

**AN ANALYSIS OF THE EFFECTS OF AN INTEGRATED LEARNING SYSTEM ON
STUDENT ACHIEVEMENT IN MATHEMATICS**

BY

©2011

Randolyn Rene Platko

Submitted to the Graduate Degree Program in Education Leadership and Policy Studies and the Graduate Faculty of the University of Kansas in partial fulfillment of the requirements for the degree of Doctor of Education.

Chairperson Dr. Argun Saatcioglu

Dr. Young-Jin Lee

Dr. Perry Perkins

Dr. Howard Ebmeier

Dr. Marc Mahlios

Date Defended: April 7, 2011

The Dissertation Committee for Randolyn Sereres Platko
certifies that this is the approved version of the following dissertation:

**AN ANALYSIS OF THE EFFECTS OF AN INTEGRATED LEARNING SYSTEM ON
STUDENT ACHIEVEMENT IN MATHEMATICS**

Chairperson: Argun Saatcioglu

Date approved:

Abstract

The purpose of this study was to contribute to the debate regarding the effects of integrated learning systems (ILS) with respect to mathematical remediation on student achievement. In addition, the results of the study were intended to provide information and analysis to school district leaders with respect to curricular, scheduling, and financial decisions. The study was guided by the following research question: Will the use of ALEKS®, an online mathematical ILS, significantly affect the achievement of at-risk eighth grade students by way of growth on the Kansas Mathematics Assessment?

The study was designed to measure the achievement of students in a treatment group (students who utilized the ALEKS® program) and compare that to the achievement of a control group (students who did not utilize the ALEKS® program). The participants in this study were 1,269 eighth grade students from the Shawnee Mission School District in northeastern Kansas. Using data from 2007, a multivariate linear regression was used to determine the effects of the ALEKS® program on student achievement while controlling for student characteristics and school and teacher fixed effects.

Results from this quantitative, quasi-experimental study showed that at-risk students that utilized the ALEKS® program experienced more growth on the KMA in one year's time compared to at-risk students who did not utilize the ALEKS® program. However, this was only true for a small portion of the ALEKS® users. By including a variable in the regression that accounted for the effects of the interaction between ALEKS® users and their prior score on the KMA, the results revealed the ALEKS® program only showed significant and positive effects for students who entered the ALEKS® program with a prior KMA score below 33.8%. The

results from this study coincided with current literature that expresses the effectiveness of utilizing ILS as a remediation strategy for at-risk students.

Keywords: Computer-based instruction, integrated learning systems, mathematics

Acknowledgements

I can almost pinpoint the day that I decided I wanted to go back to school and pursue a doctoral degree in education. That day just so happened to be roughly fifteen years after the seed was planted into my head by my step-father, Dr. Clay C. Blair III. Though it took those fifteen years to become a reality, without that initial seed and continued support, I would not be here today. Dr. Blair, thank you for believing in me and encouraging me all those years when I wanted nothing to do with a doctoral degree. In some ways, you knew me better than I knew myself.

Not a day goes by that I am not thankful for the encouragement, love, and support from my mother, Janet Blair. You have helped me get through each and every joyous occasion and stumbling block throughout this journey called life. Your strength, courage, and perspective are just what a daughter needs in any circumstance. Thank you for building the foundation that helped me arrive here today.

To my wonderful husband Niko, I thank you for being the person by my side every day to help me achieve this goal. You continually remind me about the importance of balance and you refuse to let me take myself too seriously. Thank you for being the daily support that I needed (and will always need) whether that be a hug and a kiss, a bigger desk, a joke, or someone to help me fix my excel spreadsheets. I hope you understand that you played a large part in this accomplishment.

Acknowledgement is given to my advisor Dr. Argun Saatcioglu for his guidance, persistence, and commitment throughout the dissertation process. I am lucky to have worked with someone so knowledgeable and helpful. I am thankful to have learned from him and the other professors at the University of Kansas in the Education, Leadership, and Policy Studies program.

Finally, my appreciation is extended to my relatives, colleagues, and friends. I am so very grateful for the support and conversations regarding this chapter of my life.

Table of Contents

| | Page |
|--|------|
| ABSTRACT..... | iii |
| ACKNOWLEDGMENTS..... | v |
| LIST OF TABLES..... | viii |
| Chapter | |
| I. INTRODUCTION..... | 1 |
| Overview..... | 1 |
| Introduction of Computer-based Instruction..... | 4 |
| Purpose of the Study..... | 5 |
| Research Question..... | 7 |
| Contributions to the Literature..... | 8 |
| Delimitations..... | 8 |
| Summary..... | 9 |
| II. REVIEW OF LITERATURE..... | 10 |
| History of Computer-based Instruction..... | 10 |
| Computer-based Instruction, Mathematics, and No Child Left Behind..... | 13 |
| Computer-based Instruction Evolves into Integrated Learning Systems..... | 15 |
| III. METHODOLOGY..... | 20 |
| Description of Participants..... | 20 |
| Procedures..... | 20 |
| Materials..... | 24 |

| | |
|---|----|
| Data..... | 25 |
| Identification of the Variables..... | 25 |
| Data Analysis Procedures..... | 28 |
| Summary..... | 28 |
| IV. RESULTS..... | 30 |
| Summary..... | 33 |
| V. CONCLUSION, DISCUSSION, AND RECOMMENDATIONS..... | 34 |
| General Results..... | 34 |
| Limitations..... | 35 |
| Contributions to the Literature..... | 37 |
| Contributions to Practice..... | 38 |
| Implications for Policy..... | 38 |
| Future Research..... | 39 |
| Summary..... | 40 |
| REFERENCES..... | 41 |

List of Tables

| TABLE | Page |
|---|------|
| 1. Demographics for 8 th grade students in the Shawnee Mission School District 2006-2007.... | 46 |
| 2. Basic Descriptive Statistics for Participants in the Study..... | 47 |
| 3. Results of Hierarchical Linear Regression Models Predicting the Effects of the ALEKS® Program on Student Growth on the KMA..... | 48 |

Chapter 1

Introduction

Overview

Technology has been a feature of educational practice and learning since the early 1900s and has continued to influence education well into the 21st century. In 1912, Edward Thorndike suggested that pictures be utilized with instruction for the purpose of establishing efficiency in teaching and learning. Thus began the earliest studies of the influence of media on education. The first educational television broadcast occurred in Iowa in 1933 triggering a new debate on how television media may or may not enhance teaching, learning, and education (Reeves, 1998). Throughout the 1960s and 1970s, technological tools such as video-recording devices, laser discs, and microcomputers were the trend in classrooms across the country (Hasselbring, 1986). Seymour Papert (1980) hypothesized that the computer would revolutionize education by providing students new ways to learn, think, and grow intellectually. He advocated that computers would modernize education and the classroom by empowering students to control their own learning.

Numerous studies have demonstrated positive effects of media and technology on learning, and in some cases, general conclusions have been made about the affirmative influence of technology on education. For instance, in a historical review of technology studies, Reeves notes forty years of research demonstrating positive effects on learning from television programs when the programs are specifically produced and used for instructional purposes (1998). Similarly, as early as 1970, it was widely accepted that the computer was a valuable tool in the presentation of drill and practice, particularly in the interest of mathematics and vocabulary development (Alpert & Bitzer, 1970). More recently, in a review of research, Bialo and Sivin-

Kachala conclude that educational technology has demonstrated significant positive effects on student achievement, students' self-concepts, students' attitudes towards learning, and the interactions involving students and teachers in the learning environment (1996). While there is a vast and historic community of support for technology in the classroom, other researchers and authors remain skeptical about the influence of media and technology on education.

Some researchers have noted the possibility that utilizing technology for educational purposes may not enhance learning (Clark, 1983; Joy & Garcia, 2000, Oppenheimer, 1997). Specifically, in 1983, Richard E. Clark profoundly interpreted the debate on the effects of media on student achievement by stating, "Five decades of research suggest that there are no learning benefits to be gained from employing different media in instruction, regardless of their obviously attractive features or advertised superiority." Clark suggested that the reviews and meta-analyses demonstrating positive effects on student achievement are confounded for a variety of reasons. First, the confounding may be related to the uncontrolled effects of instructional method or content differences between treatments that are compared. In addition, confounding may be a result of the uncontrolled effects regarding the novelty implications for newer media, which may disappear over time. Clark stood firmly behind the idea that it is not the medium that causes heightened performance, rather the curricular reform that accompanied the change; and the positive effect for incorporating media essentially disappears when the same instructor delivers all of the treatments or lessons. He boldly stated, "The best current evidence is that media 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). While Clark specifically referred to the effects of media comparison studies, he continued on to say computer learning studies are beginning to emerge and that they too belong to the "fruitless media comparison

approach.” He then called for the cessation of media comparison research unless a novel theory is suggested.

Clark made an intense statement to the research community. While he might have made some legitimate points regarding media comparison studies in the 1960s and 1970s, he was not prepared for the technological advancements that were about to occur. In the 1980s computers became faster, smaller, and more widely accessible. According to the United States Office of Technology Assessment, the percentage of schools with one or more computers grew from 18 percent in 1981 to 95 percent in 1987 (U.S. Congress, 1988). It was estimated that as of December of 1994, nearly 6.2 million computers had been installed in the nation’s more than 109,000 public and private K-12 schools (Public Opinion Strategies, 1995). Throughout the 1980s and early 1990s, computers began to establish a profound presence in classrooms across the nation.

Along with the substantial increase of technology and computers in schools came the calling for more research regarding its effectiveness on students and student achievement. In 1991, Robert B. Kozma reignited the question, “Does media influence learning?” He wrote an article in response to Clark’s request for a novel theory regarding the relationship between media and learning. Kozma changed the theoretical framework of the question by addressing the image of a learner actively *collaborating* with a medium to construct knowledge. In this way, more research is necessary to extend the understanding between technology and learning. Kozma stated, “Our ability to take advantage of the power of emerging technologies will depend on the creativity of designers, their ability to exploit the capabilities of the media, and our understanding of the relationship between these capabilities and learning,” (1991).

Introduction of Computer-based Instruction

With so many ways to regard the effectiveness of utilizing technology in the educational setting, the research has been broken down into various categories. Reeves discusses the difference between learning “with” technology and learning “from” technology (1998). Learning “with” technology is exhibited by students using computer-based cognitive tools that have been developed to facilitate critical thinking and higher order learning. Examples of these cognitive tools are databases, spreadsheets, communications software, and computer programming languages. Learning “from” technology consists of utilizing televisions and computers to expose students to messages, assume that students perceive the messages, require a response to the messages, and provide feedback on the accuracy of the response. This type of learning is called computer-based instruction (CBI) or computer-assisted instruction (CAI), a feature of technology in learning since the early 1960s. Recent technological development has elicited newer forms of CBI called Integrated Learns Systems (ILS). (For the purposes of this paper, CBI, CAI, and ILS will be used interchangeably.) These types of learning systems have been studied over time and continue to improve in their infrastructure and design.

Schools are now utilizing this modern form of CBI to assist students in various curricular areas such as mathematics, reading, and writing. Results of research studies regarding these types of learning systems are varied across age groups and curricular areas. This study is designed to feature the effectiveness of a particular ILS called ALEKS® (ALEKS® Corporation, Tustin, CA, www.aleks.com).

Purpose of this Study

The purpose of this study was to determine the impact of ALEKS® ILS on improving students' achievement on the Kansas Mathematic Assessment for eighth grade students in one northeastern Kansas school district.

Importance of this Study

America's current status regarding technology in education demonstrates that there is a strong sense of support and need for the partnership. In 1984, the ratio of students to computers in schools was 125 to 1 (U.S. Department of Education, 1998). This ratio has changed substantially in the last 25 years. According to the National Center for Education Statistics, in 2009, the ratio of students to computers in America's public schools was 5.3 to 1 and internet access was available to over 90% of the computers in classrooms. Today, it is not uncommon for an entire building of students to receive laptops or handheld computing devices to be used as personal resources. While technology and computers have established a profound presence in classrooms across America, their existence has come at an extreme cost.

Throughout the 1980s and 1990s, significant levels of funding and public resources were devoted to the development of classroom technologies (Reeves, 1998). Between the years of 1997 and 2000, the federal government enacted the Technology Literacy Challenge Fund that provided financial support for new computers, software, and professional development for teacher training at the cost of 1.25 billion dollars (Johnson, 2000). In addition, the President's Committee of Advisors on Science and Technology suggested that the federal government spend 6 to 28 billion dollars annually to increase computer infrastructure, training for teachers, and research regarding the effects of technology on student achievement (Panel on Education Technology, 1997).

A vast amount of money continues to be spent on the utilization of technology in education, particularly regarding the implementation of CBI and ILSs. In the early 1990s, it was estimated that nearly a quarter of all US schools were using ILSs and one-half of the money schools spent on software went to ILS companies (Bailey, 1992). ILSs have become especially popular with educators who are responsible for making financial decisions regarding curriculum. According to Bailey (1993) and Becker (1992), there are a variety of perceived advantages to utilizing ILSs. First, there is a centralized management system that can carry a student's records through a variety of grade levels. Second, ILSs provide a diagnostic and prescriptive analysis of each student, establish individualized lessons, and monitor the student's progress. Next, most of the systems utilize a central server which helps alleviate logistical problems. Finally, ILSs are created to use standardized assessment approaches and therefore are purposeful in an era of high accountability and testing.

It seems as though ILSs have the capability to effectively and efficiently reach a wide range of students. Since the onset of No Child Left Behind in 2001, school district leaders and building administrators have been implementing a variety of remediation strategies related to CBI to ensure all students score at proficient levels or above on standardized assessments, particularly in the areas of mathematics and reading. While they play a large role in the technology market, are they educationally meaningful?

Large commercial vendors such as ALEKS® (ALEKS® Corporation, Tustin, CA, www.aleks.com), CompassLearning (www.compasslearning.com) and SuccessMaker (<http://support.pearsonschool.com/index.cfm/successmaker-family-of-products/successmaker/>) are marketing versions of ILSs and receiving financial results. For instance, CompassLearning claims to have served more than 11 million students while ALEKS® contends to have been used

by millions of students across the world. Regarding its effectiveness, “The Average Historic Learning Rates with ALEKS are ~90%,” (www.aleks.com). There is a heavily advertised sense of effectiveness, though it has been found that the positive effects are often more modest than what the vendors suggest. Some newer versions of ILS have not been subjected to rigorous research and evaluation studies; there are testimonials and anecdotal evidence yet also a lack of large-scale rigorous research (Reeves, 1998).

It is inevitable that technology and computers will remain a major component of American schooling. While large investments regarding money and time have been made to ensure the success of the implementation of technology, it is undetermined which ones seem to be the most effective regarding academic achievement and financial responsibility. Though vast amounts of research studies have emerged over the last century regarding media, technology, and computers and their influence upon education, there continues to be an even greater demand to analyze the effects of technology on education and student achievement (National Mathematics Advisory Panel, 2008).

Research Question

Does ALEKS® ILS significantly enhance the mathematical achievement of at-risk eighth grade students compared to traditional face-to-face remediation?

Contributions to the Literature

This study contributes to the literature in a variety of ways. First, this study adds to the knowledge regarding the value of computer-based instruction on a general level and with respect to the ALEKS®, a specific form of ILS. There are a variety of studies that have explored the implications of computer-based instruction and the utilization of ILSs at a breadth of grade levels (Kulik & Kulik, 1991; Becker, 1992). However, there are only a limited amount of studies that have focused specifically on the results of the usage of ALEKS® program (Carter, 2004; Love, 2004).

In addition, this study adds a level of understanding to the implementation of remediation through ILS by exploring the academic characteristics of students for which the ALEKS® program might work best.

Delimitations

This study is limited for a variety of circumstantial reasons. However, the limitations are within the reasonable confines of any single research study and are not so widespread so as to interfere with the potential contribution that can be made to the current body of research regarding this topic.

First, the study only analyzes the effects of the ALEKS® program in one school district at one grade level. However, the sample for this study includes 1,269 participants which is a large sample size with respect to many of the research studies reviewed. Statistical rules suggest that a large sample size leads to increased accuracy in research studies. Second, based upon the implementation of the ALEKS® program within the school district, the treatment and control groups in the study may have experienced slightly different curricular instruction. In an effort to eliminate issues regarding this component of the study, the analysis was designed to control for

school and teacher fixed effects. Third, this study did not measure students' or teachers' level of comfort with technology which may or may not have impacted the results of the study. Finally, the level implementation of the ALEKS® program could have varied from teacher to teacher. Some teachers may have utilized the program to its full potential while others may have showed little interest in integrating the program into their daily instructional practices. The current study does not provide a way to determine the level of implementation conducted by the teachers.

Summary

Significant amounts of money have been spent over the last 30 years to ensure that American classrooms are rich with technology and computers. A variety of research studies have demonstrated that computer-based instruction programs and integrated learning systems have contributed to student achievement in a variety of curricular areas (Hannafin & Foshay, 2006; Kulik & Kulik, 1991; Kulik, 2003; Mintz, 2000). In this way, educators continue to incorporate CBI into classrooms particularly to assist with remediation in an era of educational accountability and high-stakes testing. The ALEKS® ILS software is one form of CBI and is largely advertised with a sense of effectiveness, yet there is limited empirical research regarding this specific type of ILS.

This study was conducted to determine the effectiveness of the ALEKS® program on the student achievement of at-risk eighth grade students in one school district in northeastern Kansas. The results of this study indicate that the ALEKS® program was significantly more effective than face-to-face remediation for a particular group of at-risk students.

Chapter 2

Review of Literature

The following review of scholarly literature related to the use of computer-based instruction in public education presents arguments that either support or refute the idea that CBI benefits the educational environment and attributes to success regarding student achievement. While an overview of research based upon CBI is beneficial for this dissertation, studies of particular interest are those guided towards understanding the relationships between CBI, at-risk learners, and high-stakes testing environments. A brief history of CBI precedes the closer look of the current literature associated with CBI.

History of Computer-based Instruction

In the 1960s and 1970s, there was a demand for more individualized instruction and instruction to the masses (Alpert & Bitzer, 1970). Computer-based instruction technologies developed in the early 1960s as a response to that demand, and have been utilized since for four main reasons: drill and practice, tutorials, games, and simulation and modeling. At the onset of CBI, there was support and concerns about its use in the classroom. On one hand, some viewed CBI as a powerful new medium that had the capability to instruct in various modes; it would help students become efficient and independent in a variety of educational realms. At the same time, others viewed CBI to be merely drill and practice, and in essence, a programmed textbook (Alpert & Bitzer, 1970). Another concern at the time was that CBI was not cost effective, as computers were not easily accessible. Studies emerged and opinions regarding CBI were formed. All the meanwhile technology continued to advance and become more available to the majority of schools and students. With the influx of technology in the 1980s, the role of CBI in

the classroom continued to grow. Numerous studies and meta-analyses emerged in hopes of determining its effectiveness in the classroom.

Computer-based instruction has made powerful and positive impacts on education, specifically regarding student achievement. In recent technology studies, results are often reported through an effect size. Effect sizes are popular because they can express results from different studies on a single, uniform scale of effectiveness. An effect size specifies the number of standard deviation units separating the outcome scores of treatment and control groups in a particular study. Kulik & Kulik (1991) produced a meta-analysis of findings from 254 controlled evaluation studies of the effects of computer-based instruction to determine that CBI usually produces positive effects on student achievement. The median of the effect sizes reported was an average of .42, however, the average changed based upon the level of schooling where CBI was incorporated. The mean effect sizes by level were as follows: college .26, secondary .32, elementary .46 and special education .56. In addition, in an average study, CBI increased student final exam scores by .30 standard deviations, which is considered a moderate but not significant effect. Similarly, in 1986, Hasselbring published a review of the research on the effectiveness of CBI. At that time, evaluative studies had positive effects. Specific programs such as PLATO had positive effects for Mathematics only while TICCIT has significant positive effects for Mathematics and English. Overall, studies have established that CBI has positive effects on student achievement.

Not only has computer-based instruction shown to have a positive effect on student achievement, CBI has been known to increase learning by improving student attitudes and self-concepts. A meta-analytic report was conducted by an independent consulting firm (Interactive Educational Systems Design, Inc.) sponsored by the Software Publishers Association (Bialo &

Sivin-Kachala, 1995). According to the report which analyzed 176 studies, students' attitudes towards learning and their self-concepts increased consistently when working in a technology-rich environment. In agreement with these findings, the meta-analysis conducted by Kulik & Kulik (1991) found that 16 of 22 studies reported more favorable attitudes regarding the quality of instruction for students participating in a CBI class; the average effect size in this case .28. When working with the Geometry Tutor (one of Carnegie Mellon's *cognitive tutors*), Schofield and Evan-Rhodes reported significant improvements in motivation of students and time on task (1989). According to Kinzie, Sullivan, and Berdel (1992), ninth grade students who were given CBI on a science topic revealed a strong preference for instruction on the computer in addition to an increased interest in studying science if conducted on the computer. The students who did not receive CBI did not show a greater desire to study science. Studies such as these demonstrate that the use of technology and CBI creates a positive effect on students' perceptions of learning.

While CBI has demonstrated a variety of success stories, there are still those in opposition to CBI. Clark suggests it is not the media that enhances student achievement and positive attitudes, rather the notion there has been a curricular reform (1983, 1994). He argues that students exhibit increased attention and effort due to the fact the method of instruction was novel (1983). A few studies have supported his ideas. In an eight-week study conducted by Kulik, Bangert, and Williams (1983) it was discovered the effect size of the usage of a new medium would decrease in two week intervals, from .56 to .3, and down to .2 after 8 weeks of data collection. Along with this finding, the average effect size for a CBI program lasting four weeks or less was significantly larger than CBI programs that lasted longer, suggesting that the novelty of the computer wears off and students naturally lose interest in the new nature of instruction (Kulik & Kulik, 1991).

Authors also suggest the increase in student achievement regarding CBI could be related to uncontrolled variables. For example, Hannafin and Foshay (2006) found students who participated in CBI had significantly higher test scores than students who did not participate in the CBI course. However, they also note that the success of the overall remediation in their study could be attributed to better alignment of the curriculum, staff development regarding strategies for underperforming students, or an easier test. “The combination of CBI 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,” (2006). Kulik and Kulik (1991) agree that effects of CBI lessen when control for an instructor is included. When different instructors teach the experimental and control groups, effect sizes are larger compared to when the same instructors teach both groups, thus indicating an instructor effect. Though studies with positive results for the use of CBI on student achievement are abundant, the results often cannot solely be attributed to CBI.

Computer-based Instruction, Mathematics, and No Child Left Behind

Among the ongoing debate of the effects of CBI, the United States has entered an accountability era in regards to education. With the development of No Child Left Behind comes high stakes testing and the pressure for schools to perform at a level at which all students are at proficient or above on standardized assessments. Since the onset of computer-based instruction and the accountability era of education, software companies have created computer-based instruction programs to provide students a new, enhanced technological education. Thus, the research revolving around CBI has once again changed. Many researchers are focusing on the specific curricular area of mathematics.

Current evidence shows CBI produces positive effects, particularly when used in a mathematical setting. The United States Department of Education sponsored a two-year quantitative study to determine the effectiveness of ten different reading and mathematics software programs on students' test scores. The study found nine of the ten products had statistically insignificant effects on their scores. However, the one study that did produce significant, positive effects was a result of a mathematical software product (Campuzano, Dynarski, Agodini, & Rall, 2009). Biesinger and Crippen (2008) conducted a study showing that students who used a web-based supplemental instructional tool designed to assist with a mathematical high-stakes test significantly outperformed students who did not use the program. Hannafin and Foshay (2006) conducted a study that used CBI as a remediation strategy with at-risk 10th grade students in mathematics. Overall, the scores from all 10th graders compared to their 8th grade year increased significantly when exposed to CBI compared to the students who did not receive CBI. This report denotes that CBI might play an important role in the mathematical, high stakes test environment (Hannafin and Foshay, 2006).

Baum (2001) conducted a study of 85 students at Madison Park High School. The purpose of the study was to analyze the effects of the students' participation in PLATO (CBI software) by way of student performance on the BPS City Algebra Test. Baum concluded that the number of PLATO modules conducted by a student has a positive and statistically significant effect on the change in test scores. Hannafin (2002) studied the effects of the PLATO technology on under-performing high school students in Mashpee, MA. PLATO was used exclusively to help students improve math scores on the Massachusetts Comprehensive Assessment System exam, a state-mandated competency exam. Findings from this study show that math scores improved significantly for the 87 at-risk students in the math remediation

program. The at-risk students had a gain score of 20.4 points, which was significantly higher than the gain score of 11.2 points for those students that did not participate in the PLATO remediation program. Overall, Hannafin found a significant positive relationship between the number of PLATO modules mastered and the MCAS math scores.

Computer-based Instruction Evolves into Integrated Learning Systems

CBI has recently been taken to newer levels called Integrated Learning Systems (ILS). According to Reeves (1998), these software systems utilize computer networks to combine comprehensive educational “courseware” with centralized management tools. Large commercial vendors such as Computer Curriculum Corporation (CCC) and Compass Learning (formerly known as Jostens Learning System) are marketing these new systems at high speeds and schools are purchasing the software in large quantities. In the early 1990s, it was estimated that nearly a quarter of all US schools were using ILSs and one-half of the money schools spent on software went to ILS companies (Bailey, 1992). ILSs have become especially popular with educators who are responsible for making financial decisions regarding curriculum.

Kulik (2003) wrote a report focusing on instructional technology and research since 1990 and therefore the effects of newer ILSs. He suggests that the studies revolving around technology in the 1970s and 1980s have been heavily reviewed and general conclusions have been made. However, since then, technological advancements have occurred. Former versions of ILS programs presented information in text screens of black and white where students predominantly experienced drill-and-practice lessons. The ILSs found in schools today now use color graphics, sounds, sophisticated visual simulations, and enhanced methods for students to provide or select answers to questions. The technological changes and advancements elicit reasons to review the technological literature of the 1990s to present.

The *cognitive tutor*, an ILS designed and developed at Carnegie Mellon University, is one program that has been subject to extensive amounts of research. Over the last 30 years, researchers at Carnegie Mellon University have been working to create cognitive models of mathematics and programming via computer tutoring systems called *cognitive tutors*. *Cognitive Tutors* differ from traditional computer-based instruction programs and their behaviorist approach. *Cognitive Tutors* set appropriate curriculum objectives and properly interpret the actions of the students, therefore providing helpful assistance to the student. The theory is "...If students never get any information about errors in their solution, they are not going to learn to avoid them," (Anderson, Corbett, Koedinger, & Pelletier, 1995). Originally, these systems did not play a large role in classrooms outside of Carnegie Mellon University. At CMU, the tutors were used in a self-paced, learn on-your-own environment. However, over the years, the programs have adapted to address the needs of K-12 public education. Many of the results regarding student achievement have been positive. Results from *cognitive tutor* studies suggest cognitive tutors have arguably closed the gap with and surpassed human tutors (Corbett, 2001). Early evaluations of the Programming and Geometry Tutors showed effect sizes of nearly 1 standard deviation (Anderson, Corbett, Koedinger, & Pelletier, 1995). In a more recent summary of research results, students taking Cognitive Tutor Algebra I have been shown to perform 14% better on average on standardized assessments of basic mathematical skills. In addition, students enrolled in Cognitive Tutor Algebra I have been shown to be 69% more likely to pass traditional Geometry and 71% more likely to pass traditional Algebra II (Koedinger, Corbett, Ritter & Shapiro, 2000). It should be noted that Cognitive Tutor programs are typically used in place of traditional instruction, where some CBI and ILS are utilized along-side traditional teaching methods.

Kulik reviewed 16 controlled studies conducted between 1993 and 2003 that focused on ILS in mathematics and reading (2003). In each of the 16 studies, test scores in mathematics were at least slightly higher in the group that utilized the ILS. Seven of the studies used ILS in a mathematical setting alone. Of those seven studies conducted by McCart (1996), Clariana (1996), Fletcher, Hawley, and Piele (1990), Laub (1995), Spencer (1999), Stevens (1991) and Howell (1996), the range of effect sizes was between 0.14 and 1.05. The strongest effect size was demonstrated in McCart's 1996 study reviewing the ILS by WICAT Systems. McCart focused on an ILS that was used as supplemental instruction for at-risk eighth graders in New Jersey. McCart's groups of students were from the same school district but different schools. He determined equivalency between his experimental group ($n = 24$) and his control group ($n = 28$) using the New Jersey Early Warning Test, which also served as the post-test. McCart found that the experimental group clearly outperformed the students in the control group. The effect size was 1.05.

Clariana's study (1996) examined effects of an ILS from Jostens Learning Corporation in a rural western school district. Using three consecutive school years, the control group ($n = 579$ students) consisted of students from the first two years of the study that were taught mathematics traditionally. The experimental group ($n = 294$) were students from the third year of the study who received traditional math instruction supplemented by ILS in mathematics. Group equivalency was established by scores on the Stanford Achievement Test and the math scores also served as the post-test. Clariana reported growth for the students who received ILS with an overall effect size of .40.

Another study, conducted by Fletcher, Hawley, and Piele (1990) was a quasi-experiment conducted in one school in Canada. Third and fifth graders from one classroom served as the

experimental group ($n = 39$) and received ILS from the Milliken Math Sequences as part of their math instruction. The control group was 40 students who did not receive ILS as part of their math instruction. The Canadian Test of Basic Skills served as the pre- and post-test for the study. Students in the ILS group performed higher on the posttests in both grade levels. An effects size of .40 was reported.

In Laub's study (1995), 314 fourth and fifth grade students in a Pennsylvania school district were given ILS as a supplement to traditional mathematics instruction. The students' gains on the Stanford Achievement Test were compared to the gains for 679 fourth and fifth graders in the same school in previous years who had not received ILS instruction. The gains from the pre-test to the post-test were larger for the experimental group with an effect size of .56.

In a longitudinal study conducted by Spencer (1999), a school district in southeastern Michigan used stratified random sampling to select second and third grade students to participate in a magnet school program. Students in the program received a Jostens ILS as a supplement to traditional math instruction for 5 years. Students who did not participate in the magnet school program did not receive supplemental ILS instruction. The scores of 46 students in the experimental group were higher than the scores of 46 students who did not receive the ILS treatment. The reported effect size was .38.

In Steven's study (1991), an analysis of the effects of an ILS from Jostens Learning Corporation were reported. The study compared the mathematical achievement of 90 third, fourth, and fifth graders from one school in a Texas school district to 90 comparable third, fourth, and fifth grade students in another school in the same district. In this quasi-experiment, the Metropolitan Achievement Test was the pre-test and post-test for the study. By utilizing an

analysis of covariance, Steven reported that the experimental students performed at higher levels on the mathematics posttest than the students in the control group (effect size = .54).

The last of the seven studies reported by Kulik showed a very minimal difference between the group receiving the ILS and the control group. In Howell's 1996 study, an ILS from Jostens Learning Corporation was used with 66 at-risk seventh and eighth grade students in a Georgia public middle school. The gains on the scores from the Iowa Test of Basic Skills were used to compare the students in the experimental group to 65 students in the control group that did not receive ILS instruction. The groups were selected from students eligible for Chapter One support and therefore had equivalency. The gains in the mathematics scores were higher for the experimental group (effect size estimated as .14); however, the difference was not large enough to be considered educationally meaningful. The overall median effect size for the seven studies in Kulik's review was .40. While this displays general evidence that ILSs are effective in mathematical settings, Kulik contends that it is still not clear how much computer-based programs can contribute to the improvement of instruction in American schools.

Chapter 3

Methodology

For this study a quasi-experiment, both longitudinal and cross-sectional in design, was developed to determine the effectiveness of the ALEKS[®] intelligent learning system (ALEKS[®] Corporation, Tustin, CA, www.aleks.com) on student achievement of at-risk middle school students. Based upon similar research studies in this area it was expected that this study would show that at-risk students who utilize computer-assisted software would exhibit greater academic growth compared to at-risk students who do not utilize computer-assisted software (Biesinger & Crippen, 2008; Hannafin & Foshay, 2006; McCart, 1996). The level of statistical significance set prior to data collection was $p < .05$.

Description of Participants

The participants for this study were 1,269 at-risk 8th grade students selected as a convenience sample from the Shawnee Mission School District (SMSD) in Shawnee Mission, Kansas. The Shawnee Mission School District is located in northeastern Kansas and is currently comprised of 27,149 students. In the district, there are five high schools, seven middle schools, and 35 elementary schools (see Table 1 for the demographics of all 8th grade students in the Shawnee Mission School District in 2006-2007).

Procedures

Selection of the participants. The predominant factor in determining the participants for this study was the implementation of the ALEKS[®] program within the school district. The ALEKS[®] program was first utilized in the Shawnee Mission School District (SMSD) in 2006 and since then has been utilized in various capacities. In 2007 the ALEKS[®] program became a standard part of certain middle school classes to assist at-risk students with remediation in

mathematics. Students enrolled in a double-block math class (Math 8 or Math 8 Plus) were automatically given an ALEKS® license. A double block math class consisted of traditional mathematical instruction for the first 45 minutes then computer-assisted instruction via ALEKS® for the second 45 minutes. Six of the seven middle schools had double-block math classes and therefore ALEKS® licenses for each student enrolled in those courses. The comparable math course at the seventh middle school utilized traditional mathematical instruction for 45 minutes in addition to a math focused study hall where ALEKS® was utilized. The difference between this comparable course and a double-block math class would potentially be the timing of the math focused study hall. The math focused study hall could occur at anytime of the day where in the double-block class, the implementation of the ALEKS® program occurred directly after the traditional math instruction. The district purchased a total of 423 ALEKS® licenses for 8th grade students in the 2006-2007 school year.

The term at-risk was first brought into educational conversation in 1983 with the publication of *A Nation At Risk: The Imperative for Educational Reform*. The report established a sense that American schools are failing and was a predictor to multiple local, state and federal educational reforms. Since 1983, the term at-risk can be defined in a variety of ways, depending on the context. In Kansas the term encompasses many definitions including but not limited to a student who is not meeting the requirements necessary for the promotion to the next grade level or graduation from high school or a student whose education attainment is below other students of their age or grade level. Since the onset of No Child Left Behind in 2001, a common description of at-risk students has become those students in jeopardy of failing standardized assessments. The SMSD utilizes these prior definitions as criteria for determining at-risk students and has established programs in various realms to help these students succeed. The

ALEKS® software is one program the district has utilized to assist at-risk students with mathematical remediation.

A student's opportunity to utilize the ALEKS® program in the year 2007 was largely dependent on student enrollment in particular courses. While the district attempts to enroll students based upon consistent guidelines, there are a variety of factors that could influence a student's placement in a particular course. First, enrollment could be enacted based upon teacher, counselor, or principal recommendation. Second, enrollment decisions might occur due to availability and size of classes. Third, the district incorporates data-based decision-making into their enrollment process by utilizing the MAP (Measure of Academic Progress) test to guide enrollment decisions. Students take the MAP test in all grade levels typically during the fall, winter, and spring of each year.

The MAP test, provided by the NWEA (Northwest Evaluation Association, www.nwea.org) is capable of measuring a student's achievement and academic growth independent of grade level and across time. The NWEA established status norms to allow educators to compare the scores of their students with a wide variety of students across the country. The status norms were established when NWEA assessed over 2.8 million students in 42 states and identified scales of norms for a variety of curricular areas (mathematics, reading, and science.) Educators utilize a student's MAP score to determine instructional levels or to identify the skills that the student may find academically challenging.

In 2006, the NWEA identified that the median MAP score for a student entering the eighth-grade was 230 and the appropriate curricular class would be equivalent to an introductory Algebra course. In this way, students in the SMSD that scored below 230 on the MAP test in the spring of their 7th grade year were typically placed in a Math 8 or Math 8 Plus double-block class

and therefore received an ALEKS® license. (Students scoring above 230 would likely be enrolled in a standard Algebra 1 course). It is possible that a student might have transferred into the district and therefore may not have a MAP score. Various considerations were utilized regarding how to enroll students without MAP scores.

The control group for the experiment was at-risk eighth-grade students who did not utilize the ALEKS® program (n = 931) and the treatment group for the experiment was at-risk eighth-grade students who did use the ALEKS® program (n = 338). In order to establish commonalities between the two groups, only students who scored below 230 on the MAP in the spring of the prior year were incorporated into the study.

Many of the students in the data set had missing MAP scores from one or more of the following assessments: the spring of 2006, the fall of 2007, or the spring of 2007. These missing scores signify a loss of sample size within the data. This data limitation led to the decision to use students' scores on the Kansas Mathematics Assessment to determine academic growth, as the majority of students had test scores for the KMA for each year. In 2006, the district acknowledged a MAP score of 230 (for students entering the 8th grade) as a cut-off to determine which students should have mathematical remediation and therefore should be enrolled in a remedial mathematics course. This score of 230 on the MAP test corresponded to a score of 80 on the KMA¹. Therefore, in this study, a score below 80 on the KMA was used to identify students in need of mathematical remediation.

¹ Equivalence of cut-off scores for the KMA and MAP was determined based upon the correspondence of the distributions of the scores on each scale.

Materials

Kansas Mathematics Assessment. The Kansas Mathematics Assessment (KMA) is a state mandated test that is administered every year across the state of Kansas at grade levels 3 through 8 and 10. Scores on this assessment are utilized for No Child Left Behind and Adequate Yearly Progress (AYP) reports. A student's score on the KMA is based upon a percentage of questions correct so the score range is 0 to 100. In the eighth grade there are 86 questions, each of which are multiple choice.

The ALEKS® program. ALEKS®, which stands for **A**ssessment and **L**earning in **K**nowledge **S**paces, is an online ILS and CBI. The program consists of complex educational software that has the capability to precisely and efficiently assess the knowledge of an individual in a variety of disciplines and produce a comprehensive list of topics an individual is ready to learn. When a student first logs into ALEKS®, he or she will receive a brief tutorial regarding the usage of ALEKS® tools. The student then begins an assessment comprised of 20-30 free-response questions. The assessment adapts to the student's responses and individualizes the experience for each student, depending on his or her knowledge level. After the initial assessment, the student enters learning mode where he or she is offered a choice of topics that ALEKS® has determined he or she is ready to learn. The student chooses from the list of tutorials and begins to learn and practice. As the student progresses through the ALEKS® program, he or she is periodically reassessed to determine how much learning has taken place. The list of topics available to the student changes based upon these assessments and mastery of the assessments.

Data

The data collected for this study included individual level data on 8th grade students from the Shawnee Mission School District database from the year 2007. For each student the following information was generated: student identification, gender, age, grade, race, ethnicity, ALEKS® status, socio-economic status, special education status, three MAP scores including the spring score from the prior year and the fall and spring scores from the current year, pre- and post- Kansas State Mathematics Assessment scores, teacher identification, and school identification. In order to preserve the personal identification and security of the schools, students, and teachers, an individual identification coding system was used throughout the data set. Specifically, the data set for this study contains 1,269 eighth grade students representing each of the seven middle schools during the year 2007 (see Table 2 for the basic descriptives for the participants in the study).

Identification of the Variables

Outcome: Student normed growth on the Kansas Mathematics Assessment (KMA).

The outcome variable for this study was a student's normed growth on the Kansas Math Assessment (KMA) in one year's time. The normed growth was calculated by taking each student's score on the KMA from the prior year, subtracting that from the student's score on the KMA from the current year (post), and dividing that number by the value found when subtracting the student's prior score from 100. Normed growth = $(\text{post KMA score} - \text{prior KMA score}) / (100 - \text{prior KMA score})$.

Central Predictors: Use of the ALEKS® software, Prior Kansas Score, and their Interaction (ALEKS*Prior Kansas Score).

ALEKS®. Using the integrated learning system ALEKS® was the central predictor in the study. ALEKS® was chosen as the independent central predictor for three reasons: One, the school district issued a total of 2,135 ALEKS® licenses in the year 2007 costing the district \$53,375.00, two, there is limited research regarding the effectiveness of utilizing the ALEKS® program with respect to mathematical remediation, and three, program evaluation is a valuable tool for school districts leaders making curricular and financial decisions. The use of the ALEKS® program was dummy coded with a 1 for ALEKS® users and a 0 for non-ALEKS® users.

Prior Kansas Score. Another central predictor in the study was the student's score on the Kansas Math Assessment from the prior year. Since the outcome being tested is student growth, it was important to acknowledge the fact that different students have varying prior scores which might play a role in the amount of possible growth. In this way, it was necessary to adjust the estimate for the prior Kansas score to level the playing field of differences in initial student performance. The student's prior score on the KMA was coded numerically.

*Interaction: ALEKS®*Prior Kansas Score.* The last central predictor of the study was the effect of the interaction between an ALEKS® user and his or her prior Kansas score. This predictor was used to determine if the ALEKS® program had different effects for students with lower prior scores (on the KMA) compared to students with higher prior scores (on the KMA). In this way, predictions could be made regarding which types of students benefit or do not benefit from the ALEKS® program.

There are a variety of other factors (aside from the ALEKS® program) that could potentially contribute to academic growth on the KMA. The following factors related to student characteristics were used as control variables in the study: gender, lunch status, special education status, race, teacher identification and school identification.

Control Measures

Lunch status. In educational studies, the free-and-reduced lunch status of a student is often associated with his or her poverty level. According to the United States Department of Agriculture with respect to the National School Lunch Program, a student qualifies for free-and-reduced lunch if he or she comes from a family with an income at or below 30 percent of the poverty level. In this study, the student's free and reduced lunch status was included as a control variable dummy coded (free and reduced lunch = 1) to determine if a student's socio-economic status has an effect on the student's growth on the state assessment.

Special education status. A student's special education status may have an effect on his or her growth on the state assessment. For this study, three categories of students were established with regard to special education. A student's special education status was dummy coded as 0 for general population, 1 for students identified as disabled, and 2 for gifted students.

Student gender and race. In this study, a student's gender and race were considered to be potential factors related to growth on the KMA. The student's gender was dummy coded male = 0 and female = 1. Student race was dummy coded in the following manner: White = 1, African American = 2, Hispanic = 3, Asian & Pacific = 4, and Other = 5.

Teacher and school identification. In addition to the control measures, dummy indicators for teachers and schools were also included in the data set. The purpose of these indicators was to control for the variety of factors that might influence student growth on the

state assessment that are associated with a particular school (culture, size, climate, etc.) or a particular teacher (gender, teaching style, years of experience, etc.) Including these indicators and accounting for these fixed effects allows for a further adjustment of the ALEKS® effects.

Data Analysis Procedures

Three regression models were established to analyze the data in this study. In each model, a linear multiple regression was run on the gain score estimation to determine whether ALEKS® remediation establishes an added value to the growth of the students' state assessment scores compared to students who do not utilize ALEKS® remediation.

$$\text{Gain} = f(\text{Prior Assessment Score, ALEKS utilization, ALEKS*Prior, controls})$$

The first model consists of a linear regression on a student's gain on the state assessment in one year while controlling for the student's prior score of the KMA and if he or she was an ALEKS® user. The purpose of this model is to get a baseline understanding of the estimated and unadjusted effects of the ALEKS® program. The second model duplicates model one and includes the student's lunch status, gender, race, special education status, teacher identification and school identification. In this way, the effects of the ALEKS® program become further adjusted as control for other factors is included. The final model uses all variables from the second model and includes the interaction term ALEKS®*Prior Kansas Score. The final model is designed to show not only the adjusted effects of the ALEKS® program but how the ALEKS® program works based upon a student's assessment score before starting the program. In this way, general predictions can be made for students with different ranges of scores on their prior Kansas assessment.

Summary

The research design and methodology presented in this chapter were used to determine the relationship between utilization of ALEKS® ILS and student growth on the KMA for 8th grade students in the SMSD relative to a control group of matched middle school students (in the SMSD) who did not use the ALEKS® program. Multiple regression analyses were conducted to determine statistical significance.

Chapter 4

Results

A multivariate linear regression was conducted using STATA IC 10 statistical and data management package. Data from 8th grade students in the Shawnee Mission School District (SMSD) in northeastern Kansas was analyzed to determine statistical support of the hypothesis that the Integrated Learning System ALEKS® has a positive effect on student growth on the Kansas Mathematics Assessment (KMA). Three regression models were established in an effort to interpret the effects of the ALEKS® program on a variety of levels. The intent of the final model, which included mostly demographic variables and one operational variable, was to control for a variety of student, school, and climate effects to better interpret and isolate the effect of a student who utilized the ALEKS® program.

The purpose of the first regression model was to get a baseline understanding of the effects of the ALEKS® program and a student's prior score on the KMA. This model did not include any controls for student characteristics. The model returned an $R^2 = 0.029$ explaining 2.9% of the growth on the KMA (see Table 3 for the results of the hierarchical linear regression models). Both the Prior Kansas Score and the ALEKS® variables were significant negative predictors of growth. The coefficient for the Prior Kansas Score was $B = -0.003$, $p < .001$ and the coefficient for the ALEKS® variable was $B = -0.087$, $p < .01$. The constant produced a significant and positive coefficient ($B = 0.251$, $p < .001$). The results from this model indicate that students with higher prior KMA scores experience less growth on the KMA in one year's time than students with lower prior KMA scores. Specifically, as a Prior KMA Score increases by 1% the potential for growth on the KMA decreases by .3%. If a student is an ALEKS® user,

he or she experiences 8.7% less growth on the KMA in one year's time compared to students who are not using the ALEKS® program. The first model refutes the hypothesis of this study.

The second regression model included the variables from the first model and the following student level controls and school and teacher fixed effects: gender, race, lunch status, special education status, teacher identification and school identification. The purpose of this model was to include control measures to determine if student characteristics and fixed effects contribute to student growth on the KMA in one year's time. This model yielded an $R^2 = 0.194$ accounting for 19.4% of the variance in student growth on the KMA as show in Table 3. In this model, the ALEKS® coefficient remained significant and negative ($B = -0.080$, $p < .05$). In addition, the Prior Kansas Score coefficient remained significant and negative ($B = -0.008$, $p < .001$). None of the controls returned significant coefficients. Also, the constant was not significant in this model. These results indicate that while controlling for a variety of student characteristics and climate fixed effects, ALEKS users continue to experience 8% less growth on the KMA in one year's time compared to students who do not utilize the ALEKS® program. Similar to the first model, the students with higher prior KMA scores experience less growth (.8%) on the KMA. The findings are robust to key student level controls and school and teacher fixed effects.

The final regression model utilized the same variables from the second model and included the interaction term (ALEKS*Prior Kansas Score). The purpose of the interaction term is to further understand the relationship between a student being an ALEKS® user and his or her Prior Kansas Score. The model yielded an $R^2 = 0.223$, representing 22.3% of the variance in growth on the KMA as shown in Table 3. Including the interaction term substantially changed the coefficients in the final model. In this final case, ALEKS® produced a significant and

positive coefficient ($B = 0.508$, $p < .001$), which supports the hypothesis of this study. The Prior Kansas Score coefficient remained negative and significant ($B = -0.005$, $p < .001$). Finally, the interaction term (ALEKS*Prior Kansas Score) produced a significant and negative coefficient ($B = -0.010$, $p < .001$). Similar to the second model, none of the student controls or fixed effects nor the constant yielded significant coefficients. The results of this model further extend the understanding of the relationship between a student's growth on the KMA, his or her Prior Kansas Score, and his or her utilization (or lack thereof) of the ALEKS® program. Students with higher Prior Kansas Scores continue to experience less growth on the KMA in one year's time compared to students with lower Prior Kansas Scores. As a student's Prior Kansas Score increases by 1%, he or she will experience a decrease in growth by .5%. An eighth grade student utilizing the ALEKS® program experiences more growth on the KMA compared to a student who does not utilize the ALEKS® program, but only if the student initially has a very low Prior Kansas Score. To interpret, ALEKS® users will experience nearly 51% more growth on the KMA compared to students who are not utilizing the ALEKS® program, however, this model requires for ALEKS® users to also experience a 1% decrease in growth for every 1% increase in their Prior Kansas Score compared to non-ALEKS® users. Since the study solely observed students with Prior Kansas Scores that were less than 80, these two coefficients balance each other out for the majority of the students. It is not until an ALEKS® user has a Prior Kansas Score of nearly 30 or below that he or she will begin to experience more growth on the KMA in one year's time compared to non-ALEKS® users.

Summary

There was statistical support for the causal claim that at-risk ALEKS® users experience more growth on the KMA compared to non-ALEKS® users. However, ALEKS® users only had the potential to experience more growth when their Prior Kansas Score was extremely low (a score of 30% or less). Multiple regression beta coefficients for the variable ALEKS® were significant at the eighth-grade level. These findings are robust to key student level controls and school and teacher fixed effects.

The adjusted R^2 for the final eighth-grade multiple regression model indicated that the model explained 22.3% of the variation in the growth on the KMA, thus leaving 77.7% unexplained. The regression model indicated that the ALEKS® program was a good predictor of growth on the KMA, but only if a student had a low score (below 33.8%) on the pre-test utilized to compute growth for the study. A student's prior score on the assessment significantly impacted growth on the assessment for all students with higher prior scores yielding less growth compared to students with lower prior scores.

What do these findings truly indicate? Even though the district implemented a remediation program to a vast number of eighth-grade students, the results demonstrated that only 47 of those students had the potential for growth based upon their Prior Kansas Assessment score. This is close to 13.9% of the students using the ALEKS® program with initial prior Kansas scores less than 80 ($n = 338$). The district should consider re-evaluating the implementation of the ALEKS® program.

Chapter 5

Conclusion, Discussion, and Recommendations

The purpose of this study was to determine the comparative benefit of ALEKS®, an educational Integrated Learning System (ILS) used at the eighth grade level in the Shawnee Mission School District, to traditional mathematical improvement approaches for remedial students. The research question addressed in this study was: Does the ALEKS® ILS significantly affect the academic growth of eighth-grade students on the Kansas Mathematics Assessment?

General Results

Multivariate regression yielded statistical support for the causal claim that the ALEKS® program does have a significant positive effect on student growth on the Kansas Mathematics Assessment (KMA), specifically for low-achieving students. This finding is dependent upon the interaction variable that was used in the final multivariate regression model, ALEKS*Prior Kansas Score. By including the interaction term, the regression model produced results that identified the academic characteristics of students for which the ALEKS® program is most beneficial. The final regression model generated a significant and positive coefficient for ALEKS® users ($B = 0.508$, $p < .001$); however, the coefficient for the interaction term ALEKS*Prior Kansas Score was significant and negative ($B = -0.010$, $p < .001$). The combination of these two coefficients creates a balance of growth and non-growth on the assessment for ALEKS® users until a Prior Kansas Score drops below 33.8%². Only ALEKS® users that have a Prior Kansas Score below a 33.8% on the KMA will have the potential to

² The score of 33.8% is generated by using only the significant coefficients produced by the regression model. While the model included key student level controls and student and teacher fixed effects, none of the coefficients were significant.

experience more growth compared to students not using the ALEKS® program. These findings are robust to key student level controls and fixed student and teacher effects, none of which produced significant coefficients in the regression. The regression analysis at eighth grade indicated that 22.3% of the variance in the average growth on the KMA test was accounted for in the model by the variables listed above ($R^2 = .223$). The argument that ALEKS® ILS had a greater impact on learning compared to traditional improvement approaches was supported by the results of the multiple regression analysis.

Limitations

A limitation of this study was that it took place in one school district and grade level in an affluent part of the state. While the schools within the district have diverse populations, the predominant status of the district is middle to upper-class.

Another limitation of this study was the lack of randomization regarding the establishment of treatment and control groups. In this case, students were not chosen at random to utilize the ALEKS® program. The study focused on at-risk students and therefore analyzed all eighth grade students that scored below 80 on the Kansas Mathematics Assessment from the spring of 2006. The district assigned ALEKS® licenses to all students enrolled in Math 8 or Math 8 Plus. Students in the control group (non-ALEKS® users) were typically enrolled in other courses with curricular differences from Math 8 and Math 8 Plus. While the classroom content for the control and treatment groups was not identical, the assessment preparation was the same for all students in the eighth grade. Test preparation strategies followed uniform standards at each grade level in the district. Teachers were therefore expected to utilize the grade-level district-established daily exercises that targeted review material for the KMA.

In 2007 the ALEKS® program was assigned to every eighth grade student in the district that was enrolled in a double-block math class. The district's goal was to provide another resource for enhancing academic achievement in remedial students. In this way, the teachers of the double-block math classes were automatically associated with ALEKS® and it was their responsibility to guide student usage of the program. Some teachers may have seen initial value in the ILS and took advantage of it from the beginning. Other teachers may have avoided use of the program due to a lack of comfort regarding teaching with technology. There are a variety of factors regarding teachers and teaching style that could be related to the relative success of the 8th grade students using the program. The data collected for the study does not permit testing these alternatives.

Finally, some studies have shown that students who spend more hours utilizing a mathematical ILS or completing more sections (or modules) of a mathematical ILS often demonstrate significant growth compared to students who accomplish less within the program (Baum, 2001; Kulik & Kulik, 1991; Kulik 2003, Van Dusen & Worthen, 1995). This could explain the reason why ALEKS® only worked for low-achieving students in this study. The ALEKS® program provides the capability for students to utilize the software outside of school, since it is internet-based. It is possible that some of the 8th grade students completed more modules or sections of ALEKS® thus advancing their knowledge of mathematical concepts and therefore exhibited growth on the Kansas Mathematics Assessment. This study did not allow for an analysis of the relationship between the students' time spent utilizing the ALEKS® program and student achievement.

Some other factors that may have influenced the results of the study include teacher preparation regarding usage of the ALEKS® program, student maturity and development over

the course of one year's time, or experience with computer programs (for both students and teachers). While these options provide avenues for follow-up discussion, the data did not allow for testing these alternatives.

Contributions to the Literature

The present study provides several contributions to the literature associated with computer-assisted instruction and integrated learning systems. First, it specifically contributes to the knowledge regarding the effectiveness of the ALEKS® ILS and CBI software at the middle school level. Multivariate linear regression analysis yielded statistically significant and positive results for low-achieving ALEKS® users compared to traditional academic improvement strategies for remedial 8th grade students in Kansas schools. There seems to be very little research specifically regarding the ALEKS® program and its effects on student achievement in the area of mathematics at the middle school level. Two dissertations have previously addressed the effects of the ALEKS® program on student achievement, though studies included participants at the collegiate level (Carter 2004, Love 2004). In Carter's study, the results indicated there was no significant difference with respect to achievement when comparing the group that used ALEKS® to the group that inherited traditional instructional methods. Love's study revealed a significant and positive effect of student performance in the ALEKS® group compared to the control group.

The current research also contributes to the broader literature regarding the effects of utilizing ILS or CBI to enhance student performance in the area of mathematics or on high-stakes standardized assessments. Historically, the results from studies such as these have varied.

This study significantly enhances the current literature by including the interaction term between the ALEKS® and Prior Kansas Score variables in the regression model. The interaction

term provided an avenue to look intricately at the academic characteristics of the students for which the ALEKS® program was working. The first two regression models in this study concluded that ALEKS® users were not experiencing growth compared to non-ALEKS® users. However, by including the interaction term in the third model, it was discovered that in fact certain low-achieving ALEKS® users were experiencing more growth on the KMA compared to non-ALEKS® users.

Contributions to Practice

The results of this study provide administrators with additional research-based information related to the use of computer-based instruction and Integrated Learning System software regarding mathematical remediation. The main implication is that a large-scale implementation of a mathematical ILS on at-risk students will not produce positive results. The results of this study signify that implementation should be targeted to a certain group of low-achieving students in order for the growth to be significant, positive, and effective. Administrators can use the results from this study to make better decisions regarding the utilization of remediation strategies via ILS in classrooms.

Implications for Policy

With regards to policies regarding educational administration, this study highlights the importance of program evaluation. According to the No Child Left Behind policy, school districts are encouraged to make decisions regarding the use of educational materials based upon scientific research. The research gathered and results found in this study insinuate that district administrators should be leery when choosing mathematical ILS programs. Research regarding the effectiveness of ILS software is varied with respect to grade level, implementation practice, brand of ILS, and characteristics of students receiving the ILS. School districts should conduct

research before choosing a particular ILS and making a wide-scale, expensive implementation across the district. This study suggests that implementation should be done on small scales with certain types of students and the effectiveness of the implementation should be evaluated consistently.

In addition, school district leaders should make the selection of curricular materials with financial responsibility in mind. One ALEKS® license cost the SMSD school district \$25. In the year 2006-2007, the SMSD purchased a total of 423 licenses for students in the eighth grade, costing the district a total of \$10,575. Based upon the results of this study, the ALEKS® program was only effective in contributing to the growth on the KMA for students who entered the study with a prior assessment score of 33.8% or below. This statistic only produces positive effects for 47 students, less than 12% of the total ALEKS® licenses purchased. The potential savings for the district would have been \$9,400.

Future Research

The results of this study suggest that utilizing ILS in mathematical remediation for at-risk students might be working for the most low-achieving students in the at-risk sample. Future studies could incorporate the interaction effect between the ILS users and their academic characteristics. This might provide insightful evidence as to how ILS should be utilized in schools.

Many ILS and CBI studies currently take into consideration how much time each pupil spends utilizing the program or the number of “modules” or “lessons” completed by each pupil. Some researchers have demonstrated that the amount of time or modules completed is directly related to the results of the study. Future research studies could be designed to include an

analysis of the correlation between the number of modules or amount of time spent using an ILS and academic achievement.

Finally, future studies such as these may include surveys for students and teachers regarding implementation of the program and feelings about the program. This could be an attempt to understand the best implementation practices for ILS and CBI in mathematics.

Summary of Conclusions

Examining the effectiveness of the ALEKS® Integrated Learning System in the Shawnee Mission School District was important because the district integrated it into the curriculum on such a large-scale basis, similar to the practice of many other school districts around the county. According to the National Mathematics Advisory Panel (2008), the policies and practices within the educational system will only become more effective if high-quality research based upon current practices is conducted.

This study attempted to determine if the ALEKS® ILS had a significant impact on the academic achievement of eighth grade students in the Shawnee Mission School District, a public school district in northeastern Kansas. The results of this study indicated that the utilization of the ALEKS® program is a significant and positive predictor of student growth on the Kansas Mathematics Assessment for low-achieving students.

The overall conclusion from this study is that the ALEKS® program has the potential to assist certain students in the progression of their mathematical endeavors. More research is needed to determine if these findings would hold true in a variety of settings with different groups of students.

References

- ALEKS® Corporation. Retrieved from www.ALEKS.com
- Alpert, D., & Bitzer, D. L. (1970). Advances in computer-based education. *Science* , 167 (3925), 1582-1590.
- Anderson, J. R., Corbett, A. T., Koedinger, K. R., & Pelletier, R. (1995). Cognitive tutors: Lessons learned. *The Journal of the Learning Sciences* , 4 (2), 167-207.
- Bailey, G. D. (1993). *Computer-based integrated learning systems*. Englewood Cliffs, NJ: Educational Technology.
- Bailey, G. D. (1992). Wanted: A road map for understanding integrated learning systems. *Educational Technology* , 32 (9), 3-5.
- Baum, C. F. (2001). *Evaluation of madison park PLATO training on august 2000 BPS city algebra test achievement*.
- Becker, H. J. (1992). Computer-based integrated learning systems in the elementary and middle grades: A critical review and synthesis of evaluation reports. *Journal of Educational Computing Research* , 8 (1), 1-41.
- Bialo, E. R., & Sivin-Kachala, J. (1996). The effectiveness of technology in schools: A summary of recent research. *School Library Media Quarterly Online* , 25 (1).
- Bialo, E. R., & Sivin-Kachala, J. (1995). Report on the effectiveness of technology in schools, '95-'96. Washington, D. C. Software Publishers Association.
- Biesinger, K., & Crippen, K. (2008). The impact of an online remediation site on performance related to high school mathematics proficiency. *Journal of Computers in Mathematics and Science Technology* , 27 (1), 5-17.

- Campuzano, L., Dynarski, M., Agodini, R., & Rall, K. (2009). Effectiveness of reading and mathematics software products: Findings from two student cohorts. Institute of Education Sciences, National Center for Education Evaluation and Regional Assistance. Washington, DC: U.S. Department of Education.
- Carter, M. B. (2004). An analysis and comparison of the effects of computer-assisted instruction versus traditional lecture instruction on student attitudes and achievement in a college remedial mathematics course. Retrieved August 2, 2010, from Proquest Information and Learning Company (UMI 3128520).
- Clariana, R. B. (1996). Differential achievement gains for mathematics computation, concepts, and applications with an integrated learning system. *Journal of Computers in Mathematics and Science Teaching* , 15 (3), 203-215.
- Clark, R. E. (1994). Media will never influence learning. *Educational Technology Research and Development* , 42 (2), 21-29.
- Clark, R. E. (1983). Reconsidering research of learning from media. *Review of Educational Research* , 53 (4), 445-459.
- Corbett, A. (2001). Cognitive computer tutors: Solving the two-sigma problem. In M. Bauer, P. J. Gmytrasiewicz, & J. Vassileva, *User Modeling 2001* (pp. 137-147). New York: Springer-Verlag Berlin Heidelberg.
- Fletcher, J. D., Hawley, D. E., & Piele, P. K. (1990). Costs, effects, and utility of microcomputer-assisted instruction in the classroom. *American Educational Research Journal* , 27 (4), 783-806.
- Hannafin, B. (2002). *Evaluation Series*. Edina, MN: PLATO.

- Hannafin, R. D., & Foshay, W. R. (2006). Computer-based instruction's (CBI) rediscovered role in K-12: An evaluation case study of one high school's use of CBI to improve pass rates on high-stakes tests. *Education Technology Research and Development* , 56, 147-160.
- Hasselbring, T. S. (1986). Research on the effectiveness of computer-based instruction: A review. *International Review of Education* , 32 (3), 313-324.
- Howell, C. A. (1996). A comparison of chapter one middle school students who received jostens integrated learning instruction and those who received chapter one services only. *Dissertation Abstracts International*, (UMI Number: AAG 726930).
- Johnson, K. (2000). Do computers in the classroom really boost academic achievement? *The Heritage Foundation*, . Retrieved June 3, 2010 from <http://www.heritage.org/Research/Education/CDA00-08.cfm>.
- Joy, E. H., & Garcia, F. E. (2000). Measuring learning effectiveness: A new look at no-significant-difference findings. *Journal of Asynchronous Learning Networks* , 4 (1), 33-39.
- Kinzie, M. B., Sullivan, H. J., & Berdel, R. L. (1992). Motivational and Achievement Effects of Learner Control over Content Review within CAI. *Journal of Educational Computing Research* , 8 (1), 101-114.
- Koedinger, K. R., Corbett, A. T., Ritter, S., & Shapira, L. J. (2000). *Carnegie learning's cognitive tutor: Summary research results*. Pittsburgh: Carnegie Learning.
- Kozma, R. B. (1991). Learning with media. *Review of Educational Research* , 61 (2), 179-211.
- Kulik, C. C., & Kulik, J. A. (1991). Effectiveness of computer-based instruction: An updated analysis. *Computers in Human Behavior* , 7, 75-94.
- Kulik, J. A. (2003). Effects of using instructional technology in elementary and secondary schools: What controlled evaluation studies say. (SRI Project Nuber P10446.001) Standfor Research Institute International. Arlington, VA.

- Kulik, J. A., Bangert, R. L., & Williams, G. W. (1983). Effects of computer-based teaching on secondary school students. *Journal of Educational Psychology* , 75 (1), 19-26.
- Laub, C. M. (1995). Computer-integrated learning systems and elementary student achievement in mathematics: An evaluation study. *Dissertation Abstracts International* (UMI Number: AAI 9535758).
- Love, T. R. (2004). Computer-assisted remedial mathematics instruction. Retrieved August 2, 2010, from Proquest Information and Learning Company (UMI 1423779).
- McCart, C. L. (1996). The effect of the accelerated reader program on the reading comprehension and the reading motivation of fourth-grade students. *Dissertation Abstracts International*, (UMI Number: AAG 9632076)
- Mintz, K. S. (2000). A comparison of computerized and traditional instruction in elementary mathematics. Retrieved July 18, 2011, from *Dissertations & Theses: A&I database*. (AAT 9966705).
- National Mathematics Advisory Panel. (2008). *Foundations for success: The final report of the national mathematics advisory panel*. Washington, DC: U.S. Department of Education.
- Oppenheimer, T. (1997, July). The computer delusion. *The Atlantic Monthly* , 45-62.
- Panel on Educational Technology.(1997). *Report to the president on the use of technology to strengthen k-12 education in the united states*. Washington, D. C: U.S. Government Printing Office.
- Papert, S. (1980). *Mindstorms: Children, Computers, and Powerful Ideas*. New York: Basic Books Inc.
- Public Opinion Strategies. (1995). *Software Publishers Association Market Study Report*. Washington, D. C.: Software Publishers Association.

- Reeves, T. C. (1998). *The impact of media and technology in schools*. Athens, GA: The Bertelsmann Foundation. Retrieved from <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.129.9680&rep=rep1&type=pdf>.
- Schofield, J. W., & Evans-Rhodes, D. (1989). The impact of a computer-based tutor on teachers and students. In D. Bierman, J. Breuker, & J. Sandbers (Eds.). *Artificial Intelligence and Education: Proceedings of the 4th International Conference on AI and Education*. Springfield, VA: IOS.
- Spencer, T. M. (1999). The systemic impact of integrated learning systems on mathematics achievement of elementary students: A six-year longitudinal study. *Dissertation Abstracts International*, (UMI Number:9946070).
- Stevens, J. W. (1991). Impact of an integrated learning system on third- fourth-, and fifth- grade mathematics achievement. *Dissertation Abstracts International*, (UMI Number: AAG 9132228).
- U. S. Congress, Office of Technology Assessment. (1988). *Power on! New tools for teaching and learning*. Washington D.C.: U.S. GPO OTA-SET-379.
- U.S. Department of Education, National Center for Education Statistics. (1998). *The Condition of Education 1998*. Washington DC: U.S. Government Printing Office.
- Van Dusen, L. M., & Worthen, B. R. (1995). Can integrated instructional technology transform the classroom? *Educational Leadership* , 53 (2), 28-33.

Table 1*Demographics for 8th grade students in the SMSD 2006-2007*

| | <u>Percentage of Population</u> |
|--------------------------|---------------------------------|
| Free and Reduced Lunch | 18.5 |
| Gender | |
| Male | 53.8 |
| Female | 46.2 |
| Ethnicity | |
| White | 77.2 |
| African American | 7.9 |
| Hispanic | 8.9 |
| Asian & Pacific | 2.9 |
| Other | 3.1 |
| Special Education Status | |
| General Education | 80.0 |
| IEP | 11.8 |
| Gifted | 8.2 |
| ALEKS® Users | 18.9 |

TABLE 1: (n=2,265)

Basic Descriptive Statistics for Participants in the Study

| | Variable Name | Variable Description | Mean | Standard Deviation | Minimum | Maximum |
|------------|----------------|---|------------------------------|--------------------|---------|---------|
| Outcome | Normed Growth | Represents a student's growth on the KMA in one year | 0.039 | 0.326 | -1.955 | 0.904 |
| Predictors | Prior KS Score | Represents a student's score on the KMA from the Spring of 2006 | 60.338 | 16.006 | 3 | 79 |
| | ALEKS | Represents a student's status with regard to the ALEKS program | 0.266 | 0.442 | 0 | 1 |
| | ALEKS*Prior | Represents a the interaction between the student's ALEKS status and his or her Prior KS Score | 13.164 | 23.195 | 0 | 79 |
| | | | <u>Percent of Population</u> | | | |
| Controls | Lunch | Free & Reduced Lunch Status | 23.3 | | | |
| | Gender | Male Female | 54.7 45.2 | | | |
| Controls | Race | White | 72.0 | | | |
| | | African American | 10.6 | | | |
| | | Hispanic | 11.4 | | | |
| | | Asian & Pacific | 3.2 | | | |
| | | Other | 7.8 | | | |
| Controls | SPED | NO IEP | 81.1 | | | |
| | | IEP | 17.9 | | | |
| | | Gifted | 1 | | | |
| | Teacher_ID | Represent's a teacher by identification number | | | | |
| | School_ID | Represents a student's school by identification number | | | | |

TABLE 2: (n=1,269)

Table 3

Results of Hierarchical Linear Regression Models Predicting the Effects of the ALEKS® Program on Student Growth on the KMA.

| | Model 1 | | Model 2 | | Model 3 | |
|---------------------------------|------------|---------|------------|---------|------------|---------|
| Central Predictors | | | | | | |
| Prior Kansas Score | -0.003 *** | (0.001) | -0.008 *** | (0.001) | -0.005 *** | (0.001) |
| Aleks | -0.087 ** | (0.026) | -0.080 * | (0.034) | 0.508 *** | (0.105) |
| Aleks*Prior | | | | | -0.010 *** | (0.002) |
| Lunch | | | -0.014 | (0.278) | -0.014 | (0.027) |
| Gender | | | -0.030 | (0.020) | -0.028 | (0.019) |
| Race/Ethnicity | | | | | | |
| African American | | | -0.036 | (0.039) | -0.040 | (0.038) |
| Hispanic | | | -0.035 | (0.035) | -0.041 | (0.035) |
| Asian & Pacific | | | 0.033 | (0.054) | 0.049 | (0.053) |
| Other | | | 0.001 | (0.059) | 0.003 | (0.058) |
| Special Education Status | | | | | | |
| IEP | | | -0.029 | (0.034) | -0.036 | (0.033) |
| Gifted | | | 0.160 | (0.102) | 0.147 | (0.100) |
| Constant | 0.251 *** | (0.045) | 0.513 | (0.317) | 0.516 | (0.311) |
| R-Squared | 0.029 | | 0.194 | | 0.223 | |
| F | 14.880 | | 4.480 | | 5.650 | |

NOTE: 273 students had missing values and were removed from the data set.

*** p < 0.001; ** p < 0.01; * p < 0.05