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The effects of computerized instruction in intermediate algebra

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THE EFFECTS OF COMPUTERIZED INSTRUCTION IN INTERMEDIATE ALGEBRA

by

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ABSTRACT

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by

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This study was designed to measure the effects of a reform oriented computer assisted instructional environment (R-CAI) on community college students' procedural skill acquisition and conceptual understanding. Also examined were the effects of a computerized instructional environment on students' attitudes toward mathematics.

The R-CAI involved the use of Prentice Hall's Interactive Mathematics with lessons created to provide opportunities for students to learn within "real world" contexts. Using these activities, students collected information, analyzed data and applied mathematical concepts.

After controlling for initial differences, it was concluded that students taught by the R-CAI environment significantly outperformed students taught by the Traditional Algebra (TA) instructional environment on the Conceptual Tests demonstrating their ability to apply the mathematics within a context. Additionally, the focus on applied

mathematical concepts yielded equivalent results on the Procedural Skill Test, hence, procedural skill was not sacrificed for the conceptual understanding gain. The R-CAI students still maintained the same level of procedural skill while surpassing the Traditional Algebra students in conceptual understanding.

Lastly, students' attitudes toward mathematics were measured at the beginning and end of the semester. Statistically, the students in the R-CAI environment reported a significant increase in mathematical confidence and a significant decrease in mathematical anxiety at the end of the semester as compared to their initial attitudes toward mathematics. The students in the TA environment yielded no significant difference in attitude toward mathematics.

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CHAPTER I

DESCRIPTION OF THE STUDY

The state of mathematics education needs to be reformed, in an effort to increase students' mathematical skill and conceptual understanding. *Everybody Counts,* a report from the National Research Council (NRC), noted that improved mathematical skills lead to opportunities in the workforce for those who are capable and are essential to science and technology (NRC, 1989). Unfortunately, most students leave school unprepared in the area of mathematics, thus rendering them less prepared for the workforce than students mastering important mathematical skills. Additionally, over 60% of the high school graduates who enter college are required to take high school equivalent courses for remediation of material they either "covered" in high school, but did not learn or simply never encountered (NRC, 1989).

Community colleges are assuming the responsibility of offering courses to prepare students that come from the K-12 setting and are not prepared for university level, transferable mathematics courses. Developmental courses in mathematics at the college level have been created to serve as remediation, stimulated by the need to prepare students for university level mathematics courses that are transferable. Transferable courses, generally, count toward a bachelor's degree requirement whereas developmental courses, generally, are not transferable, but in some cases count toward an associate's degree requirement. Community colleges tend to shoulder this responsibility of providing

developmental mathematics classes. Intermediate Algebra is one example of a developmental mathematics course taught at the college level, which corresponds to the traditional Algebra II sequence in a high school setting. The overall content is usually the same, but at the college level, the course is taught in one semester while the high school equivalent is taught in one academic year.

The demand for developmental mathematics courses is clear due to the lack of preparation for university level courses. This point is supported by the Third International Mathematics and Science Study (TIMSS), which states that the United States was one of the lowest scoring countries in relation to twenty other countries in general mathematics and fifteen countries in advanced mathematics (National Center for Education Statistics (NCES), 1996). Since a decline in students' mathematics scores beyond 8^{th} grade becomes even more apparent by 12^{th} grade, as reported in TIMSS (NCES, 1996), it is clear that the facilitation of students' learning of Intermediate Algebra at the community college level is essential. This has serious implications for those who progress through traditional K-12 education and realize, in their adult lives, they are in need of remediation or more mathematics. Therefore, it is crucial that new methods emerge to meet the demand for mathematics skills and help create opportunities for our students.

In response to the increased demand for mathematics before calculus in colleges, the American Mathematical Association of Two-Year Colleges (AMATYC) published the Crossroads in Mathematics: Standards for Introductory College Mathematics Before Calculus. This publication lists four major goals: 1) to improve mathematics education at two-year colleges and at the lower division level of four-year colleges and universities, 2) to encourage students to study mathematics, 3) to provide environments where students

are active learners in worthwhile mathematical tasks, and 4) to challenge students, but at the same time foster positive attitudes and build confidence in their abilities to learn and use mathematics (AMATYC, 1995). Faculty will need tools to reach the goals that AMATYC advocates and to help their students think critically, learn how to learn, and motivate them to study mathematics in appreciation of its power and usefulness. AMATYC promotes the use of technology as an essential component to a current curriculum and charges faculty to use dynamic computer software and appropriate technology to aid students in learning mathematical concepts. According to AMATYC (1995), "Students will use appropriate technology to enhance their mathematical thinking and understanding to solve mathematical problems and judge the reasonableness of their results" (p. 11).

Computers in the classrooms may be useful tools to assist teachers in meeting the needs of their students, addressing the goals of AMATYC, and preparing students for the demands of the labor market. With the expanding role of computers in today's society, learning about and working with computers have been considered necessary and basic mathematical skills that should receive increased attention in education (Gressard & Lyod, 1987). Therefore, emphasis should be placed on the use of high quality flexible tools that enhance learning and conceptual understanding to prepare students for problems they may encounter in future work.

This point is well documented by the U.S. Department of Education (1998) that states, "By the year 2000, 60 percent of the new jobs in America will require advanced technological skills." Additionally, the Secretary's Commission on Achieving Necessary Skills (SCANS, 1991) indicates that those who are unable to use technology will face a

lifetime of menial work. In response to this concern, the President's Educational Technology Initiative (1996) supports the plan to incorporate technology into the classroom and to prepare students for the world of work and life in the community. This plan is consistent with the missions of two-year colleges. Educators, including those in two-year colleges, are charged with this responsibility. The two-year college mathematics curriculum must be appropriate for the world of a global information age economy. Technology will enhance the preparation of our students in an era of faxes, electronic mail, teleconferencing, and computers. It is, therefore, the obligation of mathematics educators to consider these issues seriously and to research potential ways of using technology to promote necessary mathematical and technical skills with students at the community college level.

In order to facilitate learning with under-prepared students entering a community college setting requiring developmental mathematical skills it is important to consider several factors. These factors include the adult learner, situated learning, computer assisted instruction, and attitude toward mathematics. Due to the complexity of mathematics education in community colleges, these four factors are explored further in the following sections, in an effort to provide an understanding of the issue.

Adult Learner

It is important to note that the students at the community college level are adult learners. As such, community college educators may need to foster their learning through alternative methods and recognize the characteristics of their learners. According to Knowles (1990), adults see themselves as self-directing and want others to view them in the same way. To design an environment that is conducive to the adult learner: (1)

experiences need to be structured carefully to stimulate open dialogue, exchange of ideas, and respect for the heterogeneity of the group; (2) teachers need to be facilitators or resources to learners; (3) content should be based on real-world scenarios "telling like it is, not how it should be"; (4) target audiences should be included in planning learning experiences; (5) self-evaluation components need to be incorporated into experiences rather than solely relying on instructor directed evaluation; and (6) "talking down" to the audience must be avoided.

Adults tend to be problem-centered in their orientation to learning (Cross, 1981; Knowles, 1990). For example, when adult students face career changes or choose careers for the first time, they may want to consider all of their options. Is it worthwhile to them to work toward a bachelor's degree to become a teacher, but earn far less money than a paramedic that requires an associate of arts degree? This is an example of a real life scenario for some students, and a wonderful opportunity to create a dialogue about all of the important variables especially as they apply to mathematics. This could be molded to the interests of the students in the class and initiate the problem solving skills necessary to solve many other real world scenarios for themselves. The teacher acts only as a facilitator by bringing in the appropriate resources such as a school district pay schedule, benefits, day and hours worked per year, etc. and the same information about the paramedic and/or any other professions the students in that particular class may be considering. The students would have the opportunity to decide what information may be important for their mathematical model, analyze their data, and generate graphs to display the information in a visual format. Ultimately, there is no right answer. The students would have to decide and make their best case for which career they should choose. In a

traditional mathematics class, the focus is on discrete skills, which does not give adult students an opportunity to develop their desire to be problem-centered in their learning. The ability to apply mathematical skills to real problems that students face in their lives will bring their problem-centered focus to fruition. This is the common bond between adult learners and situated learning. Adults are motivated by a purpose for learning and situated learning provides one.

Situated Learning

Proponents of situated learning suggest that meaningful learning will occur only if it is embedded in the social and physical context within which it will be used (Brown, Collins, & Diguid, 1989; McLellan, 1996; Lave & Wenger, 1991). The learning environment should be situated in a "real world" context. The definition of "real world" would include tasks that are not isolated, but rather parts of a larger context (Brown et al., 1989; Lave, 1984). In this learning environment, students are not asked to solve word problems from the text, but rather to investigate projects that capture a larger context in which the problem is relevant (Bednar, Cunningham, Duffy, and Perry, 1992). The context does not have to be from the "real world" of work for it to be authentic; rather the authenticity arises from engaging in tasks that require the use of authentic tools to that domain (Brown, et al., 1989). The computer is an authentic tool to the application of mathematics.

The availability of computers in the classroom provides tools to support the development of situated learning (Von Glasersfeld, 1995; Jonassen, 1991; Lebow, 1993). Examples of how computers, in a mathematics classroom, lend themselves to situated learning include instant access to the Internet to collect real world data, immediate data

manipulation to generate tables, graphs and numerical responses, which all led to mathematics in a situated context. With the enrichment of these tools, computers free students from cumbersome manipulations, and enable them to spend time in class discussing the output and analyzing the outcome within a real world context. Ultimately, computers have the ability to enhance the situated learning context and foster the development of adult learners who are problem-centered in their learning. Additionally, integrating computers into the mathematics curriculum exposes students to skills beyond the mathematics. Students gain the opportunity to develop their keyboarding skills, improve their ability to maneuver through the Internet, experience telecommunications, and gain exposure to the computer that they would not have in a traditional classroom setting. In addition to the development of these skills, traditional Computer-Assisted Instruction (CAI) historically has fostered the development of procedural skills in the particular content area.

Computer Assisted Instruction

Among the earliest applications of computer technology within the field of education were systems designed to automate certain forms of tutorial learning. Such systems, first deployed on an experimental basis during the 1960s, commonly are referred to as Computer-Assisted Instruction (CAI). Computer Assisted Instruction may be an appropriate response to this charge for the integration of technology and educational software, but in its traditional form lacks the pedagogical /andragogical concerns of situated learning and the adult learner. Traditionally, CAI has been designed to teach by providing information or demonstrations of procedures and then requiring the student to practice in a reinforced environment where the sequence is determined by the system. In a

classical CAI application, short blocks of instructional material are presented to an individual student, interspersed with questions designed to test that student's comprehension of specific elements of the material. Questions posed are answered with either multiple-choice, or in such a way as to admit a simple, concrete answer (such as a numerical quantity) that can be interpreted by the system in a straightforward manner. Feedback is generally provided to the student as to the accuracy of his or her responses to individual questions, and often as to the degree of mastery demonstrated within a given content area.

Systems typically allow students at least some degree of control over the pace of instruction. Such systems generally also support "branched" structures, in which the student's performance on one question, or degree of mastery of one content area, determines the sequence, and in some cases, the level of difficulty, of the instructional material and questions that follow. Additional time can then be spent on material with which the student is having difficulty, while avoiding needless repetition of subject matter that has already been mastered.

More "intelligent" CAI systems may be capable of inferring a more detailed picture of what the student does and does not yet understand, and of actively helping to diagnose and "debug" the student's misapprehensions and erroneous conceptual models. If students are having difficulty learning to subtract, for example, the computer may recognize that they are systematically failing to "borrow a one," making it possible to offer specific coaching rather than a simple repetition of the original instructional material.

Conventional CAI systems have historically been in use primarily for individual

instruction in isolated basic skills, most often in a "drill-and-practice" mode. Instructional sessions generally have focused on a single content area rather than on the integration of a wide range of skills to solve complex problems. Recent computer-based tutorial systems provide a more integrated approach, which may prove useful within a situated learning framework. CAI systems in use today increasingly include reform elements that for the purpose of this study will be referred to as Reform CAI (R-CAI).

R-CAI surpasses traditional CAI by augmenting the tutorial-based system with the inclusion of exploratory activities promoting the development of situated learning. R-CAI systems are designed with multimedia intended to facilitate student learning by providing greater student control and involvement than the traditional CAI programs have in the past. Additionally, R-CAI provides the context for student discovery and/or guided discovery.

For adult learners, one of the greatest strengths of R-CAI is the capacity of the technology to accommodate their desires and enable them to become self-directed (Caffarella, 1993), allowing the students to initiate, plan, manage, and become problem-centered in their own learning. Uniting the strengths of classical CAI, established to enable the learners to have control over pace and timing, with R-CAI, considered to build conceptual understanding through contextual problem situations, may maintain the adult learners' interest and be an effective tool to implement into community college Intermediate Algebra.

Attitude

Caffarella (1993) and Summers (1985) support the use of CAI in reformed ways with adult learners by acknowledging that Computer Assisted Instruction creates an

intrinsically motivating environment generating a powerful tool for adult learners. In a pilot test conducted by this researcher using Prentice Hall Interactive Mathematics software, an instructor made the following comment supporting the use of R-CAI, "The Beta test with Introductory Algebra has taught me that students don't need a lecture presentation to learn and actually seemed to enjoy the class much more without it." Enhancing instruction with R-CAI facilitates a milieu customized to the needs of individual students, which is responsive to adult learners' backgrounds and fosters the development of conceptual understanding. Utilizing contextual situations integrated with a tailored instructional environment, students have the opportunity to explore the mathematics and gain an appreciation of its usefulness.

When investigating the effects of a computerized mathematical environment on adult learners, it is also important to address students' attitudes. Since student attitudes have important implications for student learning (Bohlin, 1993), attitudes will be one of the focuses of this study, in addition to procedural skill development and conceptual understanding. If computers enhance students' motivation to learn, this increased motivation to achieve could transfer into a greater desire to pursue mathematics and possibly progress to higher levels of mathematics.

Description of the Software

The program used in this study was Prentice Hall's Interactive Mathematics (Prentice Hall, 1997). One of the advantages of this program is its flexibility to allow teachers to choose their desired teaching style, specifically, a traditional Computer Assisted Instruction environment with a procedural skill emphasis or a reform oriented CAI framework stressing conceptual understanding. The use of the software, Prentice

Hall's Interactive Mathematics (1997), for the dynamic presentation of tabular, graphical, and symbolic mathematical representations and the development of conceptual activities may be an appropriate vehicle to aid in adult students' learning of mathematical concepts. Additionally, this program incorporates the use of electronic mail, internal communications (similar to electronic mail but within the confines of the class), spreadsheets, graphing tools, and scientific calculators, which may foster the development of important auxiliary skills by means of available technologies in the workforce today. Therefore, this software supports situated learning in various mathematical contexts, tends to the needs of adult learners, and supplements skills that are necessary in the workforce today.

The program Prentice Hall's Interactive Mathematics is designed around a text format, which includes chapters that contain sections supported by two to five objectives. The program integrates objectives with a problem-centered element. The objectives cover the discrete skill and segmented information while the problem-centered situations are activities that encompass several of the sections covered in a chapter. The problem-centered situations are conceptual in nature and are designed around "real world" contexts. For example, "Snow, Skill, and Speed" is a Real World Activity (RWA) that covers several concepts such as slope, rate of change, equations of a line, and graphing sections in the chapter on graphing linear equations. The students are guided to collect "real world" information; in this case, statistics from downhill skiing at the 1998 Winter Olympic Games. From the data collected, students construct equations, apply skills covered from the current or preceding chapters, and demonstrate their understanding of the concepts through written exercises that require comparing, contrasting, and analyzing

skills. (The Real World Activities may be further explored through the Web address: http://cw.prenhall.com/interactive_math2/chapter1/deluxe.html.)

When exploring concepts the facilitator gains insight into the interests of the learner, which enables the instructor to design instruction around the adult learners' desires. Additionally, with the assistance of the software such as the one described the instructor gains physical freedom to move around the classroom to work with students individually more freely than in a traditional lecture based classroom. In a traditional lecture based classroom, all eyes are on the instructor and time does not permit the instructor to stop and work with students individually. To support this argument, another instructor involved in the pilot test using Prentice Hall's Interactive Mathematics software said the following, "This is one of the things I love about Interactive Math, each day I talk to each of my students . . . It certainly makes it easier to "teach" them. (Yeah, I know, facilitate their learning.)." The computer-based environment frees up the instructor to work with students individually and respond to their specific needs and interests. While one group of students is working on a particular problem on the computer, the instructor can be working with a group or individual discussing another concept.

Technology not only allows the students and teachers more freedom to work together, but it also enables them to spend less time on redundant tasks and allows more time to spend with exploration of the concepts. For instance, rather than spending time on cumbersome point plotting of one polynomial, technology leads to exploration of several polynomials and patterns and relationships between them. From this situation, a dialogue can be created about the applications of various types of polynomials and how they may model real world scenarios, which motivates students to learn and build the skill while

gaining conceptual understanding of the problem in a more holistic manner. Burrill (1999) recognizes this argument that technology aids in the full development of a concept by moving freely among tables, graphs, and symbols, which helps to develop the underlying relationships. Without technology, these features generally are taught as separate entities. R-CAI environments, such as the one described, may be appropriate vehicles to prepare students for the workforce in the 21st century and improve the state of mathematics education in the United States.

Statement of the Problem

In order to improve the state of mathematics education in the United States, AMATYC (1995) and NCTM (2000) have called for major reform. Recommendations have been made to decrease the focus on procedural skills in discrete settings and increase the emphasis on higher order thinking skills (NCTM, 1989; NCTM, 1991; AMATYC, 1995). Calls for reform need to become standard operation in the classroom for the goals of these national organizations to become successful. Unfortunately, teachers claiming to be using practices recommended by NCTM were studied by the U.S. Department of Education, and it was found that the American high school teachers involved in the study still largely drilled their students on low-level procedures focusing on textbook questions (Olson, 1999).

The standards in mathematics education have stimulated the reform movement, but the research to support alternative methods needs strengthening, specifically at the community college level. The weight of the research will contribute to the body of knowledge, but it may also influence the practitioners to heed the calls for reform. The teaching tools and methods used by community college mathematics instructors need to

receive attention as researchers investigate plausible ways to meet these standards so that community college mathematics instructors will embrace the reform. At this time, many mathematics educators believe that these standards do not apply to them. One of the major concerns is time in the classroom. Finding time to cover the curriculum and integrate various teaching methods may seem overwhelming and sometimes impossible to many practitioners. In addition to time constraints, educators are concerned with the lackluster performance of American students on standardized tests. Since American students demonstrate poor mathematical ability on standardized tests, many mathematics educators believe that the NCTM and AMATYC standards are the culprits and thus ineffective measures to implement in the classroom. However, Schoenfeld (1988) discovered that the standards were not the culprits. In fact, Schoenfeld (1988) found that teaching methods still focus on textbook questions encouraging the development of procedural knowledge. Thus, the emphasis has continued to be situated around procedural knowledge, which leads to calls for reform that are not being implemented properly or not at all. This situation must be rectified.

Knowles (1980) contributes to this argument specifically for the needs of adult learners by suggesting emphasis be placed on relating the material to the adult learners' lives and recognizing the importance of moving away from strictly using a textbook (Knowles, 1980). Knowles recommends building on the experience and knowledge that the adult learner brings to the classroom. Adult learners want to know why it is important for them to learn, and they want to know how it relates to them (Knowles, 1980); an environment that is created to challenge the traditional textbook format may not only add

to the skills of the student but may also be viewed as an additional motivating factor for an adult student.

In addition to the knowledge base about adult learners and mathematics education, situated learning research has been found to promote higher-order thinking (Jonassen, 1990). Hence, an environment that emphasizes application of the skills within various contexts, and exceeds symbolic manipulation would seem to be a sound investment in our students' future success. Additionally, several studies in the area of CAI have found the application of CAI with adult learners to be a superior supplementary teaching tool and a prime motivation for teaching basic skills (Buckley & Rauch, 1979; Caldwell, 1980). The Kulik, Kulik, & Schwab (1986) meta-analysis was conducted on 199 studies, but only 30 studies fell into the adult education category. Only three related specifically to mathematics education. Research is available indicating that computer based education usually has positive effects on learners (Kulik, Kulik, & Schwab, 1986), but there seems to be insufficient evidence for the adult learner.

Mathematics instructors remain unconvinced because insufficient research has been conducted that evaluates the impact of situated learning elements on students' thinking regarding the use of interactive multimedia programs (Herrington & Oliver, 1999), at the college level. Therefore, a computer-based curriculum, incorporating real world activities, may enhance the current textbook curriculum, especially with the adult learner. This study was conducted in an effort to bridge the gap between the national standards, research, and practice in the mathematics classroom. Furthermore, the study responds to a need to unite situated learning and computer applications to further support reform in two-year college mathematics.

Purpose of the Study

The purpose of this study was to determine and assess the effects of teaching developmental mathematics students through the use of R-CAI when compared to Traditional Algebra techniques. Three questions were generated to examine the influence of instructional methodology on the students': (1) conceptual understanding; (2) ability to manipulate symbols and/or procedural skills; and (3) attitude toward mathematics. The first question was designed to explore the students' conceptual knowledge through their ability to transfer knowledge. Transfer of knowledge is critical because it illustrates a students' ability to apply the mathematical skills to various contexts. The second question was designed to examine the question of competency with procedural skills, and to determine if a situated context within a R-CAI provides students with at least the same level of skills gained in traditional classes. The intent was to examine student achievement and provide evidence that R-CAI is a viable method of instruction for adult students in developmental levels of mathematics. The third question was designed to investigate the effect of instructional strategies in the affective domain. The affective domain is a sensitive issue for adult learners and can directly influence students' performance in mathematics (Bessant, 1995; Fennema, 1976). Specifically, mathematics anxiety, mathematics confidence, mathematics usefulness, and mathematics motivation were investigated.

The Research Questions

In an effort to gain a better understanding of students' development of conceptual knowledge, procedural skill, and attitude toward mathematics three questions were developed. These questions relate to the instructional method's influence on students. The

general hypothesis tested was: Students in a Reform oriented Computer Assisted Instruction (R-CAI) environment will develop a better conceptual understanding of Intermediate Algebra than that of their counterparts in a Traditional Algebra (TA) environment (a traditional lecture based environment without technology) while achieving at least the same level of competency in procedural skills (symbolic manipulation and algorithmic procedures). The question to be answered was, "Will the use of R-CAI in a community college, algebra classroom improve students' conceptual understanding?" This initial statement generated the three specific questions of the study, which are listed below.

Questions

1. Will there be a significant difference in conceptual understanding of Intermediate Algebra, as a result of the type of instruction received, taught by R-CAI or TA?
2. Will there be a significant difference in procedural skills, in Intermediate Algebra, as a result of the type of instruction received, taught by R-CAI or TA?
3. Will there be a significant difference in students' attitudes about mathematics, in Intermediate Algebra, as a result of the type of instruction received, taught by R-CAI or TA?

Definition of Terms

Reform - Computer Assisted Instruction (R-CAI) – Treatment Group

The treatment in the R-CAI environment emphasized conceptual understanding through the use of projects which required students to collect, analyze, and interpret data

from either the Internet or experiments conducted in groups. These projects are defined as Key Concepts Activities and Real World Activities.

The Key Concept Activities (KCA) are an integrated portion of the program which combine a variety of concepts from the textbook into one activity. The Key Concept Activities are various types of problems to which adult students may relate, and they engage the students in active learning. For example, students interested in careers in the health professions and those interested in how body weight is maintained by the Body Mass Index will benefit from an activity in Chapter 1, which covers Body Mass Index and the required energy to burn calories. "Mileage Roulette" is an activity that many people who drive may be able to relate to; it is based on whether the driver will have enough gas in the tank to get to the store and at what rate the driver will have to travel to get the optimal mileage per gallon. Chapter 3 appeals to students with a curiosity about biology based on the "Cricket Thermometer" activity, and Chapter 4 covers solving systems of equations brought together with the "Get Wired!" activity.

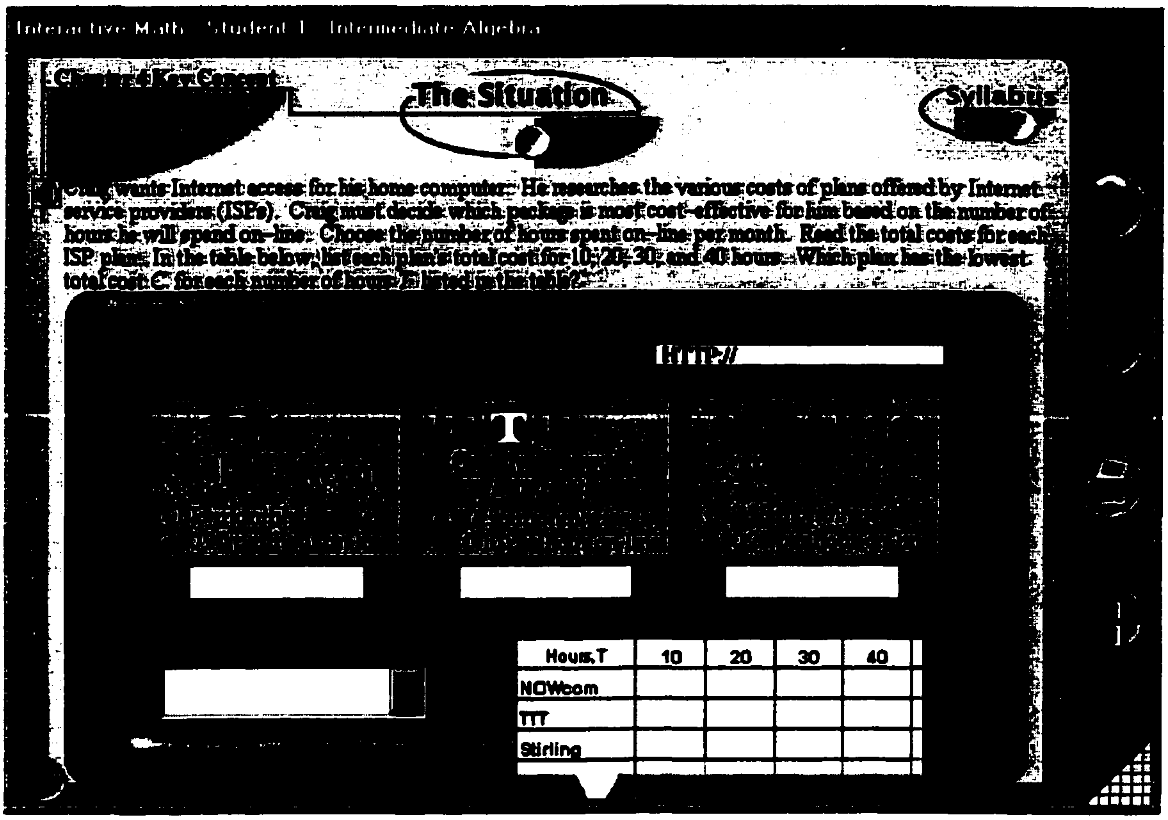


Figure 1. Chapter 4 KCA: The Situation

Through guided discovery, the students use the concepts in algebra within the context of real and thought-provoking tasks. Many of the activities have multiple solutions and are open-ended; requiring careful analysis of the results is crucial. Shown in figure 1 is an introduction screen to the Chapter 4 KCA. Figure 2 demonstrates the mathematical tasks the students are guided through.

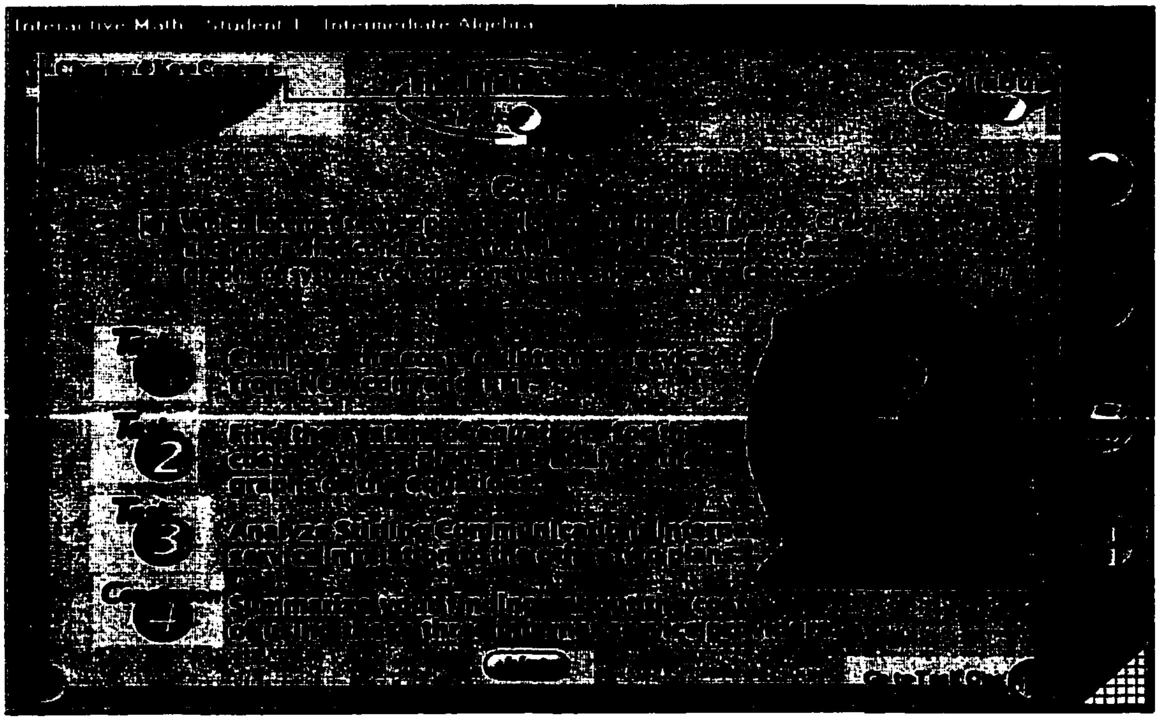


Figure 2. Chapter 4 KCA: The Plan

The Real World Activities (RWA) are selected through the computerized syllabus which connects the user directly to the Prentice Hall Web site. Students can access the activities and link to other Web sites from here. Figure 3 demonstrates a chapter activity where the student is guided through a real world scenario in which the students maneuver through Web sites to collect data and information to answer questions pertaining to real-world situations.

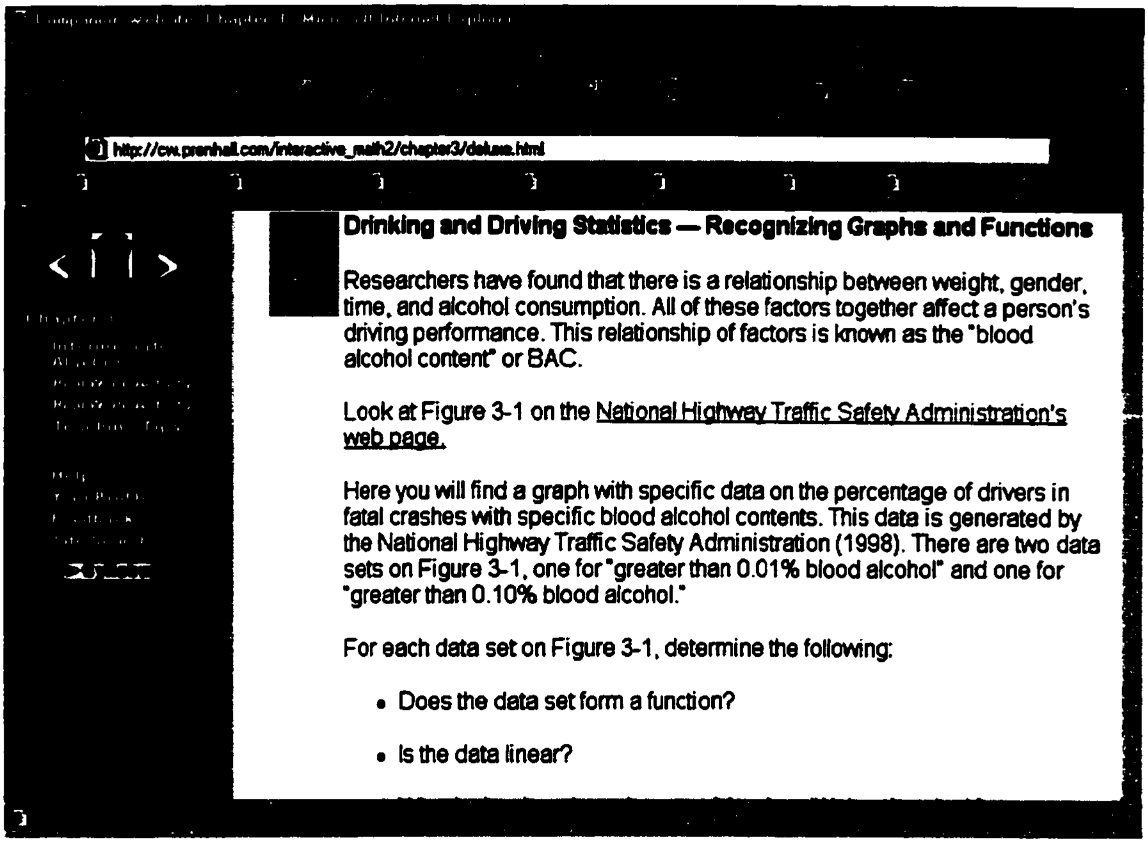


Figure 3. Chapter 3 RWA

The Real World Activities are within situational contexts, and they guide students through applications of mathematical skills. “Snow, Skill, and Speed”, as stated earlier, is an example of a real context where the data is collected from the actual 1998 Winter Olympics. Students are asked questions regarding the slope of the men's downhill in relation to the women's and are asked to calculate the slopes based on the information given. As illustrated in Figure 3, “Drinking and Driving” is another example of a RWA that guides the student through several questions that require the students to perform calculations, use formulas, and analyze data. RWAs are available for each chapter.

Within both of these activity structures, RWA and KCA, students were expected to make conjectures and justify their results through group discussion and/or written assignments. In the R-CAI environment, students had the opportunity to choose which projects they participated in and gauged which skills they needed to develop. In both the RWA and the KCA a link icon is available. If at anytime the students were unsure of how to solve or work a particular problem, they could click on the link button, which identified for them where they could locate these skills, for example, section numbers from the book and the corresponding objectives. The objectives could then be clicked on directly from the link button or alternatively they could be found in the computerized syllabus if students felt they needed instruction in a particular area or additional practice at any time.

The instructors, in the R-CAI group acted as facilitators of the learning environment. Direct instruction was minimal, 10 – 20% of class time, allowing for the majority of class time to be spent on projects with students working individually and in groups. Students in this group had the opportunity to interact with the computer, other students, and the instructor. The flexible structure allowed students to maneuver through the program at their own pace, but within the semester time constraint.

The objectives are designed around a textbook-based format corresponding to the days they are covered in class, illustrated in Figure 4. This is the computerized version of the syllabus that the students engaged in when entering into the software. Students double clicked on the corresponding day and that would open the folder, which contained the required work for that particular day.

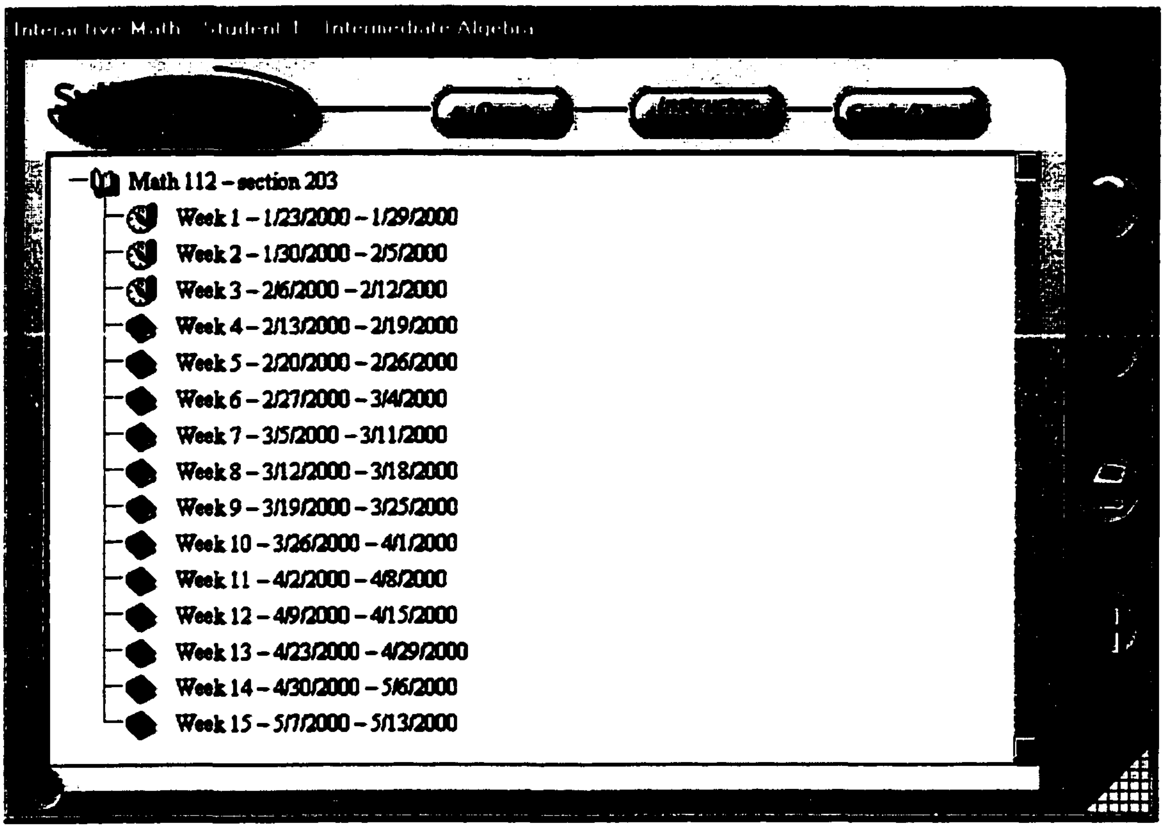


Figure 4. Computerized Course Syllabus

Figure 5 illustrates two sections from chapter 3, one example would be "3.5 Equations of the Line." The objective would be the subsection such as "3.5.1 Use the Slope-Intercept Form of an Equation." Once the students selected the particular day, the folder would then open to the objectives and or activities for that day. Then the students would double click or select "Open" while highlighting the listed items in the folder for the corresponding day.

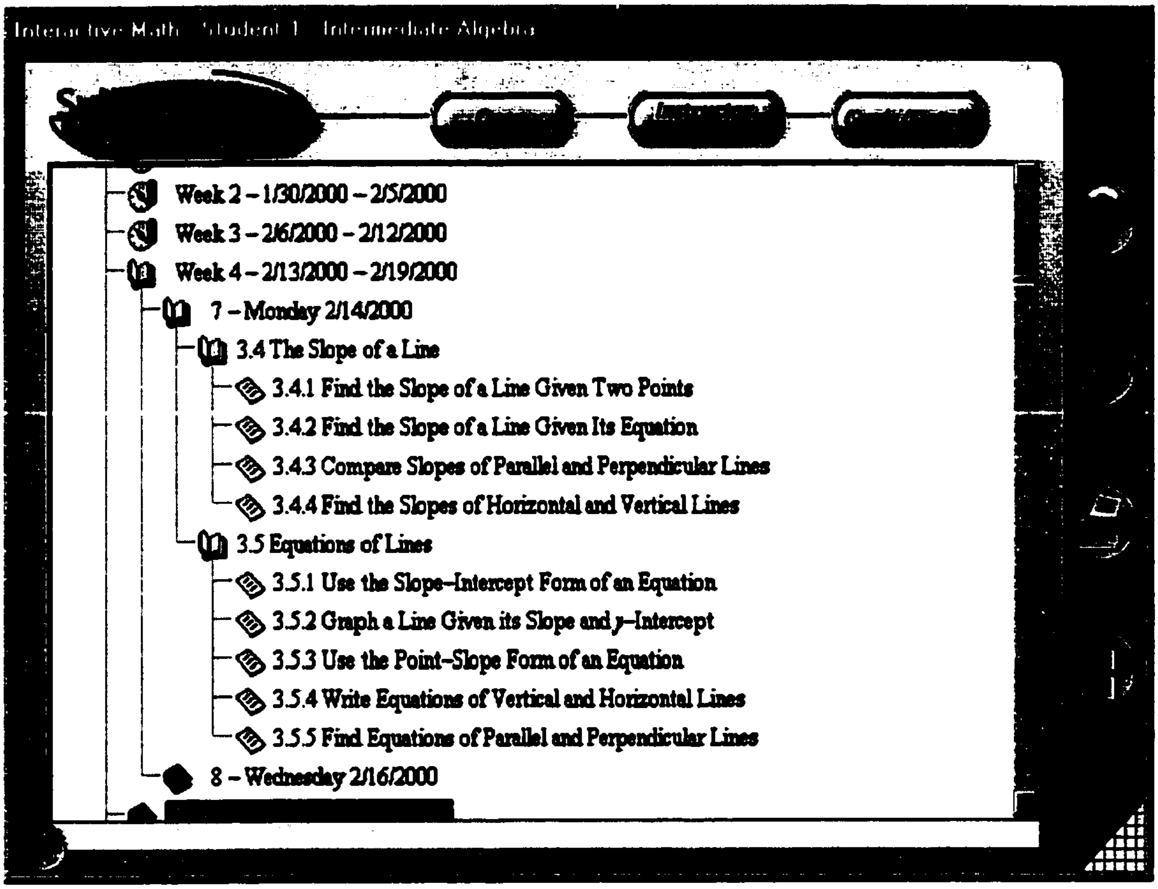


Figure 5. Chapter 3 Objectives

Within each of these objectives the students have the opportunity to select their preferred learning style from the introduction screen illustrated in Figure 6. In the treatment group, emphasis is placed on the projects and group activities, but the objectives are available to build the procedural skills necessary to complete the conceptual activities. Students in the objective environment may select from their desired learning style to read, watch, or explore.

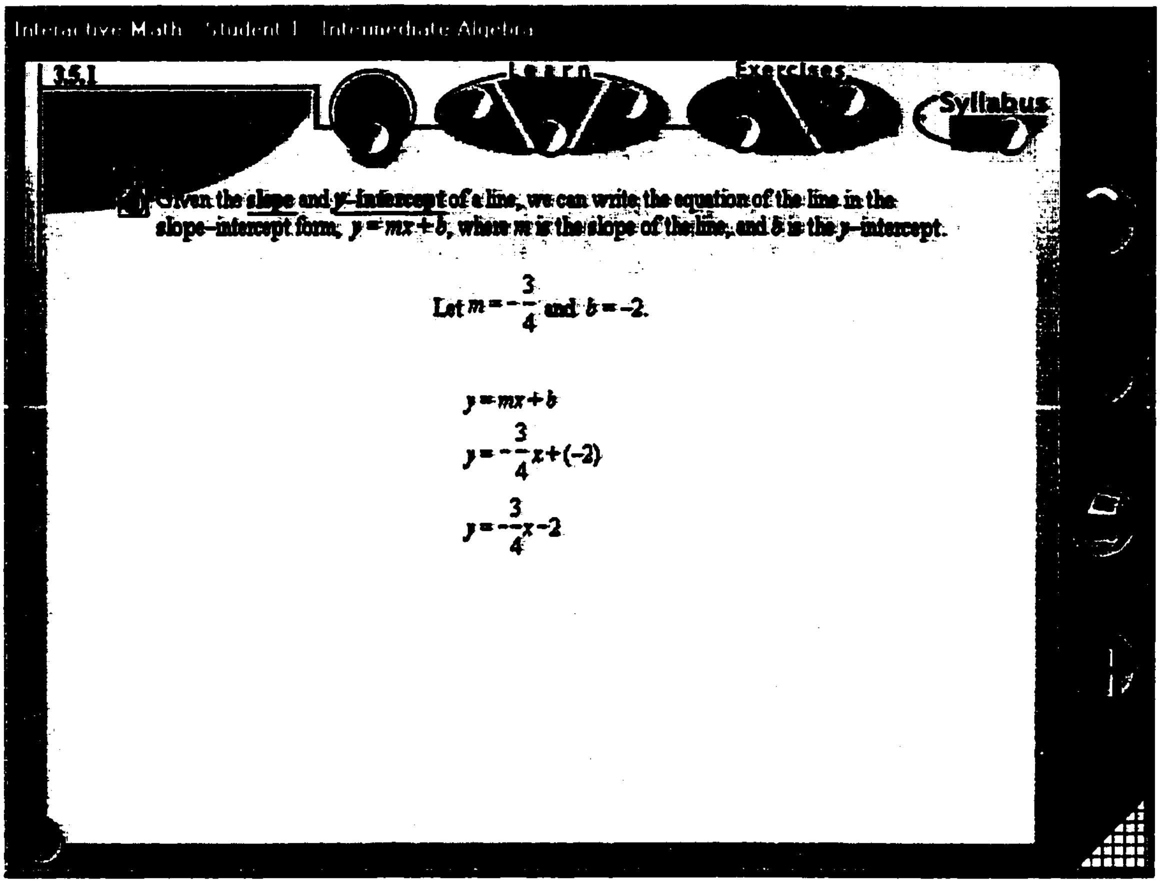


Figure 6. Objective 3.5.1: Introduction Screen

The students that chose the "read" section gained access to text material through the software which corresponded to the textbook (Figure 7), Intermediate Algebra by Elayn Martin-Gay. Key words or vocabulary were written in blue identifying links to glossary cards which defined these important words. Additionally, examples were given for students to follow, similar to a textbook presentation.

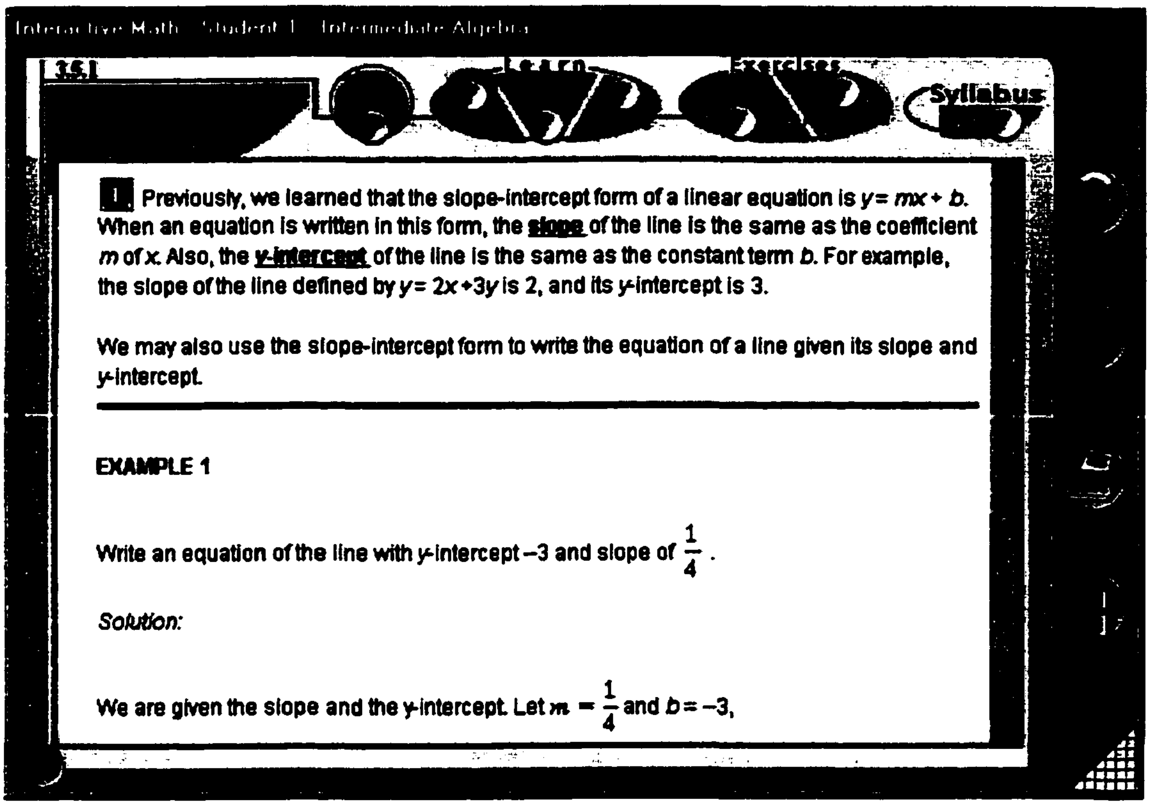


Figure 7. Objective 3.5.1 Read Screen

In the "watch" section, there are short video clips of the author demonstrating algorithmic steps that coincide with the content of the section covered in the book (Figure 8). Corresponding to the video clip was an audio clip with dialogue that students could hear with their headphones. The students were able to adjust the scroll bar at the bottom of the video to watch and hear the clip as many times as they deemed necessary.

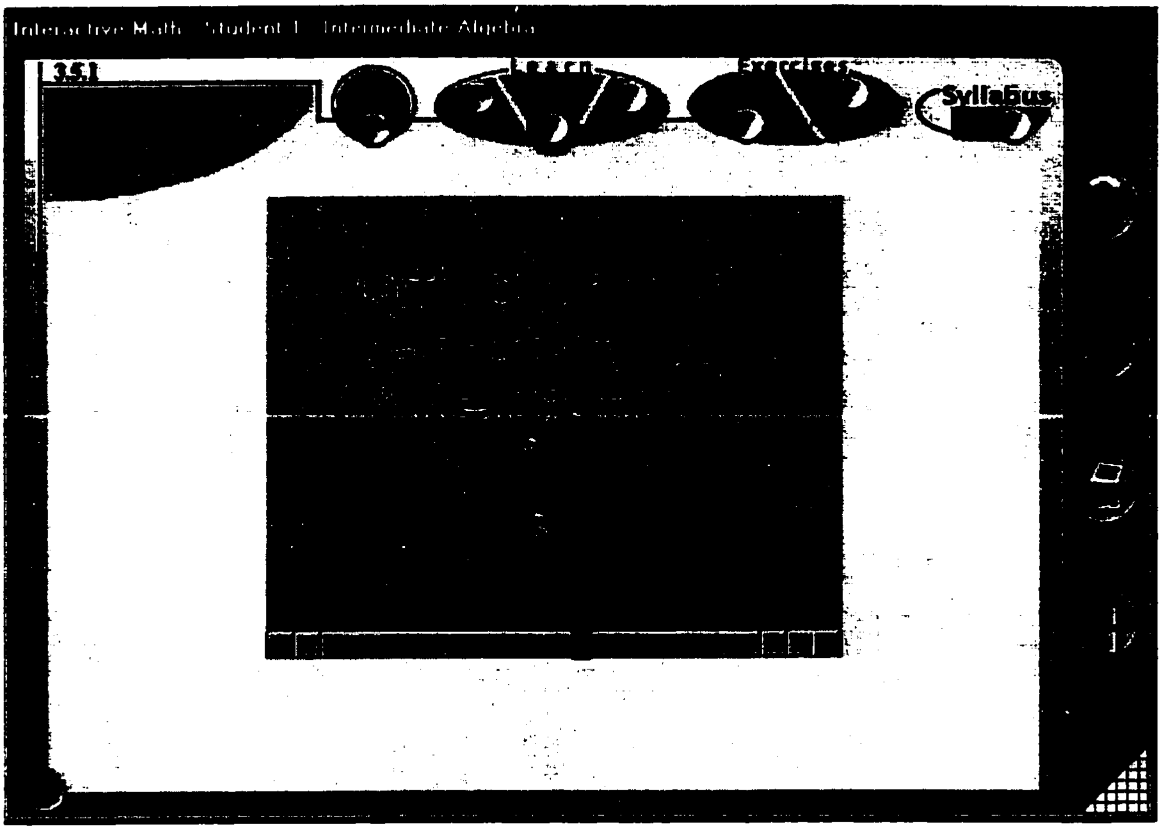


Figure 8. Objective 3.5.1 Watch Screen

Lastly, the "explore" section, allowed students to decide which problems to work, and involved them by clicking and dragging numbers and multiple-choice tasks (Figure 9). This screen is enhanced with an audio component for students that prefer to listen.

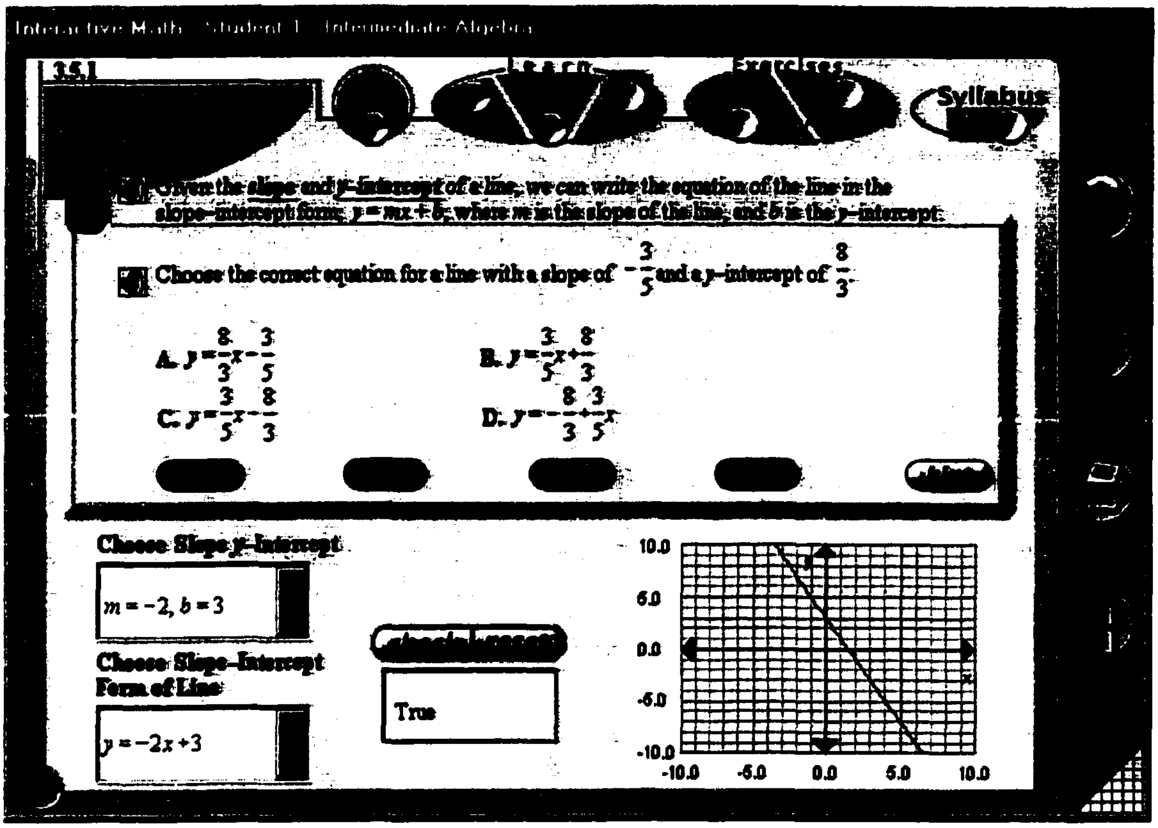


Figure 9. Objective 3.5.1 Explore Screen

Once students are prepared to try the procedural skill, they have the opportunity to practice and repeat similar types of problems that they went through in the read, watch and explore screens. They can practice until they are comfortable with the content in the objective sections. Figure 10 shows the type of screen that a student practicing the procedural skills experience for each objective.

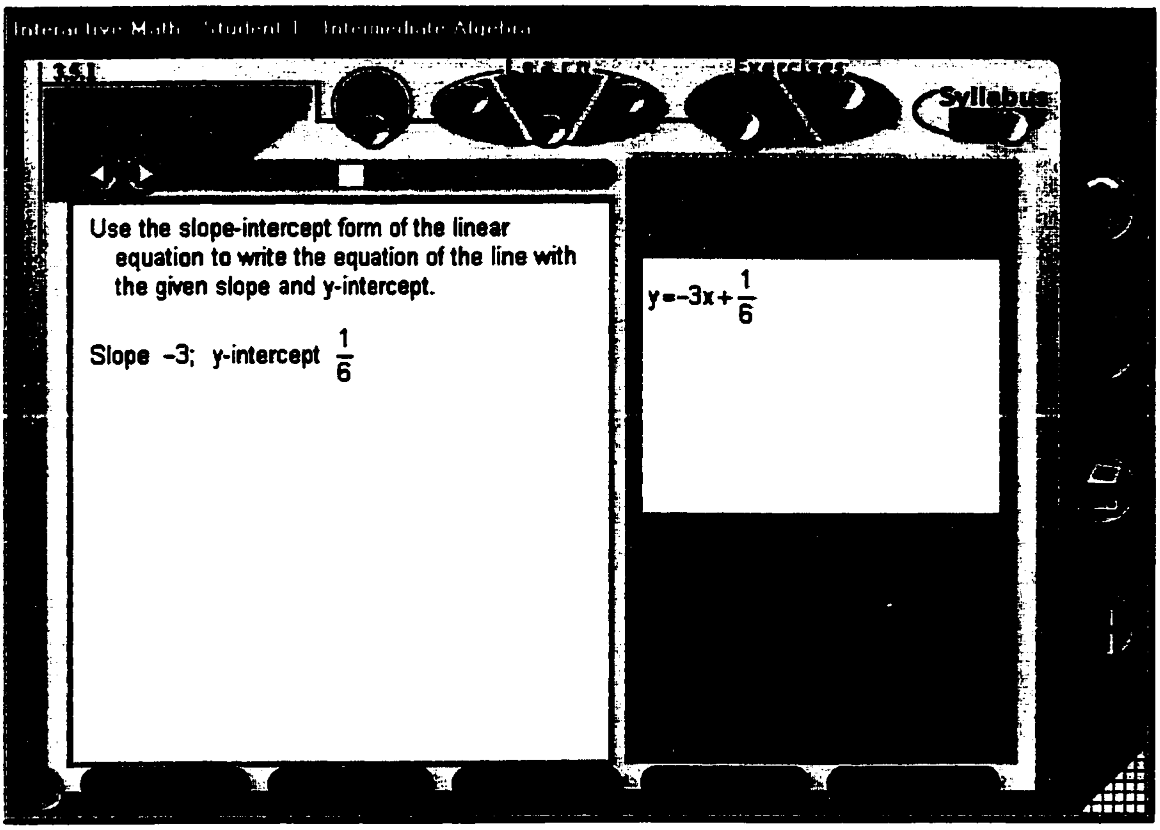


Figure 10. Objective 3.5.1 Practice Exercises

Once the students are comfortable with the procedural skills and are satisfied with the feedback that they have received, e.g. positive or negative, they can then go to the assessed exercises (Figure 11). The assessed exercises are scored through the program for the students' benefit, but the individual instructor can decide to weight these exercises into the students' overall grade. Each objective is supported by a set of assessed exercises. When students completed the exercises, they received a score based on the number correct. If they were satisfied with their score, they could continue on to the next object. If they were not satisfied with their score, they could select a new set and start again with a fresh slate. The highest score automatically replaced the lowest score.

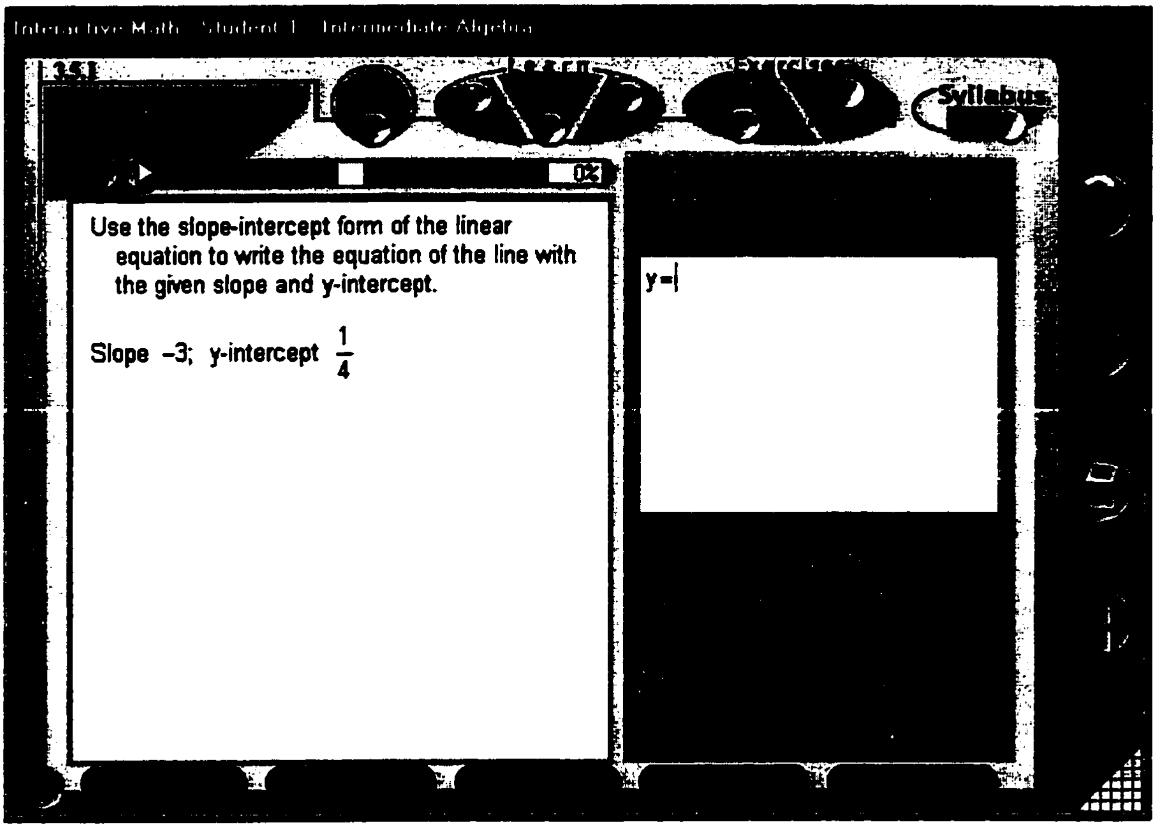


Figure 11. Objective 3.5.1 Assessed Exercises

Traditional Algebra (TA) - Control Group

The control group received traditional instruction, which consisted of textbook based lecture format following the same content as the treatment groups. The traditional group was established as a lecture only class. The instructors spent 20%-50% of class time responding to questions from the previous nights homework and other review questions. The instructors presented new material after students' questions were answered. This new material was presented entirely by the instructor with no student-to-student interaction. During class time there was no group work, no use of technology, no

practice time in class, and no handouts given other than a course outline. Discrete skills were emphasized and homework was assigned every meeting to reinforce the skills taught in class. The textbook used for the traditional classes was Intermediate Algebra by Bittenger, Ellenbogen & Johnson.

Organization of the Dissertation

This chapter included the statement of the problem and the research questions to be addressed in this study. Chapter II includes: (1) a background of computers in mathematics education, (2) the conceptual framework in which this study was framed, and (3) a literature review including the community college, relevant research regarding CAI in adult learning. The design and methodology are described in Chapter III. In Chapter IV, results of the quantitative analysis and limitations of the study are provided. A summary of the results, implications and recommendations for future research are presented in Chapter V.

CHAPTER II

LITERATURE REVIEW

Introduction

The purpose of this chapter is to review the relevant research that supports the theoretical background of the study. Four main components of this study are explored. First, the background of computer-based technologies that provides direction for the conceptual framework is examined. Second, the conceptual framework based on situated learning and Andragogy is investigated. Third, a background of community colleges is explored to explain the educational setting and lead to a deeper understanding of the adult learner. Fourth, relevant literature of studies conducted on CAI is reviewed. The areas that were examined were conceptual understanding, procedural skills achievement, and attitude toward mathematics.

Background

Educators have been exploring the use of computer-based technologies as instructional tools since the mid-20^{th} century. Skinner (1968) was one of the first proponents for what he termed "teaching machines" which became a reality in the 1960's. The teaching machine was intended to give complete instruction via the computer. It would act as a tutorial for the student to progress at their desired pace. The design was based on stimulus response. Students who produced a correct answer received reinforcement. The computer would reprimand students, who responded incorrectly.

Computerized instruction was focused on programmed instruction, which was behaviorally based with a concentration on required performance and immediate reinforcement (Cooper, 1993).

Similarly, traditional Computer-Assisted Instruction (CAI) is a method of instruction in which the computer provides drill and practice, or tutorials in a sequence determined by the software (Means, 1994). This system provides for expository learning where a particular procedure is displayed, and then practice for the student is provided. Students using this type of program are generally given immediate reinforcement during a practice session. The goal is to make the teachers' job easier and to make certain that all students are obtaining immediate feedback on their responses in an effort to diagnosis any deficiencies. The "teaching machine" was suppose to address these issues, however the state of mathematics education has not been improved since the advent of such technologies (Schoenfeld, 1988).

Part of the issue may be that traditional CAI is based on a behaviorist model. Several implications from behaviorism on traditional CAI include: (1) prompt reinforcement to encourage learning; (2) use of prompting to elicit a response; (3) evaluation based on response; (4) fragments material into small segments to develop specific skill for easier learning; (5) sequence material from easier to more difficult; and (6) self paced according to students proficiency with each level of the program (Cooper, 1993). Traditional CAI programs were seen as automated page turners where small chunks of material on single skills were reinforced and rewarded, yielding fragmented, low level skills development (Golub, 1983). Behaviorist principles were applied

computerized education in the 1960s due to the physical technology available, but also based on the theoretical understandings of education of that time.

In the late 1970s and early 1980s, Apple Computer, Inc. and IBM, Inc. introduce the small computers such as the Apple II series and the IBM PC which would be considered “desktop” computers today (Erickson & Vonk, 1994). Since the introduction of these computers, the use of a large variety of educational materials have become commonplace in many schools and colleges. During this time, new developments in human cognition were being realized, based on the initial conception of short- and long-term memory. The new cognitive perspective drives educational software development into new directions and gives rise to dynamic, interactive systems (Cooper, 1993). The need to encompass individual differences emerges stimulated an increased complexity in the technology required. However, as this paradigm shifts, technological advancements lead the way to instructional design within this new context. The new form of CAI generally has a branching mechanism to anticipate various responses from the learner. This is the main difference to the programmed instruction that is based on a linear format and isolated skills.

During the 1980s, mathematics education in the United States was in a state of continual transition. Schoenfeld (1992) describes the changes as 30 years of crisis in mathematics education. In the 1950s, the U.S. responded to Sputnik, “New Math” in the 1960s, and calls for reform beginning in the 1980s that created the background for the rapid technological gains in computer hardware and software. Therefore, there was pressure from all directions, national calls for reform, a historical need for advancement, and research supporting the individual differences of learners in the cognitive domain to

drive educational software in new directions with technological gains that could now support more advanced instructional design.

Additionally, in 1993, Cooper (1993) argued that the traditional CAI instructional design models did not support cognitively based activities such as the ability to capture the learner's response and preferred style of learning. Meanwhile, another shift in paradigms began to occur that resulted in the movement toward the constructivist perspective. Constructivism established the premise that learning is constructed by an individual's experience. It is problem solving centered, based on personal discovery. Most important to Constructivism, the learner needs a responsive environment in which consideration is given to the learner's style as an active, self-regulating, reflective learner (Seels, 1989). The goal of R-CAI is to develop relevant learning that facilitates knowledge construction by the learners. The typical CAI programs in current use are still founded on a behavioral view, however, the technology has developed in correspondence with the educational paradigms, thus the only limitations are in terms of the goals of the teachers and learners and not the designs.

In accordance with the changes in education and developments in human cognition, NCTM (2000) and AMATYC (1995) have recommended reforming traditional methods of instruction by de-emphasizing discrete procedural skills and emphasizing conceptual understanding. Based on this background and the calls for reform, this study has been framed on situated learning and andragogy to implement a Reform Computer Assisted Instruction (R-CAI) environment in a community college setting and to measure the effects of a curriculum focusing on a conceptual orientation in Intermediate Algebra.

Conceptual Framework

Rutledge (1997) describes situated learning as a contribution to constructivism. In Rutledge's depiction, situated learning has helped to shape constructivism. A slightly different perspective is to categorize situated learning as a branch or sub-component of constructivism. Situated learning, andragogy, cooperative learning, cognitive apprenticeship, and discovery learning are all examples of learning models that fall under the umbrella of constructivism. Cognitive research founded on a constructivist perspective encompasses each of these areas. Since constructivism is such a vast arena of cognitive research, this researcher has chosen to focus primarily on situated learning and andragogy. Figure 12 is a visual representation of a few of the learning models that are subcomponents of constructivism. Figure 12 is in not an exhaustive representation of all

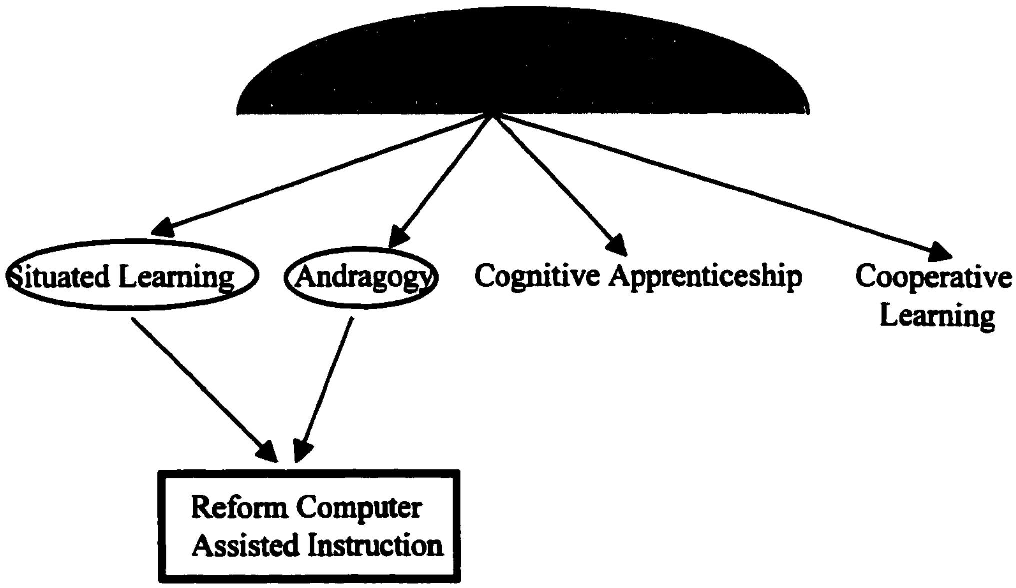


Figure 12. Examples of Learning Theories under the Constructivism Umbrella

the underlying learning models, but shows the learning models that have an impact on Reform Computer Assisted Instruction (R-CAI) and drive this study.

Situated learning and andragogy contribute to a conceptual framework that suits community college intermediate algebra students. These learning models provide a theoretical framework to organize the underlying premise of this study, which was designed to explore whether adult students taught in a computer environment with an emphasis on situated learning would result in conceptual understanding, build procedural skills, and improve student attitude toward mathematics. The two models used to guide this research had particular relevance to teaching mathematics at the community college level.

Figure 13 represents these two learning models influencing this study, acting on a computerized environment R-CAI, and the outcome variables that were measured; skill achievement, conceptual understanding, and attitude toward mathematics with intermediate algebra students at the community college level.

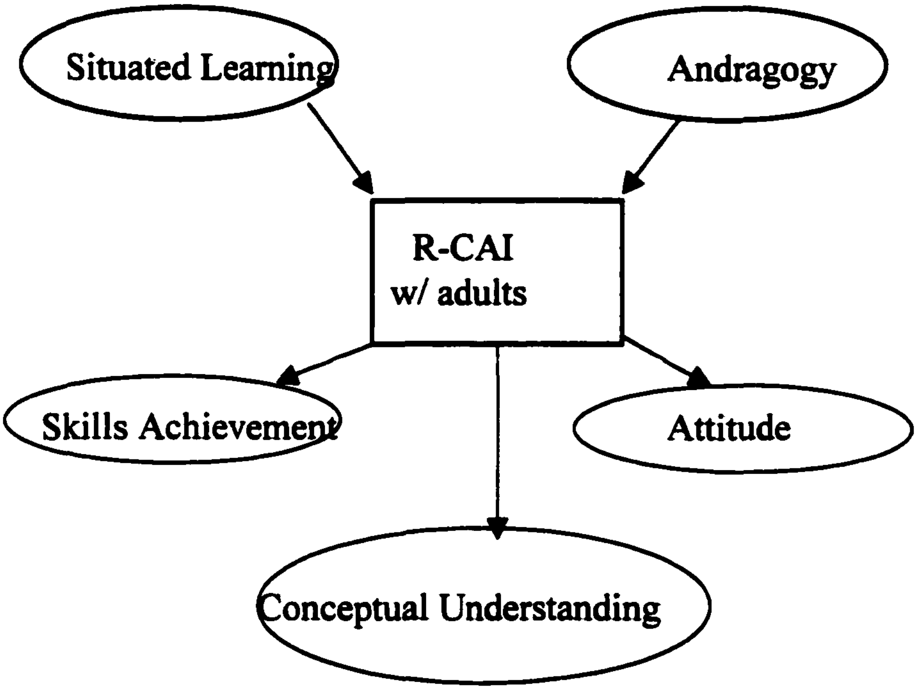


Figure 13. Reform Computer Assisted Instruction

Situated Learning

Situated learning calls for varied contexts, reflecting how knowledge is applied in everyday situations. Within this model of learning, knowledge and skill are attained through a situated context. Thus, according to this paradigm, learning is best situated in the social context similar to that in which the skills and knowledge will be used. Transfer of that knowledge is dependent upon the various contexts where the material has been applied and transformed to suit the educational setting. Traditionally taught discrete facts and concepts learned through memorization, lecture, and drill and practice, tend to fail to transfer to appropriate situations where the facts must be applied (Lave & Wenger, 1991; Rutledge, 1997). For example, if students learn correct rules for manipulating symbols

without learning what the particular mathematical expressions represent, students may not gain an understanding for the underlying concepts and relationships. Thus, what they learn is abstract, but not widely useable.

Whitehead (1929) distinguishes between the acquisition of inert concepts and the development of robust knowledge. It is common for students to memorize formulas and algorithms, but have no ability to apply the concepts. Therefore, the concepts lie inert. Just as one can buy weight equipment to workout, but if they do not know the appropriate exercises to use it, it will remain unused. Students may be able to manipulate algorithms, perform step-by-step routines, and apply definitions, but when encountered by a "real" application may have no idea how to apply the relevant discrete skills learned in a classroom setting appropriately. Therefore, it is clear, that the learning environment should be situated in a "real world" context, in an effort to enrich students' mathematical knowledge and ability to utilize their skills. Several researchers of situated learning suggest that meaningful learning only takes place when embedded in the social and physical context within which it will be used (Brown, Collins, & Diguid, 1989; McLellan, 1996; Lave & Wenger, 1991). However, the context does not have to be from the "real world" of work for it to be authentic, rather the authenticity arises from engaging in tasks that require the use of authentic tools to that domain (Brown, et al., 1989). The mathematical tasks, according to the NCTM (1989) and AMATYC (1995) standards, should be "authentic" tasks that are related to meaningful applications.

In the situated learning camp, authentic tasks are described as tasks that transfer to various contexts. Students that exhibit conceptual understanding have the ability to apply their knowledge to various situations and contexts (Lave, 1988). Lave (1988) found that

the importance of the situation or context in which learning is encountered is linked to the way that the learning will be used. Therefore, the tasks students are expected complete must require more than manipulation of symbols and rote memorization, otherwise, students may not be obtain conceptual understanding enabling them to transfer these skills to a "real world" context. Tasks should involve varying contexts to build the learners conceptual understanding enabling them to apply the tools they have gained to the appropriate situation (Jonassen, 1990).

Situated learning is also described as a sub-component of constructivism. Jonassen (1990) and Cooper (1993) argue that constructivism can be realized through the use of tools such as databases, hypermedia, expert systems, and simulations that model reality and allow the user to physically interact with the application. A perspective on constructivism is rooted in experience, stressing the importance of "real world" activities (Brown, Collins, & Duguid, 1989). This is the primary focus of situated learning and a major element of AMATYC (1995) and NCTM (1989) calls for reform. Students exposed to various applicable contexts for mathematics will be better able to apply that knowledge in the appropriate context.

To address this reform, research should shift its focus to designing an environment supported by the constructivist perspective with adult learners. Jonassen (1994) claims that learners construct their own knowledge within the learning environment, and a R-CAI curriculum such as the one used in this study, could be designed on the ideas of situated learning within constructivism. Several of the points made about situated learning are consistent with Andragogy, a model of adult learning. In addition to instruction situated in context, adult learners have complex issues and

concerns that must be addressed in a community college setting. Therefore, it is important to join together situated learning with Andragogy.

<u>Andragogy</u>

Andragogy, a model of adult learning, addresses the issues of adult learners. Andragogy is a model of assumptions, principles and strategies about adult learners and their learning (Knowles, 1984). Cross (1981) describes four key characteristics of adult learners: (1) The adult learner is self-directed; the self-concept of an adult shifts from dependence toward a self-directed view. Therefore, in the learning situation, for an adult, there is a mutual teacher-learner responsibility for evaluation needs, setting goals, formulating objectives, and evaluation; (2) An adult has a reservoir of life experience that may require the use of new methods and techniques for building on such experience. The shift from traditional techniques such as lectures and assigned reading to using action learning techniques of CAI, simulation, and project learning is more useful to the adult learner than discrete skill based instruction; (3) Adults' readiness to learn is almost always coincidental with their immediate developmental tasks in respect to role and responsibilities compared to the younger learner's indignation to relate learning to self-development and the discovery of personal identity; and (4) The orientation of learning differs with the adult; their desire to learn is directly related to immediate application of learning. Andragogy is a process model, which provides procedures, and resources for helping learners acquire information and skills (Knowles, 1990).

Knowles (1990) describes the necessity within Andragogy, adult learning model, for the context in which the material is to be learned to be real. The content must be applicable to the adult learner's life, thus putting the content into a real context is crucial

for the learner to understand why they must learn the material. In an adult learning setting, exploiting the adults' talents and experiences as resources for group and class discussion can accomplish this goal.

According to Knowles (1990), adults see themselves as self-directing and want others to view them in the same way. In order to design an environment that is conducive to the adult learner: (1) experiences need to be structured carefully to stimulate open dialogue, exchange of ideas, and respect for the heterogeneity of the group and its individuals; (2) teachers' need to be facilitators or resources to learners; (3) content should be based on real-world scenarios "telling it like it is, not how it should be"; (4) target audience should be included in planning learning experience; (5) self-evaluation components need to be incorporated into the experience rather than instructor directed evaluation; (6) "talking down" to the audience must be avoided. Adults tend to be problem-centered in their orientation to learning.

Hence, the teaching of adults requires different methods and approaches than those used with children (Knowles, 1990; Cross, 1991; Lenz, 1982; Lewis & Williams, 1994; Sutherland & Bonwell, 1996). To this end, educators must recognize that the teaching methods of adults are uniquely different from those used in the educational process of children and youths. The adult learner approaches the learning situation with a problem-centered focus (Knowles, 1990) and shifts from dependence to independence in their learning. Therefore, it is the duty of the teacher to facilitate self-direction among adult learners and set up an environment of respect that is conducive to learning. In a traditional classroom, students are considered passive while the professor professes knowledge. In the computerized classroom, students usually take on a new role. They

tend to become active participants in their learning. They are actively involved with the instruction and in the R-CAI classes they are also involved in projects that emphasize conceptual understanding. According to the research (Bonwell & Eison, 1991; Lewis & Williams, 1994; Sutherland & Bonwell, 1996) adults learn best in active, experience-based environments and are more likely to internalize, understand, and remember material learned through active engagement in the learning process. An application-based, problem centered curriculum may be a potential way to foster learning in adults.

Lenz (1982) describes adult students as learners that receive as much as the instructor provides and implies that there must be two-way communication for this to occur. Within this framework, Lenz (1982) describes a learning environment that requires the teacher to continually adapt and adjust teaching skills, plans and objectives to fit the students being taught. Furthermore, Odell and Moel (1989) offered this challenge:

> It is time to confront some of higher education's core values and customary behaviors. The pleas that teaching should be accorded as much recognition as research and publishing is hardly new, but now there is added a compelling reason to reorder these values. For at the heart of effective education for all student is good teaching - teaching that is both strong in substance and attuned to the character of the students it will address ... (p. ix)

This challenge reinforces the point that understanding students' characteristics is critical to good teaching and must be addressed. Therefore, an important element of Andragogy is to fully understand the characteristics of the adult learner.

Unlike high school or traditional-age college students, adults compose an extremely heterogeneous population who are at vastly different stages of life (Lea & Leibowitz 1992). Thus, it is important to understand the qualities of these learners. Their lives are complicated by family responsibilities, plus work and life experiences that color their attitudes, values, and decisions. Some may already have a great deal of experiential knowledge. Others may have drifted into their career and family situation with little planning or guidance, have difficulty making decisions, and lack awareness of their skills, abilities, and interests. While others may be self-directed learners who just need to be pointed in the right direction. Adults bring all of these varying experiences and background with them to the learning situation. Supporting this point, Knowles (1980) and Cross (1991) agree that in an adult educational environment, the influences of prior knowledge and experience greatly influence adults in the learning situation.

The set of experiences and knowledge that adults bring to the learning setting is diverse. Adults have led distinct lives that may not coincide with other students in that setting and in addition, are at varying levels of development. The varying stages of development of an adult are not clear-cut, but Cross (1991) synthesized several models and research about adult development and created a cohesive model to give educators insight into the developmental stages of adults. Cross (1991) indicates that several educators and counselors use this model to assist in understanding their adult learners. The model Cross developed has seven age-linked stages of adult development: (1) 18 - 22 is the leaving the home stage, (2) 23 - 28 is the moving into the adult world stage, (3) 29 - 34 is the searching for stability stage, (4) 37 - 42 is the reassessing personal priorities and becoming ones own person stage, (5) 45 - 55 is the settling down and gaining higher

levels of self -awareness stage, (6) 57 - 64 is the mellowing stage, and (7) 65+ is the life reviewing stage.

This chronological explanation of the development of an adult may help an educator to visualize the stages in some order. However, educators who have worked with adults may realize that people do not always fit into these orderly categories. In fact, personal situations and the social context the person may be in will take precedence over this age definition of adult development (Cross, 1991).

A supplement to the above model would be the model proposed by Loevinger (1976). This model is based in the concept of ego to create stages of development. Loevinger's model is clearly a closer explanation of students' level of development based on four main life phases that are not age specific. Loevinger explains that students that are at lower levels of development define education as a thing; something to be obtained. Students at the community college level regardless of age may never exit this stage of development. Students may be at this stage for various reasons such as parental pressure to go to school, peer pressure, and/or the social aspect, when in fact, they do not realize any value in the educational experience itself. Thus, there are several potential reasons an adult may be stagnate at a lower level of ego development.

The next level of ego development is considered the conformist stage. People at this stage view education as a necessity to acquire a good job translating it to its practical usefulness. Again, there are various reasons that a person would be at this stage, which is not age specific. For example, a student that has recently graduated from high school and has been told he/she can't get a decent job without a college education, a housewife returning to take care of her family after a bitter divorce, and/or a single mother realizes

she needs some job training to get a good job. These people could all be in different situations in their life and all various ages, yet they all may be at the same stage of development according to Loveinger's model.

At the conscious stage, individuals begin to see education as an experience that affects the inner self. One example of a person at this stage would be a retired person returning to school that does not have to return to work to make ends meet. This person may consider another career, but is looking for more in life. He/she may not yet be to the level of self-fulfillment, but close. Another example would be graduate students who are furthering their education possibly for advancement, but gain much more than they did as undergraduates.

Individuals at the autonomous stage view education as leading to self-fulfillment and an ongoing process. It is rare to find individuals in this stage of development. Generally, people who continue their education on to the doctoral level will be at this stage of development. However, if they are obtaining the degree only for professional advancement, then they may not have achieved this stage in their life yet. At the community college, it would be an exception to find a student at this stage, and many students who start at a two-year institution may never reach this level of development. The movement is from narrow stereotyped thinking to an awareness of multiple possibilities.

Penland (as cited in Cross, 1991) conducted a study with the largest and most representative sampling of American adults to date, classifying the types of learning tasks they were involved in. Seventy five percent of them were a part of learning that was practical which suggests that most adults begin a learning situation to answer some

question or to fulfill certain responsibilities. Typically, adults do not choose learning designed to achieve a liberal education. Learning for the sake of learning is inconsistent with the developmental stages of the adult that strongly suggests adults pursue a much more pragmatic education, they want to know what they need to know. Knowles (1978) identified this problem-centered orientation to learning in adults, and believed it to be an underlying assumption of the nature of the adult learner.

Understanding the various levels and/or stages of an adult learner may help educators to meet their needs. Many of the ideas of situated learning are designed to meet the concerns of students that are at the lower levels of Loevinger's model. The majority of community college students are going to be at these levels. Situated learning places the learning in an actual context that may relate to future uses in the workforce, requires an exploration of ideas, and some collaboration, which is consistent with Andragogy. This type of learning environment may address the age old question, "When am I ever going to use this?"

General Literature

The first part of this section includes an in-depth background of community colleges to led to an understanding of community colleges, which may shed additional light on the adult learner and their needs. The second part of this section leads into the research studies conducted using various forms of CAI with mathematics students.

Community College

In addition to the theories that frame this study, the setting is also an important to factor to consider. The background of the community college leads to an understanding of the underlying environment. The first published use of the term "community college"

(two-year college) was in 1936 when Byron Hollinshead proposed an agenda for making the community college more responsive to the needs of the community (cited in Witt, et al., 1994):

> That the junior college should be a community college, meeting community needs; that it should serve to promote a greater social and civic intelligence in the community; that it should provide opportunities for increased adult education; that it should provide educational, recreational, and vocational opportunities. . . (p 108)

From 1936 to the present the message is clear, community colleges have responded to the needs of the community and, on a greater scale, the nation. In the period 1939 to 1945, community colleges responded to the needs of the nation during the time of the Second World War. The Civilian Pilot Training Program, a defense effort, was located in community colleges around the nation (Witt, et. al., 1994). The colleges rushed to meet wartime needs. At the conclusion of World War II, the GI Bill of Rights was passed. For those who were not prepared to enter the university or for those who wanted career training, the best option was the community college. Therefore, several new colleges had to open their doors to meet the increased demand in higher education. Colleges also had to adjust to special needs of the veterans both academically as well as financially.

During the Cold War (1949-1958), the Soviet Union and the United States competed in technology and space exploration. This competition had a direct impact on education and profoundly impacted the development of the community colleges. Courses

were designed specifically to represent America as the defender of freedom and special programs to compete in the sciences were promoted.

After the Korean conflict ended, the Soviets launched Sputnik (Witt, et. al., 1994). A national effort to improve the U.S. science and technical fields was in full effect. The National Defense Education Act (NDEA) authorized $887 million in grants and loans to college students in the targeted areas, but most of this money went to four-year institutions (Witt, et. al., 1994). Consequently, community colleges had to fundraise for contributions. The majority of these contributions came from businesses and citizens that had not attended the college to which they contributed. They supported the community colleges with the intent that the role of the college was to prepare students for the community and the local business sector.

In addition to community colleges' responsiveness to the needs of the nation, community colleges have been in the forefront of new educational delivery methods. Pensacola Junior College in Florida was the first to use a nuclear reactor as a hands-on device in the learning process. Orange Coast College in California operated a push button lecture hall. The podium was equipped with a television screen, wireless microphone, electronic pointer, slide, filmstrip, tape recorder, and turntable. And, according to Erickson (1963) Chicago City Junior College offered what was likely the first distance education course by broadcast television in 1956. Educators from around the world came to Chicago to study this program.

By the 1960s, technology advanced quickly, and continued to advance even faster into the present day. Breakthroughs in automation, computers, and telecommunications

have changed the American workplace. Business and industry realized that continual change was essential to compete in this increasingly technologically advanced world.

Two-year colleges will also have to evolve as the technology required in the workplace progresses. The Secretary's Commission on Achieving Necessary Skill (SCANS, 1998) indicates the competencies that effective workers will need to be productive: 1) interpersonal skills; ability to work on teams, 2) information skills; acquiring and evaluating data, 3) resources; ability to allocate time and utilize necessary resources, and 4) technology; apply technology to specific tasks. These are workplace competencies that students will need to obtain, in addition to the foundation skills that SCANS (1998) recommends which include basic skills, thinking skills, and personal qualities. Educators will have to prepare their students to be flexible to the increasing pace of change influenced by the rapid development of new technologies.

Computer Assisted Instruction

Studies that focused on CAI were mainly conducted in the elementary grades. These studies did not specifically apply to this study in that the intent was to explore CAI in an adult setting. In Cotton's (1997) meta-analysis on CAI, of the 59 studies cited, five were at the post-secondary level, and none were post-secondary studies of mathematics. Computers in education is an exploding area of research, however, in mathematics at the community college level studies with this focus appear to be lacking. Much of the research that is available is peripheral to this study.

Procedural Skill Achievement

Several studies were designed to measure procedural skill gains with the use of CAI. Kulik (1994) supports this through a meta-analysis and confirms that the use of

educational technology for drill and practice of basic skills can be highly affective in the area of CAI. Students usually learn more rapidly. This is the case across all subject areas from preschool to higher education. Drill and practice have been the most common form of computerized instruction researched in education (Kosakowski,1998). Two main themes in computer instruction emerged; procedural skill achievement and attitudes toward mathematics in computerized courses versus traditional courses. Learning rate, motivation, and modality were also researched (Cassady, 1998), but were not as common in the studies.

Kulik, Kulik and Shwalb (1986) conducted a meta-analysis that reviewed twenty-four studies. These studies included only adults who were receiving credit or training for their jobs. This resulted in twenty-three studies reporting the results of the examination given at the end of instruction to measure effectiveness of computer-based education (CBE). CBE encompassed three types of computerized instruction: 1) CAI, defined by computer supported drill and practice or tutorial (18 of the studies); 2) Computer Managed Instruction (CMI), the computer evaluates test performance, guides students to appropriate resources, and keeps track of student progress (3 of the studies); 3) Computer- Enriched Instruction (CEI) the computer serves as a calculating tool, simulator, or programming device (2 of the studies). Nineteen of the studies found that the computerized classes outperformed the traditionally taught classes based on the average, but only eleven cases indicated a significant difference in performance. Additionally, it was found that students needed less instructional time when instruction was enhanced with CBE. Overall, this meta-analysis showed that CBE has positive effects on adult learners in terms of achievement on skills measures.

Chadwick (1997) also conducted a meta-analysis on CAI, but with secondary students. These meta-analysis findings are clear that overall, students achieved more with the CAI than in traditional classrooms. However, the trend in all of these studies was toward behaviorism and skills-based learning. Chadwick concluded that studies in the future will need to depart from the strictly behaviorist model and begin looking to the constructivist orientation. There were forty-eight studies combined in Chadwick and Burton's meta-analyses, which revealed a clear focus on the behavioral model. Several other studies have found the same theoretical orientation in instructional design with CAI. For example, Kulik and Kulik (1989) analyzed 254 studies in their meta-analysis that focused on results of the standardized skills examinations but failed to explore conceptual understanding or higher level thinking.

Burton (1995) and Moore (1993) conducted studies to measure the effects of CAI on adult basic education in mathematics and reading. In Burton's study, the theoretical framework was based on Skinner's reinforcement learning theory. According to this theory, for learning to occur the student must receive reinforcement and repetition which would be directly associated with the drill and practice forms of CAI. Burton's (1995) findings indicated that CAI students performed better in mathematics than the non-CAI students and demonstrated that computers are much more efficient in giving students immediate feedback. Several studies cite CAI as being more efficient and indicate that it may relate to students learning at faster rates (Burton, 1995; Kulik et al., 1986; Laffy & Helt, 1981, Moore, 1993). According to Moore's (1993) findings, students demonstrated a 1.5 year gain in mathematics skills in an 11 week period, however, Moore indicates that the use of computers should be an adjunct to teaching not a replacement. Cotton (1997)

also concludes that the best achievement outcomes are reached when CAI is use as a supplement to traditional instruction.

Conceptual Understanding

In the past decade, three studies strongly suggest that CAI and the need for a different approach leads to increased conceptual knowledge or understanding. Boers - van Oosterum's (1990) study can be rooted back from more recent studies attempting to focus on a conceptual orientation. Boers - van Oosterum (1990) found that high school students who were taught with a conceptual orientation were better able to apply their knowledge in new situations, as well as better able to interpret and read tables and graphs. O'Callaghan (1998) and Park and Travers (1996) specifically addressed the issues of the reform movement in mathematics and computer-based mathematics with adult learners. O'Callaghan's study promotes an alternative approach to measuring the effectiveness of CAI with adult learners. O'Callaghan refers to the control group as Traditional Algebra and the treatment, a computer class as Computer Intensive Algebra. The Computer Intensive Algebra curriculum is organized around the concepts of variable and function. Emphasis is placed on conceptual rather than procedural knowledge as the students become familiar with families of elementary functions (O'Callagan, 1998). The main thrust of the study was to explore the function concept and, more specifically, Computer Intensive Algebra students' versus Traditional Algebra students' ability to model real-world phenomena with functions; interpret equations, tables, and graphs; translate among different representations of functions; reify functions; and perform operations on algebraic formulas. The Computer Intensive Algebra students outperformed the Traditional Algebra students on all of the above measures with the exception of reifying.

Reifying is the creation of a mental object from what was initially perceived as a process or procedure. This mathematical object is then seen as a single entity that possesses certain properties and that can be operated on by other higher-level processes, such as families of functions that are ultimately the same function with various shifts and stretches applied.

Ultimately, this study found that the Computer Intensive Algebra fostered student development of richer concepts of variable and function, improved students' attitudes, and reduced students' anxiety toward mathematics. The types of research questions posed in this study embody many of the main features of the AMATYC (1995) standards such as promoting a positive attitude in mathematics, developing higher level thinking skills, and fostering the connections between symbolic, tabular, and graphical representations of functions.

Park and Travers (1996) also explored higher order thinking skills and conceptual understanding by including conceptual problems in the final exam and also through concept mapping. They investigated a computer based first year calculus course and attained information on outcomes in both cognitive and affective domains by using achievement tests, attitude surveys, concept maps and interviews. The main goals of this study were to compare achievement and attitude of Calculus and Mathematica (C&M) versus traditional teaching, and to assess the effectiveness of C&M in attaining key goals of calculus reform. Mathematica is a computer algebra system that can run lessons which contain problems that introduce concepts, followed by "tutorial" problems in technique and application. Students solve problems using word processing and calculating software with graphic capabilities (Park & Travers, 1996).

According to Park and Travers (1996) the primary themes of calculus reform they attempted to measure included: (a) involving students in doing mathematics instead of lecturing at them; (b) stressing conceptual understanding, rather than only computation; (c) exploring patterns and relationships; and (d) approaching mathematics as a live exploratory subject. In order to measure conceptual understanding, concept maps were used. Constructing concept maps required students to illustrate their conceptual understanding of the structure of a topic. The results indicated that the students in the C&M group scored higher on the concept maps and were better able to demonstrate cross-links between concepts (Park & Travers, 1996). This study is one of the first emerging studies to examine conceptual approach to measuring effectiveness of computer-based education in college mathematics. A trend may emanate from the calls for reform in mathematics education and the union of progress in technological developments with the progress in instructionally designed software. The technology is now available to support the new paradigms in instruction, but sufficient empirical evidence is still lacking. An investigation of higher order thinking skills in contrast to studies focused exclusively on procedural and declarative knowledge should be considered in an adult educational setting in mathematics.

Attitude

In addition to procedural skills and conceptual understanding, based on the cognitive domain, attitudes toward mathematics is important to considered. More specifically, mathematics anxiety, mathematical confidence, motivation in mathematics, and students' opinion of mathematical usefulness are factors analyzed in this study. These four factors were selected because they are critical to adult students' success in

mathematics (Bessant, 1995) and due to their interactive relationship with instruction as reported by Bohlin (1993).

Bohlin (1993) claims that instructional strategies designed to improve attitude related to student success. To support this point, research has shown that attitudes are related to participation and achievement in mathematics (Armstrong & Price, 1982; Shaughnessy, 1993). McLeod (1994) also concludes that affective factors play an increasingly important role in the teaching and learning of mathematics.

Attitude factors have a considerable impact on students' success, and mathematics anxiety is one example of a component of attitude that seriously influences students' performance. A negative relationship exists between anxiety and students' performance, thus high anxiety impedes performance in mathematical tasks (Hembree, 1990). Anxious people process information in a highly selective way. They attend to the most threatening elements of the information presented (Richards & French, 1990). This selective attention may cause math-anxious students to focus on irrelevant parts of a math problem. This drains cognitive resources and lessens performance (Eysenck & Calvo, 1992; Tobias, 1978). Due to the impact anxiety creates on learning, anxiety is one of the most widely researched affective factors in mathematics (McLeod, 1992).

Mathematical confidence is also a factor analyzed in this study. In the research, self-efficacy is defined as the sense that one has the ability to do well at a task which, is similar to the definition used for confidence in this study; confidence in one's own ability. Bandura (1977) states that self-efficacy is positively related to persistence. Student who persist at a mathematics problem in the face of obstacles and frustration are more likely to arrive at the correct answers than those who throw up their hands and

exclaim, "I can't do it." Research has shown that self-efficacy is positively related to both persistence and performance in mathematics (Brown, Lent & Larkin, 1989; Hackett & Betz, 1981; Multon, Brown & Lent, 1991; Schunk, 1987). The converse of this also holds. People with low self-efficacy may not put forth all their effort since it would be less devastating to fail without a complete effort than had they put forward a sincere concerted effort and failed anyway (Arkin & Baumgardner, 1985). If expectations of future successes are low, or if these successes are discounted, students withhold effort and avoid contact with the subject in the future (Weiner, 1986).

Adult students also have a need to see the usefulness of the material that they are learning which can be directly related to their motivation (Knowles, 1990). Confidence, anxiety, and mathematical usefulness all contribute to a students' motivation (Tobias, 1978). If students see a purpose for the mathematics in their future career or in their education they are more likely to continue with higher levels of mathematics (Eccles, Futterman, Goff & Kaczala, 1982).

Due to the influence that attitudes have on students' outcomes, attitudes are an important feature to include in studies that analyze the effects of alternative methods of instruction. However, in the meta-analysis conducted by Kulik, Kulik and Shwalb (1986) few of the studies analyzed students' attitude toward mathematics. These variables were secondary to the concern of achievement outcomes, and only two of the twenty-four studies pooled for the Computer Based Education (CBE) and adult education analyzed attitudes. Both studies that explored attitudes had non-significant effects, however, the retention rates for the computerized courses where found to be higher for the CBE courses compared to the traditional courses (Cotton, 1997; Kosakowski, 1998). Studies

revealed an improved attitude toward self and learning in CBE courses. Kosakowski (1998) suggests that the positive effects on attitude with CBE led to increased confidence and ultimately better motivation to learn.

Kosakowski (1998) reports that students feel more successful in school are more motivated to learn, and have greater self-confidence and self-esteem when using CAI. This should be particularly true for an adult learner when the technology allows the student to control their own learning accommodating the adult learners' desire for self-directed learning (Knowles, 1990).

Summary

The Center for Applied Special Technology reports that CBE can help students to become independent, critical thinkers, able to find information, organize and evaluate it, and then effectively express their knowledge and ideas in compelling ways (Center for Applied Special Technology, 1996). The use of Reform CAI may be the appropriate tool to develop these skills in adult learners. Reform CAI offers many advantages to adult learners, one of the greatest strengths is the flexibility of the current technology to accommodate the desires of the learner enabling them to become self-directed, (Caffarella, 1993) thus allowing students to initiate, plan and manage their own learning. It allows for the learners to have control over pace and timing (Caffarella, 1993) and also maintains interest through an intrinsically motivating environment which would seem to create a powerful tool for adult learners.

In light of the available research in CAI and the characteristics of the adult learner, computerized instruction is a valid and efficient method of instruction. It is attuned to the challenges adults face in returning to obtain an education and takes the

diversity of the learners into account. CAI may lend itself to addressing the issues related to constructivism, reform in mathematics, and the individuality of the diverse adult learners.

Technology is now available to support the complexities of the learner, as we understand them through the perspective of situated learning and andragogy, we must obtain empirical evidence to support the claims that have been made. If situated learning and andragogy are established in practice, they must be supported by research. Since technology to support this new paradigm in teaching and learning is also new, it is imperative that research attempts to gauge educational effects. R-CAI has the ability to support the situated learning thread of constructivism with technology that may allow for research to be conducted in this area. In addition, the research available indicates that these types of computerized programs have been studied overwhelmingly at the elementary level, fewer at the secondary level, and to a much lesser degree at the post-secondary level. The research is lacking sufficient evidence to support the validity of utilizing computer-assisted programs with adults beyond procedural skills achievement. Chadwick (1997) in his meta-analysis of CAI indicates that the area of conceptual development to support a constructivist framework in computer assisted instructional research is absent.

CHAPTER III

METHODOLOGY

Purpose of the Study

The purpose of this study was to determine the validity of using Reform-Computer Assisted Instruction (R-CAI) versus Traditional Algebra instruction (TA), extend the existing mathematics teaching knowledge base, and contribute to the current research by assessing the effectiveness of R-CAI in mathematics with the use of Prentice Hall's Interactive Mathematics. This approach is consistent with the recent developments in mathematics reform and adult educational theory that suggests learning within an authentic context is likely to motivate adult learners. A central component of this study was to explore whether either a R-CAI or Traditional Algebra (TA) approach served as an enhancement to mathematical conceptual understanding while maintaining the same level of procedural development in two groups: R-CAI and TA. Finally, the study was designed to measure the curricular effects of the two methods on students' attitude in mathematics. The following null hypotheses were tested:

1. There is no significant difference in conceptual understanding in Intermediate Algebra, as a result of the type of instruction received, taught by R-CAI or TA.
2. There is no significant difference in skills achievement scores as a result of the type of instruction received, R-CAI or TA.

3. There is no significant difference in attitudes about mathematics as a result of the type of instruction received, R-CAI or TA.

Research Design

This study employed the pretest-posttest control group quasi-experimental design to compare achievement outcomes of Intermediate Algebra students with the use of traditional methods with those of students who were taught with R-CAI methods (see Table 1). The nonequivalent control group design was employed due to the lack of random assignment of the two groups. Random assignment was not possible since the students self selected into the classes. The pretest was used as a covariate to control for initial differences through an Analysis of Covariance (ANCOVA).

Table 1

Nonequivalent Control Group Design

	Time		
	(1)		(2)
	Pre	Treatment	Post
R-CAI	O	X_1	O
Control Group	O		O

Where:

O = observation of pre- and post-tests and pre- and post-surveys

X_1 = treatment of reform based CAI, majority of time spent on projects and collaboration.

Reform methods were coupled with the R-CAI in this research design. This union was based on the premise that technology is not reform alone, but that technology serves as a tool to implement a reform instructional approach. As a control, a traditional algebra group, TA was taught without the direct computer application. This design was employed to further enhance the research base that is most heavily weighted on measuring strictly the effectiveness of Traditional CAI programs, which lack reform components. It is important to include technology in a reform approach to mathematics because technology and mathematics are mutually serving and interdependent activities. Technology is built on mathematics and mathematical concepts can be developed with the assistance of technology.

The Treatment: Reform -Computer Assisted Instruction (R-CAI)

R-CAI was the treatment with the use of Prentice Hall's Interactive Mathematics software package. This software package is a management system designed to deliver individualized, self-paced, skills-based instruction encompassing symbolic manipulation. In combination with the Key Concept Activities, Real World Activities and lab manual activities, this program was implemented in the spirit of reform. Key Concept Activities are application activities that require the use of tabular, symbolic, and graphical representations. Real World Activities direct the students to collect, interpret, analyze and write about data retrieved from the Internet. Both of these activities require the use of higher level thinking skills and communication within situated contexts.

The treatment in the R-CAI environment emphasized conceptual understanding through the use of projects requiring students to collect, analyze, and interpret data from either the Internet or based on experiments conducted in groups. These projects were divided into two categories: (1) Key Concepts Activities and (2) Real World Activities. The Key Concept Activities are an integrated portion of the program, which combine a variety of concepts from the textbook into one activity. The Key Concepts contained problems to which the students could relate, and also engaged the students in active learning. Through guided discovery, the students used the discrete skills and applied the concepts from algebra within the context of real and thought-provoking tasks. Many of the activities have multiple solutions and are open-ended, thus an analysis of the results is crucial. The Real World Activities are selected through the computerized syllabus and the students are directly connected to the Prentice Hall Website, http://cw.prenhall.com/interactive_math2/chapter1/deluxe.html. Using this Website, students may access the Website activities and link to other websites. Through framing of a particular situation, the students may use the Website to answer questions pertaining to a real-world situation. The Real World Activities are engaging and relevant, and guide students through real-world application of developmental mathematics skills. Within both of these activity structures, students are expected to make conjectures and justify their results through group discussion and/or writing assignments. In R-CAI classes, students have the opportunity to choose which projects to participate in and gauge which skill they still need to develop. The objectives are available to them at the end of the computerized syllabus where they may access them if additional practice is necessary.

The objectives are based on the Intermediate Algebra textbook objectives (see Table 2). Intermediate Algebra by K. Elayn Martin-Gay (1999) was the textbook that the program was designed around and it was utilized as a supplemental item for the students. The students have the opportunity to choose their preferred learning style. Students may choose between reading, which contains an audio feature that the students may choose to activate, watching, which contains short video clips of the textbook author demonstrating algorithmic steps that coincide with the content of the section, and exploring which is procedurally based, but allows students to choose their work or involves the student by clicking and dragging numbers and multiple choice tasks. Students have the chance to practice repeating the problems, and getting immediate feedback before going to the assessed exercises.

The instructors in this group served as facilitators of the learning environment. Direct instruction was minimal, approximately 10 –20 % of class time, allowing for the majority of class time to be spent on projects working individually and in groups. Students in this group had the opportunity to interact with the computer, other students, and the instructor. The flexible structure allowed students to maneuver through the program at their own pace, but within the semester time constraint. The instructor defined the content guidelines, but it was the students' decision regarding how they covered that content.

The Control: Traditional Algebra

The control group received traditional instruction, which consisted of a textbook based lecture format following the same content as the treatment groups. The textbook utilized in this group was a combined Elementary and Intermediate Algebra (Bittenger,

Ellenbogen, & Johnson, 1998). The Intermediate Algebra classes started in Chapter 7, which was consistent with the content of the R-CAI group, which started in chapter 3 (see Table 2). Table 2 illustrates exactly the chapters and content covered in both the TA and the R-CAI groups.

Table 2

R-CAI and TA Content

Content	Group	
	R-CAI Martin-Gay	TA Bittenger, et. al.
Graphs & Functions	Chapter 3	Chapter 7
Systems of Equations	Chapter 4	Chapter 8
Inequalities & Problem Solving	Chapter 2	Chapter 9
Exponents & Radicals	Chapter 7	Chapter 10
Quadratic Equations & Functions	Chapter 8	Chapter 11
Exponential & Logarithmic Functions	Chapter 10	Chapter 12

The traditional group was established as a lecture only class. The instructors spent 20%-50% of class time responding to questions from the previous nights homework and other review questions. The instructors presented new material after students' questions were answered. This new material was presented entirely by the instructor with no

student-to-student interaction. During class time there was no group work, no use of calculators as an instructional device, no computer technology, no practice time in class, and no handouts given other than a course outline. Discrete skills were emphasized and homework was assigned every meeting to reinforce the skills taught in class.

Subject Assignment

A quasi-experimental design was selected since random assignment was not possible. Students self-selected the class time, instructor, and computerized versus traditional settings. The mathematics departments required that the students be informed through the schedule of classes that these courses were computerized.

Subjects Characteristics

At the beginning of the semester, 100 students were enrolled and completed the pretest. By the end of the semester, the total number of students that finished the posttest was 81, but the final analysis was conducted on 67 since not all of the students took the post attitude survey. Demographics were only applied at the end of the study. The following table, Table 3, describes the number in each group, the TA and the R-CAI, at the end of the semester. The table also describes the average age and percentages of males to females by group and the total indicates overall the students involved in the study.

Table 3

Subject Characteristics

		Age		Gender by percent	
Group	N	Average	Range	Male	Female
R-CAI	33	20.41	18 - 29	44.45	55.55
TA	48	21.37	17 - 37	39.58	60.42
Total	81	20.70	17 - 37	41.67	58.33

Control for Teacher Affects

Four instructors each taught one section of Intermediate Algebra. Two instructors taught the R-CAI, and one of the two instructors for the treatment section was the researcher. Two other instructors taught the Traditional Algebra (TA). The instructors were selected based on their course syllabi and their philosophical beliefs. The TA instructors did not believe in the integration of technology, did not integrate group work and believed in an emphasis on procedural skill instruction. The R-CAI instructors were advocates of the AMATYC standards and integrated the standards into their instruction. Specifically, the R-CAI instructors emphasized higher level thinking and decreased their instructional emphasis of procedural skills. In addition to their beliefs, these instructors were selected primarily based on their expertise with the computerized software. Pleet (cited in Dixon, 1995) and Rosenbery, Warren, & Conent (cited in Dixon, 1995)

recommended that teachers who use computers in lab settings have pedagogical methodology required in the labs as well as an excellent command of the software. The traditional instructors followed the traditional lecture format without deviation. The intent was for teachers to teach according to their own style and belief system that they would be most comfortable teaching with and to help ensure that the intended treatments were realized. This attempted to take into account teacher bias of groups since they only taught one of the groups. If they had taught both sections their belief system and/or their personal preference toward a particular mode of instruction could have influenced the classroom situation. Moreover, instructional tools in one class could have been carried over into the other, thus one instructor for each section reduced the possibility of cross over between formats.

The instructors involved in this study each had taught at the community college for more than ten years. The researcher, who also taught one section, has taught for six years at the community college level. The participating instructors all had additional experience in public school settings, technical school, and/or abroad, and they all hold master's degrees in mathematical sciences. Their student evaluations indicate that they are excellent instructors and colleagues define these instructors to be dedicated to teaching and student oriented.

Additionally, the content covered in both groups was uniform to control for any difference in teaching styles (see Table 2). Five instructors and the researcher met in August 1998. One goal of this committee was to insure consistency in content regardless of college or instructional strategy. The researcher and participating teachers, in this study, matched content covered in the collaborating colleges' curriculum guidelines and

concluded that the content to be covered was equivalent across all groups. In this study, the treatments were only in association with the instructional method used to convey the course material; the mathematical content remained the same.

Instruments

The independent variable in this study was the R-CAI treatment, but other variables were also analyzed for their possible effects on the results. These included students' mathematics attitudes in terms of confidence, anxiety, and usefulness. The students' conceptual understanding was the main dependent variable, but their level of procedural skill and attitudes were also considered. In both cases, the pretests served as a control.

Tests

The procedural skills test was previously reviewed and tested twice in a pilot study. The procedural skills test was designed by the researcher to measure procedural skills and thus, resembles standard textbook problems (Appendix B). A committee of instructors involved in the pilot test agreed to the content and contributed to the development of this comprehensive examination. Since this test was designed to assess routine problems involving manipulations of algebraic formulas, it was used to address research question two.

A conceptual test was also designed by the researcher and reviewed by five other mathematics instructors at community colleges. This instrument was utilized as the conceptual understanding posttest for the study as described in research question one.

Rubric

The tests were rated according to a rubric scale adapted from Reyes, Suydam, Lindquist & Smith (1998) in Helping Children Learn Mathematics. It was developed based on Reyes' et. al. analytic scoring scale. The Procedural Skills Test and the Conceptual Test were each scored on the scale displayed in Table 4.

Table 4

Rubric Scale

Score	Description
0	No attempt; the student did not even make an effort to try the problem
1	Tried something relevant; the student made at least an effort beyond simply re-writing the problem, but they were not correct.
2	Partially correct; the student may have gone half way with an appropriate plan, but did not follow through.
3	Minor error; the student had the appropriate plan made it most of the way, but made a minor mistake that yielded an incorrect answer.
4	Completely correct; the student solved the problem with appropriate algebraic methods.

Inter-rater reliability

The researcher condensed all of the tests into a short form to enter the data easily (Appendix D). To confirm that there was no research bias a colleague who was not involved in the study agreed to rate the same tests to confirm the scores given were appropriate. After all of the tests were scored and inter-rated the final results were confirmed for agreement in scoring and then entered into the statistical software.

Questionnaires

The Fennema-Sherman Mathematics Attitude Scales were administered to measure attitudes toward the learning of mathematics. These scales were used to gain information about students' confidence in learning mathematics, mathematics anxiety, motivation in mathematics, and students' attitudes toward usefulness of mathematics (Appendix E). The confidence in learning mathematics scale was intended to measure students' confidence in their own ability to perform well on mathematical tasks. The range was from distinct lack of confidence to definite confidence. Students' mathematics anxiety was measured by the mathematics anxiety scale intended to measure feelings of anxiety, dread, nervousness, and associated bodily symptoms related to doing mathematics. The anxiety scale range was from feeling at ease to feeling distinct anxiety. The effectance motivation scale was intended to measure effectance as applied to mathematics. This scale ranges from lack of involvement in mathematics to active enjoyment and seeking of challenge. The mathematics usefulness scale was proposed to measure students' beliefs about the usefulness of mathematics currently, and in relationship to their future education, vocation, or other activities.

Four Fennema-Sherman scales were used to analyze students' attitudes toward

mathematics. The following scales were scored on a likert scale: Usefulness of mathematics scale (MU), the Confidence in learning mathematics scale (MC), the Mathematics anxiety scale (MA), and Effectance Motivation in mathematics scale (ME). The questions were coded so that the higher the score, the more positive the student's attitude. In order to achieve this the scales were scored according to the following:

- Questions 1, 3, 5, 7, 9, 11, on the MU, MC, and MA scales, were rated 5 = Strongly Agree, 4 = Agree, 3 = Undecided, 2 = Disagree, 1 = Strongly Disagree
- Questions 2, 4, 6, 8, 10, 12 on the same scales as above were rated 1 = Strongly Agree, 2 = Agree, 3 = Undecided, 4 = Disagree, 5 = Strongly Disagree.
- Questions 1, 3. 5, 8, 9, 11 on the ME scale, were rated 5 = Strongly Agree, 4 = Agree, 3 = Undecided, 2 = Disagree, 1 = Strongly Disagree
- Questions 2, 4, 6, 10, 12 on the ME scale, were rated 1 = Strongly Agree, 2 = Agree, 3 = Undecided, 4 = Disagree, 5 = Strongly Disagree.

Demographic information was also collected through a researcher designed questionnaire (Appendix F). The questionnaire was created to help gather information about the students' age and gender. These questionnaires were given at the end of the semester to determine the students' characteristics and to account for possible differences between groups.

At the beginning of the semester, both groups were given the procedural skills test designed to measure their procedural skills achievement. This test served as a base to

compare the groups. The conceptual test was given at the end of the semester to compare groups' conceptual understanding. To control for initial differences, the procedural skills test was used as a covariate. In addition, students were given the attitude survey at the beginning and the attitude survey was re-administered at the end of the semester to measure the change over the semester.

Summary

Not only has new technology made calculating and graphing easier, it has changed the nature of the problems important to mathematics and the methods used to investigate them. Because technology is changing mathematics and its uses, appropriate technology should be available to students; as a tool for processing information and performing calculations to investigate and solve problems.

When students need to calculate to find an answer to a problem, they should be aware of the choices of methods. When an approximate answer is adequate, students should estimate. If a precise answer is needed, an appropriate procedure must be chosen. Many problems should be solved by mental calculation such as multiplying by 10 or single digit multiplication. For more complex calculations, the calculator should be used. And finally, if several calculations are required, spreadsheet or computers can be used to find answers.

In addition to curricular changes, the assessment methods that mathematics teachers use will also have to change. If the hope is to achieve higher level thinking skills but teachers test students on lower level procedural knowledge, the assessment is not consistent. Knowles (1990) suggests the use of learning contracts and projects. These methods of assessment are aligned with measuring higher level thinking skills and

developing students' awareness and important aspects of learning situated learning. By contributing to this area of research and by taking a contextual approach, research can help two-year colleges, students, and teachers to understand the necessary steps to refining educational technologies in schools.

CHAPTER IV

RESULTS

The purpose of this chapter is to present descriptive data, analyze the data and summarize the results of the analysis. This portion of the study was conducted to investigate the effects of Reform – Computer Assisted Instruction (R-CAI) on student achievement, measured by the procedural skill test and the conceptual test, and attitudes about mathematics. Attitudes about mathematics included confidence in learning mathematics, effectance motivation in mathematics, usefulness of mathematics, and anxieties about mathematics, all parts of the Fennema-Sherman Mathematics Attitudes Scales. The effects of achievement, procedural skill and conceptual understanding, and attitudes of students who participated in the R-CAI were compared to the achievement and attitudes of students who participated in traditional algebra classes. Presented in this chapter is the quantitative information obtained from the pre- and post- skill tests, conceptual test, and the attitude scales.

Descriptive Statistics

The sample consisted of adult students enrolled in Intermediate Algebra at the community college level; the original sample size started with 100 students. Thirty-nine of the students were enrolled in the R-CAI Group and 61 students were enrolled in the Traditional Group. Table 5 describes the sample sizes and percent of the entire sample in each group, at the beginning of the semester and the final sample size by group at the end

of the semester for the purposes of calculating the attrition rates, which are illustrated in Table 5. This was the same sample described in Table 6, but separated by class.

Table 5

Sample Comparison: Initial and Final Enrollments

	Initial		Final		
	N	Percent	N	Percent	Attrition
R-CAI	39	39.00	33	40.74	15.38
TA	61	61.00	48	59.26	21.31
Total	100	100.00	81	100.00	19.00

Two colleges participated in this study. At each college, there was one Traditional and one R-CAI class taught. Table 6 introduces the population by class where T_1 and T_2 represent the traditional classes and R_1 and R_2 represent the R-CAI classes. T_1 and R_1 originate from the corresponding college as do T_2 and R_2. Table 6 illustrates supplementary detail to Table 5.

Table 6

Sample Comparisons by Class: Initial and Final Enrollments

		Initial		Final		
		Class N	Percent	Class N	Percent	Attrition Rate
R-CAI	R_1	25	25.00	21	25.93	16.00
	R_2	14	14.00	12	14.81	14.28
TA	T_1	40	40.00	34	41.97	15.00
	T_2	21	21.00	14	17.28	33.33
Total		100	100.00	81	100.00	19.00

This population of adults, enrolled in developmental mathematics, usually experiences a high attrition rate ranging from 50 to 60 percent (Wardlaw, 1997). This was also the case with this study each group had a loss of students. In the traditional group, 48 out of 61 completed the course, while 33 students out of 39 completed the computerized course. Overall, 81 out of 100 students finished the pre- and post-test in this study resulting in a combined attrition rate of 19%. The Traditional Group, alone, had a 21.31% attrition rate and the R-CAI Group had a 15.38% attrition rate. The Reform-CAI Group did have better retention in this particular study, and both groups reflect a higher than average retention rate. However, 14 students from the traditional group did not respond to

the attitude scales. Students that did not respond to this measure where eliminated from the final analysis.

Instruments

Descriptive statistics for the Procedural Skills Pretest, the Procedural Skills Posttest, and the Conceptual Test for the Traditional Group, the R-CAI group, and the entire sample are given in Table 6. The mean, standard deviation, and range have been calculated for each of these instruments and each group, and the results reflect that the mean score on the procedural skills test was initially higher for the traditional group.

Table 7

Descriptive Statistics By Group and Test

	Descriptive Statistics	Pretest	Posttest	Conceptual Test
R-CAI	Mean	3.47	19.61	19.45
	N	39	33	33
	Std. Dev.	3.85	7.00	11.52
	Range	14	23	45
TA	Mean	4.54	17.61	5.00
	N	61	34	34
	Std. Dev.	3.88	8.18	5.36
	Range	16	28	29

Table 7 presents the data from the sample that completed the pre-tests, post-tests, and Fennema-Sherman Mathematics Attitude Scales. The traditional group had a mean score of 4.54 while the R-CAI group had an average score of 3.47. Both the pre- and posttests were out of 28 total points possible. Figure 14 is an illustration of the groups pre- and posttest means using the format provided in Gay (1996) to represent this data graphically. On the pretest, the R-CAI group had a lower mean score, but in the end the R-CAI group surpassed the traditional group on the posttest. The conceptual test mean was 19.45 for the R-CAI group and 5.33 for the traditional group. There were 48 total points possible on the conceptual test.

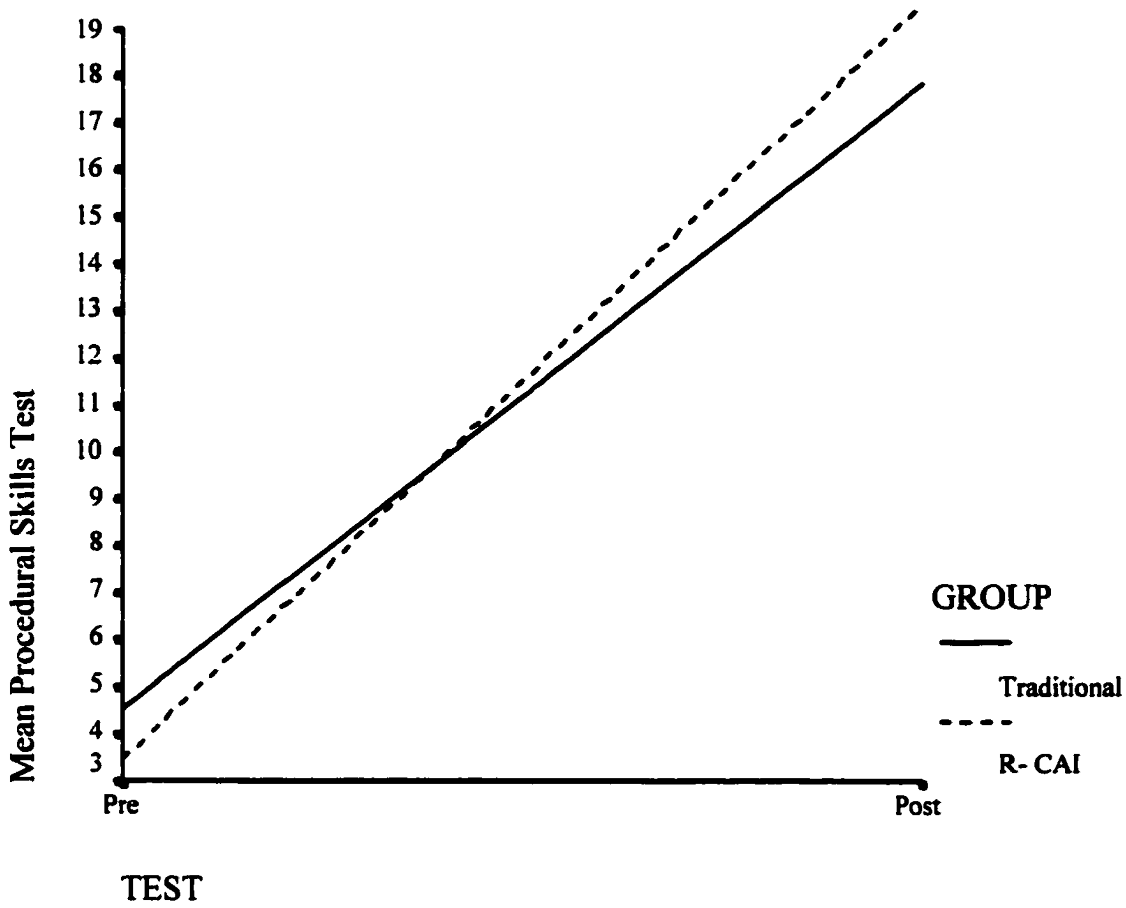


Figure 14 Pre-test and Post-test Mean Scores by Group

Table 8 illustrates the descriptive statistics of the four Fennema-Sherman Mathematics Attitude Scales given at the beginning of the semester and Table 9 illustrates the same scales given at the end of the semester. The mean, sample size, standard deviation, minimum, and maximum have been calculated on each scale for the R-CAI Group, Traditional Group, and the entire group. The sample sizes are smaller for the attitude surveys due to non-respondents. All students from the final sample of 81 took the Procedural Skills Test and the Conceptual Test, but 14 did not to respond to the attitude surveys.

Table 8

Traditional, R-CAI, and Entire Sample: Beginning of the Semester Attitude Scales

		Mathematics Anxiety	Mathematical Confidence	Mathematics Effectance	Mathematical Usefulness
R-CAI	Mean	31.47	35.35	34.15	46.94
	N	33	33	33	33
	Std. Dev.	9.08	9.10	7.41	7.53
	Minimum	12	16	18	26
	Maximum	52	50	49	58
Traditional	Mean	37.09	41.71	37.62	49.44
	N	34	34	34	34
	Std. Dev.	9.62	9.66	10.88	8.75
	Minimum	15	19	21	26
	Maximum	56	59	60	60

Table 9

Traditional, R-CAI, and Entire Sample End of the Semester Attitude Scales

		Mathematics Anxiety	Mathematical Confidence	Mathematics Effectance	Mathematical Usefulness
R-CAI	Mean	36.24	39.97	36.32	46.97
	N	33	33	33	33
	Std. Dev.	9.03	8.56	7.26	7.20
	Minimum	22	21	21	28
	Maximum	60	57	50	59
Traditional	Mean	38.36	39.71	36.85	45.09
	N	34	34	34	34
	Std. Dev.	11.33	12.78	9.22	9.49
	Minimum	13	12	13	25
	Maximum	60	60	50	60

Statistical Analysis on Tests

Initial differences in student procedural skills were not found to be significantly different in the Analysis of Variance model, Table 10. The Traditional Algebra group's initial skills mean was slightly higher (see Table 7), but not significantly different (see Table 10). Thus, the Analysis of Variance was calculated on all of the tests to measure differences by group, which demonstrated no significant difference in Procedural Skill on

the Posttest.

Table 10

<u>ANOVA: Pretest, Posttest</u>

		Sum of Squares	DF	Mean Square	F	Sig.
Pretest	Between	31.20	1	31.20	2.086	.152
	Within	1615.35	98	14.96		
	Total	1646.55	99			
Posttest	Between	57.20	1	57.20	.959	.330
	Within	4712.35	66	59.65		
	Total	4769.55	67			

To make certain that the initial differences would not affect the outcome, the Analysis of Covariance (ANCOVA) was also calculated (see Table 11). ANCOVA controlled for the Procedural Skill Test Pretest, and differences in attitude were controlled for with the Fennema-Sherman beginning of the semester survey. Although the R-CAI group did have a higher mean average, on the Procedural Skill Posttest (see Table 7), there was no statistical significance (see Table 10) to identify a difference in means. Therefore, the following null hypothesis could not be rejected:

> There is no significant difference in skills achievement scores as a result of the type of instruction received, R-CAI or Traditional Algebra.

Table 11

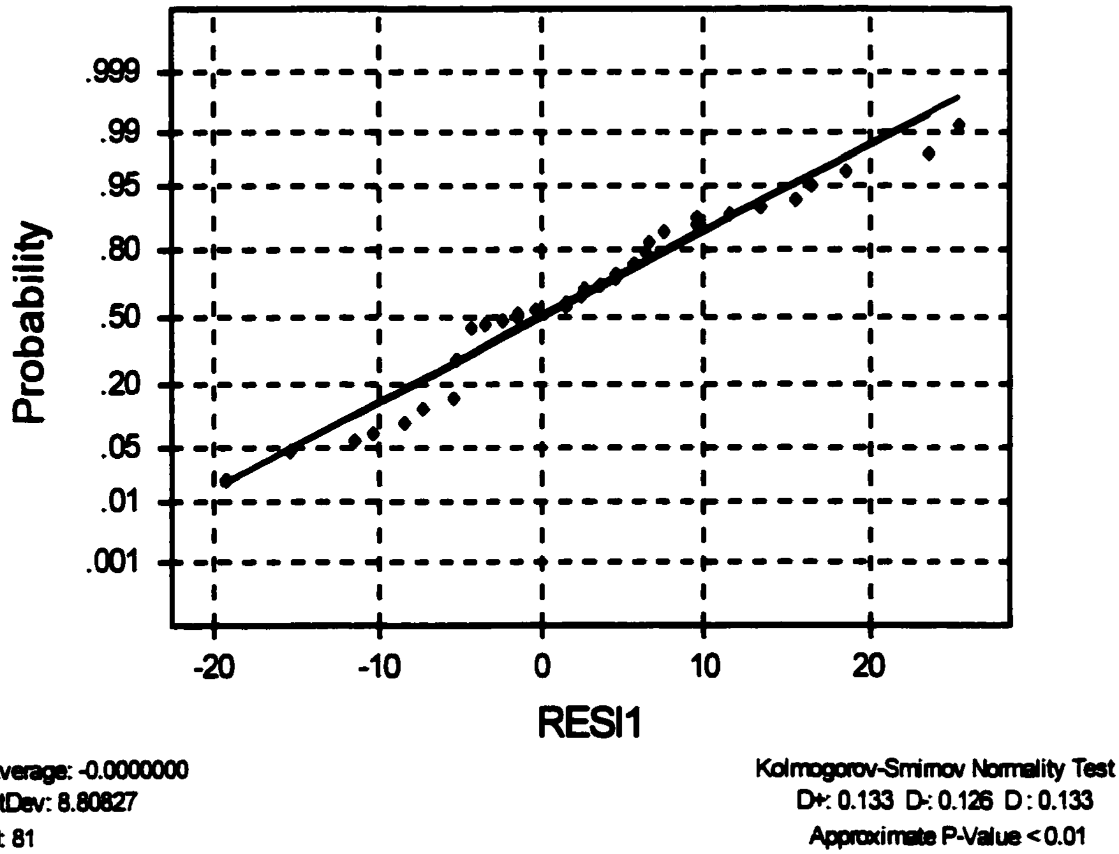
Analysis of Covariance: Posttest Controlled by Pretest

			Sum of Squares	DF	Mean Square	F	Sig.
Posttest	Covariates	Pretest	79.96	1	79.96	1.340	.251
	Main Effect	Group	35.96	1	35.96	.603	.440
	Model		15.93	2	57.96	.972	.382
	Residual		53.63	64	59.66		
	Total		69.56	66	59.619		

The R-CAI group's mean was 19.45 and the Traditional Group had a mean of 5.00 on the Conceptual Test (see Table 7). In addition to the descriptive mean, the Kruskal-Wallis Test, a non-parametric equivalent, was run on the conceptual data to analyze the statistical difference between the groups on the conceptual measure. The Kruskal-Wallis test was utilized since the residuals did not follow a normal distribution. The Kolmogorov-Smirnov Normality Test confirmed at the $p < 0.01$ level that the residuals did not follow a normal distribution (see Figure 15), thus the Kruskal-Wallis test was required. At the $p < 0.01$ level there was a statistical difference in means

indicating the R-CAI Group's mean was significantly higher (see Table 12). Therefore, the following hypothesis can be rejected:

There is no significant difference in conceptual understanding in Intermediate Algebra, as a result of the type of instruction received, taught by R-CAI or



Traditional Algebra.

<u>Figure 15.</u> Normality Test for Conceptual Test Data

Table 12

Kruskal-Wallis Test: Conceptual Test

	N	Median	Ave. Rank	DF	Z	Sig.
Traditional	34	2.5	21.9	1	-5.17	.000
R-CAI	33	21.0	46.5	1	5.17	.000
Total	67					

Statistical Analysis on Surveys

On the Fennema-Sherman scales, the higher the mean score the more positive the attitude. As indicated in Table 7, the mean scores were all higher for the Traditional Group. However, statistically, initial differences were only significant between groups, in terms of mathematics anxiety and mathematical confidence (see Table 13). The Traditional Group started the course with a better attitude toward both.

After the researcher controlled for initial differences on pre-attitude surveys, the students who received Reform Computerized Assisted Instruction maintained an equivalent attitude toward mathematics as their peers in the Traditional Algebra Group. Table 14 indicates no significant difference in combined attitude scales from beginning to end of the semester between the treatment and control. Table 15 describes the same findings that there is no significant difference in mathematics attitude, but this table lists

each scale separately to give detail that is more specific. The following null hypothesis could not be rejected:

> There is no significant difference in attitudes about mathematics as a result of the type of instruction received, R-CAI or Traditional Algebra.

Table 13

Analysis of Variance: Pre-Attitude Survey

		Sum of Squares	DF	Mean Square	F	Sig.
Anxiety	Between	536.485	1	536.485	6.133	.016
	Within	5773.206	66	87.473		
	Total	6309.691	67			
Confidence	Between	686.118	1	686.118	7.790	.007
	Within	5812.824	66	88.073		
	Total	6498.941	67			
Effectance	Between	201.191	1	201.191	2.308	.134
	Within	5666.272	66	87.173		
	Total	5867.463	67			
Usefulness	Between	106.250	1	106.250	1.594	.211
	Within	4400.265	66	66.671		
	Total	4506.515	67			

Table 14

Analysis of Covariance: All Scales Combined
Pre-Attitude entered as a Covariate to Control for Initial Differences

			Sum of Squares	DF	Mean Square	F	Sig.
Post-Attitude	Covariates	Pre-Attitude	40.914	1	40.914	.039	.843
	Main Effects		4.231	66	4.231	.004	.949
			45.145	2	22.572		
			7485.488	65	1038.238		
	Total		7530.632	67	1007.920	.022	.979

After the hypothesis was rejected, the researcher was curious how each group compared over time to themselves. Part of the hypothesis would be left unanswered if the researcher only looked at the comparison between groups. Thus, the following statistics were calculated to answer the question: Did their attitudes improve over time in their respective groups or did their attitudes toward mathematics decline? T-tests were calculated to compare each group's pre-attitude scores to their post-attitude scores.

Table 15

Analysis of Covariance: Pre-attitude as Covariate

		Sum of Squares	DF	Mean Square	F	Sig.
Anxiety	Between	75.858	1	536.485	.726	.397
	Within	795.754	66	87.473		
	Total	871.612	67			
Confidence	Between	1.191	1	1.191	.010	.920
	Within	806.029	66	118.273		
	Total	807.221	67			
Effectance	Between	4.615	1	4.615	.067	.796
	Within	459.684	66	68.611		
	Total	464.299	67			
Usefulness	Between	60.235	1	60.235	.848	.360
	Within	687.706	66	71.026		
	Total	747.941	67			

It was found that the students', in the traditional algebra environment, attitudes did not significantly change over the course of the semester (see Table 16). However,

students in the R-CAI environment had a significant increase in their attitude toward mathematics from the beginning to the end of the semester, in mathematics anxiety and mathematical confidence (see Table 18).

Table 16

Fennema-Sherman Test Comparisons Pre to Post: Traditional Algebra Group

		Paired Differences					
		Mean	Std.Dev.	Std. Error	DF	t	Sig.
Pair 1	Mathematics Anxiety	.82	13.75	2.39	33	.342	.735
Pair 2	Mathematical Confidence	-2.00	14.46	2.48	33	-.806	.426
Pair 3	Mathematics Effectance	-.94	13.29	2.31	33	-.406	.687
Pair 4	Mathematics Usefulness	-4.35	12.66	2.17	33	-2.004	.053

Table 17 illustrates the descriptive statistics found that were analyzed for the R-CAI group. For each scale, there is a mean score listed for the pre- and post-tests of the Fennema Sherman Mathematics Scales. For example, Pre-MA represents the scores from the Mathematics Anxiety Scale taken at the beginning of the semester. Corresponding to that would be the Post-MA representing the end of the semester Mathematics Anxiety score.

Table 17

Means for Reform Computer Assisted Instruction: Pre-attitudes and Post-attitudes

		Mean	N	Std. Dev.	Std. Error
Pair 1	Pre-MA	31.47	34	9.07	1.55
	Post-MA	36.23		9.02	1.54
Pair 2	Pre-MC	35.35	34	9.09	1.56
	Post-MC	39.97		8.56	1.46
Pair 3	Pre- ME	34.15	34	7.41	1.29
	Post-ME	36.39		7.36	1.28
Pair 4	Pre-MU	46.94	34	7.53	1.29
	Post-MU	46.97		7.20	1.23

Table 18

Fennema-Sherman Test Comparisons: Reform Computer Assisted Instruction Group

		Paired Differences					
		Mean	Std.Dev.	Std. Error	DF	t	Sig.
Pair 1	Mathematics Anxiety	4.76	12.23	2.0987	32	2.270	.030
Pair 2	Mathematical Confidence	4.61	14.51	2.488	32	1.855	.072
Pair 3	Mathematics Effectance	2.24	11.33	1.9728	32	1.137	.264
Pair 4	Mathematics Usefulness	.029	10.39	1.783	32	.016	.987

Limitations to the Study

This study has a few limitations, one of which is the attrition rate of students. The attrition rate was calculated as the ratio of the total number of students who did not take the Procedural Skills Posttest compared to the number of students who began the course and took the Procedural Skills Pretest. The standard attrition rate in mathematics at the community college is approximately fifty percent, and must be viewed as an unavoidable limitation of the study. The mortality factor is an issue caused by such concerns as change in shifts at work, family problems, and under preparation for college level work, self reported by students. Different times of day may also be contributing affects.

Random assignment was not possible due to issues of informing students about the unique learning environments. The main concern was that the treatment could not account for any initial differences between the two groups, that something inherently dissimilar may exist between the students who selected the computerized course compared to the students who opted for the traditional lecture method. However, students frequently chose time of day before they consider the instructor's reputation and the method of instruction. In several instances, students did not read the corresponding description stating that these were computerized sections. Some students opted to change sections while others stayed in the computerized sections because the class time was more important to them than the mode of instruction. Students in these classes had the opportunity to self-select computerized versus a traditional classroom. Thus, the study was conducted on classes that were already intact and not randomly assigned to treatment and control groups. This is not uncommon in an educational setting and even more common for studies conducted at the college level (Chadwick, 1997).

Four different teachers taught each class involved in the study. Two taught the treatment group and two taught the control group. The decision to select these specific instructors was intended to insure that the instructors teaching the computerized courses had exceptional command of the software and pedagogical methodology required in computer labs based on previous studies (Pleet, 1990as cited in Dixon, 1995).

Teacher expectations could have affected the ultimate outcome. In addition, the researcher was one of the instructors who taught the treatment group, which could have contributed to an additional layer of potential limitations. Therefore, different instructors taught each of the four sections. The intent was to avoid teacher bias toward one method

or the other; thus, different instructors for each section were chosen to attempt to eliminate any biases or corruption of the control groups. In an effort to avert the teacher bias problem, an additional potential problem arose; varying teaching styles could have led to a limitation.

CHAPTER V

CONCLUSION

Summary

This study was designed to investigate the effects of a Reform Computer Assisted Instruction (R-CAI) environment versus a Traditional Algebra (TA) instructional environment on adult community college students' development of procedural skills and conceptual understanding. The effects of a R-CAI environment and a TA environment on students' attitudes toward mathematics were also examined.

Four, intact community college Intermediate Algebra classes took part in this study. The researcher taught one of the treatment classes and another instructor, experienced with the Interactive Math software, taught the other treatment class. Two faculty members of the mathematics departments at the corresponding community college campuses taught the control classes with traditional lecture instruction. All students in these classes completed the Procedural Skills Test and the Fennema-Sherman Attitude Scales before instruction began. Students in both the treatment and control groups were administered the Procedural Skills Test, the Conceptual Test, and the Fennema-Sherman Attitude Scales at the end of the semester as well. At both colleges and in both groups, post-tests were administered after 15 weeks of instruction in their respective instructional groups.

A Nonequivalent Control Group Design was employed in this investigation. The

sample consisted of 100 students enrolled in Intermediate Algebra at the community college level at the beginning of the fall 1999 semester. Two classes totaling 61 students composed the original Traditional Algebra group, which was the control group, and two classes totaling 39 students were in the R-CAI Group, the treatment group. By the end of the semester, the sample consisted of 67 students, 34 in the Traditional Algebra classes and 33 in the R-CAI classes. The students self-selected the class they would enter, consequently, random assignment to treatment and control groups was not possible. The treatment group met twice per week in a computer classroom with a computer available to each student. Interactive Mathematics and the World Wide Web were used to explore the concepts in context, based on the constructivist view of situated learning and andragogy. The control group also met twice per week in a traditional classroom, without computers, and was taught using traditional means of instruction.

The data were treated with One-Way Analysis of Variance (ANOVA) to measure any initial differences in skills between groups, and One-Way Analysis of Covariance to confirm that any initial differences were accounted for by using the pretest as a covariate and the posttests as the dependent variable. The Levene test of equality of variance and the Scheffé follow-up test were run to insure that the ANOVA and ANCOVA were sufficient tests for the sample size and the power of the data. However, a non - parametric test became necessary since the residuals of the conceptual test did not follow a normal distribution. The Kruskal-Wallis test, which is a nonparametric equivalent to one-way ANOVA was run on the conceptual skills tests.

Based on the ANOVAs it was concluded that the groups did not have initial differences in procedural skill ability at the beginning of the study. At the end of the

study, based on the Kruskal-Wallis test it was clear that students experiencing the R-CAI environment significantly outperformed their counterparts at the $p < 0.01$ level in the Traditional Algebra instructional environment on the measure of conceptual understanding. Although, both groups' level of procedural skills did improve over the course of the semester, it should be noted, that there was no significant difference in procedural skills ability by the end of the semester between groups.

The following null hypothesis could be rejected in this empirical study:

1. There is no significant difference in conceptual understanding in Intermediate Algebra, as a result of the type of instruction received, taught by R-CAI or Traditional Algebra.

The following null hypotheses could not be rejected in this empirical study:

2. There is no significant difference in skills achievement scores as a result of the type of instruction received, R-CAI or Traditional Algebra.

3. There is no significant difference in attitudes about mathematics as a result of the type of instruction received, R-CAI or Traditional Algebra.

Discussion

This study investigated three specific research questions that were associated with the following areas: procedural skill development, conceptual understanding development, and attitudes toward mathematics all within a computerized instructional environment.

Procedural Skill and Conceptual Understanding

Research question one, indicating that there was no significant difference in conceptual understanding, was rejected at $p < 0.01$ level of significance. These findings indicate that the students in the Treatment group gained significantly more on the conceptual understanding test than the Control group. Students who were exposed to a computerized environment demonstrated more attempts at answering the questions posed on the conceptual test and a more thorough understanding of the applications of the skills developed in Intermediate Algebra.

Statistically, research question two, stating that there is no significant difference in procedural skill, could not be rejected. Although, both the Treatment and Control groups showed growth in Intermediate Algebra procedural skills, the Treatment group showed higher achievement at the end of the study than did the Control group. However, there was not a significant difference between the scores of the Treatment and the Control groups.

The findings of this study support recent research by French (1997) who found that students who received computer enhanced instruction had a larger gain in achievement, but not large enough to indicate statistical significance. Similar studies were conducted by Sadatmand (1995), Alexander (1993), and Cunningham (1992), which

support the claim that computer software can improve a student's mathematics achievement.

Mathematics Attitude

Four Fennema-Sherman scales were used to analyze students' attitudes toward mathematics. The following scales were scored on a likert scale: Usefulness of mathematics (MU), Confidence in learning mathematics (MC), Mathematics anxiety (MA), and Effectance Motivation in mathematics (ME). The questions were coded so that the higher the score, the more positive the student's attitude.

ANCOVA was performed on the Fennema-Sherman post-scales using the pre-scales as a covariate. Accordingly, descriptive statistics were also calculated. No statistically significant difference between groups could be reported. These findings are consistent with Alexander (1993), who suggests that, although students who learned algebra with computers showed improvement in their mathematics achievement, the attitude toward mathematics of the computer-enhanced and traditional groups essentially remained the same. Melin-Conjeros (1993) and Foley (1986) also found no significant difference between attitudes toward mathematics of a group taught with computer-enhancement versus a group that was taught in a traditional classroom. One common thread between these studies was that the researchers only analyzed the attitude between groups.

In this study there was a recognizable difference in pre-scale attitude versus post-scale attitude mean scores. Therefore, additional t-tests were run to compare each group's pre-scale to their post-scale. While the hypothesis could not be rejected to indicate that there was a difference between groups, there was a significant improvement in the R-CAI

group's attitude toward mathematics on both the Mathematics Anxiety Scale and the Mathematical Confidence Scale. Hence, it can be interpreted that students in the computerized class taught within a situated context did ultimately leave the class with an improved confidence toward mathematics and lower anxiety, which may have contributed to the higher conceptual test scores. It was clear, as the tests were scored, that a greater number of students in the R-CAI group at the least attempted to do the problems on the Conceptual Test. Students that attempt mathematics have a better chance of being successful in mathematics (French, 1997). This finding would be consistent with Ellison (1994), who found that technology-enhanced instruction had a positive effect on students' mental constructs of mathematics. Moreover, research by Sheets (1993) found that students who studied computer-intensive algebra demonstrated greater flexibility in mathematical reasoning, which is crucial to applying the mathematics to a situated context, than did students from traditional instruction backgrounds. The t-tests indicated that the Control group did not have a significant improvement in attitude toward mathematics on any of the scales.

Overall, these findings indicate that students who are taught with interactive computer software can significantly build their conceptual understanding without hindering their procedural skill ability. These students were able to keep up with their counterparts in the procedural skills and surpassed the traditional classroom students' conceptual understanding while gaining confidence and lowering their anxiety with respect to mathematics. Although the uses of interactive computer software in the treatment did not seem to affect the students' attitude towards mathematics versus the control group, as measured by the Fennema-Sherman Scales, the t-tests did indicate that

the students in the computer instructional environment decreased their mathematics anxiety and improved their mathematical confidence over the 15 week semester.

A great deal of debate exists in the mathematics education community regarding the appropriateness of reform-oriented methods in the mathematic classroom. This study suggests that using interactive software in a situated learning environment integrated with the principles of Andragogy may be affective in improving the overall performance of students in community college Intermediate Algebra and may contribute to building their mathematical confidence and lowering their anxiety toward mathematics.

Implications

Based on this study, it is clear that interactive computer software integrated with situated learning techniques should be an integral part of instruction at the community college level. Mathematics faculty's argument that there is not enough time in the semester to spend on authentic learning tasks is understandable, however, this study supports the claim that it is possible to implement authentic learning tasks and maintain procedural skill development. The de-emphasis on procedural skills and a shift in focus to authentic, application-type problems should be concentrated on in mathematics education at the community college level especially since students' conceptual understanding can be improved without procedural skills suffering. Since the abilities to apply mathematical knowledge and critical thinking-skills are so crucial for students entering the workforce today, various situations in various contexts should be integrated into the mathematics curriculum. Additionally, based on the results of this study, it could be suggested that students should have the opportunity to participate in the use of interactive computer software as a tool to enhance students' conceptual understanding and mathematical

confidence, as outlined in the AMATYC standards (1995).

Mathematical attitude has been found to be a predictor of mathematical achievement (Bohlin & Viechnicki, 1993), and the use of a R-CAI seems to have an influence on improved mathematical attitude; therefore, an effort to incorporate components of this curriculum should be focused on with community college students. Improving students' attitudes could encourage students to progress through their required mathematics courses more successfully. It may stimulate students to go further in mathematics; leading to more career options, and, ultimately, a greater number of students may complete degrees, no longer stymied by their own mathematical barriers.

Recommendations

The results of this study give evidence that the use of technology, in the classroom coupled with elements of reform, does not hinder students' skills development. As described in the AMATYC standards (1995), technology, when implemented in ways as described in this study, enhances student conceptual skill development. Furthermore, this study has demonstrated that students taught in a Reform Computer Assisted Instructional environment, could learn to apply the mathematics to the appropriate situation.

This study contributes to the body of research of reform in mathematics education, specifically situated learning. Therefore, it is clear that teachers will have to make project-based problem solving central to their teaching. This study supports a curriculum with authentic learning situations focused on real world data with adult learners. Integrating the curriculum with interactive computer software can enhance the learning of community college Intermediate Algebra students. Consequently, the results of this study strongly suggest that the preparation of community college teachers become

consistent with the calls for reform. The report Moving Beyond the Myths (National Research Council, 1991) indicates one of the central pedagogical problems in the training of future teachers:

> It is rare to find mathematics courses that pay equal attention to strong mathematical content, innovative curricular materials, and awareness of what research reveals about how children learn mathematics. Unless college and university mathematicians model through their teaching effective strategies that engage students in their own learning, school teachers will continue to present mathematics as a dry subject to be learned by imitation and memorization. (pp.28-29)

Community college mathematics instructors, as practitioners, face two issues of concern. First, community college instructors are role models for prospective teachers. One such role for instructors that is visible to pre-service teachers are two by two programs were students enrolled in a college of education enroll in their first two years at the community college and then go on to complete their last two year at the local university. Additionally, several students have self reported that they are intending to complete degrees in education to become teachers. It has become common for university students, in colleges of education, to complete their mathematics requirements at a local community college. Hence, mathematics instructors will need to lead by example. However, these calls for reform and the research to support it have been greatly ignored which leads to the second issue. Mathematics faculty need support in their efforts to make change in their classroom. They are likely to be modeling what they knew to be

successful in their learning experience. Thus, pedagogical / andragogical training should be incorporated into the practices of preparing community college faculty. One way that this can be addressed is through hiring practices. It would be possible for the informed colleges to begin raising the standards from which they hire candidates. The selection criteria could involve a minimum requirement of educational background in addition to their mathematical background. Additionally, the types of experiences they have had teaching should be more thoroughly considered and questions more specific to pedagogical / andragogical concerns should also be addressed. This effort would affect the training required to teach at a community college, and give direction to faculty about teaching methods and the research available. Ultimately, this would shape the instruction that students receive.

Suggestions for Future Research

On the basis of the findings of this study, the following recommendations can be made:

1. This study should be replicated in other college level mathematics courses, for example basic mathematics or calculus, to investigate whether the interactive computer software package used in this study will influence students' conceptual understanding and attitude in other levels of community college mathematics.
2. This study should be replicated in other college level mathematics course, for example basic mathematics or calculus, to investigate whether situated learning similar to that used in this study will influence students' conceptual understanding and attitude in other levels of community college mathematics.
3. This study should be replicated via distance education to investigate whether

students not bound to a classroom setting will gain the necessary procedural skills, but also improve their conceptual understanding and attitude.

4. This study should be replicated at other types of schools, e.g. private, technical training, and four-year colleges. This would investigate whether situated learning and interactive computer software were effective when used with a different population than the current study.
5. A study should be conducted to investigate whether the use of the interactive computer software affects the rate at which students enroll in subsequent mathematics courses and the students' success rates.
6. A study should be conducted to investigate the change in attitude over time with the use of the interactive computer software on students of various backgrounds; i.e., race and gender.
7. A study should be conducted to investigate the relationship between teacher's confidence in teaching with technology and the students' achievement.

Conclusion

Results of this study found that students exposed to a R-CAI environment did statistically, significantly better than their counterparts in the traditional lecture environment on the conceptual measure. Additionally, there was no significant evidence that the type of instruction used in this study affected procedural skill achievement. Students in the R-CAI reported an increase in their mathematical confidence and lower levels of anxiety toward mathematics. In light of the results of this study, R-CAI can be viewed as a necessary and positive addition to the curriculum in an adult learning setting.

APPENDIX A

RESEARCH INVOLVING HUMAN SUBJECTS

AND THE INFORMED CONSENT

FORM

University of Nevada, Las Vegas - Research Involving Human Subjects

Name: Cynthia L. Glickman, Doctoral Student
Supervising Professor: Dr. Juli K. Dixon
Department: Curriculum and Instruction
Title of Study: The effects of computerized instruction in intermediate algebra on students achievement, conceptual understanding, and student attitude.

DESCRIPTION OF STUDY:

1. **SUBJECTS**: Participants will be self selected volunteers from two community colleges: Community College of Southern Nevada, in Las Vegas, Nevada, and Maplewoods Community College, in Kansas City, Missouri. Participants will be predominately undergraduate students enrolled in intermediate algebra, mostly in their first two years of college, are the estimated population.

2. **PURPOSE**: The purpose of this study is to assess the cognitive and affective effects of students enrolled in a college level Intermediate Algebra course utilizing Computer Assisted Instruction at a community college level.

3. **METHODS**: A conceptual computerized treatment and a traditional control will be administered and an analysis of the effects will take place after the treatment.

4. **PROCEDURES**: Participants will be informed of the project's intent and given consent forms at the beginning of the project. Pre- and Post-tests and surveys will be administered at the beginning and end of the semester.

5. **RISKS**: There are no anticipated risks or discomfort associated with this research project.

6. **BENEFITS**: Students in the computerized courses may encounter individualized instruction, attain computer knowledge, and gain exposure to mathematical applications.

7. **RISK-BENEFIT RATIO**: There are no anticipated risks.

8. **COSTS TO SUBJECTS**: There are no anticipated additional costs.

9. **INFORMED CONSENT**: All participants will be requested to sign a consent form that meets the criteria identified by the University of Nevada Las Vegas. The instructors of the courses will be responsible for obtaining these documents, which will be stored by the researcher.

University of Nevada, Las Vegas **Department of Curriculum and Instruction**

Informed Consent Form

You are invited to participate in this research project about computerized instruction's effects on achievement, understanding, and attitudes. The following information is provided to help inform you about this project. If you have any questions, please do not hesitate to ask.

I am a doctoral student in the Department of Curriculum and Instruction at the University of Nevada, Las Vegas and a full-time instructor in the Mathematics Department at the Community College of Southern Nevada, Cheyenne Campus. I am the researcher conducting this study to measure students' achievement, conceptual understanding and attitudes in intermediate algebra.

The purpose of this project is to collect information about the effects of computerized instruction on achievement and conceptual understanding and about your attitudes on computers and mathematics. The study will include pre and post - tests and surveys at the beginning and end of the semester. Each of these instruments will take approximately 20 - 30 minutes of class time.

You have been invited to participate because you are a college student in an intermediate algebra course. The information collected will assist the instructor in the development of the course to better serve the needs of future students and to guide further development of computerized instruction in mathematics.

All information collected will be available only to you and the researcher. Only a given assigned number will identify any data collected. Information obtained in this study may be published in journals or presented at conferences. Your identity will be kept strictly confidential and all surveys and tests will be destroyed after completion of the study and the required storage time.

You are free to choose not to participate in this study or to withdraw from the study at any time without adversely affecting your relationship with the instructor or the University of Nevada, Las Vegas. You participation or non-participation may in no way affect your course grade or result in any loss of benefits to which you are entitled.

If you have any questions regarding your participation in this study, please ask. You may contact me, Cynthia L. Glickman, at (702) 651-4730 or via email at glickman@nevada.edu. If you need additional information, you may contact the UNLV Office of Sponsored Programs at (702) 895-1357.

Your signature certifies that you are voluntarily making the decision to participate in this research project, having read and understood the information presented. You will be given a copy of this consent form to keep.

____________________________________ ________________
Signature of Research Participant Date

Cynthia L. Glickman, M.S., Principle Investigator (702) 651-4730
Juli K. Dixon, Ph.D., Supervising Professor (702) 895-1448

UNLV

DATE: August 11, 1999

TO: Cynthia L. Glickman
Department of Curriculum & Instruction
M/S 3001

FROM: Dr. Fred Preston, Chair
Social/Behavioral Sciences Committee

RE: Expedited Review of Human Subject Protocol:
"The Effects of Computerized Instruction in Intermediate Algebra on Student Achievement, Conceptual Understanding, and Student Attitude"
OSP #: 311s0899-080x

The protocol for the project referenced above has been reviewed and approved by an expedited review by the Institutional Review Board Social/Behavioral Sciences Committee. This protocol is approved for a period of one year from the date of this notification and work on the project may proceed.

Should the use of human subjects described in this protocol continue beyond a year from the date of this notification, it will be necessary to request an extension.

If you have any questions or require any assistance, please contact Marsha Green, IRB Secretary, at 895-1357.

cc: J. Dixon (CI-3001)
OSP File

Office of Sponsored Programs
4505 Maryland Parkway • Box 451037 • Las Vegas, Nevada 89154-1037
(702) 895-1357 • FAX (702) 895-4242

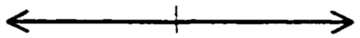
APPENDIX B

PROCEDURAL SKILLS TEST

Procedural Skills Test

If you do not know the answer, please feel free to leave the space provided blank. Circle your answer.

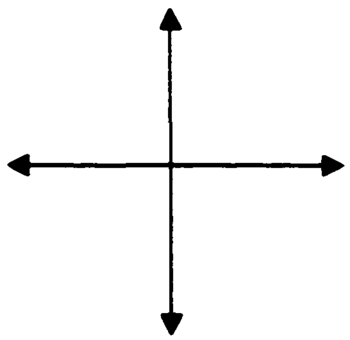
1. **Solve the inequality and graph the solution.**
   $|x - 5| \geq 20$



2. **Write an equation of the line. Through (7, 1) and parallel to 4x - y = 3.**

3. If $f(x) = -4x^2 + 3x - 6$, find $f(1)$.

4. **Solve the following system of equations. Graph the equations and label the solution.**
   $x + 3y = 19$
   $2x - y = 10$



5. **Rationalize the denominator.**

$$\frac{2}{\sqrt{2}-3}$$

6. Solve the equation by **completing the square.** $x^2 - 4x = -3$

7. **Simplify the radical expressions.** $\left(2\sqrt{3}-4\right)\left(5\sqrt{3}+2\right)$

APPENDIX C

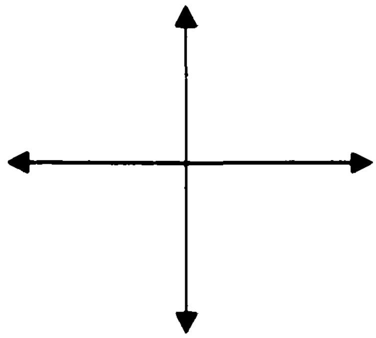
CONCEPTUAL TEST

Conceptual Test

I. The average number of hours that Americans work per week has gradually increased over the past two decades. The average number of hours Americans work per week for various years are listed in table 1. Let f(*t*) represent the average number of hours per week during the year that is *t* years since 1900.

Table 1: Average Hours Spent at Work per Week

Years	*Hours*
1975	43.1
1980	46.9
1984	47.3
1989	48.7
1993	50.0
1995	50.6



a) Create a graph by plotting the points given, label the axes.

b) Find an equation of the line that passes through at least two points and comes closest to the rest of the points. Write your answer in f(*t*) notation.

c) Predict the number of hours that Americans will work per week in the year 2003.

d) Use the graph in part (a) or the equation in part (b) that you created to predict when Americans will never stop working.

e) Use the equation (model) to estimate the number of hours that Americans worked per week in 1990. Which intercept represents this estimate?

f) If the domain of the linear model is [73, 99], what is the corresponding range? What does the range represent with respect to this situation?

g) What is the slope of this linear model?

h) What does the slope represent in this situation?

2. The life expectancy, w(t) and m(t), for women and men respectively is modeled by the following system and is listed in Table 2.

   $w(t) = 0.16t + 64.46$

   $m(t) = 0.22t + 52.65$, where t is the number of years since 1900.

Table 2

Year	Men	Women
1970	70.8	74.7
1975	72.6	76.6
1980	73.7	77.4
1985	74.7	78.2
1990	75.4	78.8
1991	75.7	79.1

   a) How much longer will women live than men, on average, in 2002? Explain your answer.

   b) Use a symbolic method to predict the years in which men will have a life expectancy longer than women. Verify your results using a graphical method and explain your answer.

   c) A women that was born in 1980 wants to choose a man to marry that she won't outlive. Should she marry a younger or older man?

   d) What are acceptable birth years for her potential husband? (Write your answer as an inequality)

APPENDIX D

TEST RATING SHEET

STUDENT#			STUDENT#		
Skills Test	Conceptual 1	Conceptual 2	Skills Test	Conceptual 1	Conceptual 2
1	a	A	1	a	a
2	b	B	2	b	b
3	c	C	3	c	c
4	d	D	4	d	d
5	e		5	e	
6	f		6	f	
7	g		7	g	
	h			h	
Total					

STUDENT#			STUDENT#		
Skills Test	Conceptual 1	Conceptual 2	Skills Test	Conceptual 1	Conceptual 2
1	a	A	1	a	a
2	b	B	2	b	b
3	c	C	3	c	c
4	d	D	4	d	d
5	e		5	e	
6	f		6	f	
7	g		7	g	
	h			h	
Total					

STUDENT#			STUDENT#		
Skills Test	Conceptual 1	Conceptual 2	Skills Test	Conceptual 1	Conceptual 2
1	a	A	1	a	a
2	b	B	2	b	b
3	c	C	3	c	c
4	D	D	4	d	d
5	E		5	e	
6	F		6	f	
7	G		7	g	
	H			h	
Total					

0 = no attempt, 1 = tried something relevant, 2 = partially correct, 3 = minor error, 4 = completely correct

APPENDIX E

FENNEMA-SHERMANN MATHEMATIC

ATTITUDE SCALES

Questionnaire

Directions for completing portions of the

Fennema-Sherman Mathematics Attitude Scales*

On the following pages is a set of statements I would like you to respond to. There is no correct answer for any of the statements. They are set up in a way that permits you to indicate the extent to which you agree or disagree with the statement that is expressed.

Do no spend much time with any one statement, but be sure to answer every statement by circling either a 1,2,3,4, or 5 only. Work fast, but carefully.

As you read the statement, you will know whether you disagree or agree with the idea stated. If you disagree, circle the extent that you disagree by either indicating strong disagreement with a number 1 or disagreement with a number 2. If you neither disagree nor agree with the statement or feel unsure, circle 3 for undecided. If you agree or strongly agree, circle either 4 or 5, accordingly.

Please circle the appropriate number that indicates the extent to which you agree or disagree with the statement that is expressed.

Fennema Sherman Math Attitude Scales

SD = Strongly Disagree	Circle the 1 if you strongly disagree.
D = Disagree	Circle the 2 if you disagree.
U = Undecided	Circle the 3 if you are undecided.
A = Agree	Circle the 4 if you agree.
SA = Strongly Agree	Circle the 5 if you strongly agree.

Once again, there is no "right" or "wrong" answers. The only correct response is the one that is true for you. Let the things that have happened to you help you make a choice.
THIS INVENTORY WILL BE USED FOR RESEARCH PURPOSES ONLY.
*Fennema-Sherman Mathematics Attitude Scales, available at the Wisconsin Center for Educational Research, School of Education, University of Wisconsin-Madison.

Usefulness of Mathematics Scale (MU)

		SD	D	U	A	SA
1.	I'll need mathematics for my future work.	1	2	3	4	5
2.	Mathematics is of no relevance to my life.	1	2	3	4	5
3.	I study mathematics because I know how useful it is.	1	2	3	4	5
4.	Mathematics will not be important to me in my life's work.	1	2	3	4	5
5.	Knowing mathematics will help me earn a living.	1	2	3	4	5
6.	I see mathematics as a subject I will rarely use in my daily life as an adult.	1	2	3	4	5
7.	Mathematics is a worthwhile and necessary subject.	1	2	3	4	5
8.	Taking mathematics is a waste of time.	1	2	3	4	5
9.	I'll need a firm mastery of mathematics for my future work.	1	2	3	4	5
10.	In terms of my adult life, it is not important for me to do well in mathematics.	1	2	3	4	5
11.	I will use mathematics in many ways as an adult.	1	2	3	4	5
12.	I expect to have little use for mathematics when I get out of school.	1	2	3	4	5

SD =Strongly Disagree,D =Disagree, U =Undecided, A = Agree, SA = Strongly Agree

Confidence in Learning Mathematics Scale (MC)		SD	D	U	A	SA
1.	Generally, I have felt secure about attempting mathematics	1	2	3	4	5
2.	I'm no good in math.	1	2	3	4	5
3.	I am sure I could do advanced work in mathematics.	1	2	3	4	5
4.	I don't think I could do advanced math.	1	2	3	4	5
5.	I am sure that I can learn mathematics.	1	2	3	4	5
6.	I'm not the type to do well in math.	1	2	3	4	5
7.	I think I could handle more difficult mathematics.	1	2	3	4	5
8.	For some reason even though I study, math seems unusually hard for me.	1	2	3	4	5
9.	I can get good grades in mathematics.	1	2	3	4	5
10.	Most subjects I can handle O.K., but I have a knack for flubbing up math.	1	2	3	4	5
11.	I have a lot of self confidence when it comes to math	1	2	3	4	5
12.	Math has been my worst subject.	1	2	3	4	5

SD =Strongly Disagree,D =Disagree, U =Undecided, A = Agree, SA = Strongly Agree

Mathematics Anxiety Scale (MA)	SD	D	U	A	SA
1. Math doesn't scare me at all.	1	2	3	4	5
2. Mathematics usually makes me feel uncomfortable and nervous.	1	2	3	4	5
3. It wouldn't bother me at all to take more math courses.	1	2	3	4	5
4. Mathematics makes me feel uncomfortable, restless, irritable, and impatient.	1	2	3	4	5
5. I haven't usually worried about being able to solve math problems.	1	2	3	4	5
6. I get a sinking feeling when I think of trying hard math problems.	1	2	3	4	5
7. I almost never have gotten shook up during a math test.	1	2	3	4	5
8. My mind goes blank and I am unable to think clearly when working mathematics.	1	2	3	4	5
9. I usually have been at ease during math tests.	1	2	3	4	5
10. A math test would scare me.	1	2	3	4	5
11. I usually have been at ease in math classes.	1	2	3	4	5
12. I do as little work in math as possible.	1	2	3	4	5

SD =Strongly Disagree,D =Disagree,U =Undecided,A = Agree, SA = Strongly Agree

Effectance Motivation in Mathematics Scale (ME)	SD	D	U	A	SA
1. I like math puzzles.	1	2	3	4	5
2. Figuring out mathematical problems does not appeal to me.	1	2	3	4	5
3. Mathematics is enjoyable and stimulating to me.	1	2	3	4	5
4. The challenge of math problems does not appeal to me.	1	2	3	4	5
5. When a math problem arises that I can't immediately solve, I stick with it until I have the solution.	1	2	3	4	5
6. Math puzzles are boring.	1	2	3	4	5
7. I don't understand how some people can spend so much time on math and seem to enjoy it.	1	2	3	4	5
8. When a question is left unanswered in math class, I continue to think about it afterwards.	1	2	3	4	5
9. Once I start trying to work a math puzzle, I find it hard to stop.	1	2	3	4	5
10. I would rather have someone give me the solution to a difficult math problem than to have to work it out for myself.	1	2	3	4	5
11. I am challenged by math problems I can't understand immediately.	1	2	3	4	5
12. I do as little work in math as possible.	1	2	3	4	5

SD =Strongly Disagree,D =Disagree,U =Undecided,A = Agree, SA = Strongly Agree

APPENDIX F

DEMOGRAPHIC QUESTIONNIARE

Demographics Questionnaire

Please fill in the blanks accordingly.

1. Student #:________
2. Age:______
3. Marital Status: (Please circle one)
   a. Single b. Married c. Divorced
4. Gender: (Please circle one)
   a. Female b. Male
5. Country of Origin:____________________
6. Ethnicity: (Please circle one)
   a. White/Caucasian
   b. African American
   c. Asian
   d. Hispanic
   e. Native American
7. Major:_________________
8. College GPA:___________
9. Academic Status: (Please circle one)
   a. Freshman b. Sophomore c. Junior d. Senior
10. How many times have you enrolled in Intermediate Algebra? _____
    What grade do you currently have in Intermediate Algebra?_______

APPENDIX G

PERMISSION TO USE SCALES

Wisconsin Center for Education Research
School of Education • University of Wisconsin-Madison

August 11, 1999

Cynthia Glickman
8520 Copper Ridge Avenue
Las Vegas, NV 89129

Dear Cynthia:

You may use the Fennema-Sherman Mathematics Attitudes Scales in your dissertation research and dissertation at University of Nevada, Las Vegas.

Note that there is no copyright on the scales; also, I do not know whether you are using one or more of the nine scales. Please credit the source, with variation depending on your use, as follows: Adapted from [From] the Fennema-Sherman Mathematics Attitudes Scales, available from the Wisconsin Center for Education Research, School of Education, University of Wisconsin-Madison.

I wish you well in your work toward a doctorate.

Sincerely,

Debbie

Deborah M. Stewart
Senior Editor

DMS/sr

1025 West Johnson Street • Madison, Wisconsin 53706-1796
(608) 263-4200 • fax (608) 263-6448 • http://www.wcer.wisc.edu

APPENDIX H

PERMISSION TO USE SCREEN SHOTS

PRENTICE HALL

Pearson Education
75 Arlington St. 3rd Floor
Boston, MA 02116
Phone (617) 848-6000
Fax: (617) 848-6155

Chris Hoag
Editor-in-Chief
Developmental Mathematics

April 10, 2000

Cynthia Glickman
8520 Copper Ridge Avenue
Las Vegas, NV 89129

Dear Ms. Glickman,

Thank you for your continued interest and research involving developmental mathematics. Continuing education, whether it is for students or instructors, is one of our goals. Your research and use of Prentice Hall materials is a compliment to those goals.

Prentice Hall Higher Education, and parent company Pearson Education, consents to all use of Prentice Hall Interactive Math screen shots in the dissertation of Cynthia Glickman, instructor at Community College of Southern Nevada.
We wish you all the best, and look forward to seeing your results.

Thank you,

Chris Hoag

Chris Hoag
Editor-in-Chief
Developmental Mathematics

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