USE OF COMPUTER-ASSISTED INSTRUCTION (CAI) AS AN INSTRUCTIONAL TOOL TO IMPROVE DIABETES SELF-MANAGEMENT OUTCOMES

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Chapter 1

Introduction and Statement of the Problem

Introduction

Data from the National Health Interview Survey (NHIS), Centers for Disease Control (CDC), and National Center for Health Statistics (NCHS) as of November 30, 1999 indicated that 45% of persons with diabetes received formal diabetes education in 1998. One of the 17 objectives of the Healthy People 2010 Objectives related to diabetes was to increase the proportion of persons with diabetes who received formal diabetes education to 60 percent (Healthy People 2010 internet site). Inherent in this objective was the belief that education would improve glycemic control. Improved glycemic control would reduce the disease and economic burden of diabetes by decreasing the incidence of both the short- and long-term complications of diabetes and improve the quality of life for persons who have diabetes.

One of the short-term complications of diabetes that would be impacted by the provision of education was diabetic ketoacidosis. Inadequate or inappropriate management of an illness in a person with type I diabetes has been reported to be one of the causes of diabetic ketoacidosis (DKA). DKA can result in coma and even death. "It is the cause of 85% of hospitalizations of children with known diabetes" (Chase, 2000, p. 137). Usually large ketones are present in the urine for four hours before acidosis develops. However, if not recognized or treated correctly, several hours of severe acidosis will require hospitalization – usually in an intensive care unit. The monetary cost can be as much as $10,000 in addition to the emotional and physical expense for both the person with type 1 diabetes and their family.

Dr. Julie A. Edge and colleagues from John Radcliffe Hospital, Headington, Oxford, UK, analyzed records covering the years 1990 to 1996 from the Office of National Statistics in England and Wales and the General Registrar Office for Scotland to determine the causes of death in persons under 20 years of age when diabetes mellitus appeared on the death certificate. They identified 128 total deaths of which 83 were a direct result of diabetes. The authors concluded that 83% of the deaths were associated with DKA (66%) or hyperglycemia (Edge, 1999). These episodes of DKA were not all related to illness but the study did illustrate the potential morbidity of DKA.

The good news in the literature was that DKA was 98% preventable when people knew how to manage an illness, took all of their insulin shots, and were taking an adequate amount of insulin. One of the observed problems with sick day management was that the time between learning how to manage an illness and application of that knowledge could be 6 months, a year, or longer. The longer the time between learning and application of knowledge, the less likely the information was to be retained.

The requirement for effective education in managing any chronic disease that has a component of self-care has long been recognized. Numerous studies have established that knowledge of self-management principles reduces the consequences of diabetes (e.g., Glasgow and Osteen, 1992; Brown, 1990). However, considering the prevalence of the long-term complications of diabetes, it can be assumed that many persons with diabetes do not adequately manage their therapeutic regimen either as a result of not receiving adequate instruction regarding self-management or, in many cases, despite receiving instruction. It is the second point that was the focus of this study.

Many factors contribute to persons with diabetes being able to self-manage their disease. According to J.L. Day (1995) mainly these are attitudes, beliefs, or perceptions of the person with diabetes. There is a need for persons with diabetes to acquire knowledge and self-management skills but they must also have the desire to apply them on a long-term basis.

Teaching (and learning) can be difficult if it involves only the presentation of verbal and written facts. "Educators should aim to teach diabetes self-management to patients in an intuitive and enjoyable way so that the knowledge can be enduring" (Lehmann, 1998, p. 341). Multi-media materials, such as CAI, provide several advantages that make learning more effective and lasting. In particular, the capability of CAI software programs to simulate real-life experience is particularly valuable for diabetes self-management training. Learning about diabetes solely from real-life experiences is not safe or practical; life-threatening consequences can result from severe hypoglycemia or hyperglycemia based on incorrect decision-making. One solution is an interactive simulation of a patient with diabetes in which the learner is allowed to make decisions regarding management without negative consequences. This can be likened to the training aircraft pilots receive on a simulator prior to flying an actual airplane.

Computer-assisted instruction (CAI), with the combination of interactivity and audio-visual capacity, makes it a powerful learning tool because "it can support some of the cognitive processes that constitute learning and the affective aspects of motivation and enjoyment that enable the cognitive processes to be engaged" (Day, Rayman, Hall, and Davies, 1997).

Problem Statement

The problem the study addressed was the perceived inability of persons with type 1 diabetes and/or their caretakers to effectively or independently self-manage days of illness despite instruction. Inappropriate application of sick day guidelines resulted in increased monetary, emotional, and physical costs not only to the patient and family but also to the health care system.

It was proposed by the investigator that this inability, at least in part, resulted from a lack of retention of sick day management guidelines because of the time between instruction and application of this instruction. Although sick day management is considered a survival skill and therefore included as part of the initial self-management training for persons with type 1 diabetes, the point at which an illness might occur, and therefore this knowledge applied, could be months later.

Purpose and Objective

The purpose of this study was to determine the effectiveness of a CAI simulation program in contrast to traditional instruction in improving the long-term retention of knowledge of persons with diabetes and their caretakers regarding the management of sick days. There is an increased awareness among health care professionals that short-term gains in outcomes (knowledge, glycemic control, etc.) appear to wane as time passes. For this reason, educators must re-examine how they have provided education to persons with diabetes in the past and seek out new educational strategies that will improve maintenance of knowledge, glycemic control, etc. over time.

The following objective was examined in the study:

To investigate whether knowledge retention of diabetes sick day management as measured by a 20-item test will be more enduring when CAI is used as a component of the educational process.

The null-hypothesis proposed was as follows:

NH1.0) There is not a difference in scores of knowledge retention regarding sick day management on a 20-item test between persons receiving regular instruction only and persons receiving regular instruction plus CAI.

The study addressed two main questions:

1. Is diabetes self-management training effective in improving knowledge of diabetes management?

2. Is CAI superior to traditional teaching/learning methods on retention of knowledge?

Background

The goal of educating persons with diabetes regarding self-management of their disease is optimal blood glucose control with reduction not only in long-term and short-term complications of diabetes but also in financial costs for both the person with diabetes and society. In spite of considerable effort being directed at diabetes self-management training, some persons with diabetes do not adequately manage their therapeutic regimen, even after receiving instruction. According to J.L. Day (1995) attitudes, beliefs, and perceptions contribute to persons with diabetes being able to self-manage their disease. There is a need for persons with diabetes to acquire knowledge and self-management skills but they must also have the desire to apply them on a long-term, ongoing basis. CAI, with the combination of interactivity and audio-visual capacity, is a powerful learning tool because "it can support some of the cognitive processes that constitute learning and the affective aspects of motivation and enjoyment that enable the cognitive processes to be engaged" (Day, Rayman, Hall, and Davies, 1997).

Several published studies have addressed the effects of educational interventions on outcomes in persons with diabetes (S.A. Brown, 1990; Padgett, Mumford, Hynes, and Carter, 1988; Franz, Monk, Barry, McClain, Weaver, Cooper, Upham, Bergenstal, and Mazze, 1995). Although the research supports the effectiveness of diabetes education in improving patient outcomes, there was a demonstrated loss of effectiveness over time. Although these studies did not address specific educational strategies and tools, perhaps better and more prolonged improvement in outcomes might have occurred with a different educational strategy.

If one evaluates CAI In relation to adult learning theory, specific characteristics of CAI can be matched to adult learning principles espoused by Knowles, Knox, Manteuffel, and Lindeman (Knowles, 1989; Knox, 1986; Manteuffel, 1982; Burgess, 1996). For example, adult learners need to feel a sense of accomplishment and proficiency after completion of a learning experience. CAI provides for this by availability of constant, positive feedback and liberal reinforcement. Adults come into a learning situation with a foundation of experience that is a resource for learning. They need to be able to integrate new ideas with what they already know. CAI provides for this by the ability of the program to adjust to various entry levels. The program can also pre-assess the learner's knowledge, skills, attitudes, and learning style and then tailor the learning to the learner's specific needs. Not all educational computer software programs currently available have the characteristics that make CAI an ideal medium for adult learning. Hopefully, with improved authoring programs and the potential of content, programming, and curriculum experts working together, CAI programs that meet adult education principles will be the norm versus the exception.

Multiple studies have been published on the advantages, disadvantages, and use of CAI in health care education. Persons with chronic diseases are appropriate targets for CAI because of the need to understand a great deal of complex information and the need to use this information to develop skills in self-care and self-monitoring.

Jelovsek and Adebonojo (1993) looked at all the reports of randomized clinical trials on CAI in health care that were published in English between January 1966 and June 1992. In terms of cognitive outcomes, they concluded that CAI was a legitimate method of instruction equal to other usual types of teaching in terms of learning and time involvement. Jelovsek and Adebonojo also concluded from their review of the literature that CAI could alter behavior as well as improve cognitive outcomes. They found however that behavioral change required more hours of CAI than cognitive change. In regards to learning theory, Jelovsek and Adebonojo found that interactive forms of teaching such as CAI were superior to linear forms, that explanation enhanced learning in any sphere and that access to information was in itself educational, and that repetition in small batches improved mastery. They noted however that few CAI programs included repetition of difficult or missed concepts. These authors overall conclusions from their review of the literature was that students learn as well with CAI as with traditional methods and in some cases better.

Lo, Lo, Wells, Chard, and Hathaway (1996) developed a computer assisted learning program that contained 16 lessons with each lesson dealing with one or two aspects of diabetes management. An evaluation study conducted by the program authors revealed that learning outcomes were similar for CAI and conventional education but improvement in metabolic control as evidenced by improved glycosylated hemoglobin levels was better overall in the CAI group versus the conventional education group. The authors concluded that this indicated that conventional education, although it increased knowledge, failed to "stimulate the motivational factors that resulted in compliance" (p 26).

Day, Rayman, Hall, and Davies (1997) developed a multi-media program for those with type 1 and type 2 diabetes. The program was evaluated by a group of three hospitals in the United Kingdom at Sheffield, Leicester and Ipswich along with some general practice physicians by 151 patients. "The results were very good showing that 87% of patients enjoyed using the program and found it useful. There were no major problems between older patients and the young. It was also shown (by before and after questionnaires) that there had been a significant knowledge transfer together with improved motivation" (personal e-mail from John Hall, one of the authors of the program).

Krishna, Balas, Spencer, Griffin, and Boren (1997) reviewed randomized clinical trials to evaluate the acceptability and usefulness of computerized patient education interventions. The authors of this review of clinical trials concluded that computerized educational interventions lead to improved health status in several major areas but did not appear to be a substitute for face-to-face contact with an educator or physician but rather a supplement to this personal contact.

It is obvious from the literature that CAI is being widely used in health care education. Despite the many benefits of CAI though there are some drawbacks.

Knowledge of the advantages and disadvantages of CAI can assist in the decision making process as to whether to utilize CAI in a particular application. Once the decision to utilize CAI has been made knowledge of the characteristics of CAI that make it a suitable medium for adult learners can aid in choosing and/or developing the best CAI software for a specific application.

Definitions of Terms

For clarification, the following terms are defined:

1. Computer-assisted instruction (CAI) – CAI refers to the use of a wide range of educational techniques that rely on the computer to deliver instruction and facilitate learning (Billings, 1986; Hannah, Conley-Price, Fenty, McKiel, Soltes, Hogan, and Wiens, 1989).
2. Adult – According to Merriam and Brockett (1997) adulthood is a sociocultural construction; it is defined by a particular culture and society at a particular time. For example, in the colonial days of America, males were considered adults at age fourteen and females at age twelve. Many cultures define adulthood based on biological definitions and therefore consider puberty to be the entrance into adulthood. In the United States today, legal definitions of adulthood are usually based on chronological age but this can vary within the same culture. It is legal to drink at age 21, to vote at age 18, and, in some states, be tried in court as an adult at age 14. R.W.K. Paterson (1979) gave this definition of the meaning of adult: "Those people (in most societies, the

large majority) to whom we ascribe the status of adults may and do evince the widest possible variety of intellectual gifts, physical powers, character traits, beliefs, tastes, and habits. But we correctly deem them to be adults because, by virtue of their age, we are justified in requiring them to evince the basic qualities of maturity. Adults are not necessarily mature. But they are supposed to be mature, and it is on this necessary supposition that their adulthood justifiably rests" (p 13).

3. Type 1 diabetes – An autoimmune disease in which the body's own immune system attacks and destroys the insulin-producing beta cells in the pancreas. People with type 1 diabetes need daily injections of insulin to stay alive. About 5 to 10 percent of people with diabetes have this type.
4. Type 2 diabetes – A disease that occurs when the cells of the body do not use insulin properly. Typically, adequate insulin production exists. About 90 to 95 percent of people with diabetes have this type. In some people with type 2 diabetes, meal planning and exercise alone will adequately manage blood glucose levels. Others require oral medications, and others insulin to achieve optimal metabolic control.
5. Gestational diabetes – Diabetes that first develops during pregnancy. It usually goes away after the baby is born. Risk factors include being over age 30, family history of diabetes, previous stillbirth, previous large birthweight baby (over 9 pounds), and maternal overweight. In 60 percent of women who have had a diagnosis of gestational diabetes, type 1 or type 2 diabetes will develop later in life.

6. Glycosylated hemoglobin – A measurement of the average blood glucose over the prior 8 to 12 weeks. In persons without diabetes, glycosylated hemoglobin as measured by hemoglobin A1c is usually between 4.8 to 6.1 mg%. Optimal control for a person with diabetes was defined by the American Diabetes Association in the 1999 Clinical Practice Recommendations (Clark, ed, 1999) as a hemoglobin A1c of 7.0 mg% or less.
7. Formal diabetes education – Self-management training that includes an initial individual patient assessment; instruction provided by a qualified health professional; evaluation of the patient's knowledge, skills, and attitudes; and ongoing reassessment with appropriate training.
8. Diabetic ketoacidosis (DKA) – A serious and potentially life-threatening condition of diabetes. Due to a lack of insulin, the body breaks down its own fat resulting in the release of ketoacids that lower the pH level of the blood. DKA is most commonly seen with a concurrent illness, with omission of regularly scheduled insulin injections, or in a person newly diagnosed with type 1 diabetes.
9. Direct medical costs – Costs associated with an illness that can be attributed to a medical service such as a hospitalization or a clinic visit and treatment supplies such as insulin or blood glucose test strips.
10. Indirect medical costs – Costs associated with an illness that occur due to lost productivity because of premature death, illness, or disability.

11. Long-term retention of knowledge – Operationally defined as the time from instruction to the 4-month post-test.

Limitations of the Study

The study was restricted to parents of children newly diagnosed with diabetes that were patients of two specific pediatric endocrinologists and adults newly diagnosed with type 1 diabetes that were patients of two adult endocrinologists that service eastern Oklahoma and parts of Kansas and Arkansas seen for initial education in an outpatient setting. Findings from this study may not be generalized to assume that other geographic areas, other age populations (most of the parents were between the ages of 20 to 45 by virtue of having children between the ages of 0 to 21 years and the adult patients were under age 45), and a different setting (inpatient at hospital versus outpatient) would produce the same results.

Overview of the Study

As has been previously stated, the purpose of the study was to determine the effectiveness of a CAI simulation program in contrast to traditional instruction in improving the long-term retention of knowledge of persons with diabetes and their caretakers regarding the management of sick days. The second chapter deals with a review and analysis of the supporting literature relevant to this topic.

The methods and procedures of the study are presented in Chapter 3 and the results of the statistical analysis of the data are presented in Chapter 4. The final chapter of the study is concerned with the summary of findings, discussion, implications, and suggestions for further research.

Chapter 2

Review of Selected Literature

This chapter provides a review and analysis of the studies that examine the effect of diabetes self-management training in general and, more specifically, CAI in contrast to traditional teaching/learning methods in improving a variety of outcome measurements including retention of knowledge. The literature review has been divided into eight sections. The first section gives definitions of diabetes, incidence in the population, and goals of diabetes management. The second section provides an overview of the literature related to the effects of education on diabetes outcomes. The third section provides a rationale for the use of CAI as an educational strategy in relation to adult learning theory. In the fourth section characteristics of CAI that make it a suitable learning medium for adult are explored. The fifth section provides an overview of the articles and studies in the literature on the use of CAI in health care. The sixth section discusses the advantages and disadvantages of CAI. The seventh section gives characteristics of a good CAI program that would aid in choosing and/or developing optimal CAI programs. The eighth section discusses issues in utilization and implementation of CAI.

Definition of Diabetes and Incidence in the Population

The National Institutes of Health estimated, as of 1997, that 16 million people in the United States had diabetes, nearly 6% of the US population (National Institutes of Health,1997). The prevalence of diabetes has increased sixfold over the past 50 years with 1.5 million people diagnosed with diabetes in 1958 to 10.3 million in 1997 (National Institutes of Diabetes and Digestive and Kidney Diseases, National Institutes of Health,1995). It was noted that diabetes was the seventh leading cause of death in the United States and that more than 187,000 persons died from the disease and its related complications in 1995. The American Diabetes Association estimated that $98.2 billion was spent on diabetes care in 1997. Of this total, direct medical costs account for about $44.1 billion and indirect costs for $54.1 billion (American Diabetes Association, 1998).

Diabetes is a chronic metabolic disease characterized by elevated blood glucose levels in which the body does not produce or use insulin properly. There are three main types of diabetes: type 1diabetes, type 2 diabetes, and gestational diabetes. Type 1 diabetes, previously called insulin-dependent diabetes or juvenile-onset diabetes, is an autoimmune disease in which the body's own immune system attacks and destroys the insulin-producing beta cells in the pancreas. People with type 1 diabetes need daily injections of insulin to stay alive. Type 1 diabetes is more commonly diagnosed in children and young adults and accounts for about 5 to 10 percent of diagnosed diabetes in the United States. Type 2 diabetes, previously known as noninsulin-dependent diabetes or adult-onset diabetes, occurs when the body makes adequate insulin but the insulin is not used properly. This type of diabetes usually develops in persons over the age of 40 although the incidence in young people is increasing at an alarming rate. About 90 to 95 percent of people with diabetes have this form of diabetes and of these 80 to 90 percent are overweight at diagnosis. Gestational diabetes is the type of diabetes that is first noted during pregnancy. It usually goes away after the pregnancy is over. However, in women who have had a diagnosis of gestational diabetes, 60 percent will develop type 1 or type 2 diabetes later in life (National Institutes of Diabetes and Digestive and Kidney Diseases, National Institutes of Health, 1995).

The goal of diabetes management is to keep blood glucose levels as close to normal as possible while avoiding blood glucose levels that are too high or too low. Diabetes is a self-managed disease because the person with diabetes must take responsibility to manage their day-to-day care. Management involves balancing diet, exercise, and sometimes insulin and/or oral medication to achieve optimal blood glucose control. A 9 year national study concluded in 1993, the Diabetes Control and Complications Trial (DCCT), showed that intensive glucose control in persons with type 1 diabetes delayed the onset and progression of eye disease, kidney disease and nerve disease by "a range of 35 to more than 70 percent" (The Diabetes Control and Complications Trial Research Group, 1993). A more recently completed 20 year study from the United Kingdom showed results similar to the DCCT in persons with type 2 diabetes (Turner, 1998).

The National Diabetes Education Program (NDEP) is a new national initiative jointly sponsored by the National Institute of Diabetes and Digestive and Kidney Diseases of the National Institutes of Health and the Centers for Disease Control and Prevention aimed at reducing the suffering and death associated with diabetes and its complications. One of the guiding principles of the NDEP as outlined in 'Control your diabetes. For Life. Campaign guide for partners' states that "people with diabetes and their family members have the right to accurate information and education needed for diabetes self-care" (National Institutes of Health and the Centers for Disease Control, 1999, p. 27). People with diabetes should have the opportunity to acquire the knowledge and skills necessary to self-manage their disease. Health care providers should be responsible for providing education that addresses not only the medical but also the emotional needs of the person with diabetes. Education enables and empowers persons with diabetes to participate more actively in their treatment and prevention of complications. This NDEP principle supports the Healthy People 2010 objective aimed at reducing the disease and economic burden and improving the quality of life for all persons with diabetes by having 60% of all people with diabetes receive formal diabetes education. One way of making the necessary clinical expertise more widely available to accomplish the NDEP and Healthy People 2010 goals might be through the use of information technology (Lehmann, 1995).

Education: Effect on Outcomes in Diabetes

The critical role of diabetes education in quality diabetes care is clearly defined in the Standards of Care adopted by the American Diabetes Association. Further, the National Diabetes Advisory Board, a body established by Congress in 1976, stated in its 1993 Annual Report that "in the case of diabetes, an ounce of ... education saves a pound of treatment". The goal of educating persons with diabetes regarding self-management of their disease is optimal blood glucose control with reduction not only in long-term and short-term complications of diabetes but also in financial costs for both the person with diabetes and society. In spite of considerable effort being directed at diabetes self-management training, some persons with diabetes do not adequately manage their therapeutic regimen, even after receiving instruction. The end point that concerns those involved in the provision of care to persons with diabetes, remains achievement of optimal blood glucose control. "Inadequacies of current methods of diabetic care are demonstrated by audits of control which continue to show that fewer than a quarter of patients achieve average normal blood sugars as manifested by glycosylated protein measurement" (Day, 1995). Several studies in the literature have addressed the effects of educational interventions and outcomes in persons with diabetes.

A meta-analysis conducted by Padgett, Mumford, Hynes, and Carter in 1988 was conducted to determine the overall effects of educational and psychosocial interventions and to provide quantitative estimates of the relative efficacy of specific types of interventions in improving knowledge, psychological status, compliance, and metabolic control in persons with diabetes. Basically their goal was to identify what types of interventions were most effective in bringing about improvements in the management of diabetes. Meta-analysis allows for the combining of data from multiple studies thus increasing the sample size and power. This analysis included a group of 93 controlled studies that included 7451 patients. Reports of studies that met inclusion criteria were coded on the basis of the following aspects: study identification, method, sample characteristics, intervention characteristics, and outcome measures. Inter-rater reliability coefficients were calculated on key categorical items using Cohen's kappa with excellent agreement found ($K > 0.75$) on all key items. All outcome measures for each study were recorded and labeled and classified into four categories: knowledge, physical, psychological, and compliance. Outcomes that did not fit any of these categories were put into the overall mean ES calculated for each study. The study authors identified eight basic types of interventions. The studies were classified as testing the effects of one of these eight types: patient education (didactic emphasis); enhanced patient education (behavioral emphasis, using a combination of techniques); diet instruction; exercise instruction; self-monitoring instruction; social learning/behavior modification; relaxation training - biofeedback, yoga, meditation, etc.; and counseling - by peer support, by mental health professional or by clinician. Effect sizes were calculated for each relevant outcome using Cohen's d. An ES value of 0.20 was considered small, 0.50 was moderate, and 0.80 was large. Regardless of the type of intervention tested, most studies looked at physical measures of metabolic control such as glycosylated hemoglobin and blood glucose levels as outcomes. However, 23 studies emphasized instead improvements in knowledge, compliance or psychological status. A total of 417 effect sizes were calculated from 93 studies. Effects were positive, with an overall mean ES of 0.51 with a 95% confidence interval of +/- 0.11 (a positive ES connotes a positive outcome for the experimental group compared to the control group or pre-test measure). Of interest was the relative efficacy of each type of intervention for each outcome measurement. For physical outcomes, diet instruction and social learning had the highest mean ES values, relaxation training the lowest, with moderate positive effects for all interventions. Of note was that didactic education, self-monitoring instruction, and relaxation training did not prove to be significant. Small sample sizes may have played a role in this result. However, relaxation training should have improved physiological parameters of control so the lower ES is surprising. For psychological outcomes, the small number of studies measuring psychological outcomes made the results inconclusive. For knowledge outcomes, effects were generally high but quite variable. Enhanced education yielded a higher ES than didactic education. The authors of this study felt that this category of outcomes should be viewed as being the least relevant to the goals of most of these interventions because of the questionable relationship between knowledge gain and behavioral changes. Only 3 of the 24 studies that used knowledge as an outcome used it as the only measure of effect. However, two points can be made about the authors' conclusion. First, enhanced education produced more positive and statistically significant improvements in knowledge than didactic education. The interactivity of CAI places this tool in the realm of enhanced education because it "can support some of the cognitive processes that constitute learning and the affective aspects of motivation and enjoyment that enable the cognitive processes to be engages" (Day, Rayman, Hall and Davies, 1997). Second, although knowledge alone does not guarantee behavior change, it is a prerequisite to any change that one hopes to take place. Without knowledge, behavior change cannot occur. For compliance outcomes, effects were low or moderate for all interventions with the exception of diet instruction. However, self-monitoring training and enhanced education showed statistically significant effects ($p < 0.05$). When mean ES was calculated across all outcomes, ES values for all interventions except relaxation training were statistically significant. Diet instruction ES values were the highest with other types showing moderately positive effects. The ES values for didactic and enhanced education were almost equal. Psychosocial interventions, with the exception of social learning, showed weaker effects. The impact of specific study and sample characteristics on outcome was tested by using correlational analyses and one-way analyses of variance (ANOVAs). Interventions that were conducted in inpatient settings yielded higher mean ES values than those conducted in outpatient settings and summer camps, with the lowest ES for interventions in the home setting. Various aspects of study methodology were found to be related to the mean ES and therefore potentially affected the ES value. For example, type of study design (i.e., single vs. control group) and assignment to treatment condition (i.e., randomized vs. non-randomized) were inversely related to mean ES ($r=-0.32$ $p<0.05$ for single vs. control group designs and $r=-0.04$ $p<0.05$ for randomization). Therefore, weaker studies were associated with higher ES values. Age, sex, and whether or not a person was insulin-requiring did not effect the ES value. The investigators looked at the long-term effects on selected outcomes for the 14 studies that reported statistics at 6 and 12 months. The investigators found that, independent of outcome measure, the effectiveness of the intervention decreased with time. Effect sizes for blood glucose, weight loss, glycosylated hemoglobin and knowledge tests decreased dramatically from the 6 to 12 month follow-up points. Some effect was retained for blood glucose, glycosylated hemoglobin and knowledge tests but not for weight loss. Weight loss was the only outcome measure to show a negative effect size over a 12-month period. The meta-analysis investigators also evaluated the clinical significance of the calculated ES values by examining the percentage improvement of the average member of the experimental treatment group over the average member of the control group. An overall ES value of +0.51 meant that the average experimental group member was better off than 70% of the control group members assuming that ES values are drawn from normally distributed populations with equal variance. In examining the results of this meta-analysis, clearly some interventions were more beneficial than others. Overall, positive effects were noted of patient education programs that employed behaviorally enhanced strategies such as diet instruction. Beneficial effects extended beyond knowledge gain to also include improved metabolic control.

A. Nicolucci, et al (2000) conducted a study to validate and correlate a questionnaire that measured patients' knowledge and practices with HbA1c levels (a measure of metabolic control). The Knowledge and Practices Diabetes Questionnaire (KPDQ) was developed to investigate patients' knowledge and practices regarding various aspects of diabetes care. The questionnaire included two scales. The first investigated patients' practices (self-monitoring of blood glucose, modality and time of insulin injections, and time and characteristics of meals) and included 12 questions. The second scale focused on patients' knowledge (how to adjust insulin doses, carbohydrate content of meals, and risk of major diabetic complications) and included 10 questions. Factor analysis and reliability analysis were used to validate the questionnaire. As a result the final questionnaire was composed of 10 knowledge items (KS, Knowledge Score) and 5 practice items (PS, Practice Score). The ability of the questionnaire to predict metabolic control was then evaluated by administering it to a sample of 77 patients with type 1 diabetes that attended the outpatient clinic of Pescara General Hospital. After adjusting for clinical and patient-related characteristics, only the knowledge score proved to be a predictor of metabolic control. Patients in the lowest quartile of the KS showed a more than 20-fold increased risk for having a hemoglobin A1c value greater than 7.0 mg% compared to those in the highest quartile. The KS showed a significant association with the mean hemoglobin A1c value over a period of 4 years. These results are particularly impressive in light of failure of other studies to show a positive correlation between knowledge and metabolic control and/or an inability to maintain metabolic control over a long period of time after educational intervention.

A meta-analysis by S.A. Brown in 1990 was conducted to answer the question of whether or not diabetes education was effective. This meta-analysis expanded on previous meta-analysis research with an expanded number of sample studies (82 studies met inclusion criteria) and the addition of psychological outcome variables to the previously studied variables of patient knowledge, self-care behaviors (compliance and skill performance) and metabolic control. The primary goals of the research were to determine: (1) the effects of diabetes education on patient knowledge, self-care behaviors (compliance and skill performance), metabolic control and psychological outcomes; and (2) the relationships between outcome effects of education and particular characteristics of the studies and/or subjects including publication date, attrition rate, mean age of patients, research quality, length of the program, and length of time between intervention and measurement of outcome. For a study to be included in the meta-analysis it had to involve: (1) a population of persons with diabetes, primarily adults; (2) an education intervention designed to improve patient knowledge, self-care behaviors, metabolic control, and/or psychological outcomes; (3) an experimental design that included both treatment and control groups or a one-group pretest/post-test design; (4) the same setting for both treatment and control groups; and (5) a measure of outcome that allowed calculation of effect sizes. Two raters, according to a Coding Sheet and Codebook that define the coding process, coded studies that met inclusion criteria. Effect sizes were computed by using the formula as suggested by Glass et al (1981) and revised by Hunter et al (1982). Homogeneity analysis of specific patient outcome variables showed the following results: (1) knowledge effects ranged from 0.49 to 1.05 which indicated that the effect of patient education on patient knowledge was moderate to large; (2) self-care behavior effects ranged from 0.17 to 0.57 with insulin injection and weight loss associated with the smallest effect sizes; (3) metabolic control ranged from 0.16 for insulin dose changes to 0.41 for glycosylated hemoglobin (the insulin dose outcome was used by some researchers as an indirect measure of metabolic control); (4) medical care composite, constructed by the investigator, was an attempt to determine the degree to which diabetes education affected the need for follow-up medical services. One could argue that if fewer hospitalizations, office visits, sick days, etc. resulted from patient participation in diabetes educational programs, then patient education could be a very cost effective activity. A weighted effect size of 0.35 provided some evidence for the cost effectiveness of diabetes self-management training; (5) psychological outcomes 0.27; and (6) the older the mean age of the subjects, the lower the effects of diabetes education on knowledge of dietary principles, composite knowledge, and serum cholesterol level. As with all meta-analysis research, the results are dependent upon the quality of the research studies included in the analysis. Quality of research methods was measured in this analysis by items on the Code Sheet. The mean quality points across the 82 studies were 11.53 with a range of 5 to 18 and a total of 21 points possible. Two major limitations were identified: (1) lack of description of the study sample and sampling procedure, and (2) lack of description of the educational intervention. Additional quality characteristics were coded such as attrition rates and presence of validity threats. The most prevalent threats to validity were selection, history, and instrumentation. Selection and history threats reflected the practice of including preformed groups in research studies with no random selection of patients and/or no randomization of patients to treatment groups. Instrumentation threats included the problem of researchers developing their own instruments without determining reliability and validity. The investigator's conclusion from this meta-analysis research was that it lent support to the effectiveness of diabetes education in improving patient outcomes.

Franz, Monk, Barry, McClain, Weaver, Cooper, Upham, Bergenstal, and Mazze in 1995 examined the effectiveness of medical nutrition therapy (MNT) provided by dietitians in the management of type 2 diabetes. The sample for the study included 179 men and women aged 38 to 76 years assigned randomly to either MNT administered according to practice guidelines (PGC) or to MNT administered with basic nutrition care (BC) with a nonrandom comparison group of 62 adults with type 2 diabetes who had no contact with a dietitian. The study was conducted at diabetes centers in three states (Minnesota, Florida, and Colorado). BC consisted of a single visit with a dietitian; PGC involved an initial visit with a dietitian followed by two visits during the first 6 weeks of the study period. Outcome measures were collected at entry to the study and at 3 and 6 months that included fasting plasma glucose, glycated hemoglobin, serum lipid levels, weight, body mass index, waist-to-hip ratio, and changes in medical therapy. Initial analysis of the discrete variables was done using the chi square statistic with Yates' correction. Initial analysis of continuous variables was done by analysis of variance (ANOVA). The changes in variables between time periods were analyzed by paired t test, and comparisons between groups were analyzed using a t test for independent groups. The level for significance was alpha=.05 for all tests. At 6 months, PGC resulted in significant improvements in blood glucose control as evidenced by a decrease in fasting plasma glucose and glycated hemoglobin levels (P<.001). A fasting plasma glucose level of 4.4 to 7.8 mmol/L or a minimum 20% decrease from entry to 6 months was considered a successful outcome. A glycated hemoglobin value of 7.5% or less or a minimum 20% decrease from initial visit to 6-month visit was also considered a successful glucose outcome. BC resulted in a significant drop in glycated hemoglobin (P<.001) from entry to 6 months but not a significantly lower fasting plasma glucose. In the PGC group, total cholesterol and triglyceride levels dropped from entry to the study to 6 months. At 6 months, 46% of the group had achieved or maintained a target cholesterol outcome, 60% a target LDL-C outcome, and 53% a target triglyceride outcome. In the BC group there was a drop in total cholesterol and triglyceride levels from entry to 3 months but an upward trend at 6 months removed that difference. Total cholesterol values of 5.2 mmol/L or less, LDL-C values of 3.38 mmol/L or less, and triglyceride values of less than 2.26 mmol/L were considered successful lipid outcomes. In the PGC group, weight from entry to 6 weeks decreased and was sustained at 6 months. Waist to hip ratios did not change significantly during the study period. At 6 months, 22% of the PGC group had achieved the target outcome. In the BC group a weight loss from baseline to 6 months was significant. 16% of the BC group achieved the target outcome at 6 months. A weight loss of 1.5 to 3.0 kg at 4 to 6 weeks and a weight loss of 4.5 to 9 kg at 6 months was considered a successful outcome. The nonrandom comparison group did not experience improvement in glycemic control during the same 6-month period. Other outcomes were not investigated for this group. The investigators in this study concluded that medical nutrition therapy provided by dietitians resulted in significant improvements in medical and clinical outcomes and was beneficial for persons with type 2 diabetes. Of note is that glycemic control showed improvement to 3 months but then began an upward trend which suggests a need for additional intervention to maintain required behaviors to prevent this upward shift.

Although this research supports the effectiveness of diabetes education in improving patient outcomes, there was a demonstrated loss of effectiveness over time. Adult learning must be effective and efficient. Effective learning is learning that changes the learner's behavior over a sustained period of time. Efficient learning is tailored to the learner, and takes place quickly with a minimum of waste of time and energy (Burgess, 1996). Specific educational strategies and effect on patient outcomes were not addressed in these studies. Although these studies provided evidence of the effectiveness of educational interventions on a variety of outcomes, perhaps improved educational strategies and tools that take into account the needs of the adult learner would result in even better or more prolonged improvement in outcomes.

Advantage of CAI as an Educational Strategy in Relation to Adult Learning Theory

Computer-assisted instruction should meet the needs of the adult learner and result in improved educational outcomes through adherence to adult education principles. "Computer-assisted instruction (CAI) can be a powerful and engaging tool for learning. An interactive, self-instructional program can simulate real situations, provide feedback tailored to the learner's response, and offer a 'safe' environment for the learner to make mistakes - and learn from them" (Biomedical Communications Department of the University of Arizona Health Sciences Center, personal communication, 1997). Not all CAI currently available is of an interactive nature as defined by the above quote. The needs of the adult learner must be taken into consideration in designing and/or choosing software for CAI. The more interactive software is, the more it will meet the needs of adult learners.

Adult learning principles

Edward C. Lindeman identified adult learning principles as early as 1930. Lindeman's basic concepts of adult learning were that: (1) adults are motivated to learn as they experience needs and interests that learning will satisfy; (2) adult orientation to learning is life centered;(3) experience is the richest source of adult learning; (4) adults have a strong need to be self-directing; and (5) differences among people increase with age (Burgess, 1996).

Since that time adult learning has been researched by several authors. Malcolm Knowles contrasted adult learning with childhood learning to examine the unique characteristics of adult learners. Knowles (1989) identified six assumptions that he contrasted/compared to differentiate pedagogy, the instruction of children, from andragogy, the art and science of helping adults learn:

- Regarding the need to know: In the pedagogical model, learners need only to know that they must learn what the teacher teaches in order to pass and get promoted; they do not need to know how what they learn will be applied in their lives. In contrast, adults need to know why they need to learn something before expending the effort to learn it. Tough (1979) found that when adults decide to learn something on their own, they will invest a great deal of energy in examining the benefits they will get from learning it and the negative consequences of not learning it. One of the maxims in adult education is that the first task of the facilitator of learning is to help the learners understand why they 'need to know'.
- Regarding the learner's self-concept: In the pedagogical model, the teacher's concept of the learner is one of dependence therefore the learner's self-concept becomes that of a dependent personality. Adults have a self-concept of being responsible for their own lives therefore they want to be seen by others as being able of self-direction. This presents somewhat of a

dilemma to facilitators of adult education; the minute adults walk into a situation labeled 'education' or 'training' they revert back to their previous experiences as children and go into the 'teach me' mode. As facilitators of adult education have become aware of this dilemma they have been working at creating learning experiences in which adults are helped to make the transition from dependent to self-directed learners.

- Regarding the role of experience: In the pedagogical model, the experience of the teacher, textbook author, multimedia developers, etc. is what counts; the learner is viewed as having very little experience to bring to the learning situation. Therefore, transmittal techniques such as lecture, assigned readings, and the like are the primary methods of teaching in the pedagogical model. On the other hand, adults come into a learning situation with a wealth of experience. This has several consequences for adult education. First, it assures that in any group of learners there will be a variety of learning styles, motivations, needs, interests, and goals that will necessitate the need for individualization of learning and teaching strategies. Second, it means that for many kinds of learning the best sources for learning are within the learners themselves. Therefore, the greater emphasis for experiential techniques in adult education – techniques that allow the experience of the learners to be utilized such as group discussion, simulation exercise, problem-solving activities, case method, and laboratory methods – instead of transmittal techniques. Data from a NCES survey done in 1975 on learning methods preferred by would-be learners and methods used by participants in adult education showed that methods that require active participation are most often preferred and used by adult learners (Darkenwald and Merriam, 1982).

- Regarding readiness to learn: In the pedagogical model, learners become ready to learn what the education system wants them to learn if they want to pass and be promoted. Adults become ready to learn those things they need to know or be able to do when the realities of day to day life dictate a need.
- Regarding orientation to learning: In the pedagogical model, learners have a subject-centered orientation to learning. Adults' orientation to learning is more life-centered. Therefore, learning experiences for adults are generally organized around life tasks or problems. For example a learning experience aimed at an adult might be 'How to Balance Your Checkbook' instead of 'Accounting 1'.
- Regarding motivation to learn: In the pedagogical model, learners are motivated to learn by extrinsic factors such as grades, parental expectations, etc. Adults are generally motivated by such intrinsic factors as desire for increased self-esteem, responsibility, job satisfaction, and the like. This is not to say that extrinsic factors for motivation don't exist such as job promotion and salary increases but the intrinsic factors serve as a stronger motivation. Research by Tough (1979) indicated that all normal adults are motivated to grow and develop but that this motivation can be blocked by barriers such as time constraints, lack of accessibility to opportunities, their

belief that they cannot learn, and programs that violate principles of adult learning.

Knox (1986) stated that part of the teacher and learner satisfaction in educational programs for adults was dependent on the use of appropriate instructional strategies including:

- Use of questions and examples.
- Provision of practice opportunities.
- Appropriate pacing of the program.
- Use of reinforcement.
- Provision of useful feedback to the instructor and participants.

Darkenwald and Merriam (1982) combined principles of learning relevant to adult education from the theories of behaviorists, Gestaltists, and cognitive theorists to form a set of principles that could serve as guidelines for educational practice in adult learning:

- An adult's readiness to learn is dependent upon the amount of previous learning. The more learning situations a person has experienced the better able that person is to engage in complex modes of thinking and absorb new information.
- Intrinsic motivation produces more effective (pervasive and permanent) learning than extrinsic motivation. What is learned becomes a part of the learner when needs are directly satisfied by the learning itself.

- Reward (positive reinforcement) versus punishment (negative reinforcement) of learning is more effective. An adult must feel successful in the learning experience to continue to participate in learning situations.
- Information should be organized in some systematic fashion to maximize learning. The starting point should be related to the adults' past experiences and knowledge.
- Learning, particularly when skills are being developed, is more effective when repeated on several occasions spaced systematically over time.
- A material or task that has some meaning to the learner will be more easily learned and longer remembered than nonmeaningful material. One of the tasks of a facilitator of adult learning is to relate the material to the experiences and needs of the learner.
- Active rather than passive participation in the learning activity brings about more meaningful and lasting learning. When adults are allowed to discover meanings, concepts, and relationships on their own the learning in and of itself becomes a reward.
- Environmental factors such as poor light, noise, a crowded room, uncomfortable temperature, etc. can negatively affect the learning process. Tension, illness, fatigue, and pressure can also impede learning.

Adult learning principles relative to CAI

The principles of adult learning espoused by Knowles, Knox, Manteuffel, and Lindeman (Knowles, 1989; Knox, 1986; Manteuffel, 1982; Burgess, 1996) and compiled by Darkenward and Merriam (1982) that are particularly relevant to adult learners and the use of CAI can be summarized as follows:

- Adults are motivated to learn when a need or interest is perceived that learning will satisfy. Adults may seek out learning experiences to cope with specific life events or because they have a use for the knowledge or skill being sought.
- Adults have a concept of being responsible for their own lives and therefore a deep need to be self-directed learners (that the learning situation is at least somewhat under their control).
- Adults are life-centered (or task centered or problem centered) in their orientation to learning making the time perspective one of immediate application versus delayed application of learning outcomes. This makes the learning both applicable and worthwhile to the learner.
- Adults come into a learning situation with a foundation of experience that is a resource for learning. They need to be able to integrate new ideas with what they already know.
- The most important motivators for learning in adults are intrinsic (the desire for increased self-esteem, quality of life, responsibility, job satisfaction, and the like).
- Adult learners need to be actively involved in the learning activity.
- Adult learners need to feel challenged.
- Adults need to feel a sense of accomplishment and proficiency after completion of the learning experience.

- Adults need to feel safe in their learning environment. Positive reinforcement versus negative (reward instead of punishment) makes the adult feel safer, thereby making the learning experience more effective.
- Adults learn best when what is being learned is in context. Information should be logically sequenced to maximize learning.
- In adults, learning is most effective when information or skills are repeated on several occasions with opportunity for practice.
- Use of questions and examples as an instructional strategy promotes satisfaction in adult learners.
- Adults will be more satisfied with the learning process when useful feedback is provided.
- Learning must be appropriately paced to maximize satisfaction.

Characteristics of CAI that Make it a Suitable Medium for Adult Learners

CAI has a number of characteristics that make it an effective medium for the application of many of the educational principles previously listed and therefore for adult learning. Several authors (e.g. Milheim, 1993; Hayward and Kahn, 1996; Burgess, 1996; Kahn, 1993; Borsook and Higginbotham-Wheat, 1991; Askov and Bixler, 1996; Beach, 1993; Edwards, 1993) discussed the characteristics of CAI that made it a suitable choice for adult learners:

- Safe, non-judgmental, comfortable, private learning environment, free of outside criticism. Schank in an interview with Beach (1993) related that learning something new was often dangerous and risky to adults who have had past experiences that have taught them that failure would result in bad grades and ridicule. CAI can provide adult learners with a learning experience that is quite different from earlier schooling in which they might have experienced some difficulty (Milheim, 1993).

- Self-paced. Adult learners benefit from the lack of speed requirements often present in other forms of instruction (Milheim, 1993).
- Individualized content.
- Multi-sensory delivery system. "Average people remember 10% of what they read, 20% of what they hear, 30% of what they see, and 50% of what they hear and see. CAI can facilitate greater retention of new information by virtue of being a multi-sensory delivery system" (Askov and Bixler, 1996, p. 24).
- Flexibility in scheduling. People can learn virtually any time and place they choose without obstacles such as poor transportation, fear of street crime, or lack of expert teachers.
- Self-directed (learner controlled).
- Cost-effective (generally).
- Open entry and exit.
- Ability to repeat exercises when desired.
- Availability of constant, positive, explanatory feedback and reinforcement in a non-threatening environment.
- Repetition of basic concepts after an incorrect response.
- Reduction in instructional time.

- Increased interaction between the learner and the system (learn by doing)
- A consistent response to each learner regardless of gender, race, or age.
- Instructional consistency.
- Development of decision-making skills by use of simulation programs.
- Documentation of the learning process and outcome measurement by linking teaching material with learning objectives.
- Ability of the computer system to allow learners to easily make up missed lessons.

The characteristics of effective CAI can be linked to the principles of adult learning found in the literature:

Adult learning principle	**Characteristics of CAI that meet this principle**
Adults are motivated to learn when a need or interest is perceived that learning will satisfy. Adults may seek out learning experiences to cope with specific life events or because they have a use for the knowledge or skill being sought.	Ability to personally select what is to be learned (menus; help keys). Computer can be made available at any time.

Adult learning principle	Characteristics of CAI that meet this principle
Adults have a concept of being responsible for their own lives and therefore a deep need to be self-directed learners (that the learning situation is at least somewhat under their control).	Open entry and exit. Not allowing the learner to exit the program until it is completed can negatively affect the learner's self-concept by letting the technology, rather than the learner, control the pace and delivery of instruction (Bixler and Askov, 1994). Individualization of pacing and content. Flexibility in scheduling. Feedback.
Adults are life-centered (or task centered or problem centered) in their orientation to learning making the time perspective one of immediate application versus delayed application of learning outcomes. This makes the learning both applicable and worthwhile to the learner.	Immediate feedback and opportunity to practice what has been learned.

Adult learning principle	**Characteristics of CAI that meet this principle**
Adults come into a learning situation with a foundation of experience that is a resource for learning. They need to be able to integrate new ideas with what they already know.	The ability of the CAI program to adjust to various entry levels. Ability of the computer to pre-assess the learner's knowledge, skills, attitudes, and learning style and then tailor the learning to the learner's specific needs.
The most important motivators for learning in adults are intrinsic (the desire for increased self-esteem, quality of life, job satisfaction, etc.)	Ability to personally select what is to be learned.
Adult learners need to be actively involved in the learning activity.	Interactive nature of simulations, drill and practice, and games.
Adult learners need to feel challenged.	Ability to adjust the level of difficulty and presentation speed.

Adult learning principle	Characteristics of CAI that meet this principle
Adults need to feel a sense of accomplishment and proficiency after completion of the learning experience.	Availability of constant, positive feedback and liberal reinforcement. The success orientation of CAI in general.
Adults need to feel safe in their learning environment. Positive reinforcement versus negative (reward instead of punishment) makes the adult feel safer, thereby making the learning experience more effective.	Provides privacy. Safe, non-judgmental, comfortable learning environment.
Adults learn best when what is being learned is in context. Information should be logically sequenced to maximize learning.	Can be organized by problem areas. "Modular organization, in contrast to conventional linear, and continuous nature, ensures that the program content is broken up into small units with interconnected links, which imitate the cognitive structure in people's memory" (Chen, 1990, p. 11).

Adult learning principle	Characteristics of CAI that meet this principle
In adults, learning is most effective when information or skills are repeated on several occasions with opportunity for practice.	Ability to repeat exercises when desired. Computer is infinitely patient. It does not tire of repeating information over and over.
Use of questions and examples as an instructional strategy promotes satisfaction in adult learners.	Practice activities. Post-tests.
Adults will be more satisfied with the learning process when useful feedback is provided.	Availability of constant, positive feedback.
Learning must be appropriately paced to maximize satisfaction.	Ability to repeat exercises when desired. Learner control over starting, stopping, skipping around in the program. Ability to adjust the level of difficulty and presentation speed.

Not all educational computer software programs currently available have the characteristics that make CAI an ideal medium for adult learning.

Software for CAI can be broadly classified as either interactive or non-interactive. Non-interactive software is designed to provide instructional handouts. In the health care setting for example "more sophisticated computer-generated patient handouts systems allow the health provider to customize, delete from or add to the corpus of instructional materials" (Hayward and Kahn, 1996, p. 4).

Several authors believe that the real potential of CAI emerges when handouts are a by-product of education and instead interactivity is the main focus (Hayward and Kahn, 1996; Kahn, 1993; Borsook and Higginbotham-Wheat, 1991). In interactive systems the information is presented to the learner who in turn reacts in a way that the computer records and acts upon. Learner understanding is assessed before moving onto the next topic. By provision of these characteristics, interactive systems conform instruction to the learner's "unique knowledge, comprehension, interests and learning style" (Hayward and Kahn, 1996, p. 4). Interactivity is not a well-defined concept especially when applied to computer-assisted instruction. Borsook and Higginbotham-Wheat (1991) listed seven variables that they felt were key ingredients of interactivity:

- Immediacy of response. To illustrate this variable one can think about the difference between a face-to-face conversation with a friend or a computer chat room and conversing by way of e-mail or regular mail. The immediacy of response with a face-to-face conversation or even a chat room is generally much more engaging than the alternatives.

- Non-sequential access of information. Borsook and Higginbotham-Wheat provided an example to illustrate this variable. They constrasted the instructor that gave a presentation, accepted no questions, and left to the instructor that tailored his or her presentation by fielding questions, restating points in different ways, and taking the participants needs, concerns, and anxieties into consideration.
- Adaptability. Non-sequential access to information necessitates adaptability. Adults adapt what they say and how they say it depending on who they are talking to and the situation in which they are involved.
- Feedback. Feedback is necessary to make adaptations. Interactivity is not possible without feedback. The feedback must be more than "right or wrong"; it must also include information for the learner on how to correct the situation if it is not right.
- Options. Software cannot be adaptive if it does not offer options.
- Bi-directional communication. Two-way communication is an important ingredient of interactivity. If what the software provides is pages and pages of texts and graphs without opportunity for learner input, instruction cannot be adapted to the learner. Think of having a one-way phone conversation; it would not be very satisfying or rewarding.
- Grain-size. This refers to the length of time the computer software is giving information before the learner can provide input. An instructional sequence

that takes 15 minutes to present before the learner can provide input is not contributing to interactivity.

According to Kahn (1993), Askov and Bixler (1996), Billings (1986), and the Texas State Department of Criminal Justice, Huntsville, Windham School System (1991) most interactive CAI uses one or more of the following techniques: drill and practice, tutorials, simulations, learning games, and assessment.

Tutorials are used to present information. In a tutorial the learner is given a block of information usually in text form and then asked questions about the information. Typically a multiple-choice option is given the learner, and, depending on the answer, the program will take the learner on a different path (reviewing the points missed, going ahead, exploring in more depth, or going in another direction). A tutorial is used when new information must be taught in a sequential manner (Kahn, 1993; Hayward and Kahn, 1996; Askov and Bixler, 1996).

Drill and practice programs are used to develop a mastery of facts. They involve solving problems or answering repetitive multiple-choice questions. Corrective feedback is given and the problems or questions are repeated until mastery of a skill or subject is achieved. Drill and practice is typically used after the initial instruction to provide further opportunity for practice. A drill and practice program might be used to learn the names and functions of vitamins and minerals.

Simulations provide an opportunity for the adult to learn in the same context in which the new knowledge is needed (Hayward and Kahn, 1996) and are perhaps the most interactive of all computer-assisted instructional systems (Borsook and Higginbotham-Wheat, 1991). "Simulations are high-level application lessons, in which an aspect of the real world is simulated and the learner must gather data and make decisions" (Billings, 1986, p. 357). Features of this type of CAI are absence of risk and time compression. The learner can make mistakes, experiment, and interact with the program with little risk or expense incurred in contrast to making mistakes and experimenting in the real situation.

CAI can be used for testing. Assessment is a part of any learning experience. Assessment via CAI can initially place a learner and then monitor that learner's progress in the curriculum (Askov and Bixler, 1996). "Tests can be used to give the rationale for correct and incorrect responses, and are, therefore, useful for studying for licensure or certification examinations" (Billings, 1986, p. 357).

Games are like simulations in that they are engaging and contain many of the same ingredients of interactivity. In addition, they use entertainment, competition, and fantasy which can aid a learner in becoming more involved in the learning activity. Simulation and gaming technology are being expanded to include 'artificial reality'. Developers of this type of software are trying to capture the look and feel of real situations through the use of three-dimensional graphics, sound and video and capture the physical movement of the user through use of input devices such as space-sensing gloves (Kahn,1993).

Multiple studies have been done and articles written on the advantages, disadvantages, and use of CAI in health care education. Persons with chronic diseases are appropriate targets for CAI because they need to understand a great deal of complex information and use it to develop skills in self-care and self-monitoring (Kahn, 1993).

CAI in Health Care

Jelovsek and Adebonojo (1993) looked at all the reports of randomized clinical trials on CAI in health care that were published in English between January 1966 and June 1992. Forty-nine clinical trials were found that focused on the effectiveness of CAI on cognitive outcome (short term knowledge retention), behavior change, or relation to learning theory. They presented a short synopsis of each study and drew conclusions on CAI and cognitive outcome, behavior, and learning theory as well as overall conclusions regarding the effectiveness of CAI in relation to traditional instruction.

Jelovsek and Adebonojo, in terms of cognitive outcomes, concluded that CAI was a legitimate method of instruction equal to other usual types of teaching in terms of learning and time involvement. Three of the articles reviewed in this section illustrate this conclusion.

Feldman, Schoewald, and Kane (1989) studied 4th year medical students who were taking a course on pharmacology and therapeutics. The authors developed a microcomputer-based instructional system to teach pharmacokinetics that was flexible, self-paced, and included narrative and problem solving components. Forty students were recruited from the fourth year medical class enrolled in the clinical pharmacology and therapeutics lecture series. Volunteer students were randomly assigned to either a conventional teaching format or to conventional teaching plus CAI. The remainder of the class not involved in the study served as a second comparison group. During the 4-week trial period the computer program was used by 23 of the 24 students in the treatment group. Of these students, 87% stated that the CAI courseware was a better way to learn pharmacokinetics compared to then current methods. Students in the treatment group reported using the package for 6.3 $\pm$ 0.8 hours. Total time spent in pharmacokinetic learning activities was significantly increased in the treatment group (treatment = 24.1 $\pm$ 3.6 hours, control = 17.6 $\pm$ 5.0 hours). The students in the conventional teaching plus CAI group scored 35% higher on the mid-term examination and spent 35% more time on pharmacokinetics learning activities. It is interesting that the improvement in short-term learning in the treatment group paralleled the increased time spent in pharmacokinetics learning activities. It cannot be excluded that the control group could have achieved a comparable increase in short-term learning if this group had spent a comparable amount of additional time in conventional learning activities. Keane, Norman, and Vickers (1991), in a review of the literature on CAI, criticized the type of experimental design used in this study. They stated that the problem with this type of design was that even if the CAI and non-CAI users were equal at the beginning of the study they were not by the end in one critical respect: CAI users devoted more time than their peers to attaining the same learning goal. Since it has been fairly well established that those who devote more time to learning something learn more and score higher on tests, the authors felt that it would be impossible to distinguish between the effect due to the difference between groups in the amounts of time spent on a task and that due to any superior feature of CAI. However, the authors of this study concluded that, at the least, the computer course appeared to be stimulating enough to increase the student's interest and time spent in learning pharmacokinetics. The trial did not evaluate long-term improvement in learning (this was only a four-week trial) or whether CAI could replace conventional teaching. Students' reports were clear that they viewed the CAI program as a supplement to conventional methods of teaching and not a substitute.

Garrett, Ashford, and Savage (1987) compared tutorials and CAI in hematology and oncology. In this study the control group outperformed the CAI group but the CAI took less time.

Jacoby, Smith, and Albanese (1984) randomly divided fifty-three 4th year medical students into two groups. Twenty-six students received 30 to 45 minutes of computer instruction on CT scanning and a 50-minute lecture on child abuse. Twenty-seven students received 30 to 45 minutes of computer instruction on child abuse and a 50-minute lecture on CT scanning. Based on results of preand post-test scores, CAI was as effective as lectures according to measures of short-term knowledge gain. In the topic of head CT, both the CAI and the lecture groups demonstrated significant improvement ($t = 8.50$ and 8.29, respectively; $p < 0.0001$). An analysis of covariance was done as the CAI group had slightly higher initial test scores than the lecture group. The difference between the adjusted final test scores was not significant. Both the CAI and the lecture groups showed improvement for the topic of child abuse ($t = 9.03$ and 8.68, respectively; $p < 0.0001$). An analysis of covariance was also done for this topic with no significant difference noted. The students also completed a questionnaire asking their opinion of the teaching methods and their preference for various types of instructional material. The results of the opinion questionnaire showed a preference for CAI versus lecture format. On a Likert scale of 1 (least desirable) to 5 (most desirable), the mean score for the lecture format was 3.4 and the mean score for CAI was 4.2. The difference between scores was statistically significant ($p < 0.001$). In response to the question as to whether the instructors should prepare similar computer-assisted tutorials in other areas of radiology, a 4.6 was obtained. The authors cited two drawbacks to CAI from their experience with this study. The initial time invested in preparing the tutorials was extensive with each tutorial requiring 80 to 100 hours of preparation. There was an inability of the student to ask questions of the 'instructor' as could be done in a lecture format without sophisticated programming techniques being employed. The authors concluded that there were several advantages to CAI:

- less study time was required
- active participation enhanced acceptance of CAI by the learners
- flexibility in scheduling time of learning
- pace of lesson determined by the learner
- ability to repeat the program as often as necessary for mastery
- the ability of the program to give feedback tailored to the educational level of the individual.

Jelovek and Adebonojo concluded, based on their review of the literature, that CAI could alter behavior as well as cognitive knowledge. They found that behavioral change required more hours of CAI than cognitive change. Two studies reviewed in this section illustrate this conclusion.

Horan, Yarborough, Besigel, and Carlson (1990) randomly assigned 20 matched pairs of patients aged 12 to 19 years to receive CAI or traditional instruction. The subjects were matched on the basis of grade level in school, gender, race, and pretest measures of glycosylated hemoglobin level, diabetes factual knowledge, and diabetes applied knowledge. The Diabetes in Self-Control (DISC) computer program was used with Commodore computers in the study. DISC was a program that incorporated sections on (1) data management and review for storing, compiling, and reviewing food, glucose and other self-monitored data (insulin, weight, diet, exercise, emotional and physical stress); (2) computer-assisted factual and applied diabetes education; and (3) pragmatic problem solving and goal setting to improve diabetes management practices and glycemic control. The study design consisted of three major phases: baseline (3 weeks), diabetes education (7 weeks), and goal setting and problem solving (8 weeks). Following a no-treatment phase of 3 weeks in which participants monitored and recorded blood glucose levels, 7 weeks of instruction was presented either by CAI utilizing DISC or a printed education book. Identical information was presented to each of the groups about diabetes, diabetes management, and module posttests written at the fourth-grade reading level. The difference between groups was the presentation of education: "dynamic, colorful CAI modules and graphics for the CAI group; static, black-and-white printed materials for the CE group" (p. 208). The subjects in each group continued to monitor and record blood glucose during this phase. During phase 3, the CAI group, through CAI modules, was taught to self-rate daily and to record the stability of diabetes-related factors such as diet, exercise, emotional and physical stress using a scale of 1 to 5. Using the DISC software, subjects reviewed graphs displaying actual blood glucose results and results with changes made in exercise, diet, insulin, and stress. This helped subjects correlate changes in variables with changes in blood glucose levels and problem solve areas that would improve blood glucose control. Throughout phase 3, subjects in the CE group followed phase 2 procedures. They did not receive instruction on problem solving. Subjects' glycosylated hemoglobin levels were measured at baseline and after phase 3 and subjects were given pre- and post-tests on factual and applied diabetes knowledge. At the end of phase 3 subjects were asked if they had changed their diabetes management behaviors as a result of what they had learned and whether they were more active in controlling their insulin-dependent diabetes after participating in the study. Scores on the factual test improved in 60% of the students taught by CAI and 50% of those taught by traditional methods. Applied skills improved in 50% of the students taught by CAI and in 35% of those who received traditional instruction. This did not represent a significant difference between groups when subjected to a t-test. T-test analyses revealed no significant changes in glycosylated hemoglobin between groups. Improvement was noted in the CAI group's pre-lunch and pre-dinner glucose levels when analyzed by means of 4 separate 2 (group) x 3 (phase) analyses of variance with repeated measures on the last factor. Frequency of blood glucose testing was measured by means of a 2 (group) x 3 (phase) analysis of variance with repeated measures of the second factor. Post hoc analyses indicated that the CAI subjects tested blood glucose levels more frequently than did CE subjects in both phases 2 and 3. Subjects in the CAI group reported more behavioral change as a function of what was learned when compared to the CE group. The authors felt that this initial evaluation of the DISC system was encouraging. Adherence to the treatment regimen appeared to be enhanced when a CAI program that involved a comprehensive basic education, data management and review, pragmatic problem solving, and diabetes goal setting was used. A longer study period would be needed to determine if these changes could be maintained over a longer period of time.

Rubin, Leventhal, Sadock, et al (1986) evaluated an educational intervention by computer in childhood asthma. During routine visits, 54 children with asthma were randomly assigned to the experimental group that played a computer game, 'Asthma Command', or a control group that played other computer games. The experimental group showed more improvement in knowledge of asthma and behavior related to managing the disease. Also noted was a trend toward less emergency visits in the experimental group.

Jelovsek and Adebonojo drew three conclusions regarding learning theory from their review of the literature. First, they concluded that interactive forms of teaching such as CAI were superior to linear forms. Second, they concluded that explanation enhanced learning in any sphere and that access to information was in itself educational. Third, they concluded that repetition in small batches improved mastery. However, they noted that surprisingly few CAI programs included repetition of difficult or missed concepts. The authors overall conclusion from their review of the literature was that students learn as well with CAI as with traditional methods and in some cases better.

Finley, Sharratt, Nanton, Chen, Roy and Paterson (1998) compared classroom teaching and computer-aided independent learning of auscultation of the heart. The investigators wanted to determine if a new case-oriented CD-ROM auscultation teaching program could augment classroom teaching or perhaps even replace classroom teaching. The second-year class of medical students at Dalhousie University Medical School was randomly divided into groups of about 10 to 15 students. Two of these groups received CD-ROM-based teaching (21 students), and two groups received classroom teaching (19 students). The CD-ROM-based teaching program used by the CAI groups was 'Ears On' and incorporated a comprehensive text on the principles of auscultation, heart sounds and murmurs; approximately 250 heart sound recordings; and 21 cases each including a brief clinical description, a recording of the heart sounds and a series of questions. The students were given instruction on the use of the program and asked to answer the questions for each of the 2 cases and to read the review section for each case. From the review section, the program allowed the student to go to the relevant section of the CD-ROM textual material for more detailed explanations. Students were given 3 days to complete the material and asked to spend no more than 3 hours in so doing although they could spend longer if desired. On the fourth day the students attended a group evaluation session with eight heart sound recordings presented by a cardiologist with questions on each. The answers were then reviewed and discussed by the cardiologist and students. An evaluation form was completed by each student regarding content, approach, sound quality, usefulness of the test and review and overall impression of the teaching process. The classroom group discussed about 20 cases with heart sound recordings with the entire group using multiple stethophones attached to a single computer. The cases were chosen to include the same material reviewed by the CD-ROM group. The session lasted about 2 hours. Immediately following the session, the students in the classroom group received the same test and review session as for the CD-ROM group. The same evaluation form was completed. Analysis of individual questions and total scores for the eight cases used for the test was by nonparametric statistics, Kruskal-Wallis for two groups, using EpiInfo 6.01, with a significance level of $P < 0.05$. The classroom students scored higher on open questions than the CD-ROM-taught group, but in general performance by both groups was satisfactory and equivalent. The investigators postulated that the difference on the open questions might have been due to the ability in the classroom to emphasize particular concepts that students were having difficulty with and correcting misconceptions as compared to the more extensive body of material on the CD-ROM. The teaching evaluation used a 4-point rating scale from excellent (1) to poor (4) for nine questions. Results were reported using medians and frequencies. Group median scores of 1 or 2 were considered satisfactory. The CD-ROM group rated the duration of time allotted for teaching or learning as less than satisfactory (median = 3) which was significantly different from the rating of the classroom group (median = 2) ($P < 0.05$). Many students in both groups commented that a combination of classroom and CD-ROM auscultation teaching would be preferable since it would combine the benefits of independent study with human interaction and expert feedback. The authors concluded that CAI case-oriented auscultation teaching was generally as effective as classroom teaching except in preparing the student to answer open-ended questions. Students rated both learning methods highly but felt that a combination should be used in future curricula.

Kinney, Keskula, and Perry (1997) assessed the efficacy and efficiency of CAI for students learning evaluation and treatment skills for carpal tunnel syndrome (CTS). Ten volunteer physical therapy students were randomly assigned into either CAI or interactive lecture instructional groups. Each student completed a 36-item pretest on CTS. The CAI group used the 'Physical Therapy

Patient Simulator CAI' and the instructional group participated in lecture/discussion to complete the case studies. Following completion of instruction, an identical 36-item posttest was administered to all students. The instructor recorded individual start and finish times for the two groups. Although students' posttest scores were greater overall when compared to pretest scores, a 2x2 ANOVA revealed no significant difference in pretest/posttest scores between CAI and interactive lecture. A t-test determined the CAI group completed the case assignment 30 minutes (24%) faster than the interactive group. The findings suggest that using a CAI simulation program may be at least as effective as and more efficient than traditional methods of instruction. The investigators noted that "the absence of the personal interaction represents one of the major disadvantages noted in the use of CAI" (p 59). To address this issue, an instructor was available to answer questions immediately after completion of the case study for the CAI group as well as the traditionally taught group. This study did not comment on the time invested in development of the CAI case study. This initial development time for CAI is greater than that needed to prepare for a lecture presentation. However, once the CAI program was designed there would be a potential reduction in teaching time. The investigators felt that, in addition to CAI being as effective and more efficient as compared to direct instruction, benefits of CAI included the ability to: (1) use several instructional strategies, (2) vary instructional events, (3) individualize instruction, (4) provide ease of accessibility, (4) facilitate instructional consistency, (5) promote privacy of learning, (6) provide for more realistic clinical simulations, and (7) provide for a risk-free learning environment.

Lilienfield and Broering (1994) tested the effectiveness of an interactive multimedia computer program, the 'Electronic Textbook in Human Physiology', in improving the knowledge of students studying cardiovascular physiology. Forty-eight medical students and 12 graduate students worked with the computer program during the physiology course. The remaining 129 medical students and 63 graduate students taking the same course served as controls. The process of selection was biased against the program's success in that the students that used the program did so because they were the last to sign up for the dog laboratory and were unable to participate in the live dog laboratory because there was not room for them. The students that used the CAI program were scheduled to spend two hours with the computer program in the 'Macintosh Classroom' maintained by the medical center library. Each student was given access to a Macintosh computer and a set of earphones to listen to the soundtrack. The senior author explained the purpose of the computer program and was available throughout the exercise but only to assist in the use of the computer where needed. The program included a pre-test of the students' knowledge and a post-test that was taken on student exit that used the same nine questions as the pre-test. The post-test included feedback for both correct and incorrect responses. The mean percent correct responses on the pretest were 48.29 ± 2.39 and 54.42 ± 6.41 for the graduate and medical students, respectively, with no significant difference found using Student's t test (paired). On the posttest, a significant effect of working with the computer program was observed with a rise in the scores to 91.75 $\pm$ 1.25 ($P < 0.001$) for the medical students and to 92.6 $\pm$ 1.56 ($P < 0.001$) for the graduate students. These scores indicated that short-term knowledge increased by using the computer program. There was no difference found between the medical and graduate groups. After using the CAI program the students were asked to write a brief comment regarding their opinion of the computer program. The authors concluded, from the written comments, that the program was well received and was perceived by the students as being very helpful and enjoyable. During the same time that the computer program was being used, the remaining students (control group) participated in the scheduled dog cardiovascular laboratory. A general discussion was held for the entire class, including those that completed the CAI program, after everyone had completed the dog laboratory. At the end of the semester (about 1.5 months after the dog cardiovascular laboratory) a 141-question final examination was taken by the entire class that included 12 five-part multiple-choice questions about cardiovascular physiology. There was a statistically significant difference ($P < 0.001$) on the final exam between the graduate and medical students in the control group but not in the experimental group (the group that used the computer program). The mean percentage of correct responses for the medical students in the experimental group was 77.17 $\pm$ 1.20 and for the graduate students was 76.00 $\pm$ 1.95. Correct responses in the control group were 77.67 $\pm$ 0.76 for the medical students and 72.63 $\pm$ 1.43 for the graduate students. On the cardiovascular section of the final exam the difference between the experimental and control group scores for both medical and graduate students was highly significant [$P < 0.001$ (medical) and $P < 0.01$ (graduate)]. The mean percentage of correct scores for the control medical students was 75.29 ± 0.85 and for the control graduate students 72.46 ± 1.59. The mean percentage of correct scores for the group of medical students that used the computer program was 81.73 ± 1.11 and for the graduate group 82.00 ± 2.29. The investigators concluded that the interactive computer program, possibly by improving motivation, resulted in improved learning when compared to the traditional lecture and laboratory.

Kopelman and Sanderson (1996) developed and tested a multiple-choice training model for diabetes self-management training called PEATS (Patient Education and Training System). PEATS was designed to assess an individual's knowledge of diabetes and the degree of adherence to the treatment regimen utilizing a questionnaire format. PEATS included a separate set of questions for type 1 versus type 2 diabetes. For each question in the PEATS program four alternative answers were given with a corrective response if the correct answer was not chosen. The questions in PEATS were designed to look at a variety of areas of diabetes self-management including diet, influence of physical activity on blood glucose control, hypoglycemia, and intercurrent illness. Each question in PEATS was assigned a category (skills, knowledge, or compliance) so that specific areas of weakness could be identified and then addressed by the diabetes nurse educator. Individual patient scores were stored as part of the program and were used to determine both an individual's progress over time and the effectiveness of the local diabetes education program. The authors conducted a preliminary evaluation of the PEATS program with 45 patients with diabetes (25 insulin treated and 20 treated with oral medications). The mean PEATS score for the insulin treated patients was significantly greater than the score for the patients treated with oral medications ($p < 0.05$). No differences were found between the overall PEATS score and the duration of time since diagnosis for either group. A direct association between measures of metabolic control and PEATS score was not seen although the authors noted that there seemed to be a trend that those with less good control achieved poorer PEATS scores. Patients of Asian background scored less well than white ($p < 0.01$) or black subjects ($p < 0.05$). As a result of the findings from the preliminary study, additional education sessions were set up at the facility for patients with non-insulin dependent diabetes and those of Asian origin. PEATS was in essence a diagnostic tool versus a true education program. It allowed the nurse educator to identify areas of deficiency and then focus education on those areas. PEATS did provide some education in that explanatory feedback was given for incorrect answers.

Lewis and Nath (1997) evaluated the use of a kiosk-based computer system with an interactive multimedia program developed by the United States Pharmacopeia 'About Your Diabetes'. A multimedia learning kiosk presented the computer-based instructional program in a stand-alone interactive learning station. The kiosk consisted of a compact disc interactive player with a touch-sensitive computer monitor and instructional software. The study focused on both the feasibility and usefulness of an interactive learning kiosk in providing patient education. Participants in the study were recruited at random from clients who visited the outpatient family medicine clinic of a southeastern academic medical center. About 4000 clients visited the clinic each month. The study was conducted for a 2-week period during August to September of 1996. An invitation to use the program was posted on the kiosk and clients were given an information sheet when they checked in. The kiosk was placed in the main waiting room of the family medicine clinic and all patients in the waiting room were eligible to use the kiosk. Interviews and observations were used to answer the research questions. Interviews were conducted with clients and staff members using an interview questionnaire that was designed by the researchers. A single researcher completed the interview process at various times of the day to reduce the risk for time-of-day or interviewer bias. The interview questionnaire consisted of thirty-six items that addressed participant demographic information, indicators of perceived ease of use, and usefulness of the interactive kiosk as an educational strategy. Content validity of the instrument was established by distributing the questionnaire to eight persons with documented expertise in diabetes patient education, prevention research, or educational materials development. Twenty-four clients participated in the interviews. One participant had been diagnosed with diabetes, 12 participants had family members with the disease, and 11 participants did not have diabetes and did not have family members with diabetes. The kiosk was used by 11 and not used by 13 of the persons interviewed. Observations were done by a graduate student using an observation checklist. The student observer recorded the participants' gender and time spent using the program. Eleven independent observations of persons using the kiosk were completed. Most of the eleven clients (73%) who reported using the program did so for at least 5 to 10 minutes. Of the participants that used the kiosk most reported it to be better than or equal to other forms of patient education material they had received in the past. The participants cited the multisensory nature of the kiosk and content to be the features that most attracted them to use it. None of the participants reported difficulty in using the kiosk even though only half of the participant group had a personal computer at home or at work. Participants that did not use the kiosk cited lack of availability or time as the reasons. Participants reported that the information derived from the kiosk was equal to or better than other forms of patient education material they had received previously. Some of the reasons given for preferring the kiosk included: (1) clear information, sound, and visuals, (2) preferred visuals to books, (3) information seemed more complete, (4) information was basic and easy to understand, (5) liked being able to control pace, and (6) ability to learn something new in a limited time. Using a t-test statistic, the investigators concluded that age, highest grade level completed, and gender had no impact on participants' ability to use the kiosk. Participants' primary criticisms included lack of ability to control the volume level without disrupting the waiting room environment and the limited availability of the program since only one person could use it at a time.

Lo, Lo, Wells, Chard, and Hathaway (1996) developed a computer assisted learning program that contained 16 lessons with each lesson dealing with one or two aspects of diabetes management. The instructional paradigm used by the program authors was an iterative cycle of exposition-and-testing. A lesson could be exited only after a test was passed for that lesson. The evaluation study conducted by the investigators involved people with diabetes that attended the diabetes clinic at the Lismore Base Hospital in Australia. Community health educators randomly assigned participants to either the CAI education program or a conventional diabetes education program. Seventy-two people were invited to participate in the study; forty people agreed but four did not complete the conventional education program and useable results were obtained for 36 people. All participants had received individual diabetes education when they were newly diagnosed with diabetes between two months and ten years prior to this study. The experimental group (CAI group) consisted of twenty people who completed the sixteen lessons in the computer-aided program. Of the sixteen participants in the experimental group, 8 had type 1 diabetes and 12 had type 2 diabetes. Health educators arranged individual lessons of one hour per week at times that were convenient to subjects and to a researcher who was present during all lessons. Subjects were able to operate the computer after an average of seven minutes instruction and all were proficient at the end of the first session. They were told they could take as many sessions as they needed to complete the lessons; most subjects took four sessions but some took three, five, and six sessions. The control group (non-CAI group) consisted of sixteen people who attended conventional diabetes education sessions as one group; all had type 2 diabetes. Four sessions of between two and a half to three hours each were conducted weekly by diabetes educators and dietitians who used audio-visual aids and printed materials to reinforce learning. Subjects were given written, multiple choice tests before and three months after they completed the diabetes education. Pre- and post-education equivalent form tests were constructed by the researchers and compared to the DKN diabetes knowledge scale to ensure that no essential knowledge element was omitted. The test forms were reviewed by diabetes educators and trial tested by people with diabetes who were not participating in the trial. The effectiveness of education on diabetes control was measured by differences in glycosylated hemoglobin taken before and 3 months after lessons were completed. Post-education scores were found to be significantly higher than pre-education test scores for all three groups (CAI-type 1, CAI-type 2, non-CAI) using a two-tailed t value. There was no significant difference between knowledge increases of the whole CAI group and the non-CAI group. Both CAI groups showed a significant decrease in their post-education glycosylated hemoglobin levels but there was a significant increase in the glycosylated hemoglobin levels of the non-CAI group. ANOVA analysis showed that differences in the glycosylated hemoglobin changes in the CAI-type 2 group and non-CAI group were significant. Further ANOVA calculations showed that the CAI-type 2 group's improvement in glycosylated hemoglobin levels was significantly related to CAI education and not to age. This effect also applied to the CAI-type 1 group. The investigators in this study concluded that CAI diabetes education and conventional education had similar learning outcomes. However, the participants in the CAI group showed significantly improved overall blood glucose control in contrast to the participants in the conventional education group. This would seem to indicate that conventional education, although it increased knowledge, failed to "stimulate the motivational factors that resulted in compliance" (p 26). This finding is consistent with other reports that knowledge alone is a poor predictor of successful patient adherence to the treatment regimen (Bartlett, 1993; Day, Rayman, Hall and Davies, 1997). The investigators postulated that the improved blood glucose control seen in the CAI group might be due to the ease of access to the CAI classes as far as time and location, the novelty of the CAI approach, and/or the personal attention that CAI participants received. The investigators felt, as a result of this research, that CAI programs could successfully be used as a supplement to programs conducted by diabetes educators but not as a sole source of information. They felt that the educator's role, with the assistance of CAI programs, could shift from providing routine education to devoting more time to motivational factors, social support, and health beliefs that would result in improved metabolic control.

Malik, Horwitz, and Smyth-Staruch (1987) developed a picture representation of energy metabolism in diabetes entitled 'The Energy Machine'. It was an animated, graphic, microcomputer-based educational unit written in Apple Basic. The text of the program was written at an approximate 5th grade reading level. The effectiveness and ease of use of the computer unit was evaluated in a pilot study of 29 subjects with type 1 diabetes. Subjects were recruited through an advertisement placed in the newsletter of the Cleveland Chapter of the Juvenile Diabetes Foundation. A test consisting of 13 true or false questions that were identical to those that appeared at the end of each step of the computer program and 8 multiple-choice questions were constructed to assess subjects' knowledge about diabetes energy metabolism before and after using the program. Matching test items were also included in the posttest. In addition subjects completed a 5-point satisfaction scale to obtain a subjective evaluation of the program. The measures were reviewed by educational experts for content validity and pre-tested for readability with a group of persons who did not have diabetes. The coefficient alpha of reliability for the pre-test was calculated to be 0.69. A paired t-test compared pre- and post-test scores to determine whether knowledge of diabetes energy metabolism had changed. The Energy Machine unit increased immediate short-term knowledge about diabetes energy metabolism based on change in pre- and post-test scores. However, since the pretest served as the control, familiarity with the test could have accounted for some of the increase in score. User satisfaction scores averaged 7.7 ± 3.5 (potential range was 5 to 25 with a lower score showing high satisfaction). A significant partial correlation was seen between outcome and self-reported grade point average. Learning gains were not significantly correlated to age, sex, duration of disease, education, previous computer experience, or the satisfaction score. The authors felt that the findings of this study supported their premise that the use of this animated graphic representation of diabetes energy metabolism would provide an effective conceptual basis for the management of diabetes mellitus.

Tomita, Takabayashi, Honda, Yamazaki, Suzuki, Satomura, Tomioka, Nishimoto, Nakano, Satoh, and Nojiri (1995) developed three CAI modules – two for diabetes and one for bronchial asthma. Their premise was that CAI not only provided medical information but also encouraged patients and provided motivation for self-management. DIACIN (DIAbetic Computer INstruction) was designed to teach patients how to use an insulin pump. YUMIS (Yahashira-University Medical Instruction System) was developed to teach patients how to use an insulin injector. ASTCAI (ASThma education system with Computer Assisted Instruction) had questions and answers that were divided into nine sections for learning and self-care techniques for bronchial asthma such as medication and the usage of a peak flow meter. Two of the programs – DIACIN and YUMIS – were informally validated. From the results of using YUMIS on over 20 patients the authors noted that learning time was decreased from 40 minutes for the previous method to 26 minutes for YUMIS. Results of a questionnaire completed by participants after using YUMIS indicated that the participants found the program interesting and easy to use. Only two of the participants required further instruction after using the program, which, the authors stated, was better than the previous method. One of the difficulties noted by the authors in using CAI was in the age group over 60. The DIACIN multiple choice quiz on diabetes showed that the age group over 60 years old scored lower than the younger group and required double the time to complete the program as compared to the younger group. The authors proposed that this was due to greater difficulty in manipulating the program and the comfort level with use of computers in this age group. The authors concluded that CAI reduced the nurse's workload and at the same time provided a more in-depth, accurate, and standardized knowledge. They felt that an advantage to CAI over traditional teaching was the active learning component. These programs were designed such that the user had to perform an action correctly before moving to the next step.

Wise, Dowlatshahi, Farrant, Fromson, and Meadows (1986) studied two programs that had recently been developed in their department to determine the effects on knowledge and metabolic control of diabetes by their use. Their goal was to use the "maximum potential of a computer in learning; i.e., to systematically provide information at a rate determined by the patient, to examine priority areas of knowledge, and to maintain patient interest and involvement by the extensive use of animated graphics and by emphasis on continuous interactive involvement with the learning process without an intermediate operator" (p 504). The CAI programs used for this study consisted of sequences of text and animated graphics dealing with general diabetes concepts, hypoglycemic drug action, glucose control, blood and urine monitoring, complications, diet, and foot care. Separate programs were done for type 1 and type 2 diabetes and required about 45 to 60 minutes to complete (however, the rate of progress was entirely under the control of the patient). Subjects for the study were taken from a 2 month population of patients that attended the diabetic clinic at Charing Cross Hospital and who had diabetes for $\geq$ 2 years. Approximately 25% of patients approached for inclusion in the study declined because of inconvenience or lack of time. A total of 174 type 1 and type 2 patients were included in the study. Patients were randomized to four groups by year and month of birth:

Group 1: Patients were unaware of the study and had evaluation of only hemoglobin A1C levels.

Group 2: Patients had 2 KAP (knowledge assessment program) assessments 4 to 6 months apart. They were provided only with a total score and no prescriptive feedback until after the study was completed. KAP consisted of a panel of multiple-choice questions (34 for the type 1 program and 21 for the type 2 program) that dealt with all the major topics covered by the CAI programs.

Group 3: Identical to group 2 except the patients were provided with both score and printed prescriptive feedback immediately after the first KAP assessment.

Group 4: Identical to group 2 except that the CAI program was used by the participants within one week of the first KAP assessment.

Reevaluation was carried out in participants in groups 2 through 4 four to six months after the initial assessment. In both patients with type 1 and type 2 diabetes an increase in knowledge was noted in the reevaluation phase in Groups 3 and 4 (Group 2 did not demonstrate a significant increase in knowledge). In patients with type 1 diabetes metabolic control as defined by change in hemoglobin A1C significantly improved in Groups 2, 3, and 4 but not in the control group (Group 1). In patients with type 2 diabetes metabolic control improved significantly in Groups 2 and 3 but not in Group 4. The authors concluded that a program that gives corrective feedback (KAP) resulted in knowledge increments that were significant. Significant improvement in metabolic control as defined by a drop in hemoglobin A1C was seen with KAP/feedback with this improvement being either on the same order or greater than the groups that used the CAI program. There was a low order of correlation between knowledge status and hemoglobin A1c which the authors believed suggested that only part of the benefit of CAI was likely mediated by knowledge increment. Enhanced motivation because of the use of a novel teaching approach and better awareness of critical objectives may be explanations for the demonstrated improvement in diabetes control.

Castaldini, Saltmarch, Luck, and Sucher (1998) developed and piloted a multimedia CD-ROM for diabetes education. The CAI program, 'Take Charge of Diabetes', was written at a 5^{th} grade reading level and developed to accommodate adults with newly diagnosed type 2 diabetes. The pilot study consisted of a program evaluation that was completed by health professionals and volunteers with type 2 diabetes. Ten clients and staff members from the Diabetes Society of Santa Clara Valley completed the self-study CAI program; seven had type 2 diabetes. Study participants duration of diabetes averaged 8 years. All had received some formal diabetes education in the past. Each participant completed the CAI program individually and then filled out an evaluation form. Participants were also asked to complete a questionnaire to self-evaluate their perception of knowledge gained in each module. All of the participants indicated that the program was fun and easy to use. 70% of the participants with type 2 diabetes reported a perceived increase in knowledge in at least one of the module areas. The participants' evaluation of the CAI program indicated that the format was acceptable, the audio useful, and the animated cartoons very desirable. Health professionals that participated in the pilot study determined the information in the CAI program to be accurate and up-to-date and felt that the program would be useful as an educational tool.

Day, Rayman, Hall and Davies (1997) developed a multi-media program for those with type 1 and type 2 diabetes. The program was tested, during development, on a large number of subjects (greater than 100) in the United Kingdom, Copenhagen, and Dublin. Feedback was used to modify screen design and adjust text. They found that the program was easily used even by subjects with little or no computer experience and by people of all ages. Systematic formal evaluation of the program was underway at the writing of this article but had not been completed. The authors of this CAI program felt that the combination of interaction and audio-visual capability made CAI a powerful medium for learning. In contrast to the old technologies of print, audio and linear video, a CAI approach to learning supported both the cognitive processes that constitute learning and the affective aspects of motivation and enjoyment that enabled the cognitive processes to be engaged. The authors stated that learning programs should:

- attempt to change the attitudes, beliefs and perceptions of the user in addition to providing up-to-date accurate information about the disorder.

- meet individual needs by allowing the user to make choices of the material to be studied.
- provide for active interaction between the learner and the material.
- provide information based on real patient experiences.
- provide a system that is easily used even by people without computer expertise.
- allow evaluation of how the program is being used.
- allow changes to be easily made to the program to match the needs of those of different socio-cultural backgrounds.

The authors adopted methods based on the philosophy of improving patients' self-efficacy through self-empowerment to allow users to make choices of material within the program that they wished to deal with and to find out facts, attitudes, and behaviors related to diabetes from those familiar with them (people with diabetes). Based on this latter principle 'Learning Diabetes' contained an extensive amount of video of patients using short clips (maximum 2 minutes) totaling 2.5 hours. All audio within the program was done by persons with diabetes to eliminate the professional voice. The authors had originally intended to do a number of voice-over sequences giving information. From their informal evaluations, in general, it was found that users did not find the voice-over sequences very useful. The text in the program utilized a reasonably large font and black text on a white background so as to be easily read. There was considerable use of graphics throughout the program. Activities were provided throughout the program in which the user participated with appropriate feedback given after choices were made. The authors concluded that, from the informal evaluation done, 'Learning Diabetes' fulfilled the learning objectives of a diabetes program, allowed for more interaction than other audio-visual material, was capable of being adjusted to meet different socio-cultural needs, and could be used as a framework for other chronic disease management programs.

Lehmann (1998) developed an interactive computer-based educational diabetes simulator that was offered as a freeware program on the World Wide Web in June 1996. The AIDA system contained a compartmental model that provided a description of typical glucose-insulin interactions in patients who completely lacked endogenous insulin secretion (those with type 1 diabetes). A knowledge-based system (KBS) was provided within AIDA to identify possible problems that could be simulated using the blood glucose data. The working hypothesis for this approach is that patient education may be enhanced through the use of such interactive software leading to an improvement in self-management and glycemic control.

Krishna, Balas, Spencer, Griffin, and Boren (1997) reviewed randomized clinical trials to evaluate the acceptability and usefulness of computerized patient education interventions. The Columbia Registry, MEDLINE, Health, BIOSIS, and CINAHL databases were searched with the following inclusion criteria used: (1) randomized controlled clinical trials, (2) educational patient-computer interaction, and (3) effect measured on the process or outcome of care. Twenty-two studies met the selection criteria. Of these, 13 (59%) used instructional programs for educational intervention, five (22.7%) tested information support networks, and four (18%) evaluated systems for health assessment and history-taking. The clinical areas covered by the studies included diabetes, asthma, AIDS/HIV, arthritis, Alzheimer's disease, stress management, hypertension, occupational rehabilitation, alcoholism, and general health management. Of the studies that used instructional programs for educational intervention, six provided patient education related to diabetes, two tested asthma education, with the remainder in the areas of hypertension, rheumatoid arthritis, urine specimen collection, medication-recall training, and alcoholism. Studies that provided diabetes education on how to monitor blood glucose levels and information on preventive care measures reported a 10 to 20 percent decrease in blood glucose levels. In one study 40 percent more subjects in the treatment group reported greater involvement in the management of their diabetes than in the control group even though no significant difference between groups in knowledge scores was noted. Two studies demonstrated increased knowledge after use of a CAI program in general diabetes management and nutritional management of diabetes. One study showed that use of a CAI program with corrective feedback resulted in higher knowledge scores than simple right or wrong feedback. In another study, patients that used a memory meter with computer capabilities spent 39% more time with their physicians, were more satisfied with care delivery, and had a more positive attitude toward monitoring their own blood glucose levels than did the control group. The two asthma studies that were reviewed evaluated the use of CAI in educating patients about allergen-avoidance activities. The studies showed that the participants that used the CAI program in addition to traditional education demonstrated greater compliance with asthma management strategies and improved knowledge than those that received only traditional education. In the hypertension, rheumatoid arthritis, and urine specimen collection studies, gains in knowledge were greater with the CAI program versus conventional education. In the rheumatoid arthritis study patients that used the CAI program reported improvement in care taken to protect joints, amount of rest, increased hopefulness of a good prognosis, and an increased belief in a chance to affect their health status. The only study that showed no greater information gain or improved outcomes was a CAI program designed to educate alcoholics on the medical effects of alcohol. The computer group did report a higher satisfaction with the program versus those that received videotaped instruction. The authors of this review of clinical trials utilizing CAI concluded that computerized educational interventions led to improved health status in several major areas but did not appear to be a substitute for face-to-face contact with an educator or physician but rather a supplement to this personal contact.

Kohlmeier, Althouse, Stritter, and Zeisel (2000) evaluated the use of computer-based instruction (CBI) by first-year medical students at the University of North Carolina at Chapel Hill to learn the nutritional principles of cancer prevention. 163 first-year medical students at the university's medical school used the nutrition and cancer program. Multiple-choice tests were administered to the students before and after using the program to determine knowledge change and attitudes regarding use of the computer-based program. The percentage of correct responses increased from 22% before using the program to 86% immediately after its use. A randomly selected subset of the original group took the same test 3 months later with 62% of the questions being answered correctly. Students' confidence in providing advice regarding nutrition's role in cancer prevention increased from 5.7% prior to use of the computer-based program to 66.9% after use of the program. However, not as many students felt that they were prepared to advise patients about nutrition therapy after using the program but the increase was still significant (35.1% compared with 5.2%; $P<0.01$). Most of the students rated the Nutrition and Cancer program as useful (79.7%). The authors concluded this CBI program was a useful and effective tool for teaching the nutritional principles of cancer prevention. They felt that a potential strength of CBI was its standardized presentation. By virtue of being standardized, instructional effectiveness could be tested with subsequent correction of detected weaknesses with resultant improvement in the quality of instruction. A control group was not included in this study to determine if there was a difference in knowledge gain and retention between CBI and traditional lecture format of the same information.

Advantages and Disadvantages of CAI

It is obvious from review of the literature that CAI is being widely used in health care education. Since the early 1960's, CAI has become an important tool in teaching and has many powerful instructional features. Despite the many benefits of CAI though there are some drawbacks. Knowledge of these advantages and disadvantages can assist in the decision making process as to whether to utilize CAI in a particular application and in the planning and implementation for use of CAI when the decision has been made that it would be an appropriate medium for teaching and learning.

Advantages of CAI.

CAI offers a variety of instructional strategies including tutorials, drill and practice, decision-making, and simulations (Hannah, Conley-Price, Fenty, McKiel, Soltes, Hogan, and Wiens, 1989; Billings, 1986). A review of over 15 published studies in diabetes patient education done by Bartlett (1986) revealed that the most effective programs incorporated a combination of educational methods rather than just teaching and instruction alone. CAI can also be used for testing. Post-tests at the end of individual lessons or a program can monitor an individual's progress. This information could then be used by the educator to reinforce any unclear concepts (Sinclair, 1985). Tests can also be used to give feedback on correct and incorrect responses. This prompt reinforcement of the correctness or incorrectness of responses has been termed the computer's "interactive pinball machine effect" (Sinclair, 1985).

"CAI's rich multi-sensory integration of text, sound, graphics, and video facilitates the learning process. Average people remember 10% of what they read, 20% of what they hear, 30% of what they see, and 50% of what they hear and see (Askov and Bixler, 1996, p 24). The ability of CAI to utilize multiple senses in the learning process results in greater retention of new knowledge.

CAI can offer individualized instruction (Billings, 1986; Hannah, 1989). Some CAI programs include a pre-test that will assess the user's strengths and weaknesses in a particular content area. This information can then direct the user to the areas of the program that need particular emphasis. Learning can also be individualized within each lesson. For example, tutorials can be designed so that learners can obtain as many examples as are needed to master the content. The computer program can include multiple pathways dependent on age, sex, or health history of the user (Sinclair, 1985). For example, a CAI for diabetes might ask the user if he/she has type 1 or type 2 diabetes and follow a different pathway based on the answer.

CAI can provide for varied instructional events (Billings, 1986). Instructional events are the strategies an instructor uses to facilitate learning, such as gaining the learner's attention, presenting instruction, and evaluating learning. According to Gagne, Wager, and Rojas (1981) the instructional events that CAI is most adept at delivering are giving feedback, improving memory, providing interaction and practice, and enhancing motivation.

Kim and Phillips (1991) found that complex corrective feedback resulted in higher knowledge scores than simple right or wrong feedback. One of the major advantages of CAI is the ability to give corrective feedback to the learner immediately (Peterson, 1996) and in a nonthreatening way. Feedback reinforces correct answers and can be used to "shape incorrect responses toward correct ones" (Billings, 1986, p 357).

Memory is the ability to recall that which has been learned or experienced when needed. CAI can improve memory through drill and practice or by using memory devices and diagrams that have been inserted during the screen design (Billings, 1986).

Learning is improved when the learner is actively engaged in the learning process. Interactivity, through response to questions or solving problems, and practice, which helps solidify learning, are key features of CAI that engage the learner in the learning process (Hannah, 1989; Billings, 1986). Most people learn faster when they have an opportunity to test their understanding of the content, make mistakes, and learn from those mistakes (Dennis, 1994).

Several motivational theories have been proposed to explain why adults participate in a learning process (Cross, 1981). Reasons cited for the motivating effects of CAI are fast pace, variety of instructional strategies utilized, visual interest, and suspense that can be aroused by instructional strategies such as simulations (Sinclair, 1985; Billings, 1986). Enhanced motivation because of novel teaching approach was one of the proposals made by Wise, Dowlatshahi, Farrant, Fromson, and Meadows (1986) as a possible explanation for the demonstrated improvement in diabetes control noted with the CAI and KAP programs used in their study.

Another argument in favor of CAI is constant and on demand availability (Dennis, 1994; Billings, 1986; Sinclair, 1985; Peterson, 1996). The computer can be made available at any time so that learners can use it when needs and time dictate. Use of Lehmann's CAI program, AIDA, which has been placed on the world wide web is limited only by access to the internet. With access to the internet, AIDA can be used at any time of the day and when the learner recognizes a need that the program can fulfill.

Another potential advantage of CAI is a reduction in teaching (Peterson, 1996; Vargo, 1991) and learning time. Dennis (1994) reported that organizations that use CAI have reported reductions in training time of 20 to 75 percent compared to instructor-led courses. Time can be maximized for the learner through learner control of pace of instruction, mastery tests, the ability to access only the training that is needed, and the ability to proceed to the next lesson. Tomita, Takabayashi, Honda, Yamazaki, Suzuki, Satomura, Tomioka, Nishimoto, Nakano, Satoh, and Nojiri (1995) noted that, from the results of using YUMIS on over 20 patients, learning time was decreased from 40 minutes for the previous method to 26 minutes for YUMIS. Kinney, Keskula, and Perry (1997) assessed the efficacy and efficiency of CAI for students learning evaluation and treatment skills for carpal tunnel syndrome (CTS). A t-test determined the CAI group completed the case assignment 30 minutes (24%) faster than the interactive group. There would also be a potential reduction in time spent in development and presentation of instruction because once the instruction was designed it could be used over and over again. This benefit would only be realized however if the material was static (did not often change requiring revision of program) and lent itself to a format (such as teaching repetitive content) that did not require an instructor. A time saving aspect for an organization would be the capability of CAI to automate record keeping and reporting. Dennis (1994) reported that many organizations have automated information systems that maintain a history of the training programs that employees have utilized. Education and training for employees in industry and for patients with many chronic diseases has been shown to be very important but does not come without significant cost to the organization and society in general. Training and education costs can be minimized if delivery systems and instructional methods are used that decrease training/learning time while maintaining instructional effectiveness.

CAI has been shown to be an effective medium for promoting knowledge gain in numerous studies (Wise, Dowlatshahi, Farrant, Fromson, and Meadows (1986); Malik, Horwitz, and Smyth-Staruch (1987); Lilienfield and Broering (1994); Rubin, Leventhal, Sadock, et al in 1986; Horan, Yarborough, Besigel, and Carlson (1990); Jacoby, Smith and Albanese (1984); and Feldman, Schoewald, and Kane (1989)). When compared to other teaching strategies, CAI produced at least as good as or better knowledge retention for most students. If knowledge gain is the primary outcome of instruction CAI is an effective method of delivery.

Another advantage of CAI is consistency of instruction (Hannah, 1989; Billings, 1986; Peterson, 1996). The standardized information offered by the computer program is more consistent, accurate, and thorough than that given by a variety of health care providers (Sinclair, 1985).

A CAI program that utilizes simulation gives the learner the opportunity to develop decision-making skills (Billings, 1986; Sinclair, 1985). A CAI simulation program gives the learner the ability to acquire skills in a safe environment. A widely utilized example is a simulation lab for driver's training. Student drivers have the ability to experience driving in a controlled situation in which they cannot hurt themselves or others if mistakes are made. Learning through simulations also has the advantage of a longer retention time (Dennis, 1994). Unfortunately, sophisticated simulations are rare (Sinclair, 1985).

Educational theory indicates that learning is increased when factual information is presented with examples (Hannah, 1989). An individual instructor has only a limited number of examples to draw upon. A computer program can draw from the experiences of several content experts with a resultant increase in the data base for the learner.

CAI is self-paced (Sinclair, 1985; Peterson, 1996). The learner can progress at his or her own pace without feeling rushed as can happen in a traditional classroom environment.

One final advantage of CAI is that the learning can take place in private (Hannah, 1989; Billings, 1986; Sinclair, 1985; Hauser and Chisholm, 1992). For many learners this would provide for decreased pressure from peers or instructors as the learner is free to make mistakes and learn from them without negative input from others.

Disadvantages of CAI

CAI is not appropriate for all instruction and does have some limitations. Disadvantages of CAI include expense, lack of courseware, emphasis on technology, changes in teacher and learner roles, low utilization rate, and accessibility.

CAI is expensive both to develop and to implement (Billings, 1986; Bartlett, 1993; Hannah, 1989; Sinclair, 1985; Peterson, 1996). Costs include the hardware, memory, software, courseware, and ongoing maintenance and repair. Development of courseware will result in additional expense. The amount of time required to develop effective software is substantial (Pelican, 1987). Billings (1986) estimated time for development at 50 to 700 hours to create 1 hour of a CAI lesson. Vargo (1991) found that it took 20 hours to write one 20-minute CAI lesson and stated that the author must be familiar with writing educational lessons as well as computer assisted program lesson formats and principles. The use of instructional video such as was used in the program 'Learning Diabetes' (Day, Rayman, Hall, and Davies, 1997) costs from $2000 to $5000 per linear minute (Chen, 1990). Software developers not only need to be knowledgeable about their subject, they also need to be creative in their approach (Pelican, 1987). Expertise in the form of a computer programmer or CAI author experienced in using an authoring program is required in addition to a content expert and instructional developer to develop a successful CAI program. The hardware that will most enhance the learning experience in terms of color, graphics, high resolution, and ease of use is also the most costly (Pelican, 1987).

The most significant disadvantage of CAI is lack of appropriate software (Hannah et al, 1989; Billings, 1986; Sinclair, 1985; Peterson, 1996). In searching for an already developed CAI program on some aspect of diabetes self-management for this thesis study it was discovered that there is either a lack of program availability or an unwillingness on the part of authors of such programs to allow use outside of their educational setting. Three programs were made available and the authors' willingness to share their programs was greatly appreciated. Unfortunately, an excellent program from Great Britain was culturally sensitive to the extent that, without revisions, it could not be used in the United States. Another program was directed toward type 2 diabetes and the population for this study involved type 1 diabetes. The third program, although very well done in terms of graphics, included a method of teaching meal planning that was different enough from the approach taken at the Diabetes Center that it could not be used. As can be determined from the literature review, other programs have been developed in the past. It is unclear whether these programs are no longer available because they have not been updated to keep pace with changes in diabetes management or the authors feel the programs are not universal enough to make them available to other diabetes educators.

CAI is viewed by many to be an impersonal approach to teaching and learning. Too much CAI may prove dehumanizing to some learners because the computer lacks empathy and compassion (Sinclair, 1985). Day, Rayman, Hall, and Davies (1997) found that in preliminary evaluations of the program 'Learning Diabetes' that video sequences of people with diabetes describing their experiences was an essential part of the program. Perhaps the video proved essential because it provided the human component of empathy and compassion lacking in most CAI programs. Some learners prefer a setting in which spontaneous dialogue occurs among participants in a class setting and in which the instructor can be asked questions (of course this is not to say that this necessarily occurs in the traditional classroom setting either). Some learners need the structure of a scheduled class time to prevent procrastination which can be a problem when computer session times are selected by the learner.

Use of CAI can change the role of the instructor. The instructor becomes a manager of instruction or an instruction developer instead of a teacher or facilitator. This may create resistance in instructors accustomed to the traditional one teacher/one classroom learning environment (Chen, 1990; Billings, 1986).

Characteristics of the learner may determine whether CAI is an effective learning medium. Not all learners obtain the same benefit from using CAI. For example, Tomita, Takabayashi, Honda, Yamazaki, Suzuki, Satomura, Tomioka, Nishimoto, Nakano, Satoh, and Nojiri (1995) noted that one of the difficulties in using CAI was in the age group over 60. The DIACIN multiple choice quiz on diabetes showed that the age group over 60 years old scored lower than the younger group and required double the time to complete the program as compared to the younger group. The authors proposed that this was due to greater difficulty in manipulating the program and the comfort level with use of computers in this age group. Learners are accustomed to teaching-learning methods of lecture, discussion, and textbooks but may lack computer literacy skills to the point of needing a computer orientation class before CAI can be used. Fear of the computer will reduce learning and is a very real experience for many learners (Peterson, 1996).

A previously stated advantage of CAI is that it is an effective medium for promoting knowledge gain. Awareness has increased however that knowledge, alone, seldom induces lasting behavior change (Bartlett, 1993). In diabetes self-management training, improved metabolic control is the intended outcome of instruction. It has been demonstrated in several studies that improved knowledge does not necessarily equate with improved metabolic control (i.e., Kopelman and Sanderson (1996) and Horan, Yarborough, Besigel, and Carlson (1990)).

Bartlett (1993) reported low utilization rates when ELFIN, a health education program, was installed in four British clinics. Over a one-year period, the patients at each clinic accessed the computer program about six times a day. This represented a very small percentage of the total number of patients seen at each clinic.

Another previously stated argument in favor of CAI is constant accessibility. This accessibility usually comes with a cost attached. In a clinic setting for example, dedicated space and hardware would have to be available. The question of reimbursement for this service would undoubtedly be an issue because of the cost of space, hardware, and software.

Some computer programs frustrate users by placing limitations on their choice of responses (Sinclair, 1985). A simulation program can potentially offer an unlimited number of options but would be limited by many factors not the least being the developer's ability to think of every option in a particular scenario.

Peterson (1996), Sinclair (1985), and Vargo (1991) all felt that a disadvantage to CAI was that only literate patients could benefit from programs. Even in a very simple educational game program developed for children, 'Marlon and Packy', reading ability was required to answer the pop-up questions that served as the educational component of the program (Brown, Lieberman, Germany, Fan, Wilson, and Pasta, 1997).

Characteristics of a Good CAI Program

Recognition of the advantages and disadvantages of CAI and the characteristics of CAI that make it a suitable medium for adult learners can aid in choosing and/or developing the best CAI software for a specific application.

Characteristics of effective computer-assisted instruction software include:

1. The product's content should be accurate, comprehensive, appropriate for the targeted audience, and free of stereotypes (Askov and Bixler, 1996).
2. The product should be designed for the adult learner including graphics and audio. Graphics should be simple but appealing enough to keep the learner's attention focused on the task (Bixler and Askov, 1994). Avoid 'cutesy' audios. Avoid products that were originally designed for children and later adapted for adults (Askov and Bixler, 1996). The product should be interactive as adults learn through active engagement (Bixler and Askov, 1994).
3. Title and summary screens should notify learners when they begin and end a section. Adults have a sense of accomplishment when material is organized into units or modules (Bixler and Askov, 1994).
4. The product should provide feedback to the learner. Correct answers or progress should be positively rewarded (Askov and Bixler, 1996; Chen,

1990). Even a 'good job' is better than no feedback but ideally the feedback should be corrective and explanatory in nature to ensure remediation. A good program will give feedback even for correct answers as the user may have guessed at the answer (Bixler and Askov, 1994). Anderson, Kulhavy and Andre (1971) conducted two experiments using a computer-based instructional system in which they looked at feedback procedures. Students that received knowledge of the correct response (KCR) after every frame performed better on a criterion test than students who received no KCR. Avoid products that belittle or insult the learner when an incorrect response is given. Avoid products that reward incorrect responses.

5. The product should be accompanied by print and electronic documentation that describe the product and how to use it. Products that include manuals for the instructor and students will allow learning to occur even away from the computer.
6. The product should allow the user to move about in it easily. If the user gets stuck a help system should be available that can guide the user through any difficult areas. The format should be nonlinear to allow the learner to choose various paths through a program based upon individual needs (Chen, 1990). The program should allow users to stop at any point in the program and re-enter where they stopped (Bixler and Askov, 1994).
7. All CAI should have the ability to track learner progress in a management system.

8. No product will ever meet everyone's needs and specifications. Therefore being able to modify the program is a real plus.
9. The vendor of the product should be available for support. Look for vendors with an 800 number and minimal wait time. Look for vendors that regularly update their products at no or minimal cost (no more than 30 percent of the purchase price) (Askov and Bixler, 1996). "Unlike wine, software does not age well!" (Askov and Bixler, 1996, p 25).
10. Perhaps, above all, the program should be easy to use (Skinner, Siegfried, Kegler, and Strecher, 1993). Many people are afraid of breaking the computer. Instructions need to be simple. A touchscreen, mouse, or joystick versus a keyboard may make the computer more 'friendly'.

<u>Issues in Utilization and Implementation of CAI</u>

Montague and Wulfeck (1983) argue that the potential for computer-based instruction to increase the quality of education and training depends directly on careful design and implementation. As stated earlier, expertise in the form of a computer programmer or CAI author experienced in using an authoring program is required in addition to a content expert and instructional developer to develop a successful CAI program. Unfortunately, CAI software development does not always include a person with a background in education. In fact, software is typically designed by computer programming experts or content experts and therefore may not include the required design elements that would make it most effective for the adult learner.

The use of CAI requires appropriate space and equipment and an ongoing commitment of staff (Mills and DeJoy, 1988; Bartlett, 1993). Hardware must be monitored including maintenance.

Computer-assisted instructional materials need to be continually evaluated and updated as information can change rapidly in many fields (Mills and DeJoy, 1988). In fact, in assessing whether to develop CAI materials, one must consider the time that it will take to develop the materials in contrast to the time in which the materials will be obsolete due to changing information.

Summary of Literature Analysis

Chapter 2 has presented selected literature that examined the effects of diabetes self-management training on diabetes outcomes and the effectiveness of CAI as an educational strategy to facilitate learning. To facilitate the presentation the chapter was arranged into eight sections. The first section provided a rationale for the allocation of resources to develop better educational strategies to help people optimally self-manage this disease. The staggering incidence of diabetes and economic cost to the nation was presented along with results of a long-term trial that found that intensive treatment would delay the onset and progression of a number of long-term complications related to diabetes.

The critical role of diabetes education in promoting optimal blood glucose control was presented in the second section. The literature reviewed reported beneficial effects of patient education programs that extended beyond knowledge gain to also include improved metabolic control and other outcomes. It was noted in one study however that glycemic control tended to wane after 3 months suggesting a need for additional intervention to maintain required behaviors that optimized positive outcomes.

The third and fourth sections established that CAI has multiple characteristics that make it a suitable medium for adult learners as evidenced by the application of these characteristics to the principles of adult learning espoused by Knowles, Knox, Manteuffel, and Lindeman. For example, the interactive nature of CAI simulations, drill and practice, and games meets the adult learning principle of the need for adult learners need to be actively involved in the learning activity.

The analysis of the literature on the use of CAI in health care in the fifth section established that CAI is as effective as and may be more efficient than traditional instruction as measured by cognitive, behavior, and learning theory outcomes. The majority of the studies reviewed demonstrated at least as good or improved knowledge or outcomes as a result of utilizing a CAI program compared to traditional instruction. Unfortunately, none of the studies were of long enough duration to demonstrate that knowledge or improved outcomes were maintained for an extended period of time. However, as Lehman points out (1997), patients cannot be expected to take in everything that they need to know about diabetes self-management in one clinic appointment. Education needs to be an on-going process, which must be repeated. Drawbacks to CAI cited in the literature included the substantial initial time investment in preparing CAI programs and the inability of the student to ask questions of the "instructor" as could be done in a lecture format. In the studies that evaluated subject satisfaction with CAI programs, the concensus was that the programs were well received and perceived by the subjects as being helpful and enjoyable. In the studies that were reviewed, CAI was either used as an adjunct to or in place of a traditional teaching/learning format. Evaluations of use of CAI as a teaching tool in conjunction with regular instruction was not found in the literature.

The sixth section reviewed the advantages and disadvantages of CAI. Advantages of CAI cited in the literature included the ability to provide a variety of instructional strategies; multi-sensory integration of text, sound, graphics, and video; potential for individualized instruction; ability to give feedback; ability to provide interaction and practice; provision of memory-enhancing strategies; enhanced motivation through visual interest and suspense; on-demand availability; potential for reduction in teaching time; consistency of instruction; opportunity to develop decision-making skills; ability to provide multiple examples; self-paced; and learning can take place in privacy. Disadvantages of CAI included expense, lack of courseware, emphasis on technology, changes in teacher and learner roles, low utilization rate, impersonal approach, and accessibility.

In the seventh section the characteristics of an effective CAI program were reviewed. Knowledge of these characteristics would assist in choosing and/or developing the best CAI software for a specific application.

Issues in implementation and utilization of CAI established that careful design and implementation are key in the ability of CAI to increase the quality of education and training.

The literature generally supported the premise that diabetes self-management training results in better patient knowledge and better metabolic control. However, results were conflicting when the relationship between patient knowledge and metabolic control were investigated. Also, most of the studies reported a gradual decline in whatever outcome was being measured over time. The literature supported the premise that CAI is at least as good as, and sometimes better than, traditional instruction when short-term knowledge retention was used as the outcome measurement. Although use of CAI as an instructional tool was not specifically addressed in the literature, one could postulate that when used as an instructional tool most of the advantages of CAI would be maintained and the majority of the disadvantages eliminated. When used as an instructional tool, the human component would be made available to the learner. Also, an instructor that was present both during and after computer use could answer questions and, in the case of health education, assist the person in developing a plan for dealing with the information provided by the computer program (Skinner, Siegfried, Kegler, and Strecher, 1993). In a study comparing classroom teaching and computer-aided independent learning of auscultation of the heart (Finley, Sharratt, Nanton, Chen, Roy and Paterson, 1998), the authors concluded that CAI was generally as effective as classroom teaching. The participants in the study rated both learning methods highly but felt that a combination should be used in future curricula since it would combine the benefits of independent study with human interaction and expert feedback. The traditional role of the instructor is maintained when CAI is used as an instructional tool. Learners are accustomed to teaching-learning methods of lecture, discussion, and textbooks but may lack computer literacy skills to the point of needing a computer orientation class before CAI can be used. Fear of the computer will reduce learning and is a very real experience for many learners. These disadvantages are resolved when CAI is used as an instructional tool because the instructor would guide the learner through the computer skills needed to use the program effectively.

The literature provides support for the use of knowledge as an outcome measurement. It was determined by the investigator that the only measurable outcomes that would have been appropriate for the particular subject matter (sick day management) used for this study were knowledge retention and visits to the clinic, ER, or admission to the hospital for rehydration or DKA. Knowledge retention was chosen and visits to the clinic, ER, or admission to the hospital for rehydration or DKA rejected for two reasons: (1) retention of knowledge is important for this particular aspect of diabetes management since the time frame between learning the information and applying that knowledge could be as short as 2 weeks or as long as 1 year (and, in some cases, longer), and (2) using admission to the hospital or a visit to the clinic or ER for rehydration or DKA would have necessitated lengthening the data collection period. Although this would be valuable data to gather since it directly impacts cost of the disease to the person and society, the time frame needed for data collection was not within the scope of this study. Padgett, Mumford, Hynes, and Carter (1988), in their meta-analysis of 93 controlled studies, found that only 3 of the 24 studies that used knowledge as an outcome used it as the only measure of effect. In this meta-analysis enhanced patient education (the CAI program used in this study fits the authors definition of enhanced patient education) yielded a higher effect size and one that was statistically significant compared to didactic education for knowledge outcomes. The authors felt that knowledge outcomes should be viewed as being the least relevant to the goals of most of the interventions used in the studies because of the questionable relationship between knowledge gain and behavioral changes. However, enhanced patient education also showed statistically significant effects for compliance and physical (metabolic control) outcomes. Lo, Lo, Wells, Chard, and Hathaway (1996) concluded from their study that CAI diabetes education and conventional education had similar learning outcomes. However, the participants in the CAI group showed significantly improved overall blood glucose control in contrast to participants in the conventional education group. This could imply that using knowledge as the sole outcome for this study may skew the results – knowledge retention could be the same but behavior during an acute episode of illness could still differ.

The time frame used in this study is supported by the literature. Studies reviewed used follow-up testing for retention of knowledge from 1.5 months (Littlefield and Broering, 1994) to 3 months (Kohlmeier, Althouse, Stritter, and Zeisel, 2000; Lo, Lo, Chard, and Hathaway, 1996) to 12 months (Padgett, Mumford, Hynes, and Carter, 1988) post initial intervention. The second post-test was administered 4 months after initial instruction in this study. Since an illness may not occur for as long as 1 year after initial instruction on sick day management, a third post-test could be administered at 1 year to determine retention over this time frame. A 1-year post-test was not included in this study as it would have lengthened the data collection period to about 20 months.

The CAI program developed for use in this study provided corrective feedback. At least one study supported corrective feedback as an aid in retention of information. Wise, Dowlatshahi, Farrant, Fromson, and Meadows (1986) concluded that a CAI program that gave corrective feedback resulted in knowledge increments that were significant.

Although legitimate barriers still exist in use and implementation of CAI, with careful choice or development of software and appropriate arrangements for space, staffing, etc., interactive CAI can be a valuable tool in meeting adult learning needs.

Chapter 3

Methods and Procedures

Chapter 3 presents the methods and procedures of the study. The chapter is divided into six sections: Description of the Null-Hypothesis, Description of the Subjects, Description of the Research Instrumentation, Description of the Procedures, Design of the Study, and Treatment of the Data.

Null-Hypothesis

NH1.0) There is not a difference in scores of knowledge retention regarding sick day management on a 20-item test between persons receiving regular instruction only and persons receiving regular instruction plus CAI.

Study Design

A pretest/posttest control group experimental design was used. At the time a child and his/her parents entered the program or an adult patient with type 1 diabetes, he/she/they were randomly assigned as a group (if there were two parents) to either the control (regular instruction only) or experimental group (regular instruction plus CAI). If a child entered the program with two parents, the parent that would accompany the child to follow-up visits was used as the subject. Subjects were randomly assigned to either the control group (regular instruction) or the experimental group (CAI and regular instruction) by flip of a coin (heads: control / tails: experimental). Since the subjects were randomly assigned, sex, age, educational level, and socioeconomic level were eliminated as variables that might bias the outcome.

Time to complete the instruction was also controlled by virtue of the time allotted for this visit (1 hour visit was booked in the instructor's schedule). An equivalent length of time was taken to complete the instruction with subjects in the control and experimental groups.

Instruction for both the experimental and control group subjects was provided by the investigator to eliminate the possibility of content difference in using multiple instructors. In contrast to most of the studies reviewed in the literature that utilized CAI, CAI was combined with traditional instruction in that the study investigator used this as a teaching tool versus the program being used in a self-study format.

The instructional environment and testing conditions were equivalent for each group.

Recruitment for the study continued until each group contained at least 15 subjects. Although this was not a large number of subjects, it represented approximately half of the new diagnoses of type 1 diabetes at the study site in a year.

Description of the Subjects

The subjects for this study were 33 parents of children ages 0 to 18 newly diagnosed with type 1 diabetes and adult patients newly diagnosed with type 1 diabetes referred to the outpatient type 1 program at one particular diabetes center during the period of July 2000 to December 2000. The investigator limited the subjects to parents of children newly diagnosed with diabetes and adults newly diagnosed with diabetes because it was felt that a bigger difference would be noted between pre- and post-test scores if the subjects were naïve to education regarding sick day management. The population was multicultural with diverse socio-economic status and educational levels from eastern Oklahoma and parts of Arkansas and Kansas. Traditionally, at this particular diabetes center, pediatric endocrinologists receive approximately 60 referrals for children newly-diagnosed with diabetes each year. Since only 10 percent of all diagnoses of diabetes are type 1 and that the incidence of a new diagnosis of type 1 diabetes decreases with age, the number of adult patients newly diagnosed with diabetes represented a small percentage of the sample. The sample was selected from the parents of the population of children and adults newly diagnosed with diabetes. Age of the child diagnosed with diabetes did not have an impact on the study results because of the particular topic used in the CAI program. Even in an older child, sick day management is one of the few areas of diabetes management in which the person primarily responsible is the parent. Although the older child would be involved in this aspect of care, the parent is at least equally or more responsible for diabetes management on sick days.

Description of the Research Instrumentation

The questionnaire used in the study consisted of a 20-question assessment of knowledge regarding sick-day management.

The Sick Day Assessment questionnaire, developed by the investigator, consisted of 20 multiple-choice questions. Each multiple-choice question had 5 potential choices. Item validity and sampling validity of the instrument was determined by expert judgment (two pediatric endocrinologists and two pediatric diabetes nurse educators reviewed the CAI program and assessment of knowledge instrument to assure that test items represented measurement in the intended content area and that the instrument sampled the total content area). A split-half reliability was determined to assure internal consistency. A Pearson r correlation coefficient of .95 was obtained for the split half reliability. The Spearman-Brown formula was applied to estimate the reliablity of the 20-item test. The split-half estimate of .95 was corrected to an estimate of .974. This indicated an acceptable degree of reliability.

A pilot test of the Sick Day Assessment of Knowledge was performed prior to use in the study to assure that the instrument was sensitive to instruction. A pre-test was administered to 10 parents of children with type 1 diabetes prior to instruction on sick day management in a didactic format. After instruction on sick day management, an identical post-test was administered to the parents. A paired samples t-test was performed that showed a difference between pre- and post-test scores but the difference did not reach a level of significance ($p \leq .05$) because of the small sample number. However, because of the small sample number and a significance level that was less than 1.0 ($p = .089$), the Sick Day Assessment of Knowledge was accepted as being sensitive to instruction.

Description of the Procedures

A CAI program for sick-day management was developed by the investigator with the assistance of other healthcare professionals and computer software experts with both simulation and tutorial design elements. The authoring program, Quest, was used to design the program. The Sick Day Management CAI program was developed after an exhaustive search of the existing literature on management of diabetes during illness and qualities of an effective CAI program.

Before development of the CAI program began, the pediatric endocrinologists and diabetes nurse educators in the diabetes center from which the study subjects were recruited reviewed an outline on diabetes management during illness done by the investigator to assure that the content was accepted practice within that particular clinic.

Askov and Bixler (1994, 1996) felt that a CAI program should include graphics and audio, should be interactive, and provide feedback to the user. The

Sick Day Management CAI program utilized numerous graphics and clips of video with a voice over narration. The program was interactive in that, at the end of each section, a series of questions were asked which the user responded to by choosing one of several options. If the option chosen was correct, a screen popped up with a positive affirmation and explanation. If the option chosen was incorrect, the user was instructed to try again. Also, the last section of the program was a case scenario that simulated a typical sick day. The same type of questioning with feedback was used in the simulation. Anderson, Kulhavy and Andre (1971) conducted two experiments using a computer-based instructional system in which they looked at feedback procedures. Users that did not receive knowledge of the correct response did poorer on a criterion test than students that received knowledge of the correct response.

Bixler and Askov (1994, 1996) felt that it should be clear when each section of the program started and ended. The Sick Day Management CAI program was organized into 4 sections with each section having a clear start- and stop point.

Bixler and Askov (1994, 1996) stated in their articles that the program should allow users to stop at any point in the program and re-enter where they stopped. The Sick Day Management CAI program allowed users to re-enter the program at the beginning of each section. This allowed the program to be used as a review as well as for initial instruction as the user could skip to simulation if desired. Chen (1990) felt that this ability of the program to allow the learner to choose various paths based on individual needs was an important consideration.

Skinner, Siegfried, Kegler, and Strecher (1993) felt that above all the program should be easy to use. The Sick Day Management CAI program utilized a mouse to move through the screens and answer questions within the program, which made the program more 'user friendly'.

The authoring program, Quest, allowed the program to run in a Windows environment. The Quest program did not need to be loaded onto the PC that was used in the study. However, changes could not be made to the program without the use of Quest.

Once the CAI program was developed it was reviewed by one pediatric endocrinologist and one nurse educator for accuracy and completeness of sick day information and acceptability in terms of ease of use.

A written pamphlet on sick day management to match the content of the CAI program was developed by the study investigator with input from the diabetes educators and pediatric endocrinologists at the diabetes center from which the study participants were recruited.

The subjects in the experimental group received instruction via a CAI Sick Day Management program and a printed pamphlet on sick day management. The investigator was present during use of the program to read the screens and answer questions prompted by the information and visuals on the screens. A desk-top computer with a 21 inch screen and other appropriate capabilities to run the program was used in delivery of the instruction. There were feedback opportunities throughout the program via small tests at the end of the first three sections and a simulation in the fourth section.

Subjects in the control group received instruction in a didactic format with the same printed sick day pamphlet provided as to the subjects in the experimental group. Audio-visual enhancement of any type (i.e, Powerpoint presentation, videotape, etc.) was not utilized with the control group subjects.

Thirty-three parents of children newly diagnosed with diabetes and adult patients newly diagnosed with type 1 diabetes who entered the diabetes center's outpatient program for type 1 diabetes from June 2000 to December 2000 participated in the study. The Type 1 Outpatient Program consisted of an initial two day educational session with 10 hours of direct contact with the nurse and nutrition educator, a 3 hour session one week after diagnosis with 2 hours of contact with the nurse and nutrition educators, a half hour session with a nutrition educator five weeks after diagnosis, and a 1 hour session with a nurse and nutrition educator 4 months after diagnosis.

Subjects in the control and experimental groups completed 3 Sick Day Assessments - one week prior to instruction, immediately after instruction, and 4 months after instruction. Each of the Assessments was identical.

On Day 1 of the program, a pre-test on sick day management knowledge was administered to all parents/caretakers, age-appropriate children, and adult patients with type 1 diabetes participating in the program. Only the score of the parent(s) that would regularly accompany the child to follow-up visits was used in the study.

A post-test was administered at the end of the Week 1 follow-up visit of the program to all parents/caretakers, age-appropriate children, and adults newly diagnosed with type 1 diabetes who received the Instruction. Only the score of the parent(s) that would regularly accompany the child to follow-up visits was used in the study.

A post-test identical to the one administered at the end of the Week 1 follow-up was administered to all parents/caretakers, age-appropriate children, and adults newly diagnosed with type 1 diabetes that received instruction on sick-day management at the 4 month visit. A 4-month time frame post instruction was chosen to evaluate retention of knowledge regarding sick day management. because it was the last established visit of what was termed initial education for all children and adults with type 1 diabetes. Education consultations after that visit did not occur on a consistent time basis. Therefore, for retention purposes, a 4-month time frame was chosen.

Only the scores of the parents and adult patients that had been present for the initial, 1 week, and 4 month sessions were used in the study.

Treatment of the Data

The independent variable used in the study was whether the subject in the study received regular instruction only or regular instruction plus CAI to learn sick-day management of diabetes. The dependent variable was change in pre- and post-test scores among and between groups on the knowledge assessment.

The investigator compiled the data utilizing a spread sheet format. The actual paper assessments were maintained in the confidential patient record.

A split-plot analysis of variance (SPANOVA) was selected to assess differences between groups and within groups in knowledge of sick day management over time.

Time Schedule

Development of CAI program: August 1999 to June 2000

Selection of subjects, pre-testing, treatment, post-testing: June 2000 to February 2001

Data analysis: February 2001 to August 2001

Report preparation: September 2001 to October 2001

Chapter 4

Statistical Results

As was stated in Chapter 1, the purpose of the study was to determine the effectiveness of a CAI simulation program in contrast to traditional instruction in improving the long-term retention of knowledge of persons with diabetes and their caretakers regarding the management of sick days. Sick day management was chosen because of the typically extended length of time between learning about management of diabetes on a sick day and applying that knowledge. The study sought to investigate whether knowledge retention of diabetes sick day management as measured by a 20-item test would be more enduring when CAI was used as a component of the educational process.

To review, the study used 33 parents of children newly diagnosed with diabetes or adults newly diagnosed with diabetes at a diabetes center in eastern Oklahoma. The diabetes center from which the study participants were recruited was the only clinic serving children and adolescents with diabetes in eastern Oklahoma. Data collection covered the period of time between June 2000 and February 2001. Parents of every child with type 1 diabetes that was newly diagnosed and every adult newly diagnosed with type 1 diabetes at the Warren Clinic Diabetes Center from June 2000 to December 2000 were included in the sample.

The study investigator developed the instrument used to assess knowledge. A paired samples t-test was performed that showed a difference between mean scores on the pre- and post-tests in the expected direction but that did not reach a level of significance of $p \leq .05$ because of the small sample number. However, the significance level was less than 1.0 and in light of the small sample it was determined that the difference did not represent a chance occurrence. Therefore, a conclusion can be reached that the difference in scores from pre-test to post-test occurred as a result of instruction and not by chance. Results of the t-test can be found in table 1.

Table I – Results of Pilot Test on Sick Day Management Assessment of Knowledge Instrument

	Mean	N	Standard Deviation	Standard Error Mean	Correlation between pretot and posttot	Significance
Pretot	12.6000	10	1.8974	.6000	.564	.089
Posttot	18.9000	10	1.1005	.3480		

Following are the results of the analysis of the knowledge assessments that were administered prior to instruction, immediately after instruction, and 4 months after instruction. The null hypothesis stated that there is no difference ($p <.05$) in scores of knowledge retention regarding sick day management on a 20-item test between persons receiving regular instruction only and persons receiving regular instruction plus CAI. A split-plot analysis of variance (SPANOVA) was used to analyze the data. This study utilized a mixed design – pretest-immediate posttest-4 month posttest, true experimental design. Subjects were randomly assigned to the control or experimental group by the flip of a coin (heads - experimental and tails - control); this was the between subjects part of the design. Subjects received a pretest and then a posttest immediately after the instruction and the same posttest 4 months after the instruction. These repeated measurements (time of measurement) on all subjects constituted the within-subjects part of the design. The summary of the pretest (prescore), immediate posttest (posscore), and 4 month posttest (folscore) scores for the sick day knowledge assessment are found in Table 2. Table 3 summarizes the results of this data when subjected to a split-plot analysis of variance.

Table II – Mean Scores on Repeated Measurements of Sick Day Management Knowledge Assessment Instrument

	Group	Mean	Standard Deviation	N
Prescore	treatment	7.444	4.1899	18
	control	8.0667	2.6040	15
	Total	7.7273	3.5205	33
Posscore	treatment	17.3333	2.8901	18
	control	15.3333	2.4976	15
	Total	16.4242	2.8617	33
Folscore	treatment	14.9444	2.9798	18
	control	12.4667	3.1366	15
	Total	13.8182	3.2544	33

Table III – Significance of Difference in Total Means Over Time

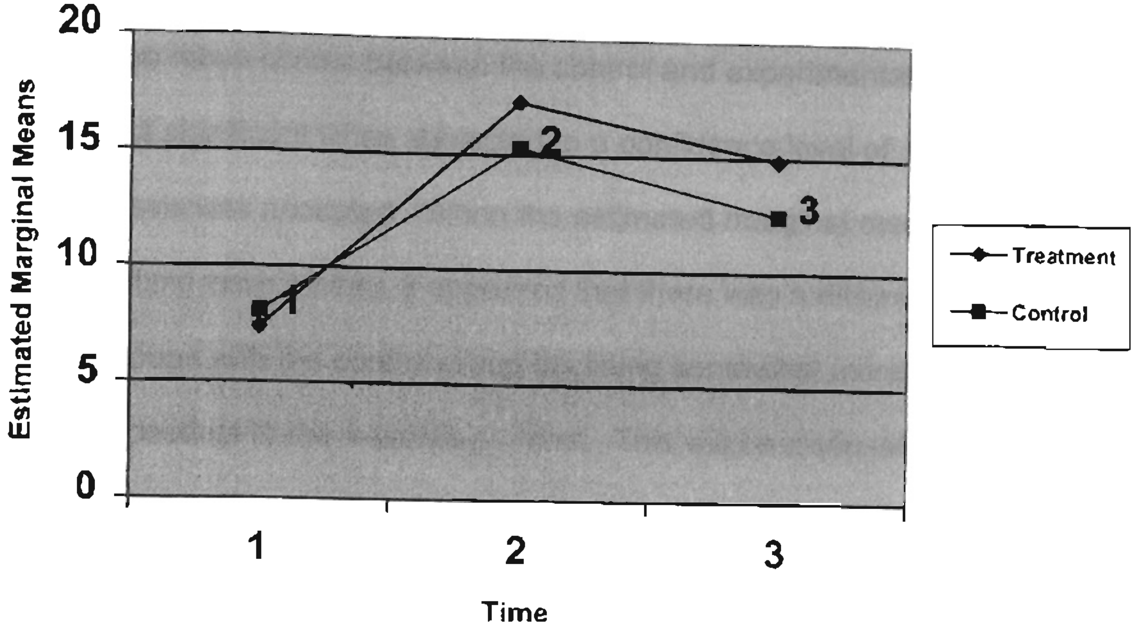
Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Time	Sphericity Assumed	1264.211	2	632.105	78.653	.000
	Greenhuse-Geisser	1264.211	1.999	632.469	78.653	.000
	Huynh-Feldt	1264.211	2.000	632.105	78.653	.000
	Lower-bound	1264.211	1.000	1264.211	78.653	.000

Table IV – Significance in Difference Between Means of Control and Experimental Groups Over Time

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Time * Group	Sphericity Assumed	45.585	2	22.792	2.836	.066
	Greenhuse-Geisser	45.585	1.999	22.805	2.836	.066
	Huynh-Feldt	45.585	2.000	22.792	2.836	.066
	Lower-bound	45.585	1.000	45.585	2.836	.102

The difference in the means of the scores on the pre-test, immediate post-test, and 4 month post-test for the control and experimental groups reached a level of significance ($p \leq .05$) (refer to Table 3). This demonstrated an improvement in knowledge from that prior to instruction to that after instruction that was maintained over time. This effect is gratifying but expected. The more interesting question is whether there was a difference in knowledge retention between the control and experimental groups over time. The difference in knowledge retention over time by group (Source – Time * Group in Table 4) did not reach a level of significance ($p \leq .05$) therefore the null hypothesis (NH 1.0: There is not a difference in scores of knowledge retention regarding sick day management on a 20-item test between persons receiving regular instruction only and persons receiving regular instruction plus CAI) cannot be rejected.

Figure 1 – Pre-test, Immediate Post-test, and 4-month Post-test Mean Scores of Participants on the Sick Day Assessment of Knowledge



When the estimated marginal means were plotted against time, it appeared that there was a more significant drop in the mean of the control versus the experimental group from immediate posttest (time 2 on the horizontal axis) to the 4-month posttest (time 3 on the horizontal axis).

Summary of Statistical Results

Chapter 4 presented an analysis of data to determine if there was a difference in knowledge retention regarding sick day management when two different methods of teaching were used: regular instruction versus regular instruction plus use of a CAI program. The data was analyzed by split-plot analysis of variance (SPANOVA) and the level of confidence was set at .05.

The analysis indicated a significant difference between the means of scores on the sick day management assessment of knowledge over time. The difference on mean scores between the control and experimental groups over time was not significant when subjected to a confidence level of .05 therefore the null hypothesis was accepted. When the estimated marginal means of each group over time were plotted, it appeared that there was a difference in the slope between groups with the control group declining somewhat more from the immediate posttest to the 4-month posttest. This will be discussed further in chapter 5.

Chapter 5

Review, Discussion and Implications

The purpose of this study was to determine the effectiveness of a CAI simulation program in contrast to traditional instruction in improving the long-term retention of knowledge of persons with diabetes and their caretakers regarding the management of sick days. It was hypothesized that there would not be a difference in scores of knowledge retention regarding sick day management on a 20-item test between persons receiving regular instruction only and persons receiving regular instruction plus CAI.

Two research questions were posed relative to the purpose of the study:

1. Is diabetes self-management training effective in improving knowledge of diabetes management?
2. Is CAI superior to traditional teaching/learning methods on retention of knowledge?

Discussion and Implications

The null hypothesis was accepted because there was not a significant difference found on immediate- and 4-month post-test scores of knowledge regarding sick day management between regular instruction and regular instruction plus CAI. Review of the literature supported the findings of this study that CAI was not superior to traditional teaching methods when knowledge retention was used as the outcome measurement.

Jelovsek and Adebonojo (1993) concluded, based on their review of all reports of randomized clinical trials on CAI in health care published in English between January 1966 and June 1922, that CAI was a legitimate method of instruction equal to other usual types of teaching in terms of learning. Jacoby, Smith, and Albanese (1984) found that CAI was as effective as lectures according to measures of short-term knowledge gain in learning CT scanning and factual information regarding child abuse. Horan, Yarborough, Besigel, and Carlson (1990) did not find a significant difference on scores of diabetes factual information or applied skills in subjects taught by CAI versus traditional instruction. Finley, Sharratt, Nanton, Chen, Roy and Paterson (1998) found that classroom students scored higher on open questions regarding auscultation of the heart than the CD-ROM-taught group, but in general performance by both groups was satisfactory and equivalent. Kinney, Keskula, and Perry (1997) did not find a difference in pretest/posttest scores between CAI and interactive lecture in teaching students treatment skills for carpal tunnel syndrome. Lo, Lo, Wells, Chard, and Hathaway (1996) did not find a significant difference between knowledge increases regarding various aspects of diabetes management in a CAI group and non-CAI group.

Only one study reported a poorer outcome with CAI versus a traditional teaching method. In a study conducted by Garrett, Ashford, and Savage (1987), tutorials outperformed CAI in hematology and oncology teaching.

Several disadvantages to use of CAI were noted in the literature. Results were mixed in the literature as to whether CAI represented a time savings in learning new material. One study found that people over the age of 60 scored lower than the younger group and required additional time to complete the CAI program in relation to a traditional learning method. In a study conducted by Garrett, Ashford, and Savage (1987) the control group that used tutorials to study hematology and oncology outperformed the CAI group but the CAI took less time.

Another disadvantage to CAI noted in the literature was lack of personal interaction. Of note was that all of the studies reviewed used CAI alone versus in combination with conventional teaching methods. In two studies students rated both traditional and CAI learning methods highly but felt that a combination would be an optimal approach to the learning process. It was noted in another study that the absence of personal interaction represented one of the major disadvantages in the use of CAI. Although this study did not address the difference between utilizing CAI as a stand-alone educational intervention versus in conjunction with a traditional teaching format, the literature provided support for the format chosen for this study. Krishna, Balas, Spencer, Griffin, and Boren (1997) concluded from their review of clinical trials that utilized CAI that computerized educational interventions were not a substitute for face-to-face contact with an educator but rather a supplement. Jacoby, Smith, and Albanese (1984) cited an inability of students to ask questions of the 'instructor' to be a drawback to CAI after their experience with a study involving the use of 2 CAI programs. Subjects in a study that compared classroom teaching and computer-aided independent learning of auscultation of the heart conducted by Finley, Sharratt, Nanton, Chen, Roy and Paterson (1998) felt that a combination of both learning methods should be used in future curricula.

Other disadvantages noted included cost, time to develop programs, and accessibility. An attempt was made to find an existing CAI program to use in the study. Few CAI programs dealing with diabetes management knowledge and skills were available. Three programs were obtained but were not used because of the regional and cultural differences in management of diabetes. One of the CAI programs was developed in England. It was a thorough and detailed diabetes self-management program that was appropriate for use in England but not the United States. For example, different insulin preparations, blood glucose meters, and foods are used in England versus the United States. The other two programs were developed in the United States but the information was enough different from practice in the diabetes center that the subjects were recruited from to deem them not useful. Therefore, a CAI program on sick day management was developed by the investigator. This process, partially because it involved coordinating several persons' schedules and was the first such undertaking, took one year to complete. Although it would likely not take as long to develop diabetes self-management training modules in the future, development of the CAI program proved time intensive and may explain the lack of existing CAI programs for diabetes self-management training currently available. The cost would be prohibitive to develop CAI programs for a single diabetes self-management training program because of the development time.

This study does support a conclusion that diabetes self-management training is effective in improving knowledge regarding sick day management. There was a significant difference ($p \leq .05$) in the mean scores on the Sick Day Assessment of Knowledge Instrument over time in a positive direction. This demonstrated an improvement in knowledge from prior to instruction to after instruction that was maintained in both groups. This result is supported by the literature. A meta-analysis by S.A. Brown in 1990 showed that diabetes self-management training had a moderate to large effect size on patient knowledge. A study conducted by Franz, Monk, Barry, McClain, Weaver, Cooper, Upham, Bergenstal, and Mazze in 1995 to examine the effectiveness of medical nutrition therapy in the management of diabetes showed, both in the basic care and practice guidelines groups, an improvement in medical and clinical outcomes. However, glycemic control showed improvement to 3 months but then began an upward trend. A similar trend was seen in this study in that there was a decline in the mean knowledge scores from immediate post-test to 4-month post-test.

The question of whether CAI supported the premises of adult learning theory was not "measured" as part of this study. However, after the 4 month post-test, subjects in the experimental group expressed to the investigator a greater confidence in their ability to manage a sick day in the future than subjects in the control group. The review of literature provided ample data to support that CAI is consistent with adult learning theory. Data from a NCES survey on learning methods showed that methods that required active participation were most often preferred and used by adult learners. Several experts in adult education theory felt that satisfaction in education programs was dependent on the use of instructional strategies that included use of questions and examples, provision of practice opportunities, appropriate pacing, use of reinforcement, and provision of useful feedback. One study found that corrective feedback resulted in higher knowledge scores versus correction without feedback. From review of the literature it was noted that CAI utilized (or could utilize) all of these strategies. Simulation programs were proposed as having particular application to diabetes self-management training. Simulations allowed the learner to make mistakes, experiment, and interact with the program with little risk.

Although the null hypothesis must be accepted, the level of significance ($p = .066$) that led to acceptance of the null hypothesis was very close to the .05 confidence level that had been set. One could argue that, since this is new and unique research, the confidence level could be set higher (at 1.0) thereby allowing a greater latitude to accept that the differences between groups over time did not arise by chance. This argument is further strengthened by the plot of the estimated marginal means of each group over time. It appeared that there was a difference in the slope between groups with the control group declining somewhat more from the immediate posttest to the 4-month posttest. These two points suggest that the problem and methodology of this research have potential and should be pursued. A larger sample and a longer time frame might show significance. This will be discussed further in the sub-section entitled "Suggestions for Future Research".

The literature lends support to pursuit of development of CAI programs and research as to their effectiveness utilizing a variety of outcomes (knowledge retention, metabolic control, decrease in hospitalizations, cost savings, etc.). Several advantages to the use of CAI are noted in the literature. Many investigators felt that the standardization of knowledge with the use of CAI was a notable advantage. CAI provided for more consistent, accurate, and thorough information particularly when instruction was provided by a variety of health care providers. Conflicting information is often given to patients and their caretakers on a given subject when education is provided by a team of providers. One of the benefits noted by the investigator in using the CAI Sick Day Management program was that instructional content did not vary. Each subject in the CAI group received the same information regarding sick day management. There was a concerted effort made by the investigator in the study to maintain a consistent content between the control and experimental groups so as not to pose a threat to validity. In day-to-day practice however consistency among educators on a given diabetes management subject is an issue. Therefore, the standardization of content that the CAI program provided would be valuable when multiple providers are involved in patient education. Kinney, Keskula, and Perry (1997) cited several benefits of CAI in their article including the ability of CAI to facilitate instructional consistency. Consistency of instruction is cited as an advantage to CAI in multiple articles (Hannah, 1989; Billings, 1986; Peterson, 1996). The standardized information offered by the computer program is more consistent, accurate, and thorough than that given by a variety of health care providers (Sinclair, 1985). The active learning component was also noted by several investigators as an advantage of CAI over traditional teaching methods. The literature also revealed other outcomes, other than knowledge, that seemed to be positively affected by use of CAI. Horan, Yarborough, Besigel, and Carlson (1990) found no difference in knowledge acquisition between the CAI and traditional instruction groups in their study but there was a difference in reported behavior change. Jelovsek and Adebonojo (1993) also noted a change in behavior with CAI versus traditional instruction from their review of randomized clinical trials on CAI in health care between 1966 and 1992. They postulated that the interactivity and repetition used in CAI programs improved mastery. Of note is that both of these characteristics were employed in the Sick Day Management CAI program utilized in this study.

In a study that evaluated a CAI program developed by the authors, Lo, Lo, Wells, Chard, and Hathaway (1996) found that learning outcomes were similar for CAI and conventional education but improvement in metabolic control was better in the CAI group versus the conventional education group. They concluded that although conventional education increased knowledge it failed to provide the motivation that resulted in adherence to the management regimen. Metabolic control as measured by hemoglobin A1c was not used in the current study as it would not have been an appropriate outcome for the particular subject of the CAI program.

There are other potential or rival hypothesis that could account for no difference being found in knowledge scores over time with CAI versus traditional instruction.

The personality and experience of the instructor may have influenced the study. The instructor has been a diabetes educator for 20 years and, therefore, with the traditional instruction only control group, utilized interactive forms of teaching such as question and answer to reinforce concepts. The instructor developed the CAI program and written pamphlet used in the study therefore was extremely well versed in the topic of sick day management.

The investigator was also the instructor, which may have represented a threat to external validity. This was done to assure consistency and quality instruction but potentially could have introduced bias through experimenter effect (Gay, 1987).

The fact that parents represented the majority of subjects in both the control and experimental groups also could have influenced the outcome of the study. When people are learning things that touch their children, learning is increased (the learning becomes emotional as well as cognitive). This effect may have overcome the delivery system.

Suggestions for Future Research

A suggestion for future research would be to extend the data collection and recruitment period. The sample size used for the study was relatively small because of the number of children and adults newly diagnosed during the data collection period (6 months). In replications of the study, it is recommended that the data collection period be extended to 1 year to recruit a larger number of subjects. Also, it is recommended that, in addition to a 4-month post-test, a 1-year post-test be included as part of the study design. It would be of value to determine if the difference in retention of knowledge would widen between CAI and traditional instruction as time lengthened. However, a threat to validity could be introduced in that it would be more likely that a child or adult would have encountered a sick day at 1 year post instruction which would impact the knowledge score.

Another suggestion for future research would be to utilize a second outcome measurement. For this particular topic, hospitalizations, emergency room visits, and office visits for the purpose of hydration or to treat DKA as a result of illness could be tracked. A longer time frame for data collection (1 year) would be needed to make this information meaningful.

Although the null hypothesis had to be accepted, an argument can be made to pursue this line of research given the unique nature of the research and the reported benefits of CAI as an instructional tool that are reported in the literature. Therefore, the investigator would strongly suggest that other CAI diabetes self-management modules be developed and evaluated through the same design utilized in this study expanding the outcome measurements. The lack of CAI programs for diabetes self-management training is unfortunate considering the availability of computers in the United States. Although more time-consuming to develop than written materials, CAI has many characteristics that make it a valuable and appropriate learning tool. Time and resources need to be devoted to expand this powerful instructional tool. It is recommended that grants be found that would underwrite the cost of a computer and content expert and authoring program with training so that future modules could be developed in a shorter time frame with utilization of all the features of the authoring program.

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Appendixes

Appendix A

Outline of Managing Well on Sick Days

Outline Managing Well on Sick Days

I. What is sick?

   A. Sick means having a fever, nausea or vomiting, diarrhea, or other symptoms of illness.

   B. Sick day rules are guldelines that help you manage high blood sugars and urine ketones that often accompany illness.

II. What happens in the body when you are sick?

   A. The body's need for insulin usually increases.

      1. Most illnesses cause the body to release very strong stress hormones.

      2. Stress hormones block the effectiveness of insulin thereby raising blood sugar levels.

      3. This is why it is very important for you to receive all of your scheduled insulin shots during any illness.

      4. Golden Rule: Not giving insulin is never, never, never an option!

   B. The body cannot properly use carbohydrates when it does not have enough insulin.

      1. As a backup source of energy the body breaks down fat.

      2. Ketones, which are acids, are a result of this fat breakdown process and can quickly build up in the bloodstream. This causes serious changes in the blood acid level.

3. The body tries to get rid of the ketones through the lungs and by flushing them out into the urine.

    a. A fruity or sweet odor to the breath is an indication that ketones are present.

    b. It is easy to measure the ketones in the urine with a urine dipstick called a Ketostix.

4. During illness the body may make ketones faster than it can rid itself of them. This buildup of ketones in the blood makes you feel tired, sickly, nauseated, and eventually can lead to vomiting.

C. If left untreated, high blood sugars and ketones will lead to a condition called diabetic ketoacidosis or DKA.

1. DKA takes several hours to occur which gives you time to prevent it if you know what to do.

2. DKA is an extremely serious condition and can result in serious injury and even death if not treated promptly.

D. The best treatment is prevention.

III. Managing on sick days

A. Goal #1: Prevent dehydration

1. Dehydration occurs quickly when you cannot keep liquids down. This is especially true when blood sugar levels are high, resulting in increased urination.

2. It's important to control the nausea that occurs with high ketones.
    a. You can do this with anti-nausea medications such as Phenergan.
    b. Phenergan is available as rectal suppositories. Give rectal suppositories every 4 to 6 hours.
    c. Phenergan is also available as a topical cream at specialized pharmacies (for example, The Apothecary Shoppe or Saffa Pharmacy). Apply cream to wrists every 4 to 6 hours.
3. If nausea and vomiting cannot be controlled after a reasonable effort (vomiting more than two times after using Phenergan), call the diabetes team or take the person to get medical attention immediately.
4. Drink lots of sugar-free fluids to correct fluid losses from the body.
    a. Remember high blood sugars cause large amounts of water to be lost from the body. Vomiting and diarrhea also result in fluid losses.
    b. Sip (don't gulp) water or other sugar-free non-caffeinated liquids such as Crystal Light. If sugar-free soda pop is used, shake the fizz out or allow it to sit open for several minutes. Carbonation can increase

the risk of developing nausea or vomiting. Clear sodas such as diet 7-Up™ or Fresca™ are generally more easily tolerated than caramel colored liquids.

c. 8 to 12 ounces of water or other sugar-free non-caffeinated liquids (for example, broth, decaffeinated diet soda, decaffeinated tea, Crystal Light) should be taken each hour while awake.

B. Goal #2: Make sure the body has enough insulin to fight off the effects of the stress hormones produced by illness and their effect on the blood sugar level.

1. Remember to take your normally scheduled shots of insulin.
2. You may need additional insulin dosing during illness.
    a. Whenever you need additional insulin you must take it in the fast acting form, either Regular or Humalog (the clear insulin).
    b. You must note two things to decide if it is necessary to take additional or supplemental insulin:
        i. Blood sugar level.
        ii. Level of ketones in the urine.
    c. With a blood sugar level > 150 mg/dl and moderate to large ketones, extra insulin is necessary (also, drink more water or sugar-free liquids).

d. With a blood sugar level < 150 mg/dl and moderate to large ketones increase fluids (drink more water and sugar-containing liquids). Extra Insulin is generally not given if the blood sugar is < 150 mg/dl. Call your doctor for advice.

e. With any blood sugar level and negative, trace, or small ketones increase fluids (drink more water or sugar-free liquids if blood sugar is > 180 mg/dl or sugar containing liquids if blood sugar is <180 mg/dl).

3. Check blood sugar and ketones every 3 hours until urine ketones are gone.

4. Timing of the insulin dose is important.

   a. If the morning or evening dose of insulin has not yet been given and you have moderate or large ketones call your doctor for advice on insulin dose adjustment. If blood sugar is > 150 mg/dl, you will likely be instructed to give an increased amount of Regular or Humalog insulin.

   b. After 3 hours, recheck the blood sugar and ketone levels. If blood sugar is > 150 mg/dl and urine ketones are moderate or large take an additional dose of Regular or Humalog insulin.

5. To figure the amount of extra insulin needed:

a. For moderate ketones, take 10% of total daily insulin dose (entire amount of all types of insulin taken each day) as Humalog or Regular insulin as a supplement every 3 hours until ketones fall below moderate (remember: extra insulin in generally not given if blood sugar is < 150 mg/dl).

b. For large ketones, take 20% of total daily insulin dose as Humalog or Regular insulin as a supplement every 3 hours until ketones fall below moderate (remember: extra insulin is generally not given if blood sugar is < 150 mg/dl).

6. Just because you may not have to take or give more insulin don't think you're out of the woods yet. As long as illness is present, high blood sugar levels and ketones could come back just as quickly as they appeared. Stay vigilant. Continue to do frequent blood sugar and ketone checks and drink extra fluids.

7. Certain medications that might be used during illness work against insulin. If you are taking steroidal medications such as Solumedrol Dose Packs, Prednisone, Cortisone, or Kenalog the quantity of insulin you take will probably need to be greatly increased while you are taking these medications. Call your physician / diabetes team for advice.

C. Goal #3: Eat / drink as tolerated and according to blood sugar level

1. If you are unable to eat regular foods and your blood sugar is less than 180 mg/dl, try to drink fluids or eat soft foods that contain 12 to 15 grams of carbohydrate every hour or 50 grams of carbohydrate every 3 to 4 hours while awake.

2. If your blood sugar is over 180 mg/dl, drink non-sugar containing liquids (decaffeinated diet soda, water, broth, bouillon, decaffeinated tea) or eat sugar free gelatin.

3. The following amounts of foods contain approximately 12 to 15 grams of carbohydrate:

   ½ cup orange juice

   ½ cup apple juice

   ¾ cup ginger ale (not diet)

   ½ cup 7-UP (not diet)

   1 cup chicken soup with noodles

   1 ½ cups chilled Gatorade (not light)

   ½ cup ice cream

   ¼ cup sherbet

   1/3 cup regular gelatin

   1 popsicle

   1 cup milk

   1/3 cup tapioca pudding

   1 cup plain or fruited yogurt sweetened with aspartame

1 slice toast

6 saltine crackers

3 peppermints

IV. You will need the following items to best manage sick days:

1. Blood sugar testing equipment.
2. Urine ketone dipsticks.
3. Regular or Humalog insulin with a syringe or pen delivery device.
4. Anti-nausea medicine.
5. A small supply of sick day medications/supplies:
    a. aspirin or acetominophen (Tylenol, Datril, Anacin III, etc)
    b. cough medication without sugar or alcohol (for example, Robitussin CF)
    c. throat lozenges without sugar (for example, sugar-free Halls, Robitussin, Nice)
    d. a thermometer so that you will be able to check your temperature
6. Liquids (both sugar-free and sugar-containing)
7. Good understanding of sick day rules and how to apply them.

IV. Sick day rules – summarized

A. Frequent monitoring of blood sugar levels – every 3 hours.

B. Frequent measurement of urine ketones – every 3 hours until they are completely gone from the urine (remember: extra insulin is generally not given if blood sugar is < 150 mg/dl).

C. Increase intake of water or other sugar-free liquids to maintain proper hydration and flush excess sugar and ketones from the body – 8 to 12 ounces each hour while awake.

D. Treat nausea when it occurs to prevent repeated vomiting – use Phenergan suppositories or topical Phenergan.

E. Do not miss any usually scheduled insulin injections.

F. Take extra Regular or Humalog insulin injections as determined by blood sugar and urine ketone levels.

G. Keep careful records of the following while you are sick:

1. blood sugar level
2. urine ketone results
3. how much, when, and what type of insulin you have taken
4. other medications you have taken
5. how long you have been sick
6. your temperature
7. food and fluids eaten
8. urine output
9. episodes of vomiting/diarrhea

H. Call for help from the diabetes team whenever you are in doubt about what to do!

[redacted]

I. Call the diabetes team immediately if ...

1. You have vomiting that does not resolve with an antivomiting medication such as Phenergan. Call immediately if you vomit twice after taking the antivomiting medication. Generally, it takes 30 to 45 minutes for the medication to work.
2. You have moderate (++) or large (+++) levels of ketones.
3. You have blood sugar levels that continue to run over 150 mg/dl and moderate to large ketones after taking 2 supplemental doses of rapid acting insulin in appropriate amounts.
4. The illness continues for 2 days without improvement.
5. You have signs of ketoacidosis, dehydration, or other serious problems. Signs to watch for include increasing drowsiness, abdominal or chest pain, rapid breathing, shortness of breath, sunken eyes, dry cracked lips, mouth or tongue, and a fruity odor to the breath.
6. You wear an insulin pump and become ill.

J. Sick day situations that require examination and possible treatment by a member of your diabetes team

1. Persistent vomiting (vomiting more than three times) or an inability to tolerate fluids by mouth.
2. Persistent diarrhea and progressive weakness.

3. Difficulty breathing, rapid and labored respirations.
4. Moderate or large ketones that do not improve after 12 to 24 hours of treatment.
5. Change in mental status.
6. Call your diabetes team to determine whether telephone management is possible or if an assessment and evaluation in the clinic or emergency room is indicated.

K. Keep the phone numbers of your health care team professionals handy. Know where to call after office hours.

1. During office hours call the main number. Do not call the pediatric nurse line or allow your message to be put on voice mail. The main number is 491-3939. Tell the receptionist that answers that you or your child is sick and ask to speak with your doctor's nurse or clinical assistant.
2. After office hours (weekends, holidays, and before 8:30 am and after 4:30 pm and between the hours of 12:30 and 1:30 Monday through Friday) call the main number (491-3939 or 1-800-888-9153 ext. 3939) and when prompted push 1. This will connect you with the answering service. Ask to have your physician paged. The doctor on call will usually respond within 30 minutes. If you have not received a call from the doctor within 30 minutes, have the doctor paged again.

Appendix B

Survey Instrument – Sick Day Assessment

Sick Day Assessment

1) What is sick?
   a) fever
   b) nausea or vomiting
   c) diarrhea
   d) all of the above
   e) I don't know

2) What happens to your body's need for insulin when you are sick?
   a) decreases because you are not eating as much.
   b) increases because stress hormones block the effectiveness of insulin.
   c) stays the same.
   d) none of the above.
   e) I don't know.

3) If there is not enough insulin in the body to use carbohydrate for energy, what backup source of energy does the body use?
   a) protein in muscle.
   b) glycogen in the liver.
   c) fat stores.
   d) glycogen in the muscles.
   e) I don't know.

4) How does the body get rid of ketones?
   a) in the urine.
   b) through the lungs.
   c) through sweating.
   d) both a and b.
   e) I don't know.

5) What are some of the symptoms of ketone buildup in the blood?
   a) a fruity or sweet odor to the breath.
   b) difficulty breathing.
   c) abdominal or chest pain.
   d) all of the above.
   e) I don't know.

6) What steps should be taken to prevent dehydration on sick days?
   a) drink lots of sugar-free liquids.
   b) take acetominophen.
   c) stop vomiting with an anti-nausea medication such as Phenergan.
   d) both a and c.
   e) I don't know.

7) What should you do if nausea and vomiting are not controlled after taking an anti-nausea medication?
   a) continue taking the medication hourly until the vomiting stops.
   b) drink 7-Up to calm your stomach.
   c) call the diabetes team or get medical attention.
   d) stop taking the medication since it's not working anyway and let the illness run its course.
   e) I don't know.

8) What determines if additional insulin is needed during illness?
   a) level of ketones in the urine.
   b) blood sugar level.
   c) food intake.
   d) both a and b.
   e) I don't know.

9) What instructions will you be given by the diabetes team if your (or your child's) blood sugar is over 300 mg/dl and moderate to large ketones are present?
   a) take only your regular dose of insulin at normally scheduled time – no extra insulin is needed.
   b) drink sugar-containing liquids.
   c) take extra short acting insulin (Regular or Humalog).
   d) take extra long acting insulin (NPH, Lente, or Ultralente).
   e) I don't know.

10) What are the two "golden rules" for sick day management?
   a) don't give the usual dose of insulin at the normally scheduled time if you (or your child) are vomiting and call the doctor if moderate to large ketones are present.
   b) never skip a normally scheduled insulin dose and call the doctor if moderate to large ketones are present.
   c) never skip a normally scheduled insulin dose and call the doctor any time ketones are present (even trace or small).
   d) don't give the usual dose of insulin at the normally scheduled time if you (or your child) are vomiting and call the doctor any time ketones are present (even trace or small).
   e) I don't know.

11) How often should blood sugar and urine ketones be checked on sick days?
   a) every 2 hours.
   b) every 3 hours.
   c) every 4 hours.
   d) every 5 hours.
   e) I don't know.

12)What percent of total daily insulin dose should be taken as Regular or Humalog if **moderate** ketones are present with a blood sugar above 150 mg/dl?
a) 5 percent.
b) 10 percent.
c) 15 percent.
d) 20 percent.
e) I don't know.

13)What percent of total daily insulin dose should be taken as Regular or Humalog if **large** ketones are present with a blood sugar above 150 mg/dl?
a) 5 percent.
b) 10 percent.
c) 15 percent.
d) 20 percent.
e) I don't know.

14)What should you do if you wake up in the morning with nausea and vomiting and moderate ketones?
a) call your doctor before taking your regularly scheduled dose of insulin because you will probably need extra short acting insulin.
b) take your regular dose of insulin and go back to bed.
c) skip your regularly scheduled dose of insulin since you don't feel like eating.
d) take half of your regularly scheduled dose of insulin and drink sugar-containing liquids.
e) I don't know.

15)How much carbohydrate should you try to consume on sick days if your blood sugar is less than 180 mg/dl?
a) 50 grams every 3 to 4 hours while awake.
b) none - you should consume non-sugar containing liquids or eat sugar-free gelatin.
c) 12 to 15 grams every hour while awake.
d) a or c.
e) I don't know.

16)How much carbohydrate should you try to consume on sick days if your blood sugar is greater than 180 mg/dl?
a) 50 grams every 3 to 4 hours while awake.
b) none - you should consume non-sugar containing liquids or eat sugar-free gelatin.
c) 12 to 15 grams every hour while awake.
d) a or c.
e) I don't know.

17)Which of the following food(s) contain between 12 and 15 grams of carbohydrate?

a) ½ cup orange juice.
b) ½ cup 7-Up®.
c) 1 cup Gatorade®.
d) all of the above.
e) I don't know.

18)When should urine ketones be checked?

a) anytime the blood sugar is greater than 300 mg/dl.
b) anytime you are sick.
c) only if you are sick **and** your blood sugar is greater than 300 mg/dl.
d) both a and b.
e) I don't know.

19)How much water or sugar-free liquids should be consumed hourly during illness to maintain proper hydration?

a) 20 to 22 ounces each hour while awake.
b) 16 ounces each hour while awake.
c) 8 ounces each hour while awake.
d) 4 ounces each hour while awake.
e) I don't know.

20)During illness, you should call the diabetes team if you have:

a) continuing moderate or large ketones after taking two extra doses of Regular or Humalog (clear insulin) as prearranged or instructed by your diabetes team.
b) moderate to large ketones present (unless you have prearranged with the diabetes team the amount of Regular or Humalog insulin to supplement).
c) vomiting that does not resolve with Phenergan® (if you vomit more than 2 times after taking Phenergan).
d) all of the above.
e) I don't know.

Appendix C

Letter to Potential Study Participants and Consent Form

June 1, 2000

Dear Participant:

I am a master's student at Oklahoma State University (OSU) and am collecting data for my thesis regarding use of computer assisted instruction as a teaching tool. This research is being conducted under the supervision of Robert Nolan, PhD at OSU and with the permission of Dr. David Jelley and Dr. William Bryant at the Warren Clinic Diabetes Center.

I would like you to participate in the study by completing three tests and, for some, one questionnaire. The study is designed to be incorporated into the normal educational sessions for the parents of a child newly diagnosed with type 1 diabetes or an adult newly diagnosed with type 1 diabetes. The results of the study will be reported anonymously and all medical and personal information will be kept in strict confidence.

If you decide not to participate it will not in any way affect the care and education your child or you will receive at the Diabetes Center.

I will be preparing a written report of the findings of the study and if you would like a copy then please let me know and I will see that a copy is sent to you.

Thank-you in advance for your assistance with my project.

Sincerely,

Sylvia Towner, RD, LD, CDE
Diabetes Nutrition Specialist

Robert Nolan, PhD
Professor – Oklahoma State University

CONSENT FORM

A. Authorization

I,______________________________, hereby authorize or direct Sylvia Towner, RD, LD, CDE , or associates or assistants of his or her choosing, to perform the following treatment or procedure.

B. Description

The investigation that you are asked to be involved in will evaluate the use of computer-assisted instruction (CAI) as an instructional tool to improve diabetes self-management outcomes. This research is being conducted under the supervision of Robert Nolan, PhD at OSU and with the permission of Dr. David Jelley and Dr. William Bryant at the Warren Clinic Diabetes Center.

The purpose of this study is to demonstrate the value of a CAI simulation program in contrast to traditional instruction in improving the ability of persons with diabetes and their caretakers to better manage sick days. A secondary purpose is to explore users attitudes towards this form of learning.

Your participation in this study will involve completion of three tests, and for some, one questionnaire. The tests include a pre-test that will be completed today, and two post-tests at 1 week following diagnosis and 4 months following diagnosis. The questionnaire of user satisfaction will be completed by half of the study participants after the week 1 educational session. The study is designed to be incorporated into the normal educational sessions for the parents of a child newly diagnosed with type 1 diabetes or an adult newly diagnosed with type 1 diabetes and, therefore, will not require any additional time beyond that which would normally be included in the educational program. The results of the study will be reported anonymously and all medical and personal information will be kept in strictest confidence.

Benefits to you as a result of being involved in the study could be a decreased incidence of future hospitalizations for diabetic ketoacidosis as a result of better retention of how to manage a sick day.

If you decide not to participate in the study it will not in any way affect the care and education your child will receive at the Diabetes Center.

If you have questions regarding this research project please contact the investigator, Sylvia Towner RD, LD, CDE, at (918) 491-3939, Dr. Robert Nolan, PhD at (405) 744-9190, or Sharon Bacher, IRB Executive Secretary at (405) 744-5700.

C. Voluntary Participation

I understand that participation is voluntary and that I will not be penalized if I choose not to participate. I also understand that I am free to withdraw my consent and end my participation in this project at any time without penalty after I notify the project director.

D. Consent

I have read and fully understand the consent form. I sign it freely and voluntarily. A copy has been given to me.

Date: ____________________ Time:________________(am/pm)

Signed: ____

Witness(es) if required: ______________________________

____

I certify that I have personally explained all elements of this form to the subject or his/her representative before requesting the subject or his/her representative to sign it.

Signed: ____
Project director or authorized representative

APPENDIX D

IRB REVIEW FORM

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD

Date: May 22, 2000 IRB #: ED-00-191

Proposal Title: "USE OF COMPUTER-ASSISTED INSTRUCTION (CAI) AS AN INSTRUCTIONAL TOOL TO IMPROVE DIABETES SELF-MANAGEMENT OUTCOMES"

Principal Investigator(s): Robert Nolan
Sylvia Towner

Reviewed and Processed as: Expedited

Approval Status Recommended by Reviewer(s): Approved

Signature:

Carol Olson by [signature] May 22, 2000

Carol Olson, Director of University Research Compliance Date

Approvals are valid for one calendar year, after which time a request for continuation must be submitted. Any modification to the research project approved by the IRB must be submitted for approval with the advisor's signature. The IRB office MUST be notified in writing when a project is complete. Approved projects are subject to monitoring by the IRB. Expedited and exempt projects may be reviewed by the full Institutional Review Board.

2

VITA

Sylvia J. Towner

Candidate for the Degree of

Master of Science

Thesis: USE OF COMPUTER-ASSISTED INSTRUCTION (CAI) AS AN INSTRUCTIONAL TOOL TO IMPROVE DIABETES SELF-MANAGEMENT OUTCOMES

Major Field: Occupational and Adult Education

Biographical:

Personal Data: Born in Toronto, Ontario, Canada, On September 23, 1954, the daughter of James and Catherine Black.

Education: Graduated from Savanna High School, Anaheim, California in June 1972; received Bachelor of Arts degree in Home Economics – Nutrition option from California State University at Fresno, Fresno, California in May 1976; completed dietetic internship at Baylor University Medical Center, Dallas, Texas in September 1977; passed Registration exam (RD) in April 1978; passed certification for diabetes education exam (CDE) initially in 1986, again in 1991, 1996, and 2001. Completed the requirements for the Master of Science degree with a major in Occupational and Adult Education (OAED) in December, 2001 at Oklahoma State University.

Experience: Employed by Baylor University Medical Center as a clinical dietitian from 1977 to 1980; employed by Saint Francis Health System/Warren Clinic Diabetes Center from 1981 to present as a diabetes nutrition specialist.

Professional Memberships: American Dietetic Association, American Diabetes Association, American Association of Diabetes Educators, Northeastern Oklahoma Diabetes Educators, Oklahoma Dietetic Association.