LAKEHEAD UNVERSITY

THE EFFICACY OF A CUSTOMIZED APPROACH TO COMPUTER ASSISTED INSTRUCTION

BY

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A THESIS

SUBMITTED TO THE OFFICE OF THE GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTERS OF SCIENCE

IN

THEORY OF COACHING

SCHOOL OF PHYSICAL EDUCATION AND ATHLETICS

THUNDER BAY, ONTARIO

ISBN 0-315-69145-X

ABSTRACT

The availability of low cost microcomputer technology has created a revolution in computer assisted instruction (CAI). A customized (CAI) package based on hypermedia graphics, animation, and artificial intelligence was implemented as an instructional tool in an undergraduate sport biomechanics course. Forty-five Physical Education students enroled at Lakehead University participated in this investigation.

The subjects were randomly assigned to two groups and subsequently required to work through different units of instruction within the CAI program. The purpose of this research was to: a) investigate the relationship between theoretical competency test scores when the student received CAI as a complement to lectures versus when the student did not receive CAI, b) examine the student attitudes towards CAI, and c) to determine tendency of students to return to the use of CAI when use was made optional. Theoretical competency tests were administered following each unit to determine if any mean score differences existed when the subject received CAI as a complement to lectures versus when the subject did not receive CAI. Semantic differential instruments were administered to assess students attitudes towards CAI. In addition, subject's CAI lab attendance records were kept throughout the eight week implementation period and during a two week optional use period.

Statistical analysis using a paired t-test and analysis of variance (ANOVA) indicated no significant differences ($p > 0.05$) in theoretical competency test scores when CAI was included as a complement to classroom instruction. Although no significant differences were encountered, a small positive change was recorded on the tests when the students received CAI. Results of the semantic differential instrument indicated an overwhelming positive response towards CAI. When use was made optional, seventy-one percent of the subjects attended the CAI lab. The positive attitudes and tendency of students to return to the CAI lab when use was made optional is indicative of their acceptance of CAI technology.

The findings of this study are congruent with those of previous research on the effectiveness of CAI when used as a complement to tradional lecture methods of instruction. A customized approach to CAI programs which allow the student to work at his or her own pace is recommended. Future research utilizing controlled designs are required before firm conclusions on the effectiveness of CAI can be inferred.

ACKNOWLEDGEMENTS

The author expresses his sincere gratitude to the following people who assisted in this thesis effort.

First and most important thanks to Dr. Moira McPherson, this study could not have been complete without Dr. McPhersons's friendship, scholarly advice, encouragement, and endless discussions relating to the investigation at hand.

Dr. Jane Crossman, Dr. Tony Bauer, Dr. John Jamieson, Dr. Thomas Song, and Dr. Luke Kelly who all took time from busy schedules to facilitate the necessary research refinements required for this thesis.

Mr. Mike Sawyer for his timely and efficient work on preparing the software and hardware necessary for the implementation of the study.

Those Lakehead University students enroled in PE 2015 during the Fall terms of 1989 and 1990 who participated as volunteers in this investigation.

Finally, thanks to Beverley, Bill, Chris W., Donna, Hans, Farzum, Greg, Ian, Kris D., Scott, Sharon, and especially Kathryn for the never-ending friendship, support, and patience with the author.

Table of Contents

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

From the development of computer assisted instruction (CAI) on large mainframe computers in the early 1960's to it's current use on microcomputers, CAI has been heralded as one of the greatest innovations in education (Kelly, 1987; Lockard, Abrams, Many, 1987; Sumner, 1988). Computer assisted instruction is perhaps the most widely used term for what is also known as computer aided instruction, computer assisted learning, computer based instruction, and other combinations of these words. Regardless of the label, CAI refers to the use of a computer as an instructional instrument. According to Wright and Forcier (1985),

> Computer assisted instruction is a term applied to a learning environment characterized by instructional interaction between computer and student. The teacher sets up the learning environment, ensures that each student has the necessary skills to engage in a particular activity, and adjusts the learning activities according to students' needs. (p. 132)

The use of CAI within the discipline of physical education is well documented (Boulton, 1988; Cicciarella, 1981; Miller, 1984). The field of sport biomechanics lends itself, in particular, to CAI as it is able to provide students with an opportunity to experiment in a controlled environment with the application of mechanical principles to moving bodies and objects. However, much that is reported in educational and professional journals on the effectiveness of CAI particularly in the physical education domain is based on speculation. Many authors in the literature have identified the necessity for further research into the effectiveness of CAI before firm conclusions supporting the integration of CAI into educational curriculum can be made (Beynon, 1985; Bullough & Beatty, 1987; Powell, 1987; Plowright & Wills, 1985; Surber & Leeder, 1988). Given such a challenge, the aim of this investigation was to explore the effects of CAI implementation as an integral part of the laboratory experience of an undergraduate course in the biomechanics of sport. The CAI used in this study was a customized computer assisted learning program based on hypermedia graphics, animated and artificial intelligence (Appendix A).

PURPOSE OF RESEARCH

The purpose of this investigation was to evaluate the implementation of a customized CAI program as part of the laboratory experience in an undergraduate biomechanics course in the School of Physical Education at Lakehead University. In order to address this purpose the following research questions were examined.

1. Does the use of CAI in conjunction with a traditional lecture format have any effect on theoretical competency?
2. What was the student attitudinal response towards CAI?
3. What was the tendency of students to return to the use of CAI when use was made optional?

DELIMITATIONS

The investigation was delimited to:

1. Sixty-two male and female students enroled in PE 2015 'Introduction to Biomechanics' during the 1990 fall term at Lakehead University's School of Physical Education who volunteered to participate in the study,

2. the implementation of a customized computer assisted learning program based on hypermedia graphics, animated and artificial intelligence,
3. implementation of the CAI program using a delivery platform of four IBM compatible AT microcomputers,
4. the number of hours per week of CAI laboratory arranged by the professor for each of the students,
5. analysis of CAI laboratory attendance records, student attitude questionnaire results, student responses on a survey of time usage, and student scores on practice theoretical competency tests.

LIMITATIONS

The study was conducted under the following limitations:

1. The subjects involved answered the surveys and questionnaires truthfully,
2. the possible experimenter effects (the investigator was involved as the writer, coordinator, and evaluator of the study),
3. the choices of research design and analysis were limited due to the inability to incorporate ideal sample sizes and a control group.

DEFINITION OF TERMS

Artificial Intelligence: A branch of computer science concerned with the development of machines and programs to simulate human reasoning (Lockard et al., 1987).

Computer Assisted Instruction: A learning environment characterized by instructional interaction between a computer and a student (Sumner, 1988).

Drill and practice: A type of computer assisted instruction that allows students to practice or study information with which they are familiar but not proficient.

Interactive: A program which instructs the computer to respond directly and immediately to a user's input.

Microprocessor: A general purpose computer that could be programmed to do any number of tasks, making it no longer necessary to design circuits specifically for each intended purpose. In the microprocessor a single chip contains all the circuits necessary to perform the basic functions of a whole computer (Sumner, 1988).

Network: Several computers and their peripherals that work together, over distances, through a common set of connections.

<u>Programmed Logic for Automated Teaching Operations (PLATO)</u>: A computer based educational system and related software developed at the University of Illinois for delivering computer assisted instruction to multiple remote users (Bullough & Beatty, 1987).

<u>Simulation</u>: A kind of computer assisted instruction that allows students to interact with models of reality that may otherwise be impossible, dangerous, or impractical (Sumner, 1988).

<u>Tutorial</u>: A form of computer assisted instruction in which the computer carries on a dialogue with the learner, presenting information, posing questions, and providing feedback.

<u>Voice Recognition</u>: The ability of a computer system to translate human speech into computer code (Bullough & Beatty, 1987).

CHAPTER II

REVIEW OF THE LITERATURE

The literature review for this study will focus on four areas; CAI and education, CAI and physical education, CAI and biomechanics, and research in CAI. An introduction to CAI was necessary to familiarize the reader with CAI concepts used throughout the review.

INTRODUCTION TO COMPUTER ASSISTED INSTRUCTION

The development of computer assisted instruction (CAI) began approximately two decades ago (Suppes & Macken, 1978). Since then, there has been an increased use of CAI technology in educational settings. As the 21st century approaches, educational institutions are beginning to rely on advanced technology such as CAI to assist in the learning process (Bitter & Camuse, 1988).

An advantage that CAI has over traditional lectures is it's ability to provide individualized learning. Through specific tutoring software and the use of hyper-text, animation, and artificial intelligence software technology, CAI can provide a learning session that is responsive to each individual user. Unlike textbooks, CAI software tutoring packages are a dynamic medium allowing the individual user to vary such properties as lesson content, level of difficulty, and speed of the lesson.

Much of the current CAI software development is aimed at individualized learning with an emphasis on learner control where the program is self-paced. Learners proceed through the lesson as fast or as slow as desired (Adams & Waldrop, 1985; Plowright & Wills, 1985; Ross, 1984). A contrast with learner control is when the CAI program makes the decisions for the student (Program control). Program control is an effective method of CAI when the user is a beginner with little or no experience with the use of a microcomputer and requires step by step instructions to become familiar with the technology (Rockart & Morton, 1975).

Depending on the capacity of the microcomputer students can be presented with instructional CAI materials in a variety of ways. Lessons can be presented as (a) drill and practice programs, which are the most common form of CAI, (b) tutorial programs, and (c) simulation programs.

Drill and practice programs are intended to reinforce skills that have been previously taught through some alternative medium, usually a teacher. For example, a biomechanics drill and practice program could be used to assist a learner to memorize fundamental mechanical principles and how they can be applied to human movement sports skills.

Most educators would agree that the ideal learning system is composed of one teacher tutoring one student. However, the cost of such a system does not make it a feasible option for the general population. Tutorial computer applications seek to place the computer in the role of a tutor, one that carries the full instructional burden of guiding a student to the achievement of a specified set of objectives. Simulation programs are ideally suited for teaching problem solving and decision making, especially in situations where training with real events is time consuming, dangerous, and/or expensive (Miller, 1984).

COMPUTER ASSISTED INSTRUCTION AND EDUCATION

During the 1960's, various computer assisted instructional programs were developed primarily for educational institutions. Notable projects during this period include the Stanford Project at Stanford University and the Programmed Logic for Automatic

Teaching Operations (PLATO) project at the University of Illinois (Bullough & Beatty, 1987). The Stanford Project consisted of mathematics and reading programs. Patrick Suppes and Richard Atkinson, the developers of the Stanford Project, saw in CAI, the potential for realizing the age old dream of teaching students on a one to one tutorial approach (Bullough & Beatty, 1987). Their goal was to individualize instruction for every student.

The Stanford program was based on three levels of interaction. The first level was drill and practice sessions, and the second level was tutorial sessions. The third level was referred to as the dialogue system whereby the student could verbally ask the computer a question and the computer would respond with an answer (Lockard et al., 1987). Unfortunately, the problems of using the spoken word for input to the computer were not sufficiently resolved to make the dialogue system a viable option. Though speech recognition has progressed markedly over the past decade, problems encountered in the early days still remain today.

The PLATO system consisted of a central computer with several individual terminals equipped with videodisplays and keyboards. The system was highly interactive utilizing such innovations as touch screens in the place of keyboard input (Bullough & Beatty, 1987). A touch screen is a monitor that permits the user to input information by touching the screen at various selected points. For example, rather than having to type in the answer to a multiple choice question, the student need only touch the answer of his choice on the screen; the display then will then change in response to the action. Unfortunately PLATO was very expensive and proved to be impractical for smaller institutions with limited budgets (Lockard et al., 1987). Although PLATO, and some other systems based on the original networked concept are still in place, the popular, less expensive microcomputer has all but monopolized instructional computing.

Educational institutions from the elementary and secondary level (Duin, 1988; Reed and Sautter, 1987; Surber & Leeder, 1988) to the post secondary level (Powell, 1987; Ries & Granell, 1985; Priest, 1987) currently take advantage of the many benefits offered by CAI at a cost that is easily affordable.

As evidence of the interest in microcomputer technology such as CAI in education, scholarly journals devoted entirely to the use of computers in the educational setting are being published (Summers, 1988). These journals include: the Journal of Computer Based Instruction, the Journal of Computer Assisted Learning, Educational Technology, Educational Computing, the Computing Teacher and Electronic Learning. A number of other journals such as the British Journal of Physical Education and the Australian Council for Health, Physical Education and Recreation (ACHPER) devote space to the application of microcomputers in education, further supporting the increased interest of CAI.

One of the most important factors in the use of CAI as an educational tool is the user's attitudes towards the technology. Regardless of how inexpensive, advanced, and sophisticated the CAI package is, it would be a useless tool in the learning process if the user's attitudes were anything less than positive. Ries and Granell (1985) developed a college level CAI lesson in nutrition and compared it's effectiveness with the traditional lecture and discussion method. Although Ries and Granell (1985) found no significant differences between the two methods in pre and post test knowledge scores, the CAI students were reported to have been highly motivated and gave positive responses towards the CAI. Several investigators (Boyce, 1988; Kulik, Kulik, Cohen, 1980; Powell, 1987; and Thompson, Jolly, Macdonald, Cookson, Holman, Keech, 1987) reported similar findings to that of Ries and Granell (1985) regarding positive attitudes towards CAI. The importance of student's attitudes towards CAI have been emphasized by other researchers (Powell, 1987, Self, 1985, and Beynon, 1985) who have all used attitude as a dependent measure in the evaluation of CAI programs.

The use of CAI has been frequently cited in the literature as a time-saver in educational institutions when compared to traditional lecture and discussion methods (Reed & Sautter, 1987; Ries & Granell, 1985; Self, 1985; Thompson et al., 1987). In an analysis of the effectiveness of CAI, Kulik, Kulik, and Cohen (1980) examined the results of eight investigators who collected data on the amount of time spent in instruction of students in CAI compared to the time spent in traditional lectures. Each of the eight investigators concluded that the computer produced a substantial saving in instructional time. On the average, the conventional approach required 3.5 hours of instructional time per week, and the CAI approach required about 2.5 hours.

Many educators feel that in spite of some obvious advantages of CAI technology, the computer is an expensive gadget or toy that increases the cost, and possibly the complexity of the educational process without increasing the quality of the education (Bullough & Beatty, 1987). Another major obstacle in the use of CAI appears to be increased cost and lack of quality individualized software (Adams & Waldrop, 1985; Boyce, 1988; Kelly, 1987; Miller, 1984). While sophisticated CAI software already exists, the development of new software is a major undertaking requiring professional programming expertise. This inadvertently may further increase the cost of software, thereby decreasing availability. In the educational setting, however, commercial software is becoming available for schools as a mass-market product, manufactured in large numbers and sold at low cost.

Several studies have suggested that the use of CAI provides little or no contribution to student achievement (Kulik et al, 1980; Ries & Granell, 1985). However, most researchers agree that even small contributions of CAI to student achievement are significant and warrant further implementation and investigation. (Adams & Waldrop, 1986; Boyce, 1988; Dence, 1980; Kelly, 1987). Some educators who use CAI have suggested that computers make a positive difference where learning is concerned (Dence, 1980; Mohnsen, 1987). Such statements are subjective in nature, because there is little research available that addresses the question of computer effectiveness. The most important criticism of CAI is that evaluation of CAI implementation has not received adequate attention.

There has been considerable debate as to whether CAI is more effective than traditional forms of instruction (Cicciarella, 1983; James, 1987). There is however, much support for the effectiveness of CAI when used in conjunction with traditional methods of teaching (Adams & Waldrop, 1985; Boyce, 1988; Priest, 1987; Walkley, 1988). As the use of CAI increases, investigators need to thoroughly evaluate it's effectiveness on many different dependent measures before it becomes an accepted widespread learning medium.

COMPUTER ASSISTED LEARNING AND PHYSICAL EDUCATION

The discipline of physical education has not been exempt from the computer revolution. At the 1983 American Alliance for Health, Physical Education, Recreation and Dance (AAHPERD) National Convention, it became evident that many physical educators were using computers, particularly micro and personal computers, for a variety of applications (Londeree, 1983). Johnson, Loper, and Cordain (1986) conducted a nation-wide survey to determine computer applications and directions in the United States in university level physical education programs. Of the 68 physical education departments which responded to the survey, 79 percent were currently employing computers in one or more of the operations in their department. The top five applications for which computers were being used were: (1) statistical analysis, (2) word processing, (3) stress test evaluation, (4) kinesiological and biomechanical evaluation, and (5) teaching faculty and students to become computer literate. Programmed learning or CAI was listed as an important application by Johnson et al. (1986), however, it was not highly emphasised by survey respondents.

A 1990 replication of the Johnson et al. (1986) study by Guthrie (1990) on twenty-three Canadian P.E departments revealed similar findings. Of the 16 Canadian physical education departments which responded to the survey, 70 percent were currently employing computers in one or more of the operations in their department. The top five applications for which computers were being used were: (1) statistical analysis, (2) biomechanical evaluation, (3) exercise physiology classroom and laboratory exercises, (4) motor learning laboratory exercises, and (5) sport psychology. However, little information was gleaned regarding the use of CAI within Canadian university physical education departments.

In the past few years there have, however, been several indicators of increased CAI use in physical education. Recently, Walkley (1988) introduced the first of a continuing series of reviews in the Australian Council for Health, Physical Education and Recreation which focused on some of the possible applications of computer technology in physical education. Walkley's reviews dealt mainly with student learning and CAI applications.

Skinsley (1986) began a regular feature in the British Journal of Physical Education on the subject of computing within physical education and outlined the importance of establishing a national registry for physical education related CAI software. By establishing such a registry, physical educators interested in CAI could be in touch with each other so that they could combine similar ideas and subsequently develop programs in specific areas of physical education. There are also reports in the literature of the use of CAI by physical educators in the areas of dance (Gray, 1983; Allen, 1983), football (Patrick & McKenna, 1986), soccer (Mayhew & Wenger, 1985), weightlifting (Grabe & Widule, 1988), and track and field (Bartlett & Best, 1983).

Despite the work of Walkley and Skinsley, many believe that the field of physical education has been left behind in terms of using available technology to improve the instructional process (Adams and Waldrop, 1985; Boulton, 1988; Boyce, 1988; Cicciarella, 1983;

Kelly, Walkley, Tarrant, 1988; Mohnsen, 1987). Possible reasons for this include: a lack of computer literacy amongst physical education instructors (Johnson et al., 1986), the high cost of developing CAI software specific to physical education (Kelly, 1987, Miller, 1984, Priest, 1987), the initial start-up costs of attaining hardware (Mohnsen, 1987), and a general unacceptance of computer technology by physical educators (Kelly, 1987). To overcome the problems of financing CAI projects, Mohnsen (1987) suggested that physical educators should take advantage of current grants available for classroom instructional improvement. Johnson et al. (1986) suggested a number of programs which could be introduced in physical education departments to increase computer literacy amongst instructors.

The effectiveness of CAI in physical education depends on how physical educators choose to apply this technology. Since the physical setting of the gymnasium, pool, or athletic field does not adapt easily to the use of electronic equipment for instruction, physical educators are able to utilize CAI laboratories as a complement to the physical setting.

Engelhorn (1983) suggested that many applications in motor learning and control are suited to CAI. Typical motor learning experiments completed using the microcomputer provide the student not only with particular theoretical concepts, but also illustrate computer use in movement science. Simulation programs are currently the most sophisticated form of CAI available for use in the physical education setting. Simulation programs are ideally suited for teaching problem solving and decision making, especially in situations where training with real events is time consuming, dangerous, and/or expensive (Miller, 1984). Current experimentation with video interfaced computers allow the physical educator to film the real event then apply a video replay of the event onto a computer screen for analysis and instruction (Kelly et al., 1988).

Further increased use and development of quality CAI hardware and software in physical education depends on the knowledge and experience only physical educators can provide. Physical educators must take the initiative by expressing their needs to the manufacturers of CAI technology, [illegible] their discipline is to advance into the next century with other educational domains.

COMPUTER ASSISTED LEARNING IN BIOMECHANICS

Sport biomechanics in physical education is concerned primarily with the application of mechanical principles to the analysis of the techniques employed in sports (Hay, 1978). The field of biomechanics lends itself to CAI because it is able to provide students with an unprecedented opportunity to experiment in a controlled environment with the application of mechanical principles to moving bodies and objects. Unfortunately, there are only a handful of researchers who have reported their attempts to explore applications of CAI in biomechanics. A review of software availability for physical education by Skinsley (1986), Boulton (1988), and King & Aufsesser (1986) reveals a great deal of biomechanics specific programs. However, the majority of these programs are geared towards the analysis of human motion (e.g. a golf swing) and are not interactive tutorials. The major research application to computer analysis in biomechanics involves photo and video analysis of motion (Miller, 1984). The major obstacle of CAI implementation in the biomechanics domain, again, appears to be the lack of quality individualized software (Adams & Waldrop, 1985; Boyce, 1988; Kelly, 1987; Miller, 1984). It has been suggested this will change in the near future, according to Miller, (1984):

> In the contemporary situation, most faculty and university students are in a period of transition. Just as we struggle to catch up and keep up, we are now dealing with undergraduate students who, by and large, have had little exposure to micros in an educational setting. This will not be true of the next generation of students. As their level of computer literacy increases, we will need to devote less time to the technology, leaving more time for instruction in concepts and analysis skills. (p. 40)

While the development of sophisticated instructional biomechanics programs complemented by quality graphics, sound, and animation, is quite clearly possible, it is a major undertaking usually requiring professional programming expertise.

RESEARCH IN COMPUTER ASSISTED INSTRUCTION

Researchers have approached the field of CAI from a variety of backgrounds (education, psychology, physical education, computer science) and have written for a number of audiences (teachers, instructors, administrators, researchers, students) on subjects ranging from performing experimental CAI research in the classroom (James, 1987) to the effect of graphic feedback on student motivation (Surber & Leeder, 1988).

In general, the literature has indicated that the researchers have spent the majority of their time acquiring, applying, and teaching new computer skills and techniques as opposed to the actual implementation and evaluation of CAI programs. However, several investigators have attempted to measure the effectiveness of CAI in the educational setting.

In examining the effect of CAI graphic feedback on student motivation, Surber and Leeder (1988) randomly assigned 55 subjects to one of three CAI treatment groups. One group received graphic feedback to responses on a CAI spelling test, the other two groups received the same test with no graphics. The dependent measures used were: (1) student scores on the CAI spelling test, (2) student scores on post-CAI paper and pencil tests, and (3) a record of whether or not students used the CAI program when made optional. Because the argument in favour of graphics in CAI is made on the basis of assumptions about the relationship between graphics and motivation, the researchers expected that the group which got the graphic feedback would be more likely to return to the optional use of their CAI program than subjects assigned to the groups without graphic feedback. The last variable, the tendency of students to return to the use of the program when use was made optional, was cited as the most important variable. The researchers found that subjects who had used the program with graphic feedback were no more likely to continue using their program than subjects who had used the program without graphic feedback. The authors cautioned that their experiment could not be considered a definitive study until further research on the motivational aspects of graphics has been reported.

In a study to determine user's attitudes on the use of CAI, Beynon (1985) sampled 164 subjects consisting of staff, teachers and students in a College of Education in the United States. Obtaining a dependent measure on user's attitudes in such an experiment can be a difficult task. Beynon (1985) stated, "obviously it is very difficult to give an objective assessment of the value of CAI in providing a context for tutorials. One can only use student opinion as a basis for evaluation" (p. 16).

Beynon (1985) used an appraisal form consisting of four questions and statements as the dependent measure for attitudinal response towards CAI and suggested on the basis of the appraisal, response to the program was favourable. The difficulty of evaluating such an experiment is a limitation to CAI implementation in educational settings; however Beynon (1985) stated, "such models should be pursued regardless of the constraints imposed by the limitations" (p. 17).

Beynon (1985) also suggested further research into teaching and learning CAI strategies based on adequate procedures and models is fundamental if any real progress is to be made in this area.

To investigate the effectiveness of color, graphics, and animation in a CAI tutorial lesson, Baek and Layne (1988) randomly assigned 119 subjects to one of the six groups which resulted from 2 x 3 factorial design (Monitor type: Color vs. Black & White) X Treatment (Text, Graphics, and Animation). Each subject participated in a single 20-minute CAI session, the purpose of which was to teach the mathematical rule for average speed. Before and after the learning session, each subject completed a pencil-and-paper performance test. Post-test scores and time spent in completing the module were the dependent variables in the study while the pretest served as the covariate variable. Results of the 2 x 3 analysis of covariance on the performance measure revealed that the animated graphics group scored significantly higher than any other group while the still graphics group scored significantly higher than the text group. The major limitation of this study was that the results were obtained after only one CAI lesson. The researchers concluded this study should be used as a pilot for future research.

In an affective response of college students to an exemplary application of CAI, Powell (1987) randomly divided 76 college students into an experimental and a control group. To assess affective responses, Powell

(1987) used two semantic differential instruments (SDI). Semantic differential instruments were selected for this experiment to assess affective response towards CAI because of their adaptability in measuring the direction and intensity of reaction to an experience. One SDI used to measure the subject's reactions to CAI contained 25 sets of bipolar adjective pairs. The second SDI was a multi-questionnaire to determine attitudinal response toward the nature of the CAI course content. A statistical analysis using the t-test procedure was applied to the results on the two SDI's. The results indicated that the positive attitudes of those students who received instruction were significantly higher than their counterparts who received traditional instruction on the same course units. The author suggested that future research designs should focus on the extent to which students are able to apply their CAI experience to actual performance in theoretical and practical tests.

SUMMARY

From the review of literature it is evident CAI is a new and exciting medium which is becoming an integral part of the educational domain from the primary to the post secondary level. However, the utilization of CAI technology is still in it's infancy within the discipline of physical education. In particular, there have been few attempts to enhance learning in the field of sport biomechanics, or any other physical education domain by using CAI as a complement to the traditional lecture method of instruction. Although there are a some physical education CAI programs in existence, few are customized to the specifications and needs of the individual instructors or individual institutions. The main reasons appear to be due to the high costs, and hard work associated with the development of customized CAI programs specific to sport biomechanics.

Although a great deal of CAI research has been undertaken, the effectiveness of CAI as an educational tool has not been well documented. Several investigators have indicated the need for future research to determine the effectiveness of CAI as an educational tool before firm conclusions can be drawn. Variables such as student acceptance of CAI, student attitudes towards CAI, and knowledge test performance related to CAI intervention have been identified as valid dependent measures for CAI research. However, information on how to best evaluate these measures is limited.

From the review of the literature it is evident research questions relating to the effectiveness of CAI in university level physical education need to be addressed. The most important of these questions included: (1) Does the use of a customized CAI program in conjunction with a traditional lecture format have any effect on theoretical competency? (2) How can theoretical competency be measured? (3) How do students in physical education respond towards CAI? (4) What are the difficulties and constraints of teaching physical education students to use CAI programs? (5) What are the problems associated with trying to evaluate the effectiveness of a CAI program in physical education? The present study represents an attempt to provide answers and greater insight into these questions.

CHAPTER III

METHODOLOGY

The procedures used for this study were divided up into the following five segments: (a) software design, (b) the preliminary investigation, (c) subjects, (d) field testing, and (e) data collection and analysis. The methodology utilized for this investigation was limited by the possible threats to the internal and external validity which are included at the end of this chapter.

Software Design

The customized CAI program used in this study was based on hypermedia graphics, animation and artificial intelligence. The CAI program was aimed at individualized learning with an emphasis on learner control. Subjects were able to proceed through the lessons as fast or as slow as they desired. Unlike books or printed notes, the central course theme was targeted to the top twenty percent of students. Key concepts were amplified in successive layers of hypertext to be accessed by those students wanting greater depth or whom were lacking in their preparation. Animation was used to replace static drawings and paragraphs of accompanying descriptions. Sound and color were added to enhance the software presentation.

The CAI program was presented in a variety of ways. Text and graphics were presented in a tutorial format, biomechanical skill analyses were presented in a simulation format using sound and animation, and interactive review questions were presented in a drill and practice format. Detailed information on the CAI package used in this study is provided in Appendix A.

<u>The Preliminary Investigation</u>

The preliminary investigation involved two stages, they were: (1) computer assisted learning laboratory monitoring, and (2) development of dependent measure instruments.

1. Computer Assisted Instruction Laboratory Monitoring

The CAI program used for this investigation was included as an integral part of the course work for PE 2015 'Introduction to Biomechanics' during the winter term of 1990 at Lakehead University. During this time the investigator was employed as a laboratory monitor and made informal observations regarding the feasibility of the proposed CAI implementation format, imposed time constraints, and student attitudes towards the CAI. The information gathered was used to refine the field implementation and evaluation of the CAI.

2. Development of Dependent Measure Instruments

An eight point questionnaire (Appendix B) was developed to determine the subject's previous computer experience and to estimate the time spent by each subject outside of the computer laboratory on academic study and non-academic activities.

Four practice theoretical competency tests (Appendix C) were developed to assess student knowledge on PE 2015 'Introduction to Biomechanics' course unit two (fundamental terms and mechanical principles), unit three (torques and levers), unit four (linear kinematics), and unit five (angular kinematics). The tests were developed by Dr. Moira McPherson, course instructor for PE 2105 and consisted of questions constructed from the course and laboratory notes. In an attempt to validate the tests, an external biomechanics expert reviewed and revised the content of each test. The review was performed by Dr. Tony Bauer, Associate Professor of Biomechanics at Lakehead University. Although the content of the practice theoretical tests were of similar nature to the course unit tests given in-class by the instructor, no questions used between the two sets of tests were identical.

The development of the dependent measure instruments concluded with the construction of a semantic differential instrument (Appendix D) described by Katz and Green (1990), Powell (1987), and Osgood, Suci, Tannenbaum (1971) to assess the attitudes of students towards CAI. This instrument was constructed using the guidelines provided by J. Powell (personal communication, January 24, 1990) and was selected because of it's adaptability in measuring the direction and intensity of reaction to an experience (Osgood et al., 1971). The survey consisted of a bipolar adjective scale with seven points and opposite descriptors. To avoid response bias, positive terms sometimes appeared on one end of the scale or the other.

Subjects

The subjects involved in this investigation were full-time students from Lakehead University during the Fall 1990 term. All enroled into PE 2015 'Introduction to Sport Biomechanics' offered by the School of Physical Education at Lakehead University. Of the 62 students enroled in PE 2015 all but two were in their sophmore year of a four year Honours Bachelors Physical Education program. There were 34 males and 28 females registered. The course instructor permitted the investigator to make a presentation to the PE 2015 class during a lecture in the first week of the term in order to recruit potential subjects. During the presentation, the purpose of the study was presented to the entire class and all of the students were given an informed consent package (Appendix E) detailing the requirements of participating in the study. Only those who volunteered to return the consent form by the end of the first CAI unit were considered as subjects involved with this investigation. Results obtained from each subject in the study were strictly confidential.

Field Testing

All students enroled in PE 2015 were provided with a CAI laboratory in addition to their lectures. The course content was divided up into six units. Each student was required by the instructor to attend the computer laboratory for two of the six units. Each unit was composed of two weeks of instruction and concluded with a theoretical competency test. The material included in the computer assisted learning program corresponded precisely to the order and presentation of material in the course lectures.

All students were given instruction on use of the biomechanics CAI program in the CAI lab during unit one by the investigator. To accommodate the large number of students in the course, the students enroled in PE 2015 were randomly divided into two groups, group A and group B. Those students randomly assigned to group A were required to attend the CAI lab during units two and four. Those students randomly assigned to group B were required to attend the CAI lab during units three and five. This arrangement provided the investigator with an opportunity to administer the dependent measure instruments to subjects under two different instructional conditions ('CAI + lectures' versus 'lectures only'). No other access to the lab was provided during units two through five since computer lab availability was restricted.

To determine the subject attitudinal response towards CAI, those students from PE 2015 who volunteered to participate in this study were required to complete the semantic differential instrument twice. The first time the instrument was given was after completion of a CAI unit; the instrument was also administered during a second unit when the subject was not scheduled in the CAI laboratory. An 8 point questionnaire to determine previous computing experience and time usage was also given to each subject at the end of the first attended CAI unit (Appendix B).

To determine if any difference existed between theoretical competency when the student received CAI versus when the student did not receive CAI, four practice tests were administered to each subject. The practice tests were given in the lab by the investigator at the end of course units two, three, four, and five. Subjects were given 40 minutes to complete each test. The completed tests were marked immediately by the investigator. Immediate feedback was given to each subject on the results of each test.

To determine the tendency of subjects to return to the use of CAI when use was made optional, all of the students in the course were given the option of attending the CAI lab during the last two weeks of the term. Attendance was taken during this final two-week unit.

Further evaluation of the CAI package included informal observations during the scheduled CAI laboratory by the investigator (Appendix F). The informal observations included records of any difficulties encountered during implementation procedures, subject feedback, and subject behaviour towards CAI. The implementation of this study took place over a period of eleven weeks commencing during the Fall semester at Lakehead University in September 1990 and concluding during the final week of classes in December, 1990. Figure 1 presents the investigation procedures in a chronological order.

WEEK	GROUP A	GROUP B
ONE	-CAI LAB UNIT 1 -INFORMED CONSENT PACKAGE	-CAI LAB UNIT 1 -INFORMED CONSENT PACKAGE
TWO & THREE	-CAI LAB UNIT 2 -ATTITUDE QUESTIONNAIRE -TIME USE SURVEY -PRACTICE TEST 1	-TIME USE SURVEY -PRACTICE TEST 1
FOUR & FIVE	-ATTITUDE QUESTIONNAIRE -PRACTICE TEST 2	-CAI LAB UNIT 3 -ATTITUDE QUESTIONNAIRE -PRACTICE TEST 2
SIX & SEVEN	-CAI LAB UNIT 4 -PRACTICE TEST 3	-ATTITUDE QUESTIONNAIRE -PRACTICE TEST 3
EIGHT & NINE	-ATTITUDE QUESTIONNAIRE -PRACTICE TEST 4	-CAI LAB UNIT 5 -PRACTICE TEST 4
TEN & ELEVEN	-OPTIONAL CAI LAB USE	-OPTIONAL CAI LAB USE

Figure 1. Research schedule of activities

<u>Data Collection and Analysis</u>

The questionnaires, attitudinal survey instruments, marked practice tests and attendance records were administered and collected by the researcher, sealed in an envelope and immediately stored under security in the School of Physical Education administration office. No access to the completed instruments was made by the course instructor or researcher until all final course marks were recorded and submitted to the records office at the end of the term. At the end of the term the responses were summarized and re-typed by the investigator to ensure the participants anonymity.

The researcher had no access to the results of the scheduled student knowledge test scores given by the instructor in PE 2015 during the fall 1990 term. A set of descriptive statistics were generated on the results of the student time usage questionnaire. Frequencies, measures of central tendencies, and measures of variability were used to describe the results of the questionnaire.

The data obtained from each subject's practice tests were analyzed (Appendix G). Scores were determined for each subject using the results of the theoretical practice tests when (1) the subject received CAI as a complement to PE 2015 'Introduction to Biomechanics' lectures and (2) when the subject did not receive CAI as a complement to lectures. A paired t-test on the scores was performed to determine if significant differences in performance existed between treatments (CAI versus NO CAI). An analysis of variance (ANOVA) was also performed to determine group differences between subjects, test differences within subjects, and test x group interaction within subjects. All analysis were performed at the 0.05 level of significance.

Descriptive statistics indicating means, mode, standard deviations, and percentages were generated on the results obtained from the semantic differential instrument to assess the student attitudinal response towards CAI. To determine the reliability of the scale, a reliability coefficient was calculated based on the results of the twenty-two adjective pairs. To determine how each of the items used affected the reliability of the scale, a reliability coefficient was calculated when each of the items was removed from the scale.

Finally, individual CAI laboratory attendance records for those subjects participating in this study were analyzed. These data were used to determine frequencies and percentages of those subjects electing to continue using the CAI laboratory when sessions were made optional.

Internal and External Validity

Internal validity refers to the extent to which one could claim that the independent variable was responsible for a change in the dependent variable (Smith & Glass, 1987). Possible threats to the internal validity of this study included history, instrumentation, nonequivalence, regression, and mortality.

The effects of history were considered a threat to this study since the subjects were attending biomechanics lectures at the same time they were attending the CAI lab (the independent variable). It was possible that the results on the theoretical competency tests (the dependent variable) were reflecting learning that took place in the lectures and not the CAI lab. While all subjects in the study had the necessary course pre-requisites, an exact measure of their previous biomechanics knowledge could not be obtained.

The effects of instrumentation were considered a threat since the level of difficulty of the theoretical competency tests were different for each biomechanics unit. The effects were reduced by using the same format on all four tests, and all tests were reviewed by an external biomechanics expert to assess content validity. However, the content validity could have been ensured only by having a greater number of biomechanists review the tests.

The effect of subject mortality was considered a threat since those subjects who completed the study may have had different characteristics from those who dropped out. An attempt to reduce this effect was made by encouraging all subjects to remain in the study until the completion date.

Other threats to the internal validity of this study were sample size and the effects of subjects working harder than they would have if they were not in the study (John Henry effect). Significance tests were affected by the small sample size used in this experiment. This effect could not be controlled since the subjects were volunteers from an actual undergraduate biomechanics class. Nonsignificant treatment differences may have been attributable to the John Henry effect, those subjects writing theoretical competency tests without receiving CAI may have worked particularly harder in order to compete with their counterparts who were receiving CAI as a complement to lectures.

The external validity refers to the extent to which the effects observed in the experiment would also be observed in broader contexts (Smith & Glass, 1987). Although the results of this study may provide suggestive evidence that the intervention of CAI is worth applying to other populations within educational institutions, the design limitations of this study confines the generalization of the findings to other students.

The effects of the setting, or ecological external validity were not considered a threat since the experiment was conducted in the natural settings of a typical computer laboratory. The effects of subject demand characteristics were considered a threat to the external validity since the subject attitude and performance were measured during a new instructional method (i.e CAI lab). Instead of behaving and responding in their true and typical behaviour, subjects could have ascertained the research hypothesis and changed their behaviour accordingly.

The Hawthorne effect was also considered a threat to the external validity of this study since performance improvements by the subjects on the theoretical competency tests may have been caused by the feeling of special handling rather than by the introduction to CAI itself. In addition, the effects of novelty were considered a threat since the results of the dependent measures may not have been caused so much the CAI program itself but the enthusiasm and high morale that accompanied the implementation of the new CAI program. The novelty effect threatens the external validity here because the results of this study may or may not be replicated if the study were to be repeated on the same subjects during a subsequent biomechanics course. The novelty effects were reduced by implementing the CAI program and administering the dependent measures over a period of eleven weeks.

A definite threat to the external validity of this study were the effects of experimenter bias. The investigator was intimately involved as the writer, coordinator, and evaluator of the study. The extent to which the investigator affected the performance of the subjects is indeterminable within the context of this investigation.

CHAPTER IV

RESULTS

To determine if the use of CAI in conjuntion with a traditional lecture format had any effect on theoretical competency, pen and paper tests (Appendix C) were administered on four occasions to the two experimental groups. Since no additional academic credit was given for participation in this study, it was not possible to ensure that the subjects would complete all four tests. Forty-seven students volunteered to participate as subjects for this study. Thirty-seven subjects met the criterion of writing at least one test during a unit where CAI was used as a complement to lectures and one test during a unit when CAI was not accessed, the results are summarized in Table 1. Eighteen of those subjects wrote all four of the tests, the results are presented in Table 2.

Table 1

Theoretical Competency Test Results

GROUP	TEST	TREATMENT	N	MEAN	S.D
GROUP A	TEST 1	CAI	16	74.33	11.20
(N = 18)	TEST 2	NO CAI	19	74.21	17.22
	TEST 3	CAI	13	65.77	18.94
	TEST 4	NO CAI	10	76.94	16.15
GROUP B	TEST 1	NO CAI	17	73.13	10.61
(N = 19)	TEST 2	CAI	15	82.50	15.27
	TEST 3	NO CAI	15	67.83	22.38
	TEST 4	CAI	14	83.13	15.19

Table 2

Theoretical Competency Test Results of Subjects Complet'ng All Four Tests

GROUP	TEST	TREATMENT	MEAN	S.D
GROUP A	TEST 1	CAI	73.18	12.18
(N = 9)	TEST 2	NO CAI	70.00	18.11
	TEST 3	CAI	71.11	7.92
	TEST 4	NO CAI	75.00	15.84
GROUP B	TEST 1	NO CAI	72.56	11.52
(N = 9)	TEST 2	CAI	81.94	17.53
	TEST 3	NO CAI	73.89	21.36
	TEST 4	CAI	82.10	16.38

Differences between the treatment (CAI vs NO CAI) theoretical competency test score means were examined using a paired t-test analysis and are summarized below in Table 3. The analysis revealed a mean score of 77.23 (SD = 10.32) was obtained from subjects who wrote tests immediately following CAI units, and a mean score of 72.86 (SD = 11.98) was obtained from subjects on tests completed on units where CAI was not accessed. Analysis of the mean scores revealed a t-value of 1.12 and indicated no significant difference.

Table 3

Paired T-test Analysis of Theoretical Competency Tests

TREATMENT	MEAN	S.D	$T^{obtained}$	$T^{critical}$ $p > 0.05$
CAI	77.23	10.32		1.74
NO CAI	72.86	11.98	1.12	(df = 17)

An analysis of variance was performed on the results of those subjects completing all four theoretical competency tests and are summarized below in Table 4. Examining the overall group differences, the results of the analysis revealed an F value of F(1,16) = 2.29. The significant value obtained for F was 0.150 and indicated no significant overall group differences. Examining the overall test differences, the results of the analysis revealed an F value of F(3,48) = 0.54. The significant value obtained for F was 0.657 and indicated no significant overall group differences. Examining group by test interaction, the results of the analysis revealed an F value of F(3,48) = 0.56. The significant value obtained for F was 0.64 and indicated no significant differences.

Table 4

Muliple Analysis of Variance

	SS	df	MS	$F^{obtained}$	$F^{significant}$
Between Subjects					
Groups	476.38	16	208.45	2.29	0.15
Within Subjects					
Tests	415.87	3	138.62	0.54	0.65
Groups x Tests	434.01	3	144.67	0.56	0.64

Results of the attitudinal response instrument appear in Table 5 and Table 6. The scale went from one to seven where, seven indicated the highest positive response, one indicated the highest negative response, and four indicated a neutral response. The data were combined across both treatments for each subject. The results presented in Table 6 indicate the percentage of responses scale for each of the items.

Table 5

Semantic Differential Summary Statistics

ITEM	POSITIVE DESCRIPTOR	MEAN	MODE	S.D
1	PLEASANT	5.94	6	1.12
2	ORIGINAL	5.24	6	1.86
3	CREATIVE	5.89	6	1.23
4	EXPERIMENTING	4.86	4	1.09
5	SOCIABLE	5.77	6	1.27
6	ACTIVE	5.72	6	1.16
7	AMIABLE	5.65	6	1.16
8	ADVENTUROUS	5.42	5	1.26
9	FAST	5.13	4	1.47
10	PLEASING	5.97	6	0.91
11	LIVELY	5.18	6	1.09
12	GOOD	6.30	7	0.87
13	ENCOURAGING	6.20	6	0.87
14	MEANINGFUL	6.21	7	0.81
15	SHARP	5.59	6	1.06
16	SATISFYING	5.69	6	1.23
17	RELEVANT	6.37	7	1.19
18	ENHANCING	6.24	7	0.95
19	EFFECTIVE	6.20	7	1.12
20	INVOLVED	5.96	6	1.11
21	INTERESTING	5.86	6	1.23
22	BENEFICIAL	6.49	7	1.05

Table 6

Percentages of Responses

	NEGATIVE			NEUTRAL		POSITIVE	
ITEM	1	2	3	4	5	6	7
1	0 %	2.8 %	2.8 %	2.8 %	11.3 %	49.3 %	31.0 %
2	7.0	7.0	1.4	14.1	9.9	31.0	29.6
3	0	2.8	4.2	5.6	9.9	43.7	33.8
4	0	1.4	7.0	33.8	22.5	32.4	2.8
5	2.8	1.4	0	7.0	15.5	46.5	26.8
6	0	1.4	4.2	7.0	23.9	35.2	28.2
7	0	0	2.8	18.3	18.3	32.4	28.2
8	1.4	1.4	1.4	16.9	29.6	26.8	22.5
9	0	0	4.2	23.9	21.1	21.1	22.5
10	0	0	0	8.5	16.9	43.7	31.0
11	0	1.4	4.2	22.5	25.4	39.4	7.0
12	0	0	2.8	1.4	5.6	43.7	46.5
13	0	1.4	0	1.4	11.3	46.5	39.4
14	0	0	0	2.8	15.5	39.4	42.3
15	1.4	0	0	12.7	25.4	43.7	16.9
16	0	1.4	5.6	8.5	21.1	33.8	29.6
17	1.4	1.4	1.4	1.4	9.9	18.3	66.2
18	0	0	2.8	2.8	9.9	36.6	47.9
19	0	2.8	1.4	2.8	8.5	35.2	49.3
20	0	1.4	2.8	5.6	15.5	38.0	36.6
21	1.4	0	4.2	7.0	15.5	36.6	35.2
22	0	2.8	1.4	1.4	1.4	23.9	69.0

The overall response means obtained for each point on the semantic differential scale are displayed below in Table 7. The data obtained on the completed instruments was arranged so that all positive terms appeared at the high end of the scale.

Table 7

Item Scale Response Means

BIPOLAR RESPONSE	ITEM SCALE	RESPONSE MEANS
VERY NEGATIVE	1	2.5 %
NEGATIVE	2	2.5
MILDLY NEGATIVE	3	3.2
NEUTRAL	4	9.4
MILDLY POSITIVE	5	15.6
POSITIVE	6	34.1
VERY POSITIVE	7	32.7

A reliability analysis of the 22 item questionnaire revealed a reliability coefficient (Chronbach's Alpha) of 0.89. To determine how each of the items affected the overall reliability, a reliability coefficient was calculated when each of the items are deleted from the scale (Appendix G). Deleting item 2 (original-conventional) and item 9 (slow-fast) increased the overall reliability of the scale to 0.91 (Table 8). Deleting any other item from the scale did not increase the reliability coefficient (Appendix G).

Table 8

Reliability Coefficients

NUMBER OF ITEMS	CHRONBACH'S ALPHA
22	0.89
20	0.91

Of the 62 students enroled in PE 2015 'Introduction to Biomechanics', 45 consented to participate in this study. An eight point questionnaire was administered to the 45 subjects (Appendix C). The questionnaire was designed to determine computer experience and time usage. The results are summarized in Tables 9 to 11. The top applications for which computers were being used were:

(1) word processing, (2) spreadsheets, (3) graphics, and (4) statistics. None of the subjects indicated previous experience using CAI.

Table 9

Computer Use and Availability

QUESTION	YES	NO
Do you have experience using a computer?	67%	23%
Do you have a computer at your disposal at home?	35%	65%

Table 10

Software Usage by Experienced Computer Users

PROGRAM TYPE	PERCENTAGE OF EXPERIENCED USERS RESPONDING
WORD PROCESSING	90%
GRAPHICS	53
SPREADSHEETS	43
STATISTICS	34

The result of the subject's time usage questions appear in Table 11. All of the subjects indicated full time attendance at university and 48 percent of the subjects reported working part-time in addition to attending classes.

Table 11

Subject Time Usage

ACTIVITY	N	MEAN HOURS PER WEEK	S.D.
University classes and labs	45	28.5	6.3
Homework and study	44	11.2	4.3
Biomechanics study and homework	40	2.5	1.2
Extra-curricular	43	7.8	4.8
Employment	22	10.3	3.3

To determine subject acceptance of the CAI lab and the tendency of subjects to return to the CAI lab when use was made optional, CAI lab attendance records were kept throughout the study. The results of subject CAI laboratory attendance are reported in table 12. Of the 45 consenting subjects, all but 3 subjects attended the required 75 percent of laboratory hours.

Table 12

CAI Laboratory Attendance

CAI Lab	Number of weeks	Number Attending	Range of Hours	Mean	S.D
Required Use	8	42	6 to 8	7.2	1.6
Optional Use	2	32	1 to 4	2.6	0.5

CHAPTER V

DISCUSSION

The discussion has been organized to focus on each of the research questions previously identified, they were; student performance on theoretical competency tests during CAI intervention, student attitudinal response towards CAI, and the tendency of students returning to the use of CAI when use was made optional. In order to gather additional information concerning previous computer experience and time usage, an 8 point questionnaire was administered to all subjects. The results obtained on the questionnaire provided subject characteristics which may have affected the results of this investigation. A summary of the information gathered appears in Tables 9 to 11. These results are used throughout the discussion to assist in the explanation of results obtained on the dependent measures. In addition, a discussion on the data obtained from the informal observations has been synthesized to enhance the discussion of data obtained on the dependent measures. Finally, the threats to the internal and external validity in this investigation have been discussed to provide alternate explanations for the results obtained.

Student Performance on Theoretical Competency Tests

The results of the theoretical competency test scores were analyzed using a paired t-test and an analysis of variance (Table 3 and Table 4). Null hypotheses of equal population means between treatments, between groups, and within groups were tested. Analysis of all test scores showed subjects who received CAI (n = 37) as a complement to lectures scored higher (mean = 77.23) compared to when they did not receive CAI (mean = 72.86), however, no significant difference was detected between the two instructional treatments. Analysis of scores from subjects who wrote all four tests (n = 18) also revealed no significant differences between tests, groups, or test x group interaction. These findings are consistent with that of previous research on student performance related to CAI intervention. Ries and Granell (1985) reported no significant differences on student performance related to CAI intervention. Kulik et al. (1980) examined the findings of 59 independent evaluations of college CAI use and showed that CAI made small but significant contributions to student achievement.

Failure to detect significant differences in all analysis may have been due to the true differences in the test scores being very small, too large a variability, sample size too small, or sensitivity of the dependent measures.

A serious limitation to the validity of these results stemmed from an inability to ensure the completion of all four theoretical competency tests by all subjects. Only eighteen of the 37 subjects wrote all four tests. All of the subjects participating in the study were full-time students in Physical Education. From the data obtained on the time usage questionnaire it was evident all subjects were kept busy with classes, studies, extra-curricular activities, and in some cases employment during the school term. Since no additional academic credit was given for completion of the theoretical competency tests, the majority of subjects gave priority to those tasks which directly reflected upon their academic transcripts. As a result, not all subjects completed all four theoretical competency tests. Table 1 indicates the number of subjects writing each of the tests. A total of 37 subjects met the criterion of completing at least one theoretical competency test after a CAI unit and one theoretical competency test while not receiving CAI.

Measuring theoretical competency and it's relationship to CAI intervention has proven to be a very difficult task due to the inability of the researcher to implement a strictly controlled research design. For example, one methodology initially considered for this experiment was a true experimental design with a control group. The design involved two groups of subjects. Both groups were to be given lectures on a biomechanics unit. In conjunction with the lectures, one group would have received CAI for that particular unit. Pre and post tests would have been administered to both groups to determine CAI treatment effects. This design could not be carried out due to limitations beyond the investigator's control. A main reason was the ethical considerations that had be taken into account before implementing the methodology for this study. It was deemed unethical to withhold a possible advantageous instructional treatment such as CAI from any group of students used for the study. Consideration was also given to the possibility of implementing the abovementioned true experimental design prior to the beginning of the school term using subjects who were intending to enter PE 2015 'Introduction to Biomechanics'. However, this method was not feasible since recruiting subjects prior to commencement of classes was not a viable option. In addition to research design limitations, the validity and reliability of the instrumentation techniques made measuring the effectiveness of CAI a difficult assignment. Although the pen and paper tests may have been a valid and reliable instrument, measuring student theoretical competency was a complex procedure due to the difficulties associated with measuring learning. Even if the assumption was made that the pen and paper tests were a representation of learning, it was not possible in this initial field test to ensure the tests were sensitive enough to capture even small learning effects. Adding to the difficulty of measuring learning, the data obtained on the time usage questionnaire indicated some subjects spent as many as four hours per week on biomechanics homework and study while others indicated only one or two hours per week. Since some subjects studied longer than others, the results on the theoretical competency tests may have reflected time spent studying and not the CAI intervention.

Although a difficult task, research into the effectiveness of CAI on theoretical competency is necessary if the technology is to be an accepted learning medium throughout the educational domain. Administering theoretical competency pen and paper tests as a dependent measure in this study was an initial attempt to establish cause and effect on the relationship between CAI and theoretical competency and the results of the implementation evaluation provided insight into future CAI evaluation refinements.

Student Attitudinal Response

A semantic differential instrument containing 22 set of bipolar adjectives (Appendix B) with a scale of one to seven was used to measure student attitudes. To avoid response bias, positive descriptors were randomly placed at the high and low ends of the scale. The data in Table 4 indicate an overwhelming positive attitudinal response towards CAI. The descriptors chosen by at least 80 percent of the subjects with a high positive response (mean > 6.0) were: good, encouraging, meaningful, relevant, enhancing, effective, and beneficial. The descriptors chosen by at least 80 percent of the subjects with a medium positive response (mean 5.5 to 6.0) were; pleasant, creative, sociable, active, amiable, pleasing, sharp, satisfying, involved, and interesting. The descriptors chosen by at least 80 percent of the subjects with a low positive response (mean 5.0 to 5.5) were; original and fast. The only response with a mean below 5.0 was experimenting (mean = 4.86). To determine the reliability of the semantic differential instrument used in this study, a reliability coefficient based on the average correlations of the items was determined using the SPSS PC+ Reliability function (Norusis, 1988). A reliability coefficient of 0.89 was determined for the 22 item questionnaire. This value indicated the correlation between the instrument used in this investigation and all other possible instruments containing the same number of items that measure student attitudes towards CAI.

To determine how each of the items affected the reliability of the scale, a reliability coefficient was calculated when each of the items was removed from the scale (Appendix G). By removing item 2 (original-conventional) and item 9 (slow-fast) from the scale, the overall reliability coefficient was increased to 0.91. Removing any other of the items did not increase the overall reliability of the scale. The resultant 20 item questionnaire (Appendix H) would be a more reliable instrument for future research on attitude towards CAI.

Although an overwhelming positive attitude was found, some caution should be taken when concluding the CAI package alone was responsible for the positive attitude. The results obtained from the attitude scale may not be valid since it could not be ascertained whether or not the subjects expressed their true attitude rather than a socially acceptable attitude towards CAI. Other threats to the validity of the attitude response included; novelty effects, experimenter bias, and subject demand characteristics. The cause of the positive attitudes may not have been so much the CAI itself but the enthusiasm and high morale that may have accompanied the implementation of the new CAI program. The novelty effect threatens the external validity here because the results of this study may or may not be replicated if the study were to be repeated on the same subjects during a subsequent biomechanics course. The enthusiasm and energy displayed by the experimenter towards implementing the CAI package and research methodology for this study may have motivated the subjects to respond positively towards CAI. Subject demand characteristics may have been a threat to the attitudinal response since the instruments were administered during the implementation of the CAI package. Instead of responding in their true and typical behaviour, subjects could have changed their attitudes towards CAI to agree with their interpretation of the research hypothesis (i.e positive attitudes associated with CAI).

The attitude questionnaire results were, however, consistent with that of previous research on student attitudes towards CAI. Powell (1987) reported positive attitudinal responses from college students receiving CAI as a supplement to classroom instruction. Ries and Granell (1985) also reported positive student response to the use of CAI when used as a complement to traditional lectures in a post secondary setting. The findings of the attitude questionnaire substantiate the view that implementation of a customized CAI package as a complement to classroom lectures can produce a positive attitudinal response from students, as well as provide a novel learning experience.

CAI Laboratory Attendance

The acceptance of an educational CAI laboratory by students is one of the key factors to consider when evaluating the benefits of CAI technology. Attendance records of the CAI lab were kept during an eight week period (Table 12) and indicated 93 percent of the subjects attended scheduled CAI lab sessions from 6 to 8 hours (mean = 7.2, SD = 2.6) over the eight week implementation period. Although the novelty effect may have been the underlying cause for the initial high attendance in the lab, subsequent attendance records when use of the lab was made optional indicate a strong acceptance of the CAI by the subjects. The tendency to return to CAI when use was made optional was considered to be an important factor in the determination of student acceptance of the educational medium. During a two week period 71 percent of the subjects utilized the CAI lab from one to three hours (mean = 1.6, SD = 0.5) per week when use was made optional, compared to attending 2 hours per week when use was required. This finding was consistent with the favourable response obtained from the attitudinal questionnaires towards CAI and may indicate that the students believed they benefited from the inclusion of CAI as a complementary study tool to their biomechanics lectures, however, alternate causes for the high optional CAI lab attendance can not be ruled out. Perhaps the subjects enjoyed using computers rather than learning biomechanics and attended the biomechanics CAI lab only to utilize the computers. Another explanation for the high attendance in the CAI lab may have been subject interaction. It is possible some subjects were attending optional use of the CAI lab only because they were aware of other subjects who were attending the CAI lab.

Informal Observations

During the implementation period, informal observations were recorded by the investigator in the CAI lab (Appendix E). The observations included: subject attitude and behaviour, any hardware or software difficulties, time constraints, and any difficulties in implementing the research methodology.

In general, introduction of the CAI program to the subjects proved to be a relatively easy task. This probably was a result of the ease in using the customized CAI program. Each computer was fitted with a logitech mouse, a two button device which allowed the user complete access to all areas within the program without using the keyboard. Initially some users preferred to use the keyboard instead of the mouse, which required a small degree of manual dexterity to operate. However, by the fourth visit to the lab all the students appeared to prefer using the mouse, since it was a faster device to move within the customized CAI program. Only one hardware problem was encountered. A monitor on one of the computers did not produce bright color images as compared to the other three monitors in the lab. Students avoided using this monitor when possible.

Subject orientation took an average of fifteen minutes. The majority of subjects managed to complete the required unit before the time limit given on each unit. Some students attempted to book more than their allowed time limit in the CAI lab especially during biomechanics course exams, but this practice was prevented by the investigator so that all students could be accommodated in the lab. Subject's initial responses to the program varied from apprehensive to enthusiastic. The 67 percent of the subjects who had previous computer experience appeared to have little or no difficulty in learning the fundamentals of using the CAI program. This finding supports the suggestion that less time will be required teaching the technology to experienced users, leaving more time for instruction in concepts and analysis (Miller, 1984). By the third CAI hour attended, all subjects appeared to be comfortable using the CAI program without the guidance of the investigator.

Several subjects expressed a positive attitude towards the color, animation, sound, and graphics used in CAI package with comments such as, "I get a better understanding of what is being taught in lectures", "The information I get in the CAI lab helps with my homework", and "I wish this type of instruction was available for more of my classes". These findings were consistent with that of Powell (1987), and Ries & Granell, (1985), who reported positive student response to the use of CAI when used as a complement to traditional lectures. The program-controlled review questions in the CAI package which prompted the subject for answers on various biomechanical principals were particularly enjoyed by most subjects. Some subjects utilized their CAI lab time as review for missed lectures and the majority of subjects took notes from the various CAI biomechanics units.

Since all subjects were full-time students, there was often difficulty in tracking down those subjects who were scheduled to write the theoretical competency tests when they were on a unit during which CAI was not used as a complement to lectures.

Although the CAI program in this study was administered in a typical university computer laboratory, subjects were periodically uncomfortable due to the room temperature. Some days the room was too hot and some days it was too cold. Excess construction noise in an adjacent room occasionally distracted the subjects in the lab.

Additional comments by the subjects included, "I have enjoyed coming to the lab as a break from studying in the library", "It would be nice to have access to this program at home", and "I have had greater interest in biomechanics this term because of the lab" and indicated satisfaction with the CAI program, biomechanics coursework, and participation in the study.

CHAPTER VI

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The purpose of this research was to determine a) if the use of CAI in conjunction with a traditional lecture format had any effect of theoretical competency, b) the student attitudinal response towards CAI, and c) the tendency of students to return to the use of CAI when use was made optional. Analysis of the data indicated theoretical competency test scores did not significantly improve when CAI was implemented as a complement to lectures. Results of an attitude questionnaire demonstrated that subjects who utilized the CAI lab as a complement to lectures responded favourably in attitudinal response. Attendance records of the CAI laboratory indicated a positive tendency of subjects to return to the CAI lab when use was made optional.

Conclusions

Based on the findings of this investigation, the implementation of a customized CAI program as a complement to traditional lectures in undergraduate biomechanics was a feasible and practical course of action.

Despite several research limitations, this study attempted to evaluate the implementation of a CAI program. Since too small a sample size may have affected the results in this experiment, increasing the number of subjects would increase the validity of the statistical analysis.

Experimenter effects could have been reduced by using examiners who were uninformed about the research hypothesis or subject characteristics to administer the dependent measures.

An extension of the present investigation would be to examine the dependent variables (student theoretical competency test scores, attitudes, and attendance records) using a control group (one that would receive no CAI at all). However, this practice would be unfavourable since those students who were not offered CAI may be at an academic disadvantage for the particular course involved.

Researching the effectiveness of the CAI lab and content should be an ongoing process. Since the dependent measurements were confined to practice test results, attitudes, and attendance records, informal observations were useful to ascertain the feasibility of the CAI implementation format.

Recommendations

Although there were no major constraints or difficulties which occurred during the implementation of the CAI used in this investigation, several recommendations were developed. Of some concern was the difficulty in scheduling the 60 students enroled in PE 2015 to attend 6 hours each in the computer laboratory. With four microcomputers dedicated solely to this project, 90 hours were required per computer to accommodate the students. Over the six week testing period, the computer laboratory was made available 60 hours per week. The only way to accommodate all 60 students was to employ a full time laboratory monitor for 60 hours per week. Obtaining a greater number of microcomputers would reduce the number of open lab hours required and reduce the lab monitor costs. Since room temperature and external noise were not under the control of the investigator a CAI laboratory away from central corridors, with temperature controls and windows is recommended.

During the preliminary investigation some hardware and software difficulties were encountered as expected. The laboratory monitor was responsible for the correct operation of all software and hardware. A computer technician was available to assist the lab monitor should any major hardware difficulty arise. Suggestions offered by the software designers and programmers resolved any difficulties in running the program. The hardware and software used in this experiment after the preliminary investigation was deemed satisfactory by the students and lab monitor. The findings from the preliminary investigation helped avoid possible problems with the hardware and software during the implementation of this study. A preliminary investigation is therefore strongly recommended when using computer technology as a learning tool.

This investigation involved the use of a customized program designed to follow the lecture content in a chronological succession. In order to make the format of this study feasible for other courses and investigations, the customized approach is essential. This approach allowed the student to work at his or her own pace while following the lectures offered by the instructor and allowed the instructor to suggest specific areas within the CAI program as review should a student have difficulty with any particular unit discussed during in-class lectures.

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Appendix A

COURSEWARE

The courseware for this investigation consisted of computer hardware and a customized CAI software package.

Hardware

The hardware consisted of four IBM compatible 286 micro computers with the following specifications:

- processor = 16 Bit 80286 CPU
- socket for numeric math co-processor
- clockspeed = 12 MHz or 6MHz
- RAM = 1 Megabyte
- Expansion = 8 slots
- Disk Drive = 3.25" Drive 1.2 Meg
- Video Card = VGA Monitor and VGA Card
- Backup and Game Port
- Pwr Supply = 200 Watt Slide Switch
- Keyboard = Enhanced keyboard (101 keys)
- Hard Drive = 40 Megabyte Miniscribe
- 2 button Logitech Mouse

Software

The CAI program used in this investigation was structured around two sections; Section 1: An Introduction to Biomechanics, and Section 2: Qualitative Skill Analysis.

Section 1

1. An Introduction to the Study & Analysis of Human Movement
2. Movements of the Skeletal System
3. Fundamental Mechanical Terms
4. Fundamental Mechanical Principals
5. Torques & Levers
6. Linear Kinematics
7. Angular Kinematics
8. Projectile Motion
9. Angular Kinematics

Section 2

1. Objectives
2. A systematic Approach to Skill Analysis
3. Pre-observation
4. Observation
5. Diagnosis & Remediation
6. Summary

At the end of the first section there was a menu option for interactive review questions. Students had the opportunity to select different types of questions on a variety of topics from the following menu.

Review Questions

1. Multiple Choice
   General
   Angular Motion

2. Fill in the Blanks
   General
   Projectiles
   Angular Motion

3. Short Answer
   General
   Linear Kinematics
   Projectiles
   Angular Kinematics

4. Problems
   General
   Linear Kinematics
   Projectiles
   Angular Kinematics

The customized computer assisted learning program used in this study was based on hypermedia graphics, animation and artificial intelligence. Key concepts were amplified in successive layers of hypertext to be accessed by those students wanting greater depth or were lacking in their preparation. For example, a student could enter into the first page of the section termed 'INTRODUCTION TO THE STUDY AND ANALYSIS OF HUMAN MOVEMENT'. Here the student would find the following screen:

> AN INTRODUCTION TO THE STUDY AND ANALYSIS OF HUMAN MOVEMENT
>
> During the past decade the term **BIOMECHANICS** has emerged as an area of inquiry in the sport science domain. When we examine the area of biomechanics we must first consider a branch of classical mechanics called Rigid Body Mechanics. **RIGID BODY MECHANICS** are based on **NEWTON'S LAWS** and involve the study of the forces acting on these rigid bodies.

The hypertext words (**BIOMECHANICS, RIGID BODY MECHANICS,** and **NEWTON'S LAWS**) lead to other textual descriptions, graphic representations and animation. For example if the student chose the hypertext word **BIOMECHANICS** the following screen would appear on the monitor:

BIOMECHANICS:

BIO = LIVING

MECHANICS = FORCES AND EFFECTS

The application of mechanics to the living organism. Involves the principals of anatomy and physics in the description and analysis of movement. However biomechanics as a field of study encompasses much more than just the application of mechanics to human movement, it has may diverse applications to all biological systems.

"The science that examines the internal and external acting on the body and the effects produced by these forces" (Hay, 1985)

The interactive review questions consisted learner control and program control. The student could select which type of question and topic while the program would prompt the student to answer before moving on to the next question. For example if the student chose **Multiple Choice** and selected **General**, the computer would show the following screen:

MULTIPLE CHOICE

GENERAL:

1. If force and mass are both doubled:

   a) acceleration is doubled

   b) acceleration is halved

   c) acceleration is unchanged

   d) displacement is doubled

The program prompted the student to select a letter to indicate the correct answer. If an incorrect answer was given the program allowed a maximum of three attempts. If no correct answer was given by the student for three attempts, the program indicated the correct answer and then moved on to the next question.

Appendix B

COMPUTER ASSISTED INSTRUCTION USER QUESTIONNAIRE

This questionnaire consists of 8 questions. Answer all questions as accurately as possible. Additional comments are welcome in an area provided at the end of the page. Please return the completed form to the laboratory monitor. All responses are confidential.

1. Do you have any experience using a microcomputer? YES NO
   If yes, please indicate which programs you are familiar with.

   ---------------------- ----------------------
   ---------------------- ----------------------

2. Do you have a computer at your disposal at home? YES NO

3. Do you have a full or part-time job in addition to attending university? YES NO

   If yes, how many hours do you work per week? --------

4. Do you participate in extra-curricular activities? YES NO
   (i.e. sports, clubs, hobbies,etc...)

   If yes, how many hours per week? --------

5. How many hours of classes (include practicals and labs) do you have per week? --------

6. How many hours of homework/studying per week do you complete? --------

7. How many hours do you spend on PE 2015 homework/studying per week? --------

8. Do you use any additional texts when studying for PE 2015? --------

   If yes, please list those texts below.

Additional Comments:

Appendix C

THEORETICAL COMPETENCY TESTS

BIOMECHANICS PRACTICE TEST #1
FUNDAMENTAL TERMS AND MECHANICAL PRINCIPLES

1. State Newton's first law, the law of inertia.

2. Define the terms kinetics and kinematics. In addition, provide an example of a question you would examine using a kinetic analysis, and one you would examine using a kinematic analysis.

KINETIC:

KINEMATIC:

3. List three ways in which a novice gymnast attempting to land a vault can increase her stability.

1.

2.

3.

4. Bart is attempting to pull a 60N computer into the lab. The pulling force is represented by the P in the diagram below. Draw in force vectors to represent the force of gravity (W) on the desk, the force of friction (F), and the normal force (N).

if the:
Coef. of static friction = .4
Coef. of kinetic friction = .2
Calculate the limiting friction.

5. List 3 external forces that will act on a curler.

1.

2.

3.

6. Define the branch of classical mechanics referred to as Rigid Body Mechanics.

7. State a question which could be addressed by each of the following types of analyses.

1. STATIC ANALYSIS

2. DYNAMIC ANALYSIS

3. QUALITATIVE ANALYSIS

4. QUANTITATIVE ANALYSIS

8. Use Newton's third law to explain the vertical propulsion upwards of the body during the performance of a vertical jump.

9. What is pressure? How would you calculate the amount of pressure exerted on the ground by an athlete.

10. Fill in the blanks

PATHS OF MOTION

------------------ ------------------

------------------ ------------------

11. Define the concept CENTRE OF MASS. What are 4 things which will affect the position of your centre of mass?

1.
2.
3.
4.

12. State the formula that arose from Newton's second law. Interpret the formula.

13. Mass is defined as the . Weight is the pull of acting on .

14. Name two variables which are examples of scalar quantities.

1.
2.

15. Draw a diagram of the arm and the forearm, with the forearm flexed so that the angle between the arm and the forearm is 120 degrees. Represent the force of flexion produced by the contraction of the biceps with a vector (B). On your diagram also indicate the point of force application (*), and the line of action.

16. State 2 ways in which we can change the magnitude of the limiting friction for a rolling lawn bowling ball.

1.

2.

BIOMECHANICS PRACTICE TEST #2
FUNDAMENTAL TERMS AND MECHANICAL PRINCIPALS

1. A rigid body will rotate about an axis if a(n) is applied.

2. Torque is defined as a(n)

3. A force arm is

4. Calculate the net torque on the teeter totter.

5. Calculate the torque produced by the pull of the biceps.

   - The biceps are attached 10mm from the proximal end of the forearm.

   - FA=11mm

6. Why are our body levers able to produce a greater torque at some joint angles?

7a. Define a 2nd Class lever.

b. Provide one example of a 2nd Class lever and draw and label: axis, motive force, resistive force, motive force arm, and resistive force arm.

8. What is/are the functions of a 3rd Class lever?

9. What type of lever is the body acting as during situp in the up phase? Consider the hip flexors as the motive force.

10. Explain why it is better to lift heavy objects by bending at the knees. (Use the concept of torque)

11. How can torque be increased?

BIOMECHANICS PRACTICE TEST #3
TORQUES AND LEVERS

1. Determine how much momentum your body has when running with a velocity of 4 m/sec. (Convert your own weight into mass)

2. Use the conservation of linear momentum principal to tell the direction and speed of these two players after they collide. Player A's mass is 80 kg and he runs North at 5 m/sec into Player b. Player B's mass is 90 kg and she runs South at 2 m/sec into Player A. Assume they both remain in contact after collision.

3. A softball player sprints from first base to second base. If her horizontal velocity is 9.3 m/sec when she is 8 m from second base and 7 m/sec when she is 5 m from second base 0.4 seconds later, what is her average acceleration over that 3 meter interval?

4. A cross country skier travels 5 Km due North, makes a right angle turn and travels 12 Km due East.

   a) If the distance is covered in 51 minutes what is the skiers average speed in Km/hr?

   b) What is the magnitude of the skiers average velocity?

BIOMECHANICS PRACTICE TEST #4
ANGULAR KINEMATICS

1. What is the velocity of a softball released by an upper extremity (arm + forearm = 0.5 meters long) that is rotating at 573 degrees per second?

2. If a body is rotating with a constant angular velocity, what is it's acceleration?

3. Why is it easier to perform jumping jacks with bent arms?

4. Define angular impulse. What does an angular impulse cause?

5. What are the two main ways in which angular momentum can be produced?

6. You are listening to some old 78's on your record player. As the first record starts you realize the machine the machine is set for 45's. You switch from 45 RPM's (revolutions per minute) to 78 RPM,s. It takes 2 seconds to get up to speed. What is the angular acceleration of the record in RPM's?

7. An object has a momentum of inertia of 200 kg.m. A torque of 58.8 NM is applied to the object. What is the angular acceleration created?

8. Can rotation be created in the air? Explain your answer.

9. What angular impulse must be applied to a rotating bat in order to double it's present angular momentum if it's movement of inertia = 100 kg.m and it's angular velocity = 5 rad/sec?

Appendix D

Attitudinal Response Instrument

Directions:
There are 22 pairs of adjectives below.
Circle the number (1 to 7) that best describes your perceptions to computer assisted learning for each pair of adjectives.

UNPLEASANT	1	2	3	4	5	6	7	PLEASANT
ORIGINAL	1	2	3	4	5	6	7	CONVENTIONAL
CREATIVE	7	6	5	4	3	2	1	ROUTINIZED
CAUTIOUS	1	2	3	4	5	6	7	EXPERIMENTING
UNFRIENDLY	1	2	3	4	5	6	7	SOCIABLE
PASSIVE	1	2	3	4	5	6	7	ACTIVE
HOSTILE	1	2	3	4	5	6	7	AMIABLE
TIMID	1	2	3	4	5	6	7	ADVENTUROUS
SLOW	7	6	5	4	3	2	1	FAST
PLEASING	1	2	3	4	5	6	7	ANNOYING
LIVELY	1	2	3	4	5	6	7	TEDIOUS
BAD	7	6	5	4	3	2	1	GOOD
ENCOURAGING	1	2	3	4	5	6	7	DISCOURAGING
MEANINGFUL	1	2	3	4	5	6	7	SUPERFLUOUS
SHARP	1	2	3	4	5	6	7	DULL
BORING	1	2	3	4	5	6	7	SATISFYING
RELEVANT	7	6	5	4	3	2	1	IRRELEVANT
ENHANCING	7	6	5	4	3	2	1	DIMINISHING
WASTEFUL	1	2	3	4	5	6	7	EFFECTIVE
INVOLVED	1	2	3	4	5	6	7	DISTANT
DULL	1	2	3	4	5	6	7	INTERESTING
BENEFICIAL	1	2	3	4	5	6	7	NONCONSEQUENTIA

Appendix E

INFORMED CONSENT PACKAGE

CONSENT TO PARTICIPATE

I ______________________________ am a Lakehead University student enroled in PE 2015 Introduction to Biomechanics. I have read and understood the covering letter of the study entitled "Efficacy of a customized approach to computer assisted learning" and I agree to participate. I realize that as a participant in this study I will be expected to regularly attend the biomechanics 2015 laboratory sessions as well as complete three questionnaires following each session. In addition I will complete a written biomechanics knowledge test every two weeks.

Furthermore, my participation in this study is strictly on a voluntary basis and I may withdraw from the study at any time. I am aware all information I give will be kept confidential until my final mark for PE 2015 has been submitted to the records department and that the results of this study will have no bearing upon my final mark for PE 2015.

Signature ______________________

Date ____________________________

COVER LETTER

A computer tutoring program has been developed for PE 2015 Introduction to Biomechanics and will be included as part of your scheduled laboratory exercises.

I am conducting a study on the efficacy of a customized approach to computer assisted instruction in the physical education domain at Lakehead University. This type of a study presents a unique opportunity for both the student and researcher as it will mark the first time such an experiment has been conducted in the School of Physical Education here at Lakehead.

The intent of this research project is to (a) evaluate the user acceptability and attitudes towards computer assisted instruction and (b) investigate the relationship between computer assisted instruction and student performance on biomechanics unit test scores.

If you select to be part of this research study you will be required to:

(1) Regularly attend your scheduled laboratory sessions for PE 2015.
(2) Complete three questionnaires at the end of each lab session (approximately 5 minutes of your time).
(3) Complete a biomechanics test at the end of each two week period throughout the fall term.

The questionnaires are designed to investigate your attitudes towards the integration of the computer assisted instruction program. Your completed questionnaires will be immediately sealed in an envelope and stored under security in the School of Physical Education administration office. No access to the completed instruments will be made by the researcher until all final marks have been recorded and submitted to the records office. At that time the results will be summarized and typed to ensure participants anonymity.

The results from this investigation will greatly assist my thesis efforts. Should you choose to take part you may withdraw from the study at any time. I thank you in advance for your time and consideration.

The findings of this study will be made available to you at your request upon the completion of the study.

Yours Respectfully

Bart Guthrie
Graduate Student

Appendix F

Informal Observations

Subject Attitude and Behaviour

1. Review questions enjoyed by most students.
2. Several students took notes from the CAI software.
3. Some students requested printouts of the CAI software to take home and study.
4. Some students used lab attendance as a review for missed lectures.
5. Subjects expressed positive attitude towards the animation, graphics, sound, and color used in the program.

Hardware and Software Difficulties

1. Some users preferred to use the mouse, others the keyboard.
2. Some difficulty in using the mouse for the first time.
3. First time computer users were apprehensive at first, but gradually comfortable with the equipment.
4. All students preferred using the mouse by week four.
5. One of the color screens was not as bright as the others and students avoided using that workstation.

Time Constraints

1. The students preferred to book their lab hours before an in-class test or exam.
2. Majority of students finished unit before three lab hours.
3. Some students attempted to attend more than required CAI lab time.
3. Generally 10 to 15 min during unit one orientation.

Implementation Difficulties

1. Temperature complaints were regular, some days it was too hot, other days it was too cold.
2. There was construction going on adjacent to the CAI lab, often it was too noisy.
3. Some competed with others for the highest mark on the theoretical competency tests.

Appendix G

Raw Data

Theoretical Competency Test Results

GROUP 1

SUBJECT	TEST 1 (%)	TEST 2 (%)	TEST 3 (%)	TEST 4 (%)
1	*	85.00	40.00	*
2	62.50	97.50	75.00	100.00
3	70.45	95.00	70.00	61.11
4	*	87.50	45.00	*
5	87.50	62.50	75.00	94.44
6	63.07	50.00	85.00	66.67
7	80.68	70.00	60.00	77.78
8	68.18	80.00	67.50	80.56
9	78.41	87.50	*	*
10	97.73	45.00	72.50	77.78
11	*	92.50	30.00	94.44
12	70.45	87.50	*	*
13	65.91	67.50	60.00	66.67
14	88.64	65.00	*	*
15	75.00	40.00	*	*
16	61.36	85.00	*	*
17	63.64	65.00	100.00	*
18	68.18	62.50	75.00	50.00
19	87.50	85.00	*	*

* = missing value, subject did not write test

Theoretical Competency Test Results

GROUP 2

SUBJECT	TEST 1 (%)	TEST 2 (%)	TEST 3 (%)	TEST 4 (%)
1	61.36	72.50	85.00	100.00
2	75.00	45.00	100.00	77.78
3	64.77	95.00	70.00	88.89
4	76.14	100.00	85.00	100.00
5	87.50	*	25.00	88.89
6	63.07	95.00	67.50	61.11
7	80.68	82.50	65.00	61.11
8	68.18	90.00	32.50	66.67
9	78.41	100.00	87.50	*
10	97.73	90.00	60.00	83.33
11	*	95.00	45.00	97.22
12	70.45	*	62.50	*
13	65.91	67.50	100.00	100.00
14	88.64	*	55.00	33.33
15	75.00	82.50	77.50	*
16	61.36	80.00	*	61.11
17	63.64	77.50	*	83.33
18	68.18	65.00	*	94.44

* = missing value, subject did not write test

Analysis of Variance for Between Subject Effects

Source	SS	DF	MS	F-ratio	F-significant
Within Cells	3335.26	16	208.45		
Group	476.38	1	476.38	2.29	0.150

Analysis of Variance for Within Subject Effects

Source	SS	DF	MS	F-ratio	F-significant
Within Cells	12302.91	48	256.31		
Test	415.87	3	138.62	0.54	0.657
Group x Test	434.01	3	144.67	0.56	0.641

Attitudinal Scale Reliability Analysis

ITEM	BI-POLAR ADJECTIVE PAIR	ALPHA IF ITEM DELETED
1	UNPLEASANT-PLEASANT	0.8850
2	ORIGINAL-CONVENTIONAL	0.9071
3	CREATIVE-ROUTINIZED	0.8898
4	CAUTIOUS-EXPERIMENTING	0.8905
5	UNFRIENDLY-SOCIABLE	0.8863
6	PASSIVE-ACTIVE	0.8826
7	HOSTILE-AMIABLE	0.8851
8	TIMID-ADVENTUROUS	0.8826
9	SLOW-FAST	0.8880
10	PLEASING-ANNOYING	0.8822
11	LIVELY-TEDIOUS	0.8850
12	BAD-GOOD	0.8843
13	ENCOURAGING-DISCOURAGING	0.8855
14	MEANINGFUL-SUPERFLUOUS	0.8857
15	SHARP-DULL	0.8799
16	BORING-SATISFYING	0.8781
17	RELEVANT-IRRELEVANT	0.8845
18	ENHANCING-DIMINISHING	0.8827
19	WASTEFUL-EFFECTIVE	0.8811
20	INVOLVED-DISTANT	0.8854
21	DULL-INTERESTING	0.8770
22	BENEFICIAL-NONCONSEQENTIAL	0.8872

Appendix H

Revised Attitudinal Response Instrument

Directions:

There are 20 pairs of adjectives below. Circle the number (1 to 7) that best describes your perceptions to computer assisted learning for each pair of adjectives.

UNPLEASANT	1	2	3	4	5	6	7	PLEASANT
CREATIVE	7	6	5	4	3	2	1	ROUTINIZED
CAUTIOUS	1	2	3	4	5	6	7	EXPERIMENTING
UNFRIENDLY	1	2	3	4	5	6	7	SOCIABLE
PASSIVE	1	2	3	4	5	6	7	ACTIVE
HOSTILE	1	2	3	4	5	6	7	AMIABLE
TIMID	1	2	3	4	5	6	7	ADVENTUROUS
PLEASING	1	2	3	4	5	6	7	ANNOYING
LIVELY	1	2	3	4	5	6	7	TEDIOUS
BAD	7	6	5	4	3	2	1	GOOD
ENCOURAGING	1	2	3	4	5	6	7	DISCOURAGING
MEANINGFUL	1	2	3	4	5	6	7	SUPERFLUOUS
SHARP	1	2	3	4	5	6	7	DULL
BORING	1	2	3	4	5	6	7	SATISFYING
RELEVANT	7	6	5	4	3	2	1	IRRELEVANT
ENHANCING	7	6	5	4	3	2	1	DIMINISHING
WASTEFUL	1	2	3	4	5	6	7	EFFECTIVE
INVOLVED	1	2	3	4	5	6	7	DISTANT
DULL	1	2	3	4	5	6	7	INTERESTING
BENEFICIAL	1	2	3	4	5	6	7	NONCONSEQUENTIA