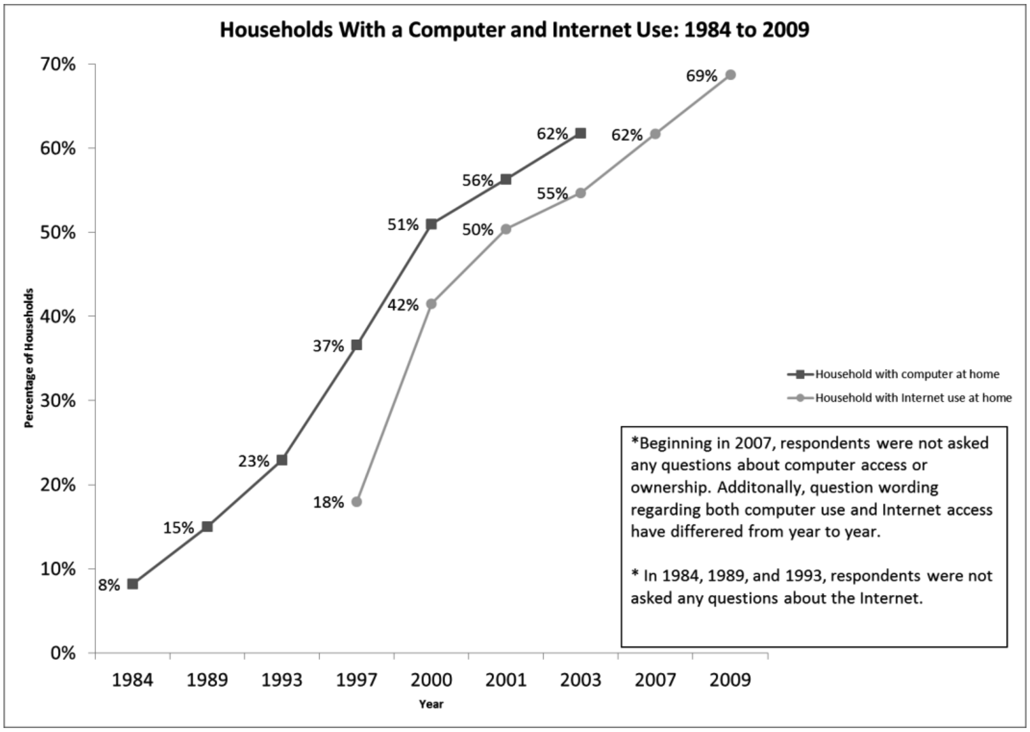

Figure 11. Computer and Internet Access Trends.

Next, the processing power of the computers had to increase in order to reduce the time that it took for the computer to give feedback. Processor power, the ability for a computer to complete a discrete task, increases according to Moore's Law. In 1970 Gordon E. Moore predicted that the processing power of computers would double every 18 months. This has been holding basically true for the past 50 years (Mack, 2011).

The next necessary innovation was for computers to be networked. Computer labs in schools were still "dumb" terminals because most of them were not networked. Computers have to be able to communicate to each other so that they can share data. This was first accomplished by connecting computers in one room. For an ILS to run effectively, the computers needed to be able to "talk" to each other throughout the world. The improvements in the internet have allowed millions of people to connect together and share information. Examples of this happening are social networks. As of March

2012, Facebook had 901 million active monthly users that can interact and share information with one another ("Facebook Newsroom," 2012). We now have millions of computers/people connected, not just 32 computers in one classroom. Some of this can be attributed to the increase in bandwidth and speed (Figure 12) in the United States.

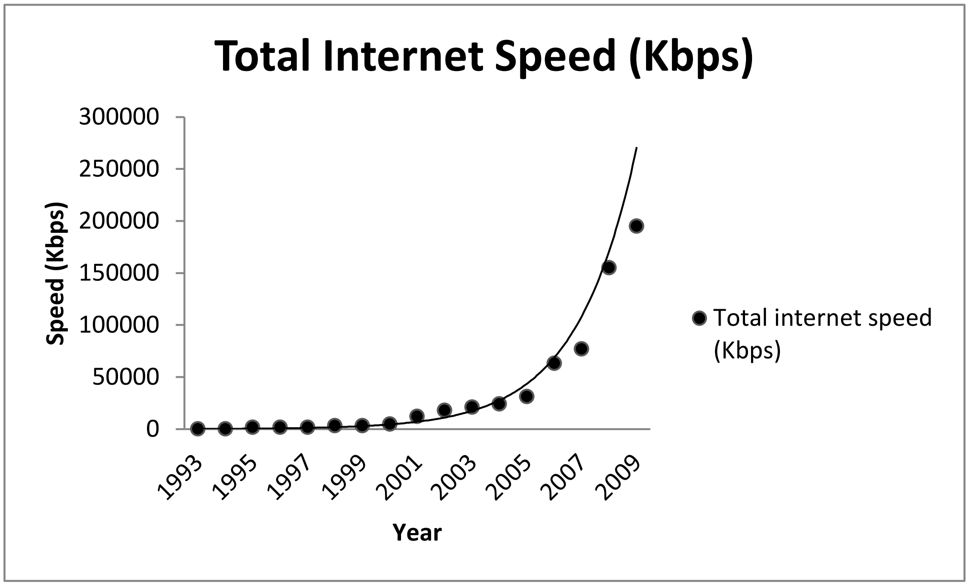

Figure 12. Growth of Internet Speed at Cedarville University.

Once computer technology has advanced to having the minimum availability, hardware requirements, and internet connectivity, ILSs could become a resource that is accessible in the school as well as in a student's home. With computers now being able to communicate with each other all over the world, the creation of massive ILSs is possible. Each ILS has pieces that are basically the same. Estep (1997) summarizes different descriptions of an ILS; his references are summarized in Table 6.

Table 6. Summary of Estep's References for ILS.

Author	Year	Description of ILS
New York City Board of Education	1994	"A simple description would characterize an ILS as a means of delivering individualized instruction in the core curriculum through a network of computers. "
Bailey	1992	"A complex, integrated hardware/software management systems using computer based instruction."
Shore and Johnson	1992	"Integrated learning systems (ILSs) are networked systems of multiple computers which deliver comprehensive educational courseware at the direction of a central management system."
U.S. Congress's Office of Technology Assessment	1998	An ILS is defined as a system that includes both courseware and management software running on networked hardware.
Becker & Hativa	1994	"Integrated, individualized computer software supplied by a single vendor and containing instruction and practice problems covering a multiple year curriculum sequence."
Holland	1993	"It is a school-based computer network that features sophisticated management software that tracks student progress and achievement."
Wiburg	1995	"An integrated hardware/software system that delivers courseware generally related to basic skills learning."

Platko, referring to Bailey's and Becker's work, defines three main components that are required for an ILS system (Platko, 2011). He states that an ILS needs the following components:

1. A centralized management system.
2. It must monitor student progress, create individualized lessons, and provide diagnostic and prescriptive analysis of each student.
3. Must be aligned to a goal or goals.

While both authors provide good overviews of the features and functions that an ILS must have, they don't do an adequate job of describing a modern ILS. A more pertinent definition of what an ILS should contain is found in Bailey (1992). His additions to the list are as follows:

1. Specify instructional objectives and tie these objectives to individual lessons;
2. Provide for integration of lessons into the standard curriculum;

3. Span several grade levels in one or more curriculum areas;
4. Run on a networked system of computers or terminals;
5. Collect and record results of student performance.

This more specific definition better describes the characteristics of modern ILSs. The key word in this description is the word “networked.” The current estimate is that 2,267,233,742 people, or about 33% of the world’s population has a connection to the internet, and therefore could have access to an ILS (Internet World Stats, 2012).

How is CAI a link to sound teaching principles?

Multiple sources list frequent testing as one way to monitor and evaluate student progress effectively (Bangert-Drowns et al., 1991; Kulik & Kulik, 1991). The “Minnesota Comprehensive Assessment” (MCA) has been historically administered once per year as a summative test in the state of Minnesota. One change in the 2011-12 school year is that the test could be administered electronically on the computer. With this change, school districts are then allowed to give the MCA to third through eighth graders up to three times during a three month testing window. This move to more formative assessment instead of summative assessment, is aided by the computer in that the processing time of the scores decreases greatly. In past years, the students would take the test at the end of the school year, using paper and pencil; scores would then be returned to the school at or near the beginning of the next year. This format is not as conducive to student learning as more timely feedback would be (Sanchis, 2001; Stiggins, 2009).

Using CAI is a form of learning from technology. There is a need to differentiate between learning “with” and learning “from” technology. Learning “with” technology is learning that is designed to facilitate critical thinking by using the technology to create something. Examples are databases, spreadsheets, and computer programming languages.

When you learn with technology you are using it as a tool to enhance your learning through delivery of information. Learning “from” technology is where, through technology, students are exposed to information, questions are asked, responses are required, and feedback is given (Platko, 2011b).

There is much research identifying the use of ILS as one strategy to help teachers learn with technology and students to learn from technology. One of the main researchers in this area is James A. Kulik. He, along with the help of others, performed three studies in 1983, 1991, and 2003 in which meta-analyses were conducted to consolidate the studies’ findings. A meta-analysis is a technique that is used to quantify many studies into one number that is comparable to other results. The number that they found is called an effect size. Effect size is the difference between two means divided by the standard deviation of the two conditions. Effect sizes tell us the relative magnitude of the experimental treatment, or the size of the experimental effect (Thalheimer & Cook, 2012). Effect sizes of 0.20 are considered small, 0.50 are medium, and 0.80 are large (Cohen, 1992). Slavin (1990) adds to this by stating that when effect sizes in educational studies are above 0.25, they are significant.

In the 1983 study Kulik, along with Robert Bangert and George Williams, used meta-analysis to integrate the finding of 51 independent evaluations of ILS. They concluded that ILS raised students’ scores on final examinations by approximately 0.32 standard deviations, or from the 50th to the 63rd percentile. They also concluded that the students taught using computers developed positive attitudes toward the computer and the course they were taking, and that the computer greatly reduced the amount of time that it took for the students to take the test (Kulik, Bangert, & Williams, 1983).

In 1991 Kulik and Kulik produced findings from a meta-analysis of 254 studies on ILSs. The median effect size for all 254 studies was 0.42 (Kulik & Kulik, 1991). Another finding in this study is that if the ILS program lasted for four weeks or longer, they saw a reduced effect size. Kulik and Kulik (1991, p. 89) suggested that this might be attributed to a “novelty effect” because students would naturally lose interest in the medium.

Kulik (2003) alone looked at ILS in 2003 when he reviewed 16 controlled studies conducted after 1990. He stated that the reviews of the 70’s and 80’s were well-documented and need not be revisited, but that the reviews of the 90’s were scattered and needed reviewing. He found that the median effect in the 16 studies was 0.38 standard deviations, from the 50th to the 65th percentile. The effect sizes ranged from 0.14 to 1.05 (Table 7).

He also found that in the studies where mathematics was looked at alone, ILS instruction was at least as effective as conventional instruction and no ILS had a negative effect on students. This is evidence that an ILS delivering content through a CAI can significantly increase the achievement levels of students.

Table 7. Results from Kulik’s Meta-Analysis on Seven Math ILS of the 1990’s

Study	Duration	Grade level	Location	Source of ILS	Sample size	Achievement effect size
Clariana (1996)	1 school year	5	Western U.S.	Jostens Learning Corporation	873 students	0.40
Fletcher, Hawley, & Piele (1990)	71 school days	3, 5	Canada	Milliken Math Sequences	79 students	0.40
Howell (1996)	1 school year	6 - 8	Georgia	Jostens Learning Corporation	131 students	0.14
Laub (1995)	7 months	4 - 5	Pennsylvania	CCC Success Maker	993 students	0.56
McCart (1996)	6 months	8	New Jersey	WICAT Systems	52 students	1.05
Spencer (1999)	5 years	2 - 3	Michigan	Jostens Learning Corporation	92 students	0.37
Stevens (1991)	1 year	3 - 5	Texas	Jostens Learning Corporation	180 students	0.54

There are studies that examine the relationship between the CAI use and state tests (Clariana, 1996; Hannafin & Foshay, 2008; Platko, 2011b). In all of these studies there is a positive correlation between use of CAI and increased state test scores. With this in mind, an administrator needs to look at possible missteps that could derail a successful CAI implementation. Researchers have found that there are some simple rules that schools can follow when implementing ILSs to make their effect stronger. These factors include the amount of time that students are allowed to spend using the ILS and the degree to which the teacher integrates the ILS into the regular curriculum (Kulik, 2003). Morton (1996) states that teachers are using computers as they would pencils and paper and not integrating them into the curriculum. Without this integration, teachers are not able to utilize the technology to its full potential. The two areas that would need close administrative attention during an ILS implementation are: “What are the parts of a good ILS?” and “What ILS should be used?”

Assessing the CAI and / or ILS

Most studies give examples of the positive features of the ILSs that are being studied. Estep and Watts summarize some of these examples in their writings (Estep, 1997; Watts, 2008a). From these findings, seven areas have been identified that need to be examined when looking at implementing an ILS. They are:

1. Access
2. Content Aligned to a Goal
3. Skill Practice
4. Diagnostic, Formative, and Summative Assessment Feedback
5. Dynamic and Generative Content
6. Motivational Components
7. Differentiation

Access.

Access to the technology can be examined in two areas: student's access outside of the school building, and their access inside of the school building. Access outside of the building consists of accessing a computer that is connected to the internet. For this to happen, the ILS must not be tied to a specific workstation or device. A device is something that can access the internet and therefore the ILS can be accessed through it. Access outside of the school building is then determined by the number of computers connected to the internet (Figure 11) and broadband speeds (Figure 12); both are continuing to increase. The NCES (National Center for Educational Statistics) published data that says American households with a computer grew from 8.2% in 1984 to 61.8% in 2003. Households with access to the internet grew from 18% in 1997 to 68.7 5 in 2009 (NCES, 2011). In looking at the access problem outside of the school, socioeconomic factors may need to be examined within the district, and solutions required in order to alleviate difficulties for those families.

The United States Census Bureau publishes statistics that show internet access levels that are differentiated by race (Figure 13) (United States Census Bureau, 2009). The Federal Communications Commission (FCC) describes the amount of broadband internet penetration as "good" but not everyone has access ("Getting Broadband FCC.gov," 2011). This information is crucial in trying to close the achievement gap. Solutions must be created by schools to decrease this difference in access to information through the internet. Students who do not have this access at home are at a distinct disadvantage.

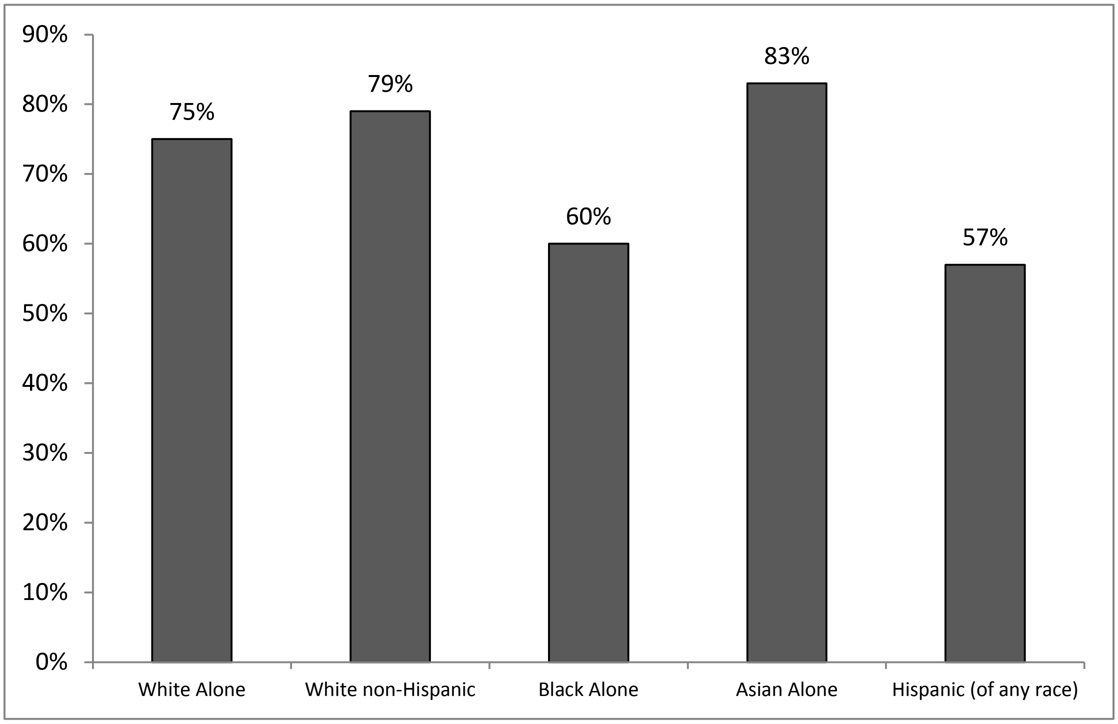

Figure 13. Percentage of Race Origin Groups That Have Internet Access at Home. Source: (U.S. Census Bureau, 2009).

Parental involvement, which is one factor in "Opportunity to Learn" (OTL), can be increased by at-home access to an ILS. This gives the parents more opportunity to be involved in their child's education. Parents can work through problems with the student or track their student's progress in the program. If the student does not have home access, they have more difficulty in working with their parents.

In conclusion, Guskey (2005, p. 10) gives us a thought on students' environments outside of school, in relationship to achievement. "Nevertheless, the impediments to learning in students' environments outside of school should never become a basis for lowering expectations about what can be done to help them learn well in school." We have to take the equal access problem into account when designing programs that use CAI, not use it as an excuse for not achieving.

Content aligned to a goal.

The content must be aligned to the goal that the teacher is trying to achieve. If the content in an ILS is not aligned to a goal—in this case the state standards that will be measured on the MCA—an ILS may be successful in raising achievement in the ILS, but not necessarily successful in raising achievement on the standardized tests (Bhola, Impara, & Buckendahl, 2003).

Skill practice.

An overall theme in learning theory is repetition. To reach mastery on any task, there is a need for repetition of that task. This is reinforced by much leading educational and learning theory research. Marzano et al. (2001) says students need to review previous content to learn the content. Skinner (1965) tells us that repetition is very important for learning after the assessment is aligned to the desired outcomes. For the ILS to successfully teach, it must provide this repetitive practice of the skills for the student. Schacter and Fagano (1999) say that an ILS can provide this practice because it can be used to dynamically replace the pencil and paper for students' drill and practice.

Diagnostic, formative, and summative assessment feedback.

As was discussed earlier, students will learn when they are told if they have answered correctly or not (Skinner, 1965), and they will learn better if they are given explanations of why their answer was right or wrong (Marzano et al., 2001). The ILS can generate this information for the students in real time and show them how their scores compare to their past work and other students' work in the program.

Dynamic and generative content.

An ILS can provide students with this dynamic and generative content with JAVA Script. JAVA Script is a programming language created by Brendan Eich. This programming language can correct answers and make real time decisions as to what information the student should see next. JAVA allows a web page to react in different ways according to different user actions, and determines the best path for the student based on the answer given. For example, poor results on a progress monitoring mechanism can lead to remediated instruction, the scaling down of the level of future practice within the program, or to the creation of new instructional paths designed to promote new learning. “Automatic item generation technology uses algorithms to create assessment items generatively that are of similar difficulty or that vary in difficulty” (Watts, 2008a, p. 13). This is based closely on Bloom’s Mastery Learning Framework that was discussed earlier. The ILS can automate the formative assessment, correctives and enrichments. This is where the teacher has to be careful. The computer cannot become the defacto teacher. The teacher must use the data generated from the ILS to modify her/his own instruction. The ILS should just be a tool used to enhance the classroom teaching, not replace it.

Motivational components.

Drill and practice can become tedious if there isn’t variation to help with the alleviation of monotony. One way to alleviate this is teaching the mastery of facts through games (Tüzün, YIlmaz-Soylu, Karakus, Inal, & KizIlkaya, 2009). Many ILS are adding game components to their programs or gamifying them. Smith-Robbins (2011) defined the three parts to gamification as the process of setting goals, having an obstacle to overcome, and then having competition. Having a game component included in an ILS can switch the rewards that the students try to achieve from purely extrinsic to intrinsic (Renaud & Wagoner, 2011).

Two examples of this are The Oregon Trail (Figure 14) and Number Munchers (Figure 15). Both of these titles were produced by Minnesota Educational Computing Corporation (MECC) as educational products with gaming components. Part of their purpose was to motivate students into seeing more content. More modern and mainstream examples of utilizing the computer for gamification are social networking sites and console games. Foursquare (www.foursquare.com) is a social restaurant check-in site

Figure 14. A Screenshot of the Oregon Trail.

where you can become the virtual "Mayor" of the business if you have checked in the most times. Facebook.com has likes and Yelp.com has the Duke. All of these sites use gamification to encourage competition amongst their users that ultimately entices the user to interact with the program or website more. This is to increase the revenue of the website. Most of these sites sell advertisements on their pages and more visits to the site means more revenue for the company. The gamification of educational software also

Figure 15. A Screenshot of Number Munchers.

hopes for its users to interact with the software at increased levels. The difference is that instead of increasing revenues for the site, educational gamification seeks to increase the achievement of its students.

Students' motivation can also be improved if they enjoy the program or method with which they are learning. Studies have shown that students' attitudes toward learning and their confidence on tests improved when using CAI (Patall, Cooper, & Robinson, 2008; Vale & Leder, 2004). It has also been shown that the medium through which material is conveyed to students also affects the students' learning (Clark, 1983; Kozma, 1994; Platko, 2011b). Students will use a program more if they enjoy using it.

A variety of instructional formats.

Differentiating instruction to reach your students' varying learning styles is one of the key components to improve student achievement (Cobb, 2010). This differentiation should not just be for the struggling learner. Matthews and Farmer point out that gifted students also benefit from the differentiation with CAI (2008). An ILS can differentiate the formats in which the questions are delivered to the students in real time. It can both remediate and accelerate for the varying students' varying needs. Cobb says that for differentiation to be successful, the teacher has to gather data on her/his students so that she/he can evaluate their progress (2010). The ILS can gather the necessary information for the teacher, analyze the data gathered on student performance, and offer the appropriate corrective for the student. This functionality allows the ILS to be very flexible and accommodate a broad range of learning styles (Rubin & Weisgerber, 1985; Shelton, 1994). For many decades, education has been looking for a tool that can help to differentiate instruction in classrooms with varying student needs (Estep, 1997).

Assessing the school environment.

When one looks at ILS implementation through the lens of a school administrator, some limitations may appear. One limitation is access. The question becomes how to provide equitable access to CAI in school for the students who might not have equitable access outside of the school. This can be done by designating times for the students to go into the computer lab specifically to access the ILS for CAI. One of the measures that can be used as an indicator of students not having enough access to the computers in the building is the ratio of students to computers. In United States classrooms, this ratio has moved from 125-1 in 1984 to 3.1-1 in 1998 (U.S. Department of Education, 1998). This fact, along with the statistic from the "National Center for Education Statistics" (NCES) that 100% of schools have access to the internet, shows us that access in schools should not be a problem if the time is structured correctly (NCES, 2011).

Cost of implementation also needs to be considered. An administrator must ask the question, "Is the financial investment justified by the results obtained?" (Estep, 1997). In other words, are the students learning more because of the money that the district is spending on the program? If the computer equipment in the school is updated enough to run the ILS program, then the main cost will be the price of the program. The cost of the ILS (*Study Island*) during the 2011-12 school year in the district that was studied, was $8.60 per student, per year.

Determining an accurate number for what the state of Minnesota spends on education technology as a whole is a difficult task. This is because the state doesn't differentiate technology budgets from general fund dollars in the state financial reports. The most recent national financial data available on school technology expenditures comes from a study that said in 1997-98, the average per-pupil expenditure for technology was $113.20 (Anderson & Becker, 2001). With one-to-one initiatives and the growth of careers in the tech industry, the per pupil expenditure surely has increased with the explosion of technology use since 1997-98. It will be important for an administrator to be able to show results to the school board and the superintendent in order to justify the additional expenditure. For the administrator to be able to show growth, he/she needs to be able to track the growth of the students.

With the expenditure of funds, there should be some measures of effectiveness. In reading Platko and Kulik, the effectiveness of an ILS seems undoubtable (Kulik, 2003; Platko, 2011b). However, not all researchers have the same opinion. Clark goes as far as to say, "The best current evidence is that media (e.g. ILS or CAI) are mere vehicles that deliver instruction but do not influence student achievement any more than the truck that delivers our groceries causes change in nutrition," (1983).

Overuse issues by teachers could also be a problem. The teachers need to embed CAI into their curriculum and make it a supplement, not a replacement to their curriculum (Costa, Galembeck, Marson, & Torres, 2008).

There might also need to be considerations in the discussion of effectiveness that address teacher quality. The influence of a great teacher cannot be ignored. Change in instructor can cause the students to show higher or lower effect sizes (Kulik & Kulik, 1991). This is a repeated theme in the study; using CAI as a supplement to make good teaching better.

Administrators also need to be cognizant of how comfortable teachers are with using the technology. For the teachers to modify the program so that it can successfully differentiate for the students, the teachers will have to have access to the student's data (Cobb, 2010). If they are not capable of using the program to access and then interpret that data, the ILS will not be used to its full potential. "The combination of an ILS and the efforts of a skillful and dedicated teacher together made a difference with a group of students who were among the toughest to reach and the most disenfranchised in the system." (Hannafin & Foshay, 2008, p. 159). If the teachers don't feel comfortable using the technology there is a better chance that they won't use the technology. If they do not use the technology, there is no chance that the technology will improve their instruction and hopefully improve achievement.

To help alleviate these fears, there needs to be staff development designed specifically for the ILS. This staff development would instruct the teachers on how to use the program, how to access the data produced by it, and how to differentiate more effectively for each student by using the data. After the initial instruction, the learning would have to be continued in departmental or school-wide "Professional Learning Communities" (PLCs) so that data can be analyzed and appropriate correctives and enrichments can be designed. These correctives and enrichments would need to be in addition to the correctives and enrichments that the computer designs.

Can Study Island be a Viable ILS for This Study?

Seven factors were earlier identified from the readings that would need to be met to qualify an ILS as having the pieces required to be successful. *Study Island*, an ILS, owned and managed by Edmentum (2013b), covers all of these factors. It has been found to "help deliver standards-based instruction, get students ready for state testing, and prepare students for college entrance exams. It is built from the individual state standards and gives the teachers an avenue to monitor student mastery of these standards, identify learning gaps." (Seymour, 2011, p. 65). Watts (2008a) found *Study Island* to have the following characteristics that directly align with what a good ILS should have: content that is developed from specific state standards; diagnostic, formative, and summative results; assessment feedback loops; ongoing and distributed skill practice; motivational components; a variety of instructional formats, dynamic and generative content; on-line learning, and parental involvement.

Study Island has been shown to increase achievement on state tests (Seymour, 2011; Watts, 2008b). Seymour said that in his school, it increased performance across all levels on their state assessment (2011). A major case study review of schools that used *Study Island* shows that there is a positive correlation between *Study Island* and increased academic achievement, especially in mathematics.

Analysis showed that, in general, within schools that used *Study Island*, student achievement improved within a grade level or, over the course of a year, across grade levels after students in the school began using the program. Although achievement consistently increased across all content areas including reading, math, science, social studies and writing, these analyses showed there was particularly strong improvement in math (Watts, 2008b). With this information, *Study Island* could be considered a viable ILS for this study.

CHAPTER THREE- DESIGN AND METHODOLOGY

Design

This study sought to complete three tasks. The first was to create a description of the usage statistics of students on a specific CAI, *Study Island*. Second, the study examined grade level and graduation year data to see if there were correlations between using *Study Island* and achievement levels on the MCA. Lastly, the study examined correlations between the proficiency levels that students achieved on *Study Island* and their proficiency levels on the MCA. These three tasks were chosen because it was thought that examining and describing data that moved from program level, to grade level, to student level would provide the most well-rounded and useful description of the program. The specific research questions are as follows:

- Question #1: Is there a significant difference between the MCA scores of students who use *Study Island* and those who do not use *Study Island*?
  - Sub Question #1a: Is there a significant difference in the average MCA proficiency between the students when they receive *Study Island* and when they do not?
  - Sub Question #1b: Is there a significant difference in the average MCA proficiency levels, for the grades that implemented *Study Island*, before and after the implementation?
- Question #2: Is there a correlation between achieving proficiency as measured by *Study Island* and achieving proficiency as measured by the MCA?
- Question #3: Is there a difference in students' usage and proficiency levels between game and practice mode when they use *Study Island?*

The purpose of these questions is to add to the literature so that teachers and administrators can make better decisions as to how to implement CAI into their curriculum. This study is a combination of an observational and a correlational study design. It looked to make observations on the students' use patterns on *Study Island* and then tried to find correlations between student *Study Island* use and MCA achievement data. The focus and goal of this research is not to determine a causal relationship but to try to discover correlational relationships that will lead to better educational design by administrators and teachers.

Methodology

Data collection.

Two online databases were accessed to download data, the *Study Island* website and the TIES Education Performance Management System (EPMS). The *Study Island* website (https://www.studyisland.com) collects information automatically every time a user logs onto its website. The privacy policy on the *Study Island* website states what data are collected:

> Whenever you use our website, we receive and store certain types of information. For example, we use cookies to monitor session information and activity on our site, record the Web browser, computer operating system, and IP address you use to connect to our site. (*Study Island*, 2013b)

Study Island allows teachers and administrators to access student use statistics through two different methods. Statistics can be accessed through a web interface where totals of the number of sessions, time spent per session, the number of questions answered, and the percent of questions that were answered correctly are calculated for the individual user and teacher-specified groups of users. This data can also be broken down per topic strand as it aligns with the MCA. Complete *Study Island* data, for the years of use, can also be downloaded from the *Study Island* website. This data can be downloaded in Microsoft Excel format or in a comma delimited text file.

The TIES EPMS is a web interface that allows users to access the student data warehouse and create reports that can be used to analyze student performance. The TIES database is powered by Cognos, a data management tool that is able to create reports from the student information database (IBM, 2013). The TIES website states that it can "look at data across multiple dimensions, drawing information from a central data warehouse, and can analyze and create reports on student performance, test results, curriculum management, attendance and absence reporting, and aggregated performance reviews, among others" (TIES, 2013). For this study, the information that was downloaded from the EPMS is classified as test data. Included in this data for each student were the student's raw score and the equivalent proficiency level that the state associates with that score. The proficiency levels are exceeds standards, meets standards, partially meets standards, and does not meet standards.

Data for this study were downloaded from online databases and stored in local databases. These local databases were then organized and analyzed in Microsoft Excel. Pivot Tables were used to filter the data into subsets that were used as descriptive statistics or analyzed for significant differences between cohorts and correlations between the students' MCA scores and *Study Island* use statistics. These data were disaggregated by the type of question answered, either practice or game. The descriptive statistics for student *Study Island* use that were downloaded from the online database were the number of individual sessions that the students logged on to use *Study Island*, the total number of questions that the students answered, the number of questions that the students answered correctly, and the total time that the students were logged onto the program (Table 8). These descriptives were organized into tables (Appendix B) and each category value was

Table 8. Types of Information That Can be Obtained by a Full Data Download from *Study Island*'s Administrator Interface.

Identifying information	Question Category	Magnitude of Use
Last Name	Program (Grade level the questions are at)	The Number Questions Answered Correctly
First Name	Subject (MCA Standard Year)	The Number Questions Answered Incorrectly
Username	Topic (MCA Strand Type)	Time (sec) logged on per session
Current Grade	Session Type (Practice or Game Mode)	
Log on Date		

divided by the number of students and the number of days that the students used *Study Island* during the school year. This was done in an attempt to compare the use of *Study Island* between cohorts over the years of study, and was necessary because of the different number of students in the cohorts, and because of the data loss during the 2010-11 school year. The percent of questions that the students answered correctly was also calculated.

Significant differences in the MCA scores were calculated for when these students used and did not use *Study Island* as preparation for the MCA. Two key factors made natural breaks in the data that could be used to examine students' MCA scores before and after *Study Island* use. First, the 5th and 6th grade teachers (elementary) did not use *Study Island* as a supplement to their curriculum during any year of the study, while the 7th and 8th (middle school) grades did. This break was used as a point of reference against the differences seen in the middle school MCA scores before and after the implementation of *Study Island.* If the elementary showed similar changes to the MCA scores without implementing *Study Island,* the changes would be more likely to be attributed to some other factor. The students in this sub question were the same students moving between grades, unless otherwise noted. Second, the 7th and 8th grade teachers (middle school) integrated the use of *Study Island* into their classroom curriculum as a supplement to instruction during the 2008-09 school year. This break allowed for examination of the average percentage of students proficient before and after the implementation of *Study Island*. The students examined with this sub question were different every school year.

Significant differences were calculated using Microsoft Excel's Data Analysis tool pack. A t-Test—two sample assuming equal variances—was performed to obtain a p-value that represents the confidence level of how sure an observer can be that the two populations' means are different. The alpha was set at .05 for the tests. This means that to be confident that there was a difference between the two means, then the t-Test would have had to return a P-value that was less than .05.

Correlations were used to compare the individual student MCA scores with their individual *Study Island* use statistics. The individual student statistics that were compared to their MCA scores were the number of sessions, time spent per session, the number of questions answered, and the percentage of questions that the student answered correctly. The strength of the correlation was determined by the following ranges (Table 9).

To determine the correlations, the correlation function (=correl) in Microsoft

Table 9: Strength Levels for Correlations.

Correlation	Strength
0.0 – 0.09	None
0.1 – 0.29	Small
0.3 – 0.49	Medium
0.5 – 1.0	Strong

Source: (Emory University, 2013)

Excel was used. Microsoft Excel calculates the correlation between the two groups using the following equation: $Correl\ (X, Y) = \frac{\sum(x-\bar{x})(y-\bar{y})}{\sqrt{\sum(x-\bar{x})^2 \sum(y-\bar{y})^2}}$

"Where $\bar{x}$ and $\bar{y}$ are the sample means AVERAGE(array1) and AVERAGE(array2)" (Microsoft, 2013).

Participants.

Data for this study were collected over a seven year time frame, from the 2005-06 school year to the 2011-12 school year. MCA scale scores, MCA proficiency levels, and *Study Island* usage statistics were downloaded from the TIES data warehouse and *Study Island* servers respectively. This was done for all of the students who were in the fifth through eighth grades during these years. Only students who had continuous data throughout the years of the study were included in the filtered dataset. An example of a student who would have been excluded from the study is a student who moved into the district between their 7th and 8th grade year. This student would not have complete data, and therefore would not have received the same treatment as the other students in the grade. The graduation year cohort class sizes (Table 10) were all smaller than the actual

Table 10: Number of Students Per Graduation Year From the 05-06 to 11-12 School Year

Cohort Grad Year	Cohort Letter	# of Students
12-13	A	63
13-14	B	56
14-15	C	38
15-16	D	89
16-17	E	80
17-18	F	62
18-19	G	75

class sizes. Cohorts A through E all received some level of CAI treatments. At the beginning of the study, Cohort A had *Study Island* included as a supplement to their curriculum during their eighth grade year only. At the end of the study, Cohort E received *Study Island* as a supplement to their curriculum during their seventh grade year only. Cohorts F and G were included in the study because they were in fifth or sixth grade during the last two years of the study. These cohorts were used for comparison to the changes in the seventh and eighth grade MCA scores.

School program design.

The seventh and eighth grade math teachers implemented the use of *Study Island* in the fall of the 2008-09 school year, and it has been used as a supplement to the classroom curriculum for each successive year. Previous to the 2010-11 school year, it was determined that there was a possible lack of student access to technology outside of the school building. To help address this possible deficiency, beginning in the 2010-11 school year, the school instituted an "OT" (OverTime) period. OT consists of two periods, one before and one after lunch, that rotate four different activities for the students. During this time, students receive extra help in math and reading from their classroom teacher, participate in sustained silent reading, and have access to a computer. What this equates to for increased computer access time for the students is 22 minutes of time that they can access a computer, every other day, or approximately an extra 32 hours per year. This time is designated exclusively for the use of *Study Island*. Other than the OT time, there were no constraints placed on the teachers as to how much or how little time that they designated for the students to participate in the program.

Data collection procedures.

Data collection was a three-step process. Data were downloaded off of *Study Island's* and TIES's respective servers, and compiled into one Microsoft Excel database.

Next, identifying information was stripped from the data, and it was encrypted and password protected. Lastly, the data were stored on a hard drive and backed up on a password protected server.

Data analysis.

The data analysis procedures used for each respective research question are discussed here.

Question #1: Is there a significant difference between the MCA scores of students who use *Study Island* and those who do not use *Study Island*?

Sub Question #1a: Is there a significant difference in the average MCA proficiency between the students when they receive *Study Island* and when they do not?

Data were analyzed by examining the differences between the mean percent of students who were classified as proficient based on their MCA score for that school year. The students who achieved this classification were considered to have earned proficiency on the standards. The mean percentages were then calculated for the following groups based on a before and after *Study Island* treatment date of the 2008-09 school year. Significances of the observed differences were determined by performing a t-Test to obtain a p-value for each comparison. The comparisons were classified into four groups. The first comparisons were of the mean percentage of students, within individual grades, who earned a proficient score on the MCA before and after the implementation of *Study Island.* The second comparisons examined the elementary (fifth and sixth grades) and secondary students (seventh and eighth grades) independently of each other. These comparisons examined the differences between the mean percentage of proficient students before and after the implementation of *Study Island.* The third comparison aimed to determine if there were differences between the elementary and middle school grades before the implementation date, and if there were differences after the implementation date. Finally, the data were grouped into a pool of all students and examined for differences in the mean proficiency percentages before and after the implementation dates.

The goal for this analysis is to determine if the observed changes for students' MCA scores were consistent across grade levels.

Sub Question #1b: Is there a significant difference in the average MCA proficiency levels, for the grades that implemented *Study Island*, before and after the implementation?

For this question the data were organized into three groups to be analyzed in two different ways: Just seventh grade students, just eighth grade students, and seventh and eighth grade students. The mean percentage of the students that were proficient before and after the implementation of *Study Island* were calculated. The p-values for the means were also calculated to determine if the differences were significant. To visually show the difference of the mean percent proficient, a bar chart was created for each grade grouping. These bar charts illustrate the means for all of the students in seventh grade from the school year of 2005-06 to the school year of 2011-12. A line graph was then created for each grade grouping to illustrate the trends that the students are moving in by grade, per year.

Question #2: Is there a correlation between achieving proficiency as measured by *Study Island* and achieving proficiency as measured by the MCA?

On each of the *Study Island* data categories (Table 8), correlations between the student's MCA proficiency and their proficiency in the category were examined. This was analyzed on an individual student basis. MCA proficiency was defined as meeting or exceeding the state standards in mathematics as measured by the MCA. Proficiency for the *Study Island* data was determined in two ways. It was measured by how much an individual student used *Study Island,* compared to other students in the district, in the following categories: the number of sessions logged in, the number of questions answered, the number of questions answered correctly, the time spent on the program, and the percent of questions that the student answered correctly. This data were then disaggregated by grade. Bivariate correlation analysis was used to calculate the correlations between the proficiency on the MCA and the usage measures and proficiency in *Study Island.* The ranges for correlations that were used for this study were as follows: 0.0 -0.09 no correlation, 0.1 - 0.29 small correlation, 0.3 - 0.49 medium correlation, >0.05 strong correlation (Emory University, 2013). Scatterplots were also made for each student's MCA scale score vs. the percent of questions that she/he answered correctly to better illustrate the correlations.

Question #3: Is there a difference in students' usage and proficiency levels between game and practice mode when they use *Study Island*?

The *Study Island* data were examined in three ways to determine if there were significant differences in the usage of games vs. practice by the students. First the percent of game and practice problems answered correctly by student were calculated; these percentages were organized by grade in school, and analyzed for difference by grade level. Next, the average time, in seconds per question, that the student spent per question on games and practice questions was calculated and disaggregated by grade level to analyze the difference. Third, the ratio of practice questions to game questions were calculated to determine if there was a difference in the numbers of questions answered per question type.

CHAPTER FOUR – FINDINGS

This chapter will report the research findings that are aligned with each of the three research questions. As was written previously, the results reported here are not meant to show causality, but to draw a picture of one district's CAI use. This picture is meant to be descriptive of a population of students, some of whom used and some of whom did not use CAI as a supplement to their math curriculum. The hope is to give administrators and teachers a better picture of what pieces of CAI correlate to increased achievement on the MCA. Three levels of data were examined and will be discussed briefly next.

The percentage of students who were proficient on the MCA was charted and compared against various subsets of the students, by grade in school, and the students' graduation year (cohort group). This was done in an attempt to measure if there were significant differences between grade levels, graduation years (cohort group), and before and after the implementation of CAI. The p-values of different populations were also calculated to determine if the differences between the two populations were significant. This was done in the elementary to add a reference point to compare to the middle school.

Second, correlations were examined between the student usage statistics for *Study Island* and the proficiency levels that the students attained on the MCA. This was done by using the correlate (=correl) formula in Microsoft Excel, which returns the correlation coefficient for two selected data groups.

Lastly, differences in the patterns of student *Study Island* use were analyzed by calculating p-values to determine if the differences observed between the data sets were significant. The patterns examined in these subgroups were the user statistics on *Study Island* disaggregated by game and practice question type. This was done in an attempt to learn if there was a difference in student use patterns between game and practice type questions.

Question #1: Is there a significant difference between the MCA scores of students who use *Study Island* and those who do not use *Study Island*?

This question examines if there is a correlation between the use of *Study Island* in general and students' MCA scores.

Sub Question #1a: Is there a significant difference in the average MCA proficiency between the students when they receive *Study Island* and when they do not?

This sub question examines the differences between the scores of students who were in fifth and sixth grades (elementary) vs. those who were in seventh and eighth grades (middle school) (Figure 16). The average percent proficient for each grade level is illustrated by Figure 16. When comparing all students over the length of the study, no significant difference was found between the elementary and the middle school

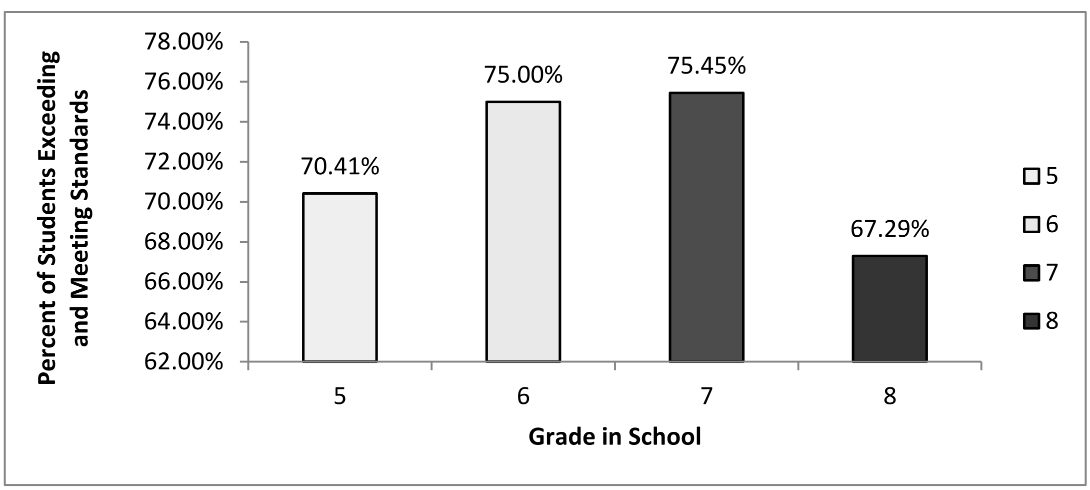

Figure 16. The Percentage of Students That Exceeded and Met Standards by Grade in School Cumulative From 2005-06 to 2011-12.

proficiency levels that students attained on the MCA. This is illustrated by a calculated p-value of 0.83 for the difference between the percent of students who were proficient in the elementary and the middle school. Students in the elementary showed no significant growth during this time, but the middle school students did show significant growth during this time.

A special subgroup of this study that was examined was the three graduation years (cohorts B, C, and D) that had four full years in the school's system while *Study Island* was in implementation (Figure 17). These four years consisted fifth and sixth

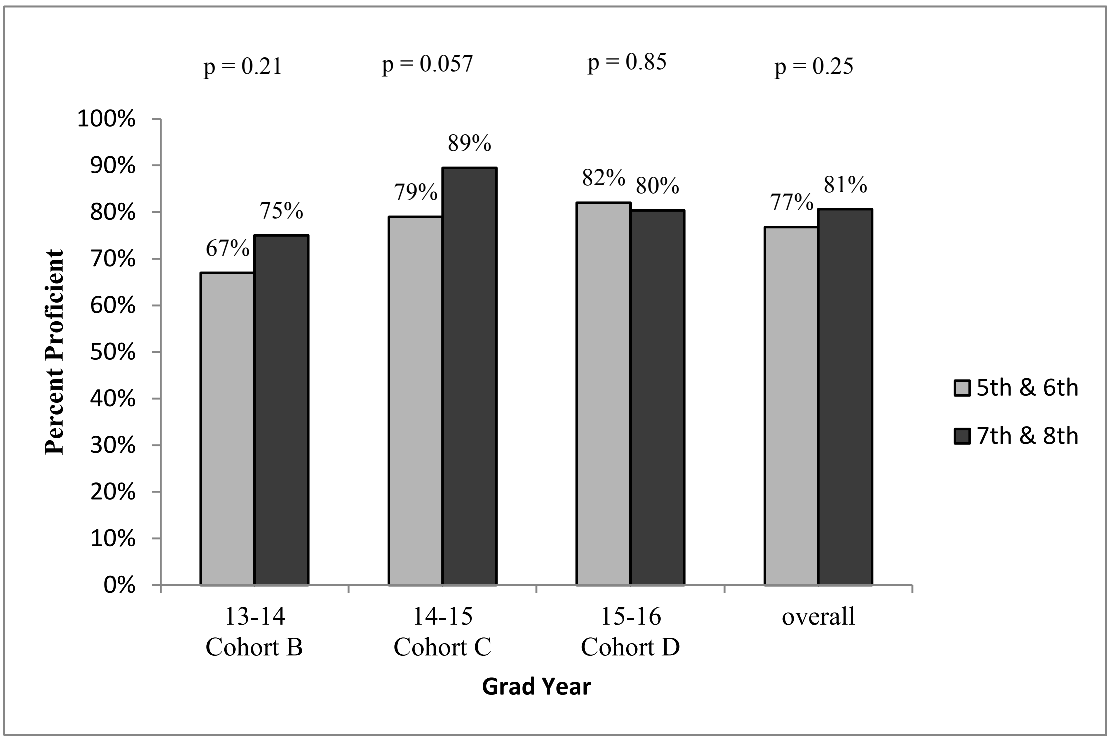

Figure 17. Percent Proficient Before and After *Study Island* Years for Full Cohort Classes.

grade without *Study Island* and seventh and eighth grade with *Study Island.* Two of the three graduation years increased their percent proficient levels after they had *Study Island* implemented, while one year, 2015-16, decreased in the percent of students who were proficient. One possible explanation for the decrease could be attributed to a change in the test. The MCA III test was implemented that year, and was seen as having an increased difficulty level as compared to the previous MCA and MCA II (MDE, 2012b). Across all three cohorts, the percentage of students who were proficient on the MCA increased by 4%. Even though there was an increase, it was not determined to be statistically significant. The significance of the findings could have been affected by the relatively small sample sizes that were being compared. The significance was calculated based on four data points, two before and two after the *Study Island* implementation year. This data does have validity, however, in that it can show us the proficiency trends for students who used *Study Island* as a treatment for two years after not using it previously.

All of the cohorts' proficiency percentages are shown in Figure 18. These show

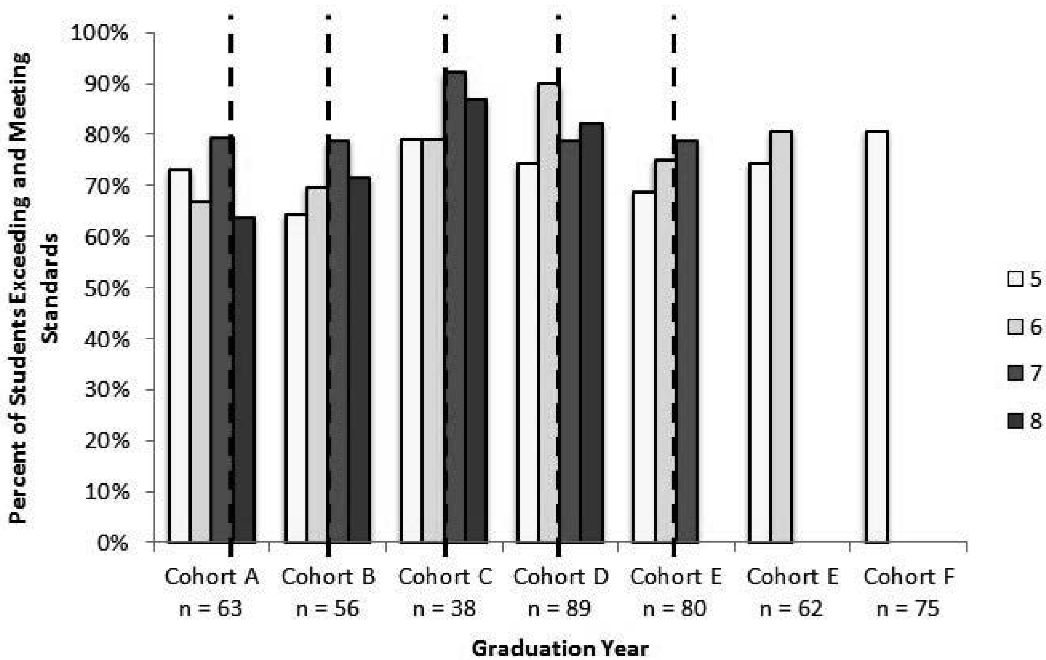

Figure 18.The Percentage of Students Who Were Proficient on the MCA by Graduation Year. Note: Grades After the Dashed Line Included *Study Island* in the Curriculum.

the trends for the cohorts as they moved through grades five through eight. The dashed vertical line on the figure indicates the year that *Study Island* was implemented for the cohort. As can be seen from the figure, some cohorts did not receive a complete two-year treatment of *Study Island.* The cohorts that did not receive a complete treatment of *Study Island* were included in the study for historical context so trends on the MCA could be examined. This will be explored more in the next question.

Sub Question #1b: Is there a significant difference in the average MCA proficiency levels, for the grades that implemented *Study Island*, before and after the implementation?

The second sub question tried to determine if the percent of students who were proficient on the MCA before implementation of *Study Island* was significantly different then the percent of students who were proficient after the implementation. This data were examined in two ways. First, the students' levels of proficiency were calculated for the years before and after the implementation. These percentages were then examined to see if they differed significantly by performing a t-test to obtain a p-value. Next, the percent of the students who were proficient was charted to illustrate the trends for each of the grades. The previous two techniques were used on data from the seventh grade individually (Figures 19 & 20), eighth grade individually (Figures 21 & 22), and the seventh and eighth grades combined (Figures 23 & 24).

All three groups increased their percent proficient from before the implementation to after the implementation. However, only the eighth grade and the middle school grades combined saw increases in their proficiency levels large enough to be considered significant. The elementary showed no significant growth during the years before and after the use of *Study Island* (Table 11). Though the elementary did not use *Study Island,* this comparison was completed to try to eliminate confounding variables that could have

Table 11. Means, % Proficiencies, and p-values for the *Study Island* Treatment Years.

Grade	Means		P-value
	Before SI	After SI	
5	72.1%	69.9%	0.68
6	64.0%	81.1%	0.02
7	68.1%	81.0%	0.15
8	55.9%	75.9%	0.03
Elementary (5th & 6th)	68.1%	75.5%	0.11
Middle School (7th & 8th)	62.2%	79.0%	0.01

Note: Significant Findings are Highlighted in Grey.

caused the observed changes in the MCA scores for all students in the school. Examples of this could be changes in the test, addition of "Professional Learning Communities" (PLCs), or changes in the students' curriculum other than the addition of *Study Island.* There were individual differences within classes that showed significance; these differences were in the sixth and eighth grade classes.

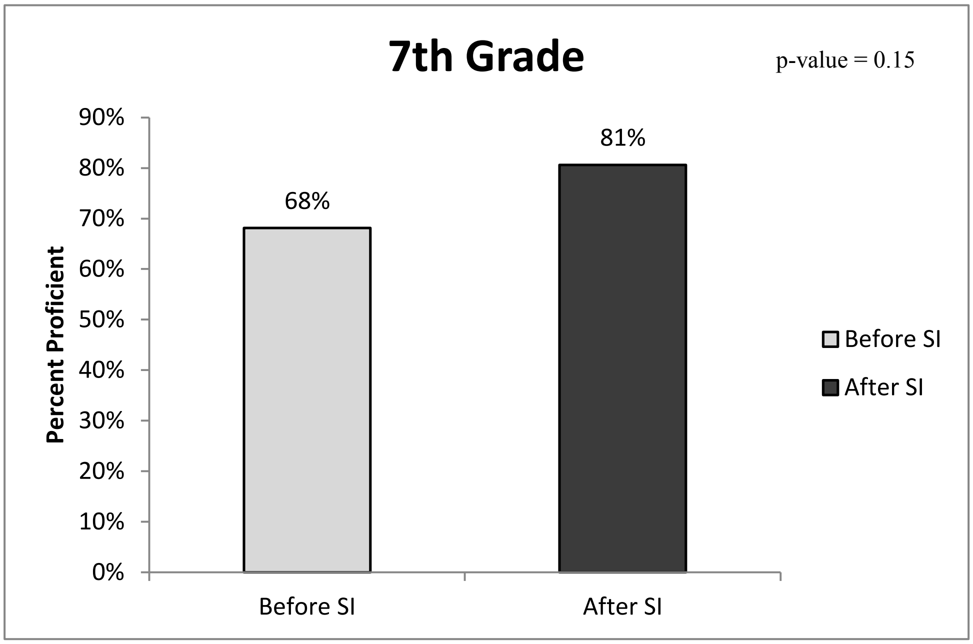

Figure 19. Percent of 7th Grade Students Who Were Proficient Before and After *Study Island* Implementation.

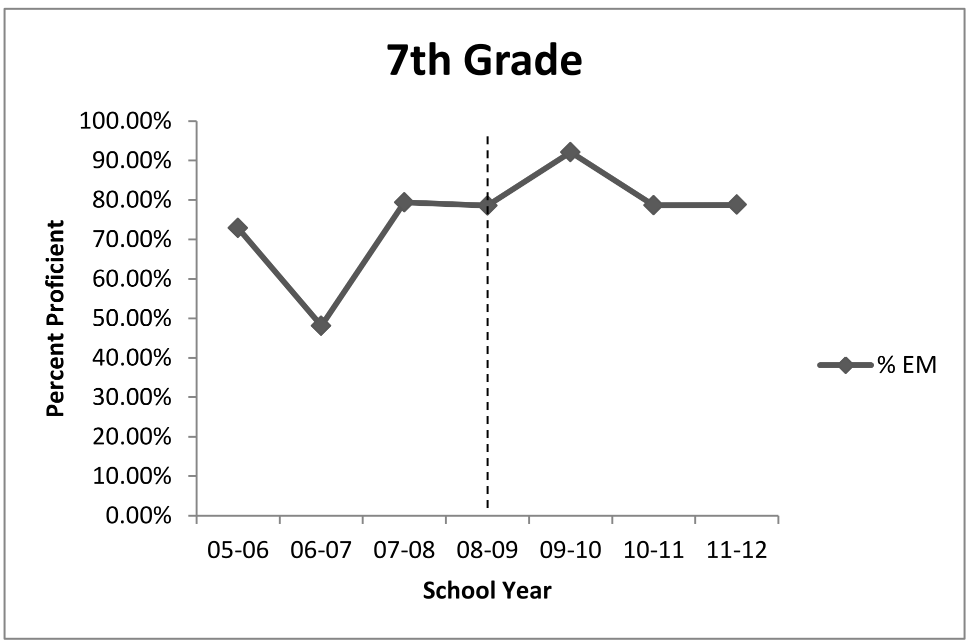

Figure 20. The Percent of 7th Grade Students Who are Proficient by Year. The Dashed Line is the Implementation Year of *Study Island*.

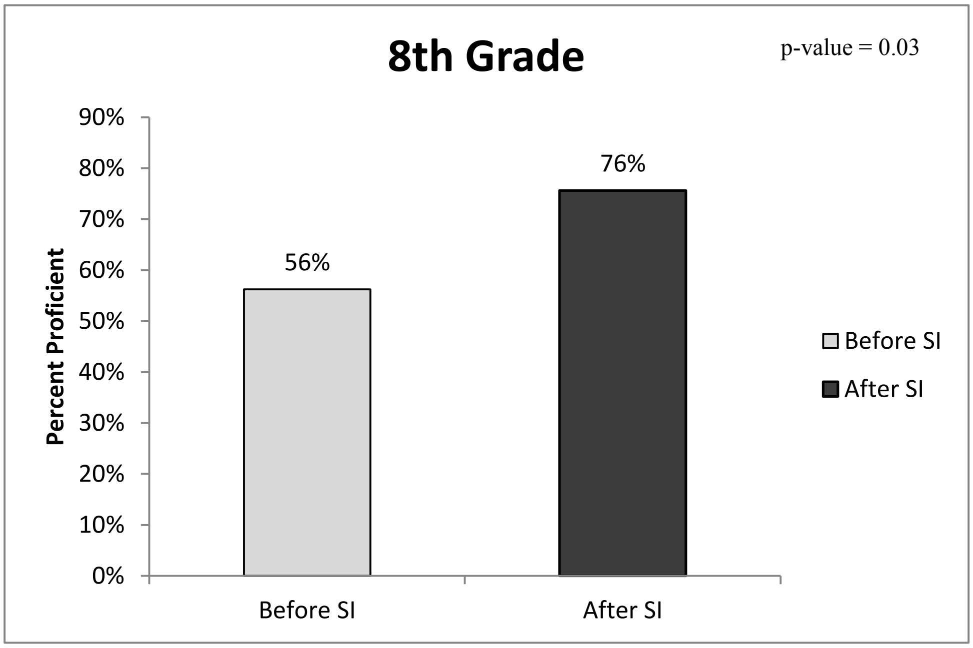

Figure 21. Percent of 8th Grade Students Who Were Proficient Before and After *Study Island* Implementation.

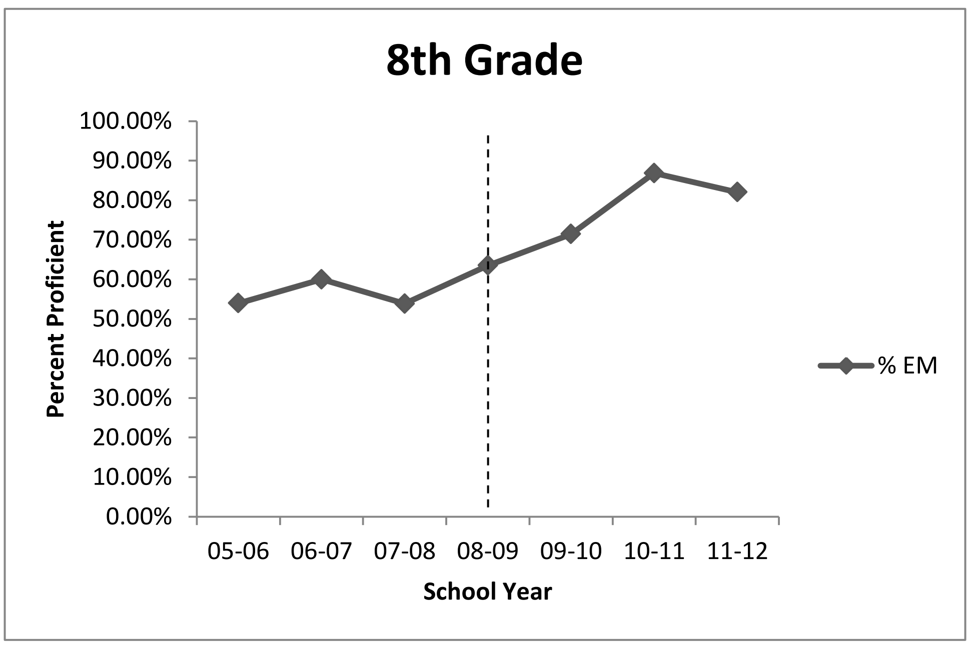

Figure 22. The Percent of 8th Grade Students Who are Proficient by Year. The Dashed Line is the Implementation Year of *Study Island.*

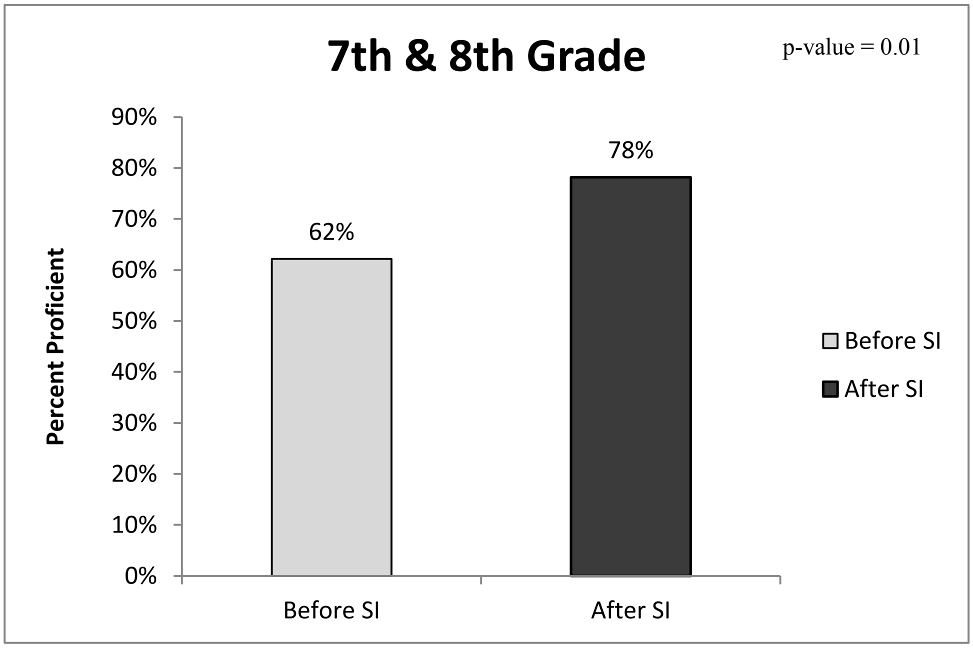

Figure 23. Percent of 7th & 8th Grade Students Who Were Proficient Before and After the Implementation of *Study Island*.

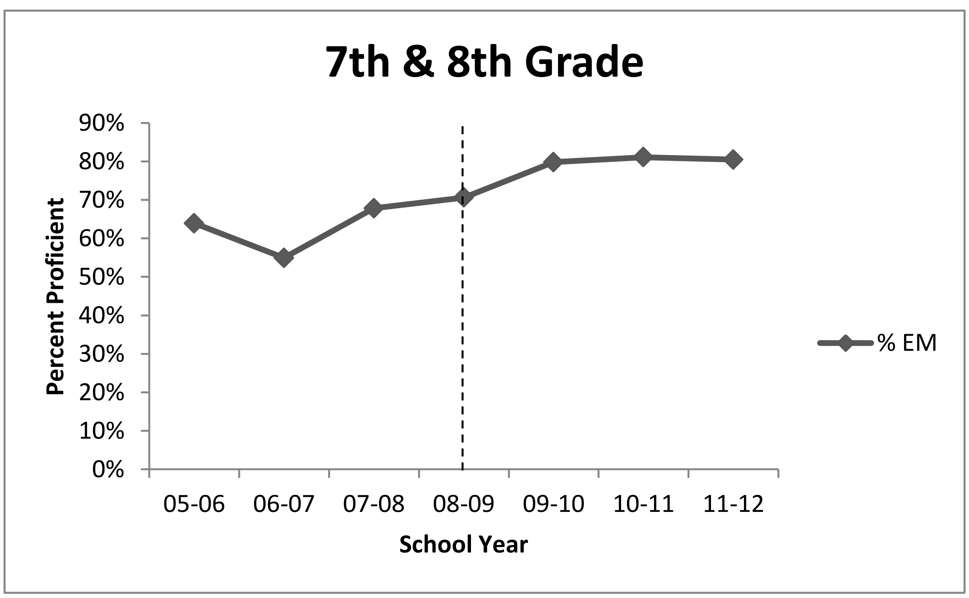

Figure 24. The Percent of 7th and 8th Grade Students Who are Proficient by Year. The Dashed Line is the Implementation Year of *Study Island*.

Question #2: Is there a correlation between achieving proficiency as measured by *Study Island* and achieving proficiency as measured by the MCA?

Unlike the previous questions which examined the difference between larger groupings of students, this question sought to reach deeper, to the individual student. Correlations were calculated at the individual student level to determine if there were similarities between the proficiency levels that a student achieved on *Study Island* data and their proficiency on the MCA, as measured by the student's scale sore. The data that were used as measures of proficiency were the number of sessions that a student logged into the program, the number of questions that they answered, the number of questions that they answered correctly, the total time that they were logged into the program, and the percent of questions that the student answered correctly. The individual correlations can be found in Table 12.

Table 12. Correlations Between the Student's Usage Statistics on *Study Island* and the MCA Scale Score. Correlations Are Based on Individual Student's Scores.

	08-09			09-10			10-11			11-12			08-12		
	7	8	Total	7	8	Total	7	8	Total	7	8	Total	7	8	Total
# of Sessions	0.09	-0.06	0.19	-0.24	-0.43	0.11	0.06	-0.31	-0.03	-0.02	-0.08	-0.05	0.14	-0.01	0.06
# of Questions	-0.05	-0.16	0.14	-0.21	-0.33	0.14	0.06	-0.40	-0.04	-0.01	-0.18	-0.11	0.10	-0.06	0.03
# of Correct	0.21	-0.01	0.26	0.16	-0.12	0.28	0.19	0.18	0.15	0.26	-0.05	0.06	0.26	0.02	0.14
Total Time	0.08	-0.12	0.22	-0.25	-0.29	0.20	0.07	0.31	0.07	0.00	-0.05	-0.03	0.15	0.03	0.11
% Correct	0.80	0.54	0.68	0.79	0.65	0.71	0.68	0.86	0.74	0.76	0.41	0.57	0.73	0.55	0.63

Note: Correlations Are Based on Individual Student's Scores

The correlations were considered to be strong if they fell within the range of 0.5-1.0. The only comparison that consistently showed strong correlations between the two variables was the comparison between the proficiency levels on the MCA and the percent of questions that the student answered correctly on *Study Island*. Figures 25, 26, and 27 illustrate the correlations between the MCA scale score and percent of questions that the students answered correctly on *Study Island* for all of the seventh graders, eighth graders, and the seventh and eighth graders combined from the 2008-09 to the 2011-12 school years. For each comparison, high levels of correlation were found.

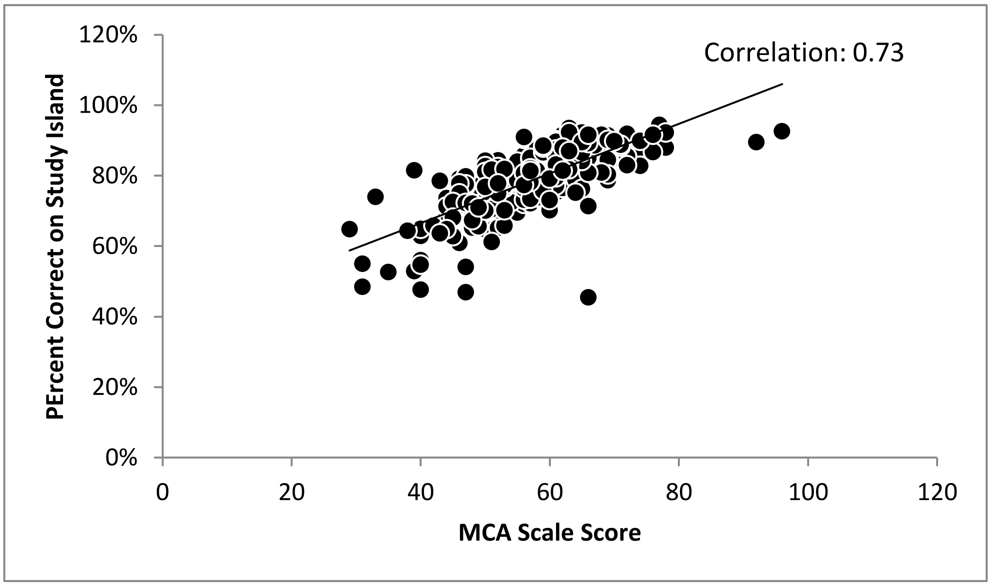

Figure 25. 7th Grade Students' MCA Scale Score vs. the Percent of Questions That They Answered Correctly on *Study Island* From School Year 2008-09 to 2011-12.

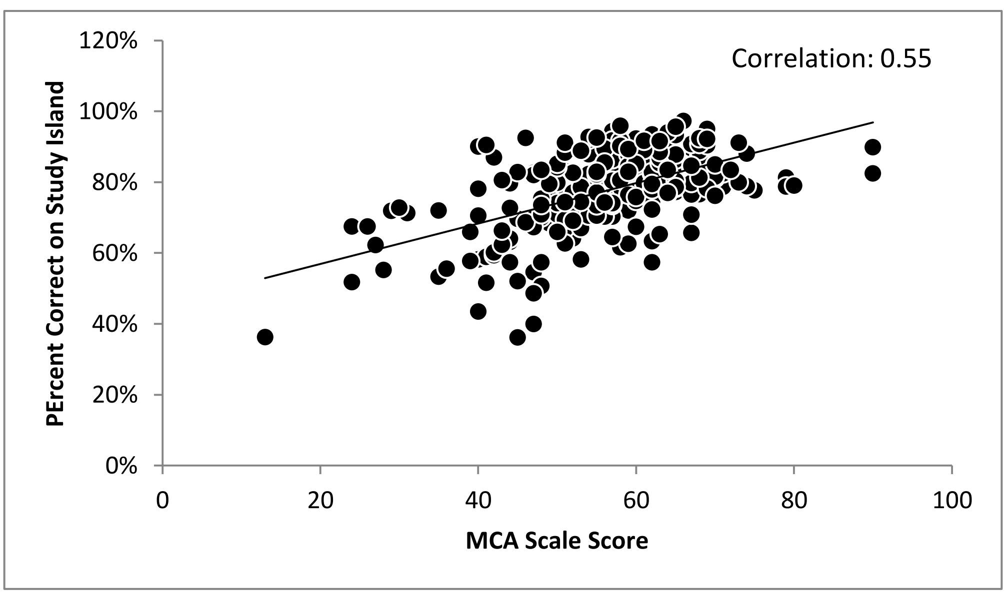

Figure 26. 8th Grade Students' MCA Scale Score vs. the Percent of Questions That They Answered Correctly on *Study Island* From School Year 2008-09 to 2011-2012.

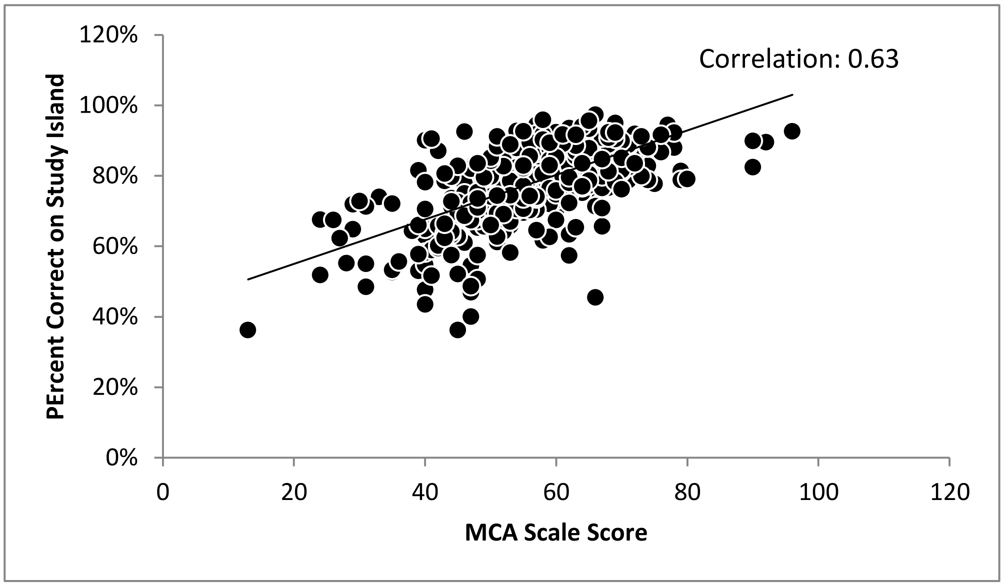

Figure 27. 7th & 8th Grade Students' MCA Scale Score vs. the Percent of Questions That They Answered Correctly on *Study Island* From School Year 2008-09 to 2011-2012.

Question #3: Is there a difference in students' usage and proficiency levels between game and practice mode when they use *Study Island*?

The final question asks if there was a difference in the usage proficiency levels for the students strictly on *Study Island* measures. This was done so that the gaming component and the student use patterns would be better described.

First, the percentage of questions that the students answered correctly in game mode and practice mode were calculated. These values were then charted on a bar chart for a visual representation (Figure 28), and p-values were calculated to determine if the observed difference was significant. For the groups examined, on average, students answered more of the game mode questions correctly than they did the practice mode. The eighth grade individually and seventh and eighth grades (middle school) combined group's differences were seen to be significant.

Next, the average time in seconds, that it took each student to answer the different question type was calculated. When comparing the time that it took to answer a game question compared to a practice question, it was found that there were no significant

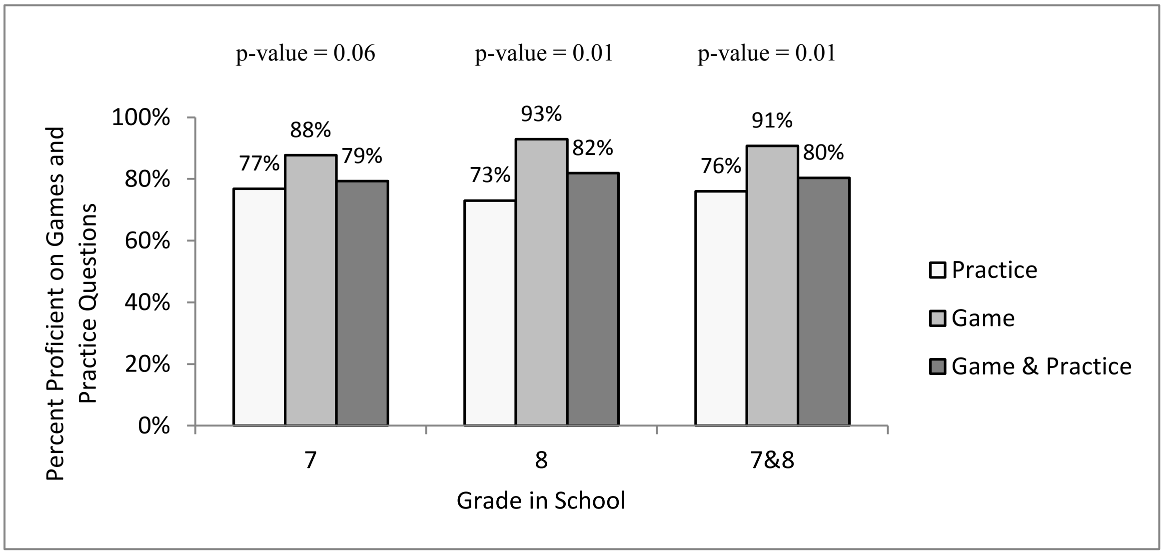

Figure 28. The Percent of Questions That Students Answered Correctly, by Grade, From the 2008-09 to the 2010-11 School Year. The p-values Associated With the Comparisons of the Practice and Game Modes.

differences in those times (Figure 29).

The final dataset was examined and the ratio of practice questions answered to game questions answered was calculated. All three groups answered a higher ratio of

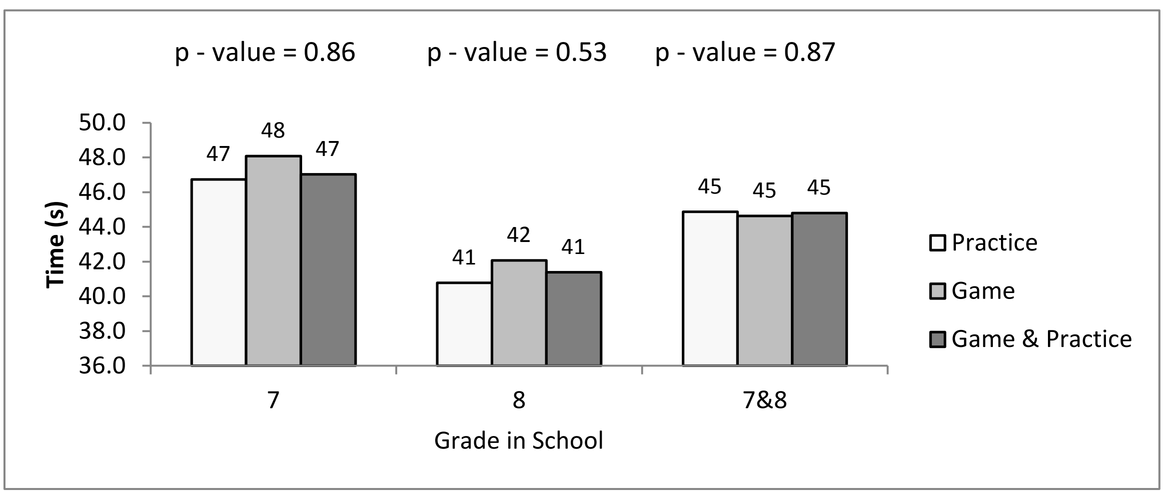

Figure 29. Average Time in Seconds Needed For Students to Answer Practice Questions, Game Questions, and Total Questions From the 2008-09 School Year to the 2010-11 School Year. The p-values are Associated with the Comparisons of the Practice and Game Modes.

practice questions than game questions (Figure 30). The ratios for practice to game type questions answered for the seventh grade, eighth grade, and seventh and eighth grades combined were 3.45, 1.16, and 2.14 respectively.

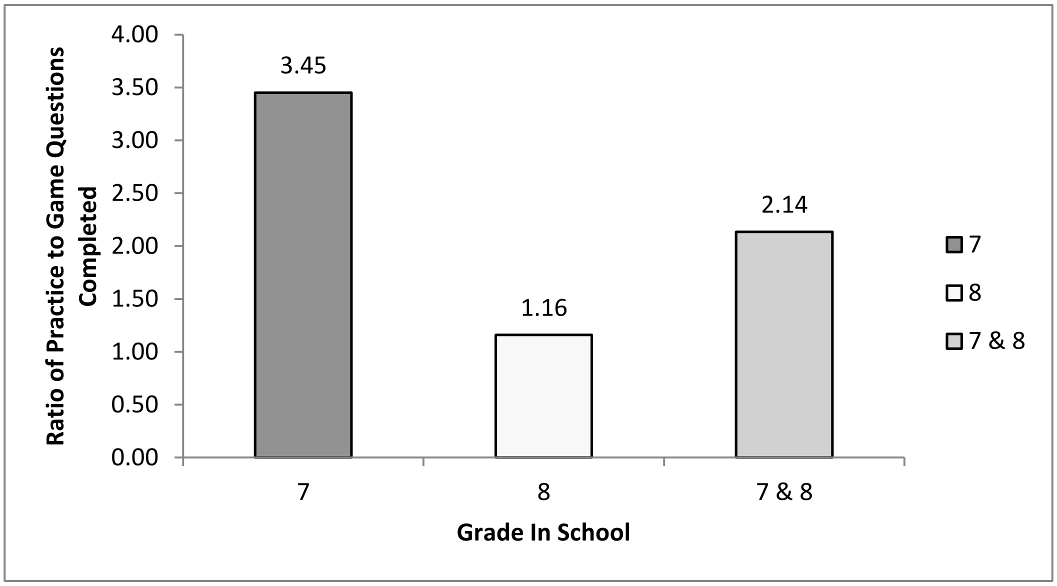

Figure 30. The Ratio of Practice Questions To Game Questions Answered by the Students From the 2008-09 School Year to the 2010-11 School Year.

CHAPTER FIVE — CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS FOR FURTHER INQUIRY

Conclusions and Implications

Conclusion # 1: Significant differences can be seen in the MCA scores of the grades that used *Study Island*, before and after its implementation.

The first sub question searched to determine if there was a difference between the elementary (fifth and sixth graders) and the middle school (seventh and eighth graders) MCA scores. No significant differences were found at any level of comparison between the two groups. The p-values calculated for this comparison was 0.83. This p-value indicates that the data for the two compared groups was not significantly different. This was an important piece in establishing the validity of the next sub question. It was necessary to establish that the observed differences were not solely because of the different teachers at the different grade levels. The fact that the data shows no significant differences between the building levels, elementary and middle school, leads the researcher to believe that, over time, students are being prepared at similar levels from grade to grade, in terms of the math MCA.

The second sub-question seeks differences in MCA scores before and after the *Study Island* implementation year. During the years of the study, the percentage of the middle school students who were proficient on the MCA increased significantly from the percentage that were proficient before the implementation of *Study Island.*

Overall, the elementary school students did not show the same significant growth between the years of pre and post *Study Island* over the same time frame. This was not the case in the middle school. Many factors could have led to this, and it was necessary to state that this data cannot be considered causal. This data should be used as a good starting point in examining the relationship between *Study Island* use and MCA proficiency.

In summary, the data does not show significant differences in MCA proficiency between the elementary and the middle school grades. The fact that there was no significant change in the percentage of students who were proficient on the MCA from the elementary to the middle school provides more evidence to the claim that the instruction between the four grade levels was doing a similar job of preparing the students for the MCA.

Significant differences were found when individual grade levels were compared before and after the implementation of *Study Island*. When looking at the grades grouped together as elementary and middle school, the middle school showed significant growth on the MCA after the implementation of *Study Island*, but the elementary did not. If the elementary had shown significant differences in growth during these years, then the significant difference in the middle school could be much more easily attributed to other factors besides the *Study Island* program. This adds to the assertion by *Study Island* that its program will increase the proficiency of the students who use it.

The significant differences that were observed before and after the implementation of *Study Island* implies that something changed after the 2007-08 school year, in the middle school, to significantly increase the proficiency levels of the students who took the MCA. There could be many factors that may have contributed to this. During that time there could have been many changes; the implementation of *Study Island* as a supplement to the curriculum being one of those many changes.

Conclusion # 2: There is a strong correlation between achieving proficiency on the MCA and the percent of questions that the students answer correctly on *Study Island*.

The proficiency measure on *Study Island* that correlates at a high level with the MCA scale scores of individual students is the percentage of questions that the students answered correctly ($p = 0.63$). Only two of the categories, the number of questions answered correctly ($p = 0.14$) and the total time spent ($p = 0.11$), showed overall correlations at a small level. The other two categories, the number of sessions ($p = 0.06$) and the number of questions answered ($p = 0.03$), showed no correlation to MCA proficiency.

One of the possible causes for the high overall correlation (0.63) between the percent correct on *Study Island* and proficiency on the MCA could be that the questions on *Study Island* have a high level of alignment with the Minnesota State Standards that are tested by the MCA. Their websites makes this claim (*Study Island*, 2013a) and the data that was found in this study add to the credibility of this claim.

This data could be used for formative assessment. An example of this is illustrated by Figure 31. Figure 31 is the same as Figure 27, but with a best fit line drawn, and the corresponding regression equation calculated. This equation can be used to calculate the proficiency level on *Study Island* that correlates with a certain MCA scale score. For a student to be considered proficient on the MCA, she/he must achieve a minimum scale score of 50. If the number 50 is substituted for **x** in the equation and **y** is solved for, the result is 73.88%. This percentage represents the minimum percent of questions that a student should answer correctly on *Study Island* and expect to be proficient on the MCA.

This regression equation represents this sample of seventh and eighth grade students and predicts what will occur with the average student when they participate in the *Study Island* program. There are students who score at a lower proficiency level on *Study Island* and are proficient on the MCA, and students who are more proficient on *Study Island* but are not proficient on the MCA. This regression line could be a good indicator for teachers as to whether the student will be proficient on the MCA or not. Setting thresholds like this also could help teachers who want to set goals for their students to achieve when preparing for the MCA.

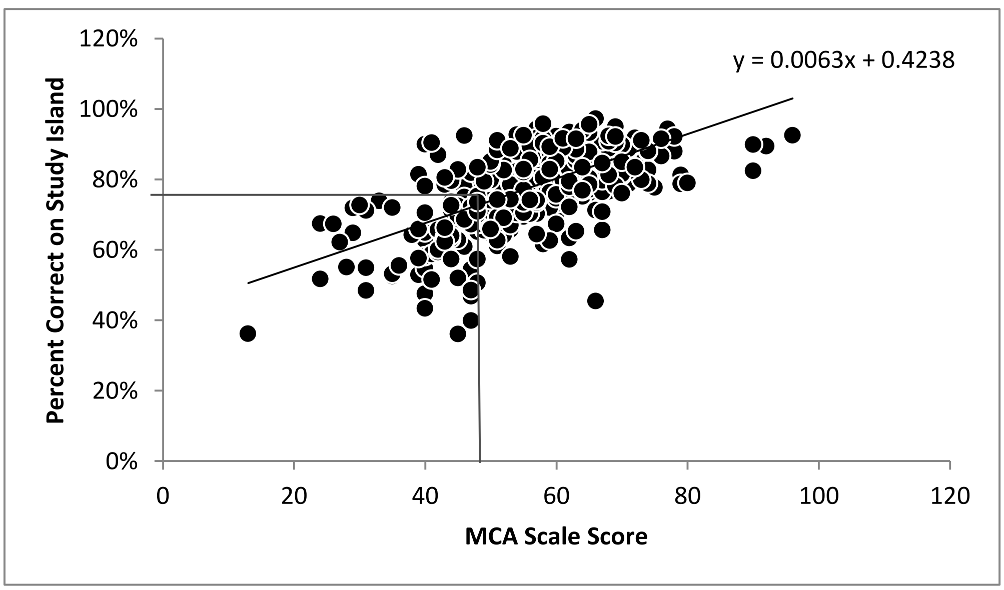

Figure 31. Percent Correct on *Study Island* vs. MCA Scale Score, with Regression Equation.

Conclusion # 3: There is a significant difference in the students' use amounts and proficiency levels between practice questions and game questions.

When looking at the middle school as a whole, students answer game type questions correctly at a significantly higher rate than they do practice type questions. The seventh grade (p-value = 0.06) was just outside of the significant threshold level of 0.05, while the eighth grade was well within the threshold (p-value = 0.01). The seventh and eighth grades combined also showed differences that were significant (p-value = 0.01).

There is no significant difference between the time that it took a student to complete a practice question and a game question. There are debates as to what the benefits are to using games in education, and that the students spend an inappropriate amount of time on the game portion of the question (Renaud & Wagoner, 2011). What this data suggests is that it does not matter what type of question that students attempt; it will take them no significantly different amount of time to answer that type of question.

The middle school students answered 2.14 times more practice questions than game questions. Seventh graders completed 3.45 times more practice than game questions, and the eighth graders completed 1.16 times more practice than game questions. This could be because of how teachers assigned questions or because of the type of questions that the students chose to answer. If it is because of teacher choice, then this finding matches with some beliefs that the students should not focus on the problems that have the game component and instead focus more on the practice problems to prepare for the MCA. If this result is because of student choice, it goes against the popular belief that the students would rather play the games than answer the problems.

Teachers should not concentrate on when the students are answering the game based questions or the practice based questions. They should focus more on whether the students are answering the questions correctly. The students in this study answered significantly more questions correctly when they played in game mode. This could have been because they were motivated to concentrate harder, and answer the question correctly so that they could play the game afterwards. As stated before, if the student answered the question incorrectly, they had to try again until they answered it correctly for both types of questions. The difference was that if they did not answer correctly on the first try in game mode, then they did not get to play the game afterward.

Answering game type questions would seemingly take more time for the student to answer the same question and then play a game. The data does not support this expectation. It shows that there is no significant difference in the time that it takes the student to answer a game or a problem question. This would suggest that students should be allowed to answer whatever question they like and not be limited to just the practice questions. This could even suggest that the student should be encouraged to play the games.

Recommendations for Further Inquiry

This study could possibly prove causation if students were randomly assigned to control and experimental groups. In schools, this is sometimes an impractical proposition. One possible grouping that could lead to results without causing undue harm to the students is to have students grouped so that they only answer game questions or practice questions. Since the students would see the same content and would not take significantly more time to complete either question, this could be a test to see if games can have a difference in the motivation of the students. This could also lead to the analysis of the groups to see if they are more proficient on the MCA.

Many other variables could also be examined. These include correlations to proficiency on the MCA or *Study Island.* Socioeconomic status, in school and out of school *Study Island* data, and disaggregating for the designated computer time during the school day could also be examined.

Another interesting factor that could use deeper analysis would be to see if there is a correlation within the individual learning strands on the MCA and the corresponding strands on *Study Island*. There could be higher or lower correlations to proficiency on the MCA based on the content that the students are receiving.

Conclusion

This paper reported the results of the data analysis of seven years of MCA scores, with four of those years having math curriculum that was supplemented with a selected CAI, *Study Island.* This study demonstrated several areas that could possibly help teachers and administrators in the implementation and use of CAI in their district and classrooms. The findings that are illustrated in the previous sections need to be examined through a lens of correlation, not causation. Because this was not a scientific experiment but an observational correlation study, there could be many confounding variables that could have influenced the results. It is hoped that the findings in this study will contribute to the growing body of literature on CAI use in the classroom and in processing the ever-increasing levels of data analysis.

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APPENDIX A. TIMSS, PISA, and NAEP comparisons.

	TIMSS Trends in Mathematics and Science Study	PISA Program for International Student Assessment	NAEP (Main) National Assessment of Educational Progress	NAEP (Long Term) National Assessment of Educational Progress
Sponsor	International Association for the Evaluation of Educational Achievement (IEA)	Organization for Economic Cooperation and Development (OECD)	The Commissioner of Education Statistics, who heads the National Center for Education Statistics in the U.S. Department of Education, is responsible by law for carrying out the NAEP project.	The Commissioner of Education Statistics, who heads the National Center for Education Statistics in the U.S. Department of Education, is responsible by law for carrying out the NAEP project.
Students Tested	4th and 8th grade students	15-year olds	grades 4, 8, and 12	grades 4, 8, and 12
Subjects	Mathematics and Science	Reading, Mathematical, and science literacy	mathematics, reading, science, writing, the arts, civics, economics, geography, and U.S. history	mathematics, reading,
Frequency of Testing	4 year cycle	3 year cycle	2 year cycle	4 year cycle
Purpose	WHAT DID STUDENTS LEARN? Purpose is to measure the skills and understandings that are typically taught determine the level of student proficiency in learning what is taught.	WHAT CAN STUDENTS DO AS A RESULT OF THEIR LEARNING. measure the "yield" of educational systems; apply their learning to solve problems presented in real-world contexts?	NAEP provides results on subject-matter achievement, instructional experiences, and school environment for populations of students (e.g., all fourth-graders) and groups within those populations	NAEP provides results on subject-matter achievement, instructional experiences, and school environment for populations of students (e.g., all fourth-graders) and groups within those populations
Participating Countries (in the most recent study)	59 Countries	65 Countries and economies (Minnesota and Massachusetts participated as mini-nations)	50 states and 2 jurisdictions—District of Columbia and Department of Defense Education Activity (DoDEA)	50 states and 2 jurisdictions—District of Columbia and Department of Defense Education Activity (DoDEA)

APPENDIX B. *Study Island* Descriptive Data

Days	Student Numbers					Type	Sessions			# Questions			# Correct			Time (s)			% correct		
	7	8	7	8	7 & 8		7	8	7 & 8	7	8	7 & 8	7	8	7 & 8	7	8	7 & 8	7	8	7 & 8
08-09	175	175	56	63	119	08-09	6436	2819	9255	59704	19647	79351	47948	14529	62477	2252962	773733	3026695	0.80	0.74	0.79
08-09	175	175	56	63	119	Game	2172	757	2929	13379	4551	17930	12304	3875	16179	561307	209317	770624	0.92	0.85	0.90
08-09	175	175	56	63	119	Practice	4264	2062	6326	46325	15096	61421	35644	10654	46298	1691655	564416	2256071	0.77	0.71	0.75
09-10	175	175	38	56	94	09-10	6684	2324	9008	39632	15225	54857	31759	10829	42588	2104195	614559	2718754	0.80	0.71	0.78
09-10	175	175	38	56	94	Game	2742	634	3376	6861	3385	10246	5761	3039	8800	383646	116466	500112	0.84	0.90	0.86
09-10	175	175	38	56	94	Practice	3942	1690	5632	32771	11840	44611	25998	7790	33788	1720549	498093	2218642	0.79	0.66	0.76
10-11	28	28	89	38	127	10-11	3744	1535	5279	22438	8840	31278	17190	6713	23903	1004403	407866	1412269	0.77	0.76	0.76
10-11	28	28	89	38	127	Game	15	9	24	68	26	94	52	20	72	2378	1470	3848	0.76	0.77	0.77
10-11	28	28	89	38	127	Practice	3729	1526	5255	22370	8814	31184	17138	6693	23831	1002025	406396	1408421	0.77	0.76	0.76
11-12	175	175	80	89	169	11-12	13151	16801	29952	83182	90717	173899	65953	78089	144042	4277133	3766434	8043567	0.79	0.86	0.83
11-12	175	175	80	89	169	Game	5139	10180	15319	25726	54276	80002	22269	50833	73102	1265483	2291231	3556714	0.87	0.94	0.91
11-12	175	175	80	89	169	Practice	8012	6621	14633	57456	36441	93897	43684	27256	70940	3011650	1475203	4486853	0.76	0.75	0.76
08-12	175	175	263	246	509	Totals	30015	23479	53494	204956	134429	339385	162850	110160	273010	9638693	5562592	15201285	0.79	0.82	0.80
08-12	175	175	263	246	509	Game	10068	11580	21648	46034	62238	108272	40386	57767	98153	2212814	2618484	4831298	0.88	0.93	0.91
08-12	175	175	263	246	509	Practice	19947	11899	31846	158922	72191	231113	122464	52393	174857	7425879	2944108	10369987	0.77	0.73	0.76

Days	Type	Ratio Practice / Games			# Correct C/S/D			# Questions Q/S/D			# Sessions S/S/D			Time (sec) T (sec)/S/D			Time (min) T (min)/S/D			time (s) per question			Average time (m) per session		
		7	8	7 & 8	7	8	7 & 8	7	8	7 & 8	7	8	7 & 8	7	8	7 & 8	7	8	7 & 8	7	8	7 & 8	7	8	7 & 8
08-09	08-09	3.46	3.32	3.43	4.89	1.32	3.00	6.09	1.78	3.81	0.66	0.26	0.44	229.89	70.18	145.34	3.83	1.17	2.42	37.74	39.38	38.14	5.83	4.57	5.45
08-09	Game				1.26	0.35	0.78	1.37	0.41	0.86	0.22	0.07	0.14	57.28	18.99	37.00	0.95	0.32	0.62	41.95	45.99	42.98	4.31	4.61	4.39
08-09	Practice				3.64	0.97	2.22	4.73	1.37	2.95	0.44	0.19	0.30	172.62	51.19	108.33	2.88	0.85	1.81	36.52	37.39	36.73	6.61	4.56	5.94
09-10	09-10	4.78	3.50	4.35	4.78	1.11	2.59	5.96	1.55	3.33	1.01	0.24	0.55	316.42	62.71	165.27	5.27	1.05	2.75	53.09	40.37	49.56	5.25	4.41	5.03
09-10	Game				0.87	0.31	0.53	1.03	0.35	0.62	0.41	0.06	0.21	57.69	11.88	30.40	0.96	0.20	0.51	55.92	34.41	48.81	2.33	3.06	2.47
09-10	Practice				3.91	0.79	2.05	4.93	1.21	2.71	0.59	0.17	0.34	258.73	50.83	134.87	4.31	0.85	2.25	52.50	42.07	49.73	7.27	4.91	6.57
10-11	10-11	328.97	339.00	331.74	6.90	6.31	6.72	9.00	8.31	8.80	1.50	1.44	1.48	403.05	383.33	397.15	6.72	6.39	6.62	44.76	46.14	45.15	4.47	4.43	4.46
10-11	Game				0.02	0.02	0.02	0.03	0.02	0.03	0.01	0.01	0.01	0.95	1.38	1.08	0.02	0.02	0.02	34.97	56.54	40.94	2.64	2.72	2.67
10-11	Practice				6.88	6.29	6.70	8.98	8.28	8.77	1.50	1.43	1.48	402.10	381.95	396.07	6.70	6.37	6.60	44.79	46.11	45.16	4.48	4.44	4.47
11-12	11-12	2.23	0.67	1.17	4.71	5.01	4.87	5.94	5.82	5.88	0.94	1.08	1.01	305.51	241.83	271.97	5.09	4.03	4.53	51.42	41.52	46.25	5.42	3.74	4.48
11-12	Game				1.59	3.26	2.47	1.84	3.48	2.71	0.37	0.65	0.52	90.39	147.11	120.26	1.51	2.45	2.00	49.19	42.21	44.46	4.10	3.75	3.87
11-12	Practice				3.12	1.75	2.40	4.10	2.34	3.17	0.57	0.43	0.49	215.12	94.72	151.71	3.59	1.58	2.53	52.42	40.48	47.78	6.26	3.71	5.11
08-12	Totals	3.45	1.16	2.13	3.54	2.56	3.06	4.45	3.12	3.81	0.65	0.55	0.60	209.42	129.21	170.66	3.49	2.15	2.84	47.03	41.38	44.79	5.35	3.95	4.74
08-12	Game				0.88	1.34	1.10	1.00	1.45	1.22	0.22	0.27	0.24	48.08	60.82	54.24	0.80	1.01	0.90	48.07	42.07	44.62	3.66	3.77	3.72
08-12	Practice				2.66	1.22	1.96	3.45	1.68	2.59	0.43	0.28	0.36	161.34	68.39	116.42	2.69	1.14	1.94	46.73	40.78	44.87	6.20	4.12	5.43