THE EFFECTS OF COMPUTER ASSISTED INSTRUCTION ON RURAL ALGEBRA I STUDENTS
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Abstract

The purpose of this review of literature was to describe the effects of computer-assisted instruction on rural high school students taking algebra courses. Michigan has a high population of students in rural communities and strategies need to be implemented to increase the probability of success for these students to learn algebra content. The literature reviewed included studies utilizing meta-analysis of computer-assisted instruction in different learning environments, with a focus on Algebra I students in rural settings. Results and conclusions from the studies indicated computer-assisted instruction may be beneficial for rural algebra students and may provide an equitable education compared to students in other settings. Recommendations for improving the effectiveness of computer-assisted instruction include providing teachers with professional development, encouraging interaction in classes incorporating computer-assisted instruction, providing students with suitable technology, and selecting students with skills to work independently.
Chapter 1: Introduction

Approximately 29% of Michigan high school taking the 2012 Michigan Merit Exam (MME) earned a passing score in mathematics, a 3.4% increase from 2008. Of these same high school students, only 33% were considered ready for a college mathematics based on the ACT’s College Readiness Standards and only 17.7% of all graduating seniors were considered college ready in all subject areas. Then take into account that just 74.3% of Michigan students are graduating in four years and the dropout rate is 11.1%. With all of these statistics, it appears that Michigan high students are leaving school with without the necessary background knowledge recommended to be successful in tomorrow’s workforce.

Michigan’s elementary children are not faring much better before entering high school. In third grade only 36% were considered proficient in mathematics, fourth and fifth, 40% proficient, and in eighth grade, 29% proficient on the 2012 Michigan Education Assessment Program (MEAP) test. This suggests that 60-70% of students are progressing into a new grade level with less than adequate skills (www.michigan.gov).

Michigan has been trying to raise the mathematical literacy of students in K-12 for many years. In 2004, Michigan released K-8 Grade Level Content Expectations (GLCE) in response to No Child Left Behind (NCLB). These expectations were a guiding force in development of MEAP tests for students in kindergarten through eighth grade. The year 2009 brought about more changes when the Michigan Department of Education, with assistance from Michigan Council of Teachers of Mathematics, reorganized mathematics expectations to correlate with the National Council of Teachers of Mathematics 2006 Focal Points. The goal was to help teachers focus instruction, make MEAP tests a reasonable length, and still assess key concepts (www.michigan.gov).
That same year, Michigan signed into law new high school graduation requirements, known as the Michigan Merit Curriculum (MMC) to support the intent of NCLB and help students increase their knowledge base in core content areas. The educational goals for these courses became known as the High School Content Expectations (HSCE) and Michigan instituted a new testing recommendation that high school students demonstrate mastery on end-of-course assessments in core subjects: language arts, mathematics, science and social studies (www.michigan.gov). From these initiatives, it was anticipated there would be an increase in MME and ACT scores, which did occur. Over a five year span, 2006 - 2011, the average ACT composite score rose from 18.6 to 19.7 and the percentage of students achieving a proficient level on the MME increased 2.6% (www.mischooldata.org).

In June of 2006, the Common Core Standards (CCS) were released by the National Governors Association Center for Best Practices (NGA Center) and the Council of Chief State School Officers (CCSSO) for Mathematics and English Language Arts. Michigan adopted the Common Core State Standards (CCSS) in 2010 for students in grades K-12 and since then, the State of Michigan has been modifying the K-8 GLCEs and HSCEs to reflect the CCSS. Testing for these new standards is expected to take place in Spring 2015.

**Statement of the Problem**

Over the last several years, Michigan’s educational system has been in a constant state of change, moving from the Benchmarks and Standards to the Grade Level and High School Content Expectations and now, the Common Core Standards. Not only has the content become more rigorous and standardized, but the achievement level has also been raised for students.

Mathematics and English Language Arts are the two content areas under the most scrutiny in this transformation. Of these two, for many students mathematics is intimidating,
challenging, and confusing. For these reasons mathematic educators have a daunting task to assist their students in comprehending the content using a method of delivery that research supports as an effective technique. These same teachers also have to find ways to overcome students’ phobias and negative attitudes about math, both of which can hinder a child’s success in the mathematics classroom. With one of the largest populations of rural students in the nation accounting for 19.8% of the students and more than twice the amount of the median number of rural students in the nation (Rural School and Community Trust, 2012), Michigan must find a way to address the needs of these students too.

Research Question

What are the differences in comprehension of algebraic concepts and rural high school students’ attitudes towards mathematics between algebra instruction through an online learning environment and a traditional teacher-led classroom?

Definition of Terms

Computer-assisted instruction.

The use of computers as an educational tool has continued to grow rapidly as a new way to teach. Computer-assisted instruction (CAI) is an instructional method that has been developing for over 40 years (Liao, 2004). This idiom equates with other modern terms such as computer-based instruction (CBI) (Hannafin & Foshay, 2006), computer-based learning environment (CBLE) (Moos & Azevedo, 2009), or computer-aided learning (CAL) (Santally, Boojawon, & Senteni, 2004). CAI, “defined as the use of a computer to provide instructional contents” (Seo & Bryant, 2009), allows for interaction between user and computer with immediate feedback. Some CAI programs adjust for student’s ability levels and others limit advancement until skill mastery is achieved. Instruction may involve using stand-alone software
or more advanced applications that deliver an entire course. Some situations involve a blended model, incorporating face-to-face instruction, referred to as teacher directed, and CAI (Graham, 2005). Regardless of delivery method, CAI is a means to mesh technology and learning. This paper will look at CAI as an instructional method to increase students’ learning and test scores on assessments for students taking algebra courses.

**Rural**

As defined in the Merriam-Webster dictionary, rural refers to the county or agriculture, not urban ([www.merriam-webster.com](http://www.merriam-webster.com)). In reality, this term is much more complicated to define; for years, even the U.S. Census Bureau and the Office of Management and Budget (OMB) could not agree on a definition ([www.hrsa.gov](http://www.hrsa.gov)). The inability to clearly define rural has hindered educational research as well as how to award state and federal funding for education (Alliance for Excellent Education, 2010). The National Center for Education Statistics along with the U.S. Census Bureau and the OMB and decided in 2006 to work together to develop a three part definition that better fit the needs of schools and education ([http://nces.ed.gov](http://nces.ed.gov)).

**Rural**

**Fringe**

Census-defined rural territory that is less than or equal to 5 miles from an urbanized area, as well as rural territory that is less than or equal to 2.5 miles from an urban cluster.

**Distant**

Census-defined rural territory that is more than 5 miles but less than or equal to 25 miles from an urbanized area, as well as rural territory that is more than 2.5 miles but less than or equal to 10 miles from an urban cluster.

**Remote**

Census-defined rural territory that is more than 25 miles from an urbanized area and is also more than 10 miles from an urban cluster. ([www.whitehouse.gov](http://www.whitehouse.gov))
Chapter 2 - Literature Review

The purpose of this literature review is to look at an overview of the introduction of CAI into education and the impact of CAI has on learning and more specifically, on students learning in algebra in rural schools.

History of Integration of Computers and Computer Assisted Instruction into Education

The idea of using technology to enhance education has been around for a long time. Back in 1928, courses began being offered through radio. These classes were for enrichment or credit and were centered in Ohio and Wisconsin (Clark, 2003). With the introduction of television, in 1932 the University of Iowa began experimenting with offering classes using this technology. Several years later in 1944 computers made their first appearance with the invention of the MARK I; a large mainframe used primarily in perform math and science calculations.

Using television as an educational tool slowly began to grow and in the 1950s, seventeen educational programs started using television as a way to reach their students and twenty-two years later there were at least 233 educational stations. Throughout this time period, computers began to filter more into the education world and in 1959 at the University of Illinois the first large scale use of a computer assisted instruction (CAI) system, PLATO, was introduced (Molnar, 1997).

Technology transitioned in the early seventies and universities began installing microwave networks to create close-captioned classes for students at remote locations. CAI systems continued to be developed throughout this time period, but lessons were dull and uninspired (Minoli, 1996) and 50% to 60% of the material in the lessons was extraneous (Saettler, 2004, p. 403-406). For this reason, even through the eighties, about 95% of public television stations and one third of universities continued to offer distance learning courses.
through the Adult Learning Service (ALS) using television. Still, the use of computers continued to grow and by 1975, 23% of schools were using them for educational purposes and 55% of schools at least had access to them (Molnar, 1997).

It was not until the nineties, when computers took on a newer, more efficient structure, became faster and more multifunctional (Harting & Erthal, 2005), did society really began to consider their potential in education. During this period, schools purchased around two million computers, resulting in almost 100% of educational institutions using this technology in their buildings (Cotton, 1991). Out of need, the Virtual High School Global Consortium was created in 1996, and by 2009 over 1,000,000 students were enrolled in at least one online class. (Picciano, Seaman, Shea, & Swan, 2012). By the beginning of the twenty-first century, computers were fully implemented into schools and being utilized in a variety of ways.

**Design Considerations**

Development of CAI software needs to take into account many factors. One factor, control over pacing of lessons, known as *interactivity effect* was suggested by Park, Gyumin, and Kim (2009). By allowing students to proceed at their own pace, more comprehension was able to take place (Park, Gyumin, & Kim, 2009; Schnackenberg & Sullivan, 2000). Another component, worked out examples, contributed to more effective learning too (Park, Gyumin & Kim, 2009; Martin & Sullivan 2006). Higher test scores were achieved by students with worked out examples than students using the same application minus worked out examples (Martin & Sullivan 2006). CAI software needs to provide different levels of interactivity: low, self-pacing and student control over pages and high, hypothesizing and testing by multiple interactions.

In a study involving seventy-two fifth grade students in Korea, higher learning efficiency and low cognitive load were observed with students having high prior knowledge using software
with high interactivity. Students having low prior knowledge using software with low interactivity also exhibited higher learning efficiency and low cognitive load. In addition, students with low prior knowledge scored better on tests with low interactivity and students with high prior knowledge scored better on tests with high interactivity (Park, Gyumin, & Kim, 2009; Schnackenberg & Sullivan, 2000).

Humans can only accommodate seven pieces of information (plus or minus two) at a time (Miller, 1956). This concept is commonly referred to as chunking and is another important consideration in the design of CAI. Chunking facilitates learning by allowing time for students to process information and reduces cognitive load (Park, Gyumin, & Kim, 2009; Chalmers, 2003; Hung, Monsicha, & Crooks, 2008). When more than seven pieces of information are presented at a time, CAI users can get overwhelmed and forget what they are trying to learn.

Nine key components of effective CAI design were identified by Crew (2004): (1) seamless integration, (2) sequenced and directed learning objectives, (3) practice, (4) assessment, (5) feedback, (6) support for learning, (7) focused cognitive effort, (8) personalization, and (9) learner oriented. Screen design also needs to be a concern along with factors such as spatial layout, organization, color, simplicity and brightness to make successful CAI programs (Chalmers, 2003; Rambally & Rambally, 1987).

Implementation

The latest statistics from the 2012 Building a Grad Nation: Progress and Challenge in Ending the High School Dropout Epidemic state that 75% of our nation’s students are graduating from high school, an increase of 3.5% from 2001 to 2009. However, the other side of this statistic is that one in four students in the United States are dropping out of school. With implementation of NCLB and almost all states adopting the CCSS, a graduation rate of 82% is
CAI Effect on Rural Algebra I Students

Projected for 2014 and a method to help reach that goal is CAI. One way CAI is being utilized is response to intervention (RTI), a tiered approach to maximize students’ learning (www.rti4success.org). CAI helps struggling students by providing individualized instruction that adjusts to new levels as mastery occurs. Another use is for remediation. Students needing reinforcement on specific benchmarks or standards can use CAI to build their skills and knowledge. CAI is also a way to assist students in credit recovery. The course can be worked at anytime, so work can be completed without a student falling farther behind in their current studies. A relatively new application is arising for students who are involved in Seat Time Waiver programs. This new philosophy allows students to creatively schedule their education and allow for options not available as part of a traditional school day. Students choose when and where learning is convenient. Another application, perhaps a more predominate use, is that CAI is being incorporated into the general education classroom as a means of deepening and expanding students’ understanding of the material or as stand-alone classes. Lastly, CAI is being implemented into rural schools to expand current offerings for students and to provide core curriculum classes when unavailable due to local issues.

**Impact on Learning**

A goal of education is to help students learn and to measure this learning, assessments are commonly used. Several studies have been done to determine if a relationship exists between CAI and learning (test scores) and long term retention. One such study involved 11 and 12 year old students using an interactive algebra program (Thomas & Tall, 2005). One year after completing the study, both experimental and control groups were retested using the original posttest. Students who used CAI scored significantly higher than students in the control group supporting other research studies (Barrow & Markman, 2009; Burch & Kuo, 2010). Conflicting
evidence has been presented in other studies that students who used CAI either had no significant difference in posttest scores or scored lower than students receiving traditional lessons (Linden, 2008; Santally, Boojawon, & Senteni, 2004) and no significant difference in long term retention was determined (Cannon, 2005).

Research conducted with 12 and 13 year old children by Thomas and Tall (2005) involved fifty-seven matched pairs of students in mixed ability classes were split into two groups. The experimental group completed a dynamic algebra module and the control group learned by teacher directed instruction. Students in the control group scored higher on skill-based questions, while students using CAI scored better on higher level thinking questions. The impact of interactive CAI on higher level thinking has been supported in other research (Wenglinsky, 1998). In one study involving 33 college students, both control and experimental groups had similar mean test scores, but students working with interactive CAI scored higher on tests involving transfer of concepts (Evans & Gibbons, 2007). A different experiment split 115 third-grade students into two groups to learn about fire safety (Chaung & Chen, 2009). The control group was exposed to text-based instruction on a computer, while the experimental group played a real time computer game with identical information. While no significant difference was observed on matching questions between experimental and control groups on the posttest, the experimental group scored significantly higher on multiple choice and application questions. Raised cognitive levels appeared to be a result of CAI with high interactivity in the form of a computer game (Chaung & Chen, 2009; Squire, DeVane, & Durga, 2008). Regardless of age or education level, high interaction between user and computer seems to increase differentiation and recall, promote problem solving skills, enhance comprehension and encourage higher level cognitive thinking (Chaung & Chen, 2009).
A meta-analysis on CAI was done by noted researchers, Kulik and Kulik (1991). For this meta-analysis, 254 studies were evaluated to insure each fit four criteria: (1) each study had to have taken place in a real classroom, (2) both control and experimental groups had to have been evaluated using the same quantitative measure, (3) no methodological flaws could be apparent, and (4) the studies had to be obtainable from select sources. The studies involved a wide range of learners, from kindergarten to adult, and were organized into similar groups; effect sizes for each group were analyzed. Students using CAI (referred to as CBI in this study) had assessments scores increase from the 50th to the 62nd percentile or typically by about 0.30 standard deviations. Another positive aspect found was CAI users used one-third less instruction time compared to students not exposed to CAI. Duration of use also had an effect on test scores. Students working with CAI four weeks or less had a standard deviation of 0.42, while extended use lowered the standard deviation to 0.26. A meta-analysis by Liao (2004) done 13 years later involving 52 studies of Taiwanese students found comparable results. The average mean of study-weighed effect size was 0.552 for approximately 5000 students with 81% of the studies showing positive effects of CAI use.

In addition to improved test scores and learning, CAI has impacted students in unexpected ways. Users of CAI demonstrated increased computer self-efficacy, an individual’s perception of their computer skills and knowledge (Moos & Azevedo, 2009; Chapman, 2000), raised self-regulatory skills (Shen, Lee, & Tsai, 2008) and increased motivation (Macaruso, Hook, & McCabe, 2006; Hannafin & Foshay, 2006; Santally, Boojawon, & Senteni, 2004).

Mathematics is considered the most difficult subject to learn out of all core classes. Some think this is because math is not considered natural or intuitive, so any method to make learning mathematics less intimidating would result in students’ learning more material (Aliasgari, 2010).
CAI has helped accomplish by promoting higher level thinking skills (Wenglinsky, 1998), making math less of a memorization task, especially with regard to formulas (Hale, 1985), developing links between abstract and non-abstract concepts (Lei, Joon, & Shaffer, 2003), and even more so for high school students than elementary (Wenglinsky, 1998). Even adding multimedia to CAI has proven to have a positive impact on learning mathematics and problem solving skills for high school students (Shyu, 2000; Chuang & Chen, 2009).

Some benefits of CAI show up in students’ attitudes towards learning math, even when no differences can be found in academic achievement. Four high schools participated in a study to see if students using a CAI, Learning Logic, would have better scores the following year in Algebra II as compared to students taught in a traditional class setting. A total of 233 students participated, but no correlation was found in academic achievement from Algebra I to Algebra II between students that used CAI and the control group. However, all students that used Learning Logic enrolled in Algebra II, but not all students taught using traditional methods, suggesting CAI gave students a more positive outlook about algebra (Carter & Smith, 2002).

**Teacher Involvement**

Teachers have an impact on the effectiveness of CAI on students learning content in the classroom. Solely using technology as a tool to deliver information will “not influence student achievement any more than the truck that delivers our groceries causes change in nutrition” (Clark, 1983). “Yet, our nutrition can be damaged by a bad choice in delivery methods (Li & Ma, 2010).” To be effective teachers, educators must use research to understand the link between technology and how students learn mathematics. (Ozel, Yetkiner, & Capraro, 2008). Wenglinksky (1998) found a positive relationship between student achievement in mathematics and the amount of professional development teachers received centered on incorporating
technology into the mathematics classroom to increase higher level thinking skills. Not only does professional development need to be available, but teachers need to be active participants to make CAI effective for their students (Cavalluzzo, Lowther, Mokher, & Fan, 2012).

Connell (1998) conducted a study over a period over one year in two rural elementary classes. The traditional teacher centered class used technology solely as a presentation tool, while the student centered classroom used technology to encourage math exploration. Both classes scored higher than other students in their school and state. However, students using technology as an exploration tool, scored significantly higher than the class using technology as a presentation tool. This idea was supported in a meta-analysis done by Li and Ma (2010) in which 85 independent effect sizes were analyzed from 46 studies. A positive correlation (0.79 standard deviations) was found between using computer technology as a learning tool to teach mathematics as opposed to a presentation tool. Haas (2005) conducted a meta-analysis to determine the effect of integrating technology into algebra classrooms and found a strong effect size of 1.42 for advanced algebra students and a smaller one of 0.63 for algebra students. The meta-analysis included 35 studies at the secondary level between 1980 and 2002 with a focus on students taking algebra. In the study, six different teaching methods were scrutinized. Technology as a stand-alone tool was the least effective of all methods, but the effectiveness increased when combined with direct teacher instruction.

**Critics of CAI**

Not all people concur with studies attributing higher test scores and acquisition of higher level thinking skills to CAI. William Rukeyser, founder of *Learning in the Real World*, an organization that examines “the costs and benefits of education technology” (www.realworld.org), and writers Jane M. Healy and Todd Oppenheimer are critics of CAI. All
three believe educators are putting too much emphasis on computers resulting in unbalanced
education for children (Chapman, 2000). Critics attribute some success of CAI to the Hawthorne
Effect: students do better when using computers because of increased attention. Another shared
concern is that computers drain financial resources from other aspects of education, such as
highly qualified teachers or availability of elective courses. A fear that students will develop
short attention spans, devalue books, and have imposed boundaries on inquiry has also been
voiced (Chapman, 2000). The U.S. Department of Education sponsored the 2008 Final Report of
the National Mathematics Advisor Panel. In this report, writers suggested insufficient research
has been done to determine if CAI has had a conclusive impact on students’ learning.

Wenglinksy (1998) stated three concerns expressed by critics in the report Does It
Compute? The Relationship Between Educational Technology and Student Achievement in
Mathematics. First, historically teachers have been resistant to change, especially with regards to
technology. Critics acknowledge that CAI could benefit students, just as any other teaching
strategy, but if teachers are unwilling to use technology, then it is worthless (Cuban, 2003; Li &
Ma, 2004; Brown, 2006). Secondly, the cost of implementing computers in a school outweighs
the effect CAI might have on a student’s learning. Lastly, students do not learn by exposure to
content alone, but also by the dynamic socialization between teacher – student and student –
student interactions. These same ideas were mirrored fifteen years later in Andrew J.
Rotherham summarized his views with, “American education desperately needs an overhaul that
goes far beyond upgrading computers in the classroom. It’s the last major American field
relatively untouched by technology.”
Samuel G. Sava, past director of the National Association of Elementary Principals (NAESP), presented a speech in 1997 to the NAESP State Leaders Conference. He made a strong argument against CAI by pointing out that of the seven countries scoring higher than U.S.A on the Third International Math and Science Study, five seldom, if ever, used computers, and yet, even with CAI available, American children are still behind in math and science.

**Case Studies**

**Plato as a CAI**

A case study to determine the effects of Plato, a CAI (referred to as CBI in this study), on students’ performance on an end-of-year state assessment was conducted by Hannafin and Foshay (2006). The participating high school had test scores second to last out of 16 regional schools. Goals were set to increase the number of students passing the state test.

In 1999, teachers were instructed in curriculum alignment, standards-based instruction, and strategies to help low achievers. The following year, 87 tenth graders identified as high risk were enrolled in a class that incorporated Plato as the instructional device; 39 students were not classified as high risk and were included in the non-CAI group. Only students having both eighth and tenth grade state assessments in their file were included in the study. High risk students had an average score of 215.7 and non-CAI students had an average of 234.2 on eighth grade state assessments; scores below 220 were considered failing.

The study started in fall of 2000. High risk students used Plato four class periods a week and received study skill instruction for one class period. The study cumulated with all participants taking end-of-year state assessments in math and reading in May of 2001. Test scores showed both groups had significant increases in learning. At risk students had an average of 234.2 while non-CAI students, 245.4. CAI students had a size effect of 1.27, which translated
to a gain score of 20.4 on the state test as opposed to a gain score of only 11.2 for non-CAI users. The teacher directly involved with the high risk students felt Plato was a key component to the success of the students involved.

Hannafin and Foshay concluded that higher test scores most likely could not be attributed only to CAI, but CAI was a large contributing factor. Teacher direction, remediation, and the Hawthorne Effect may all have played a roll in the results.

**Renaissance Learning Systems**

A second case study looked at a different approach to CAI, a blended model. In attempt to raise scores on the Arizona Instrument to Measure Standards (AIMS) test, two Arizona high schools implemented a blended model approach incorporating Accelerate Math by Renaissance Learning Systems and individualized tutoring (Springer, Pugalee, & Algozzine, 2007). A passing score on AIMS is required for students to graduate and in 2006 only 39% of Arizona’s 10th grade students had passed.

Accelerated Math is a CAI that provides customized worksheets based on a student’s skill levels. For this study, a team from participating schools and Renaissance Learning worked together to insure core standards were incorporated into the software. Students were required to complete multiple choice problem sets by means of paper and pencil and then scan answers into a computer; immediate feedback was printed out for students. To progress, 80% mastery was required on a skill level and students had to achieve 75% mastery on periodic review problem sets. Instructors and tutors were available to provide assistance, but help was automatically provided if a student failed to master a problem set after three attempts.

Twenty-eight eleventh grade students, who failed the AIMS mathematics competency test, were paired based on AIMS test scores earned as tenth graders. Control and experimental
groups were each randomly assigned 14 students. For one school year, the experimental group experienced CAI in a blended model approach for five class periods a week. Control group students received regular supplementary instruction. Two weeks before students retook AIMS, both groups received identical systematic review.

Using AIMS as pretest and posttest, students participating in the experimental group had a significant increase ($t = -6.46$) from pretest to posttest; the control group did not ($t = -1.39$). In a comparison of posttest scores for both groups, an effect size of 0.88 – 1.00 was found towards the experimental group. Using simple percentages, a more straightforward impact of using CAI in the blended approach could be seen. Only 14% of the control group passed AIMS while 57% of the experimental group passed.

Another interesting part of this study was that both experimental and control were given incentives to participate and pass AIMS. Before the study started, volunteers were offered the privilege of leaving campus one day a week at lunch time, something normally reserved for seniors. Two days before AIMS was administered, students were informed that each would receive $50 if a passing score was earned.

**Kentucky implements CAI in Rural Schools**

In Kentucky, 47 schools volunteered to participate in a two year study to determine the effects of CAI on ninth grade Algebra I students; 13 treatment schools and 12 control schools participated the first year and 11 of each in the second (Cavalluzzo, Lowther, Mokher, & Fan, 2012). Thirty of these schools were in rural communities accounting for 61.4% of the total 6098 students participating. Low performance schools were targeted where a maximum of 60% of students were considered proficient in math.
Schools were randomly assigned as either a treatment school or control, but classes were not mixed within a school. All teachers in treatment schools were offered professional development targeting algebra content and blended classroom instruction the summer before CAI was implemented as well as throughout the school year. Classroom instruction in treatment schools consisted of 60% teacher directed and 40% online using an Algebra I program provided by Kentucky Virtual High school. Students’ scores on the Grade 8 Kentucky Core Content Test and the pre-algebra/algebra strands of the ACT’s EXPLORE test given in eighth grade were used as baseline measures. The pre-algebra/algebra strands of the ACT’s PLAN test was used as a posttest. Teachers were also asked to complete a questionnaire in the spring detailing their perceptions of students’ learning during the school year. The questionnaires were identical except for modified terminology reflecting a teacher’s use of CAI or traditional teaching. In addition, attempts were made to observe each teacher in the study for at least one hour using the School Observation Measure and the Algebra I Quality Assessment as observation tools.

Analysis of results from the two year study indicated that using CAI in a blended classroom did not impact rural (difference of -0.01 scale points) students any more or less than non-rural (difference -0.74 scale points) students \( (p = 0.07) \). There was also no significant difference between rural (probability of control group, 0.88; treatment group, 0.90) and non-rural (probability of control group, 0.82; treatment group, 0.81) students with respect to enrollment in a tenth grade or higher math course; 86% of both groups enrolled. Considering all students in the study, based on a 95% confidence interval using a two-tailed test, neither the treatment group nor the control group scored significantly better on the pre-algebra/algebra scores of the PLAN test or in regards to enrolling in a math course in grade ten.

From this study, Cavalluzzo, Lowther, Mokhe and Fan concluded that CAI had neither a positive nor negative effect on math achievement in Algebra I or on students’ attitudes concerning
future math courses. Even when they examined different subgroups in the study, gender, enrollment cohort, and rurality, they found no significant impact of CAI. Several factors may have influenced the results of this study. Approximately one-third of teachers (20 out of 63) in the treatment group either did not attend any of the offered professional development, use the online learning component in class or their school withdrew from the study. Of teachers participating for the entire study, less than 50% attended professional development on a fairly regular basis and of those, 20% to 30% were considered minimally engaged. Another contributing factor was that 65% of students assigned to schools using CAI study either did not use the Kentucky Virtual Schools’ online Algebra I component or used the CAI program on an infrequent basis.

**CAI Impact on Learning and Attitude About Mathematics**

Aliasgari, Riahinia and Mojdehavar (2010) conducted a study to determine if CAI had an effect on the attitudes and learning of high school students studying mathematics. Two schools were randomly chosen from a selection of five in the city where the study took place; both schools had similar socioeconomic and educational backgrounds. A classroom of 23 students was designated as the control group in one school and a class of 27 students in the other school as the test group. The study took place towards the end of the school year so students could not be randomly assigned since classrooms had already been established.

Over a four week period, the test and control groups covered identical content. The control group was taught using traditional teacher centered instruction and the test group used CAI with support from the teacher as needed by students. The CAI was a software program provided by the Department of Educational Technology that allowed students to direct their learning.

The same ten question pre-test and post-test, developed by the teachers, was given to students to assess mathematics content knowledge. The test was determined reliable based on
Spearman-Brown formula (reliability of 0.74). A pre-test and post-test was also given to evaluate students’ attitudes about math with a reliability of 0.82 determined by Cronbach’s alpha coefficient. The twenty question test used a Likert scale, with five questions having possible negative response values.

On the math content pre-test, both groups demonstrated no knowledge of the material, but on the post-test, a $t$-test was performed on the difference of the mean scores and a $t$ value of 3.41 ($p = 0.002$) showed a significant difference in favor of the test group. The control and test groups did not score significantly different on the pre-test ($t = 1.356$) concerning attitude towards mathematics, however on the post-test, a calculated $t$ value of 9.472 showed the test group had a significant positive change about their feelings towards mathematics.

The authors of this experiment concluded that CAI could be beneficial in improving students’ content knowledge and attitude towards math over teacher directed instruction. Even though the experiment was limited in scope, it did support other research studies identifying CAI as a positive influence of learning mathematics.

**Louisiana Algebra I Online Project**

Faced with the problem of not enough highly qualified mathematics teachers in rural communities, Louisiana instituted a quasi-experiment (O’Dwyer, Carey, & Kleiman, 2007). The goal of the experiment was to determine if students taking an online Algebra I course could receive the same quality of education as students in a teacher directed classroom. The experiment, known as the Louisiana Algebra I Online project, was designed to provide students with access to a highly qualified teacher at a remote site and a teacher not qualified to teach math in the classroom. In addition, the highly qualified teacher mentored the classroom teacher on a regular basis. Online teachers were expected to carry out all of the normal duties of a classroom
teacher while the local teachers’ duties consisted of classroom management, proctoring assessments, assisting students and working closely with the highly qualified teacher. The National Council of Teachers and Louisiana’s benchmarks and standards were used to align the course, which was delivered through the Louisiana Virtual School. Both the classes using CAI and those receiving direct teacher instructions used the same textbooks and content material. Teachers in the control group were not asked to alter their teaching methods in any way.

Schools qualified for the experiment by demonstrating a shortage of highly qualified mathematics teachers, showing the school was set in a rural community, and the desire to provide professional development for teachers interested in becoming highly qualified in mathematics.

For the one year quasi-experiment, six school districts and two private schools participated and within these, eighteen classrooms were designated as treatment classes. Students in each class met at the same time each day and were provided with the necessary technology for taking a class online. Students with good communication skills and thought to have the ability to work independently along with taking algebra for the first time, were chosen for the study. From the treatment classes, 231 students completed the entire study, and from the control classes, 232 students.

All students took a 25 question, multiple choice pre-test to evaluate math skills and comprehension; the test had a reliability of 0.70 based on Cronbach’s alpha estimate. The post-test had a Cronbach’s alpha estimate of 0.81 and consisted of 25 multiple choice questions aligned to Louisiana’s Grade Level Expectations and the Algebra I content. Scores from both tests were considered valid after they were correlated with standardized tests students had taken; Louisiana Educational Assessment Program (grade 8) and the Iowa Test of Educational
Development (grade 9). For the pre-test, there was no significant difference between the treatment and control groups ($t = 0.27, p = 0.788$) as well as on the post-test, in which treatment group’s mean score was less than one point higher than the control group.

A post-test survey was also given to all 463 students to evaluate students’ perceptions on their method of instruction and attitude towards algebra. Students in the treatment group took a 38 question survey on the computer while students in the control group were administered a 10 question survey using pencil and paper. When asked how students felt about their algebra and technology skills, 67.8% of the control group responded with confident or very confident while only 49.8% of the treatment group responded in these categories. Students were also asked to consider if their course was a good learning experience. For the responses yes and satisfactory, 93.7% of the control groups’ responses fell into these categories and 79.3% of the treatment groups’.

From this study, O’Dwyer, Carey, and Kleiman observed that CAI, in this case an online algebra course, did not give students an advantage in learning algebra. However, an interesting analysis was noted; students taking an online algebra course in rural communities could receive an education equitable to a traditional teacher directed classroom. Also pointed out was, that even though the treatment groups’ perceptions of their algebra skills was lower than the control groups’, both groups had about the same mean post-test scores.

These case studies provide evidence that CAI can have positive effects on a student’s learning, and more specifically learning algebra. More importantly, they illustrate that a student’s learning is not diminished when exposed to CAI, but can provide an alternative way to help a student learn.
Chapter III – Results and Analysis Relative to Problem

CAI has been suggested as one means to assist students in learning algebra in rural schools and to change students’ attitudes about algebra in a positive direction. Several studies imply a positive correlation between CAI and learning mathematic (Hartley, 1977), however researchers insinuate many other factors may contribute to this improvement and none conclusively state CAI as the sole reason (Hannafin & Foshay, 2006). Educators’ active participation in professional development around mathematics and integration of technology (Forgasz, 2006) appear to influence the impact of CAI on students’ learning mathematics as does having teachers available to interact with students and give timely feedback. For CAI to be effective a third consideration is the ability of students to work independently. The impact of CAI diminishes when students do not take a dynamic role in the process.

Regardless, CAI seems to have several effects on students: decreased learning time, increased knowledge acquisition and a positive outlook towards instruction and algebra in general. Even with positive research in support of CAI, Samuel G. Sava’s (1997) pungent statement concerning Americas’ use of computers in education and the less than stellar standing this country has compared to others on the TIMSS assessment can not be taken lightly.

When evaluating research on CAI, one thing to be considered is the rapid evolution of computers and technology in general in a relatively short time period. Studies done before 1999 show a much higher impact of CAI on students’ learning than from 2000 to the present (Li & Ma, 2010), so careful consideration needs to be taken into account when reviewing CAI research. Many research studies try to corroborate work done when computers were a novelty, slow, and physically cumbersome, possibly leading to antiquated theories for CAI today. At one time computers were considered technology, but now, for many, computers are transparent tools
in the educational process. As computers become more prevalent in education, the Hawthorne Effect should become non-existent over time. Future studies should focus on the impact of CAI with regard to applications and software (Chaung and Chen, 2009) rather than on computer usage. Additionally, more research should be conducted to determine if traditional learning theories are indeed transferable to CAI (Chalmers, 2003) and to determine the impact of age, educational level, and duration of use on CAI.

Whether or not research demonstrates CAI to raise mathematics achievement for students, educational institutions are moving towards CAI as an alternative to teacher directed instruction. Rural communities’ inability to attract and retain highly qualified mathematics teachers leaves schools no choice but to pursue CAI to meet the needs of their students and state and federal mandates. For these educational institutions, CAI is not being examined so much as a way to improve mathematics learning, but as a means provide equitable learning opportunities for students.

Chapter IV - Recommendations and Conclusion

Recommendation

As of 2009, the percent of rural students in the United States was 20.2% and these students resided in one-third of our nations’ schools; this was a 22% increase over the last nine years with the growth expected to surpass the growth rate in non-rural communities (Rural School and Community Trust, 2012).

Education must find a way to accommodate students in these rural communities. Computer-assisted instruction appears to be a reasonable and cost effective way to provide algebra students, as well as others, with a quality education. Caution must be taken though, because “simply handing a computer to an unmotivated learner or hungry child from a broken
home will do nothing for her intellect” (Pullman, 2011). Providing ample professional development, a teacher willing to learn and work with students, and up-to-date technology are factors that influence the success of students in rural schools learning using CAI (Alliance for Excellent Education, 2010). These can seem insurmountable given budget restrictions, but considering students must have a solid foundation in algebra (NCLB, 2002) to move onto higher level mathematics courses, and that one in four rural children do not graduate, schools must do what is necessary to make their students successful in today’s global economy.

**Areas for Further Research**

Little research has been done to determine if CAI alone has had an impact on academic achievement of algebra in rural schools and much research pertaining to CAI is based on older studies, not taking into account the rapid progression of technology. Since many rural schools in Michigan are transitioning to CAI, because of need difficulties in recruiting and retaining highly qualified teachers and financial reasons, research needs to be carried out to specifically target students taking algebra and other math courses using CAI. This research should target rural students and non-rural students using CAI as the sole means of content delivery. Changes in should be educationally sound, not made because of necessity alone.

**Summary and Conclusion**

Michigan has many academic challenges facing it in the next decade. In the United States, Michigan ranks third in the area of underperforming students compared to the diversity of the states’ population and a disproportionate number of students in urban settings (Rural School and Community Trust, 2012) overshadows its large rural population. This leaves rural students’ needs underserved the state. One method suggested by research to help students and teachers meet these challenges is with computer-assisted instruction. Analysis of research studies suggest
that CAI may have a positive impact on students learning algebra in high school, but more importantly, it has been suggested by researchers that CAI does not appear to diminish the quality of a student’s education or comprehension of algebra concepts and it improve students’ attitudes about algebra. Educators need continue to transition CAI from a stand-alone platform to an integrated problem solving and analysis tool to help rural students meet the necessary goals to graduate from high school.
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