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The Effects of Cognitive Learning Styles on Human-Computer Interaction: Implications for Computer-Aided Learning

by

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ABSTRACT

This study investigated the impact of learning styles on human-computer interaction. Seventy subjects from the University of Calgary participated in the study. The Gregorc Style Delineator was used to obtain dominant and least dominant learning style scores.

Results indicated that patterns of learning indices did not differ significantly based on subjects' cognitive learning style. Five of six measures indicating human-computer interaction behavior were not significant at the $p<0.05$ level. However, learning styles significantly affected learning outcomes, as indicated by an interaction effect between learning style score and achievement outcome.

The researcher concluded, based on the review of literature and results found in this study, that computer-aided learning may not be the most appropriate method of instruction for all learners.

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As we come to understand more about learning/teaching styles and how the mind operates, I believe we will improve mental health and self-understanding as well as increase learning. Learning styles and teaching styles have already revealed much to us, and continued research will undoubtedly reveal more. This thrust can lead to the revitalization of "the noblest of professions" (Anthony. F. Gregorc, "Learning and Teaching Styles: Potent Forces Behind Them", p. 236).

CHAPTER ONE

INTRODUCTION

One of the most powerful features of computer-aided learning (CAL) is its capacity to individualize instruction to meet the specific needs of the learner (Rasmussen & Davidson, 1996). Self-paced instruction, the ability to present content in a variety of ways (e.g., text, video, sound, graphics), and features such as hypertext make CAL an effective learning medium.

The use of CAL in education (especially in primary and secondary schools) has burgeoned in recent years (Price, 1991; Nelson & Palumbo, 1992; Hawkridge, 1995; Hong, Yang & Liu, 1996). Faced with increasing class sizes and heavier work loads, teachers are looking towards CAL as a means of supplementing classroom instruction. In addition, CAL software continues to improve in its ability to engage learners and provide realistic and stimulating learning environments (Price, 1991). Learners can now choose from a variety of educational software packages designed to augment the curriculum (Dwyer, 1996).

As the use of CAL systems continues to grow, research in the area of human-computer interaction is becoming increasingly important. Currently, a select few studies examine individual differences and their effects on CAL (Nelson & Palumbo, 1992; Stanton, Taylor & Tweedie, 1992;

Marquez & Lehman, 1992; Reed, 1996). Findings generally indicate that while CAL has tremendous potential to individualize instruction, a number of learner characteristics such as motivation, learning styles, and background knowledge may affect the quality and effectiveness of a CAL instructional session.

This study seeks to identify the influences of cognitive learning styles on both achievement levels and human-computer interaction behaviors. As will be discussed in this thesis, certain forms of CAL may not accommodate all learners equally, a finding that may have significant implications for education and the future of CAL. Teachers should, therefore, remain cautious when using the computer as a learning tool. Just as teachers need to use a variety of approaches to meet the diverse needs of their students, so educators must be aware that CAL may not be the learning medium of choice for all students.

CHAPTER TWO

THEORETICAL RATIONALE

Background

According to Mills and Ragan (1994), classrooms of the next century will be significantly affected by emerging technologies and the development of new instructional delivery systems. However, research on CAL needs to move at a quicker pace in order to provide more clearly a direction for schools and a framework within which teachers can operate.

According to Alexander, educational research (1992):

> does not move forward at a measured pace. Rather, it is marked by periods of high activity within focused areas followed by periods of introspection and, possibly, reconceptualization (p. 257).

Initial studies investigating CAL focused on the benefits of computer instruction as compared with traditional forms of presenting content (Schlechter, 1991). It was thought that the computer would save time, students would be more motivated to achieve, and the computer would have the inherent power to accommodate individual differences (Schlechter, 1991). Although CAL appears to have potential for providing a variety of learning environments for students, there are limits to what the technology can do. Clark (1982) writes that most of the studies conducted from 1962 to 1982 have shown no significant differences in achievement levels to exist between students learning from the computer and those who learn from teacher-directed lessons. These findings are consistent with subsequent results found by Day (1984) and Gaston (1988).

Recently, studies examining individual differences and CAL have uncovered some of the reasons why computers have had limited success as educational tools. Research indicates that learning styles, motivation, level of domain knowledge possessed, and attitudes can impact the effectiveness of CAL sessions (Keller, 1968; Butler, 1984; Gregorc, 1985; Nelson & Palumbo, 1992; Stanton, Taylor & Tweedie, 1992).

Collins and Muir (1984) write that the changes to the school system initially anticipated by computer enthusiasts did not materialize, due in part to inadequacies which existed in software. Unfortunately, many of the current educational software packages do not adhere to sound instructional design principles, a factor that could have serious effects on student learning (Jones, 1989; Wallace & Anderson, 1993).

When planning for instruction, many educators take into account individual differences in terms of knowledge levels, learning preferences and abilities possessed by students. It can be more difficult for the computer to do the same, as the machine is at "the mercy" of the CAL software that has been created for it; and, according to Shneiderman (1988): "Designers of interactive systems have had to work from their own experience and intuition..." (p.707). This can be quite disconcerting for many educators who have neither the time nor the expertise to evaluate all educational software packages before purchase. Hence, many teachers are forced to take a "shotgun" approach when selecting software packages.

Although software continues to improve, some believe that today's educational computer programs are akin to "Edutainment" (Saddy & Watson, 1996), a term used to describe the merging of entertainment and education. Saddy and Watson (1996) suggest that many of the current educational software packages stimulate the right side of the brain (responsible for image processing) more so than the left side (responsible for language processing and higher-order reasoning). Learners may become overwhelmed by the visually appealing images and neglect to learn anything of substance. According to the authors of the report: "...heavy use of multimedia may be building a generation of learners who are deficient in left-brain skills such as language processing" (p. 57).

While it is not the intent of this study to find fault with CAL, one of the main areas under investigation is the ability of CAL to accommodate learners who have individual instructional needs. Sparked by the increasing number of schools that are using CAL to augment (and in some cases replace) certain elements of classroom instruction, it has been only recently that education has begun to evaluate critically the computer as a learning medium. Studies examining the effects of individual differences on human-computer interaction have shown that CAL and computer technology in general may not accommodate all learners equally (Butler, 1984; Gregorc, 1985; Nelson & Palumbo, 1992; Carver, Howard & Levelle, 1996; Ellis, 1996). Students with certain preferred learning styles seem to fare better with computers than others.

Purpose of Study

This exploratory study will investigate whether achievement in a specific CAL lesson is significantly affected by cognitive learning styles (as measured by The Gregorc Style Delineator). The main intention of this study is to spark further research in the area of learning styles and CAL. In addition, it is hoped that findings from this study can be used by teachers when planning for CAL use in the classroom (be it a classroom in a K-12 setting or post-secondary institution). Students and teachers need to be cognizant of the potential for mismatching (a term used by Gregorc to indicate the inability of the instructional program to meet the learning style needs of the student) and correct for such problems when observed in student behavior.

CHAPTER THREE

LITERATURE REVIEW

Overview

This chapter will be divided into three parts:

1. *Definition of terms*. Terms that are used throughout this study are defined.
2. *Cognitive learning styles*. Literature is explored in the area of cognitive learning styles. The *Gregorc Style Delineator* is discussed in detail and summary descriptions of the four mediation channels are provided. Furthermore, studies examining some effects of learning styles on CAL are examined and linked to the significance of this study.
3. *Other Individual Differences*. Included in this section are studies examining the influence of motivation, anxiety levels, domain knowledge, and prior computer experience on CAL achievement levels. In addition, literature in the area of Aptitude Treatment Interaction (ATI) is synthesized and discussed in relation to CAL.

Definition of Terms

Cognitive Learning Styles

There is no single way to describe the construct of learning styles. (Similarly, there is no one way to measure learning styles.) Three of the more robust definitions are presented.

According to Gregorc (1979): "Learning style consists of distinctive behaviors which serve as indicators of how a person learns from and adapts to his environment. It also gives clues as to how a person's mind operates" (p. 234).

Messick (1970) defines the construct of learning styles as: "Information processing habits representing the learner's typical mode of perceiving, thinking, problem-solving, and remembering" (p.188; cited in O'Brien, 1994).

Finally, James and Blank (1993) (cited in James & Gardner, 1995) define the construct of learning styles as: "The complex manner in which, and under which, learners most efficiently and most effectively perceive, process, store and recall what they are attempting to learn" (p. 47).

Regardless of the definition used, the construct of learning style is believed to be a relatively stable trait which characterizes the way a person prefers to learn (Davidson, Savenye & Orr, 1992).

Computer-Aided Learning (CAL)

In a CAL system, the computer mediates learning by controlling such things as pacing, the way material is presented, and testing protocols. CAL is a comprehensive instructional system that uses computer hardware and software to deliver instruction (Price, 1991). CAL is also referred to as computer-aided instruction (CAI), computer-mediated instruction (CMI), and computer-mediated learning (CML).

Domain Knowledge

Domain knowledge is defined as the realm of knowledge an individual has about a particular field of study (Alexander & Judy, 1988 in Alexander, 1992).

Multimedia

The term multimedia is used to describe the delivery of materials not limited to static text presentation. Multimedia systems use video, computer graphics, sound, animation, and any other technologically feasible form of presentation (Hammond, 1989).

Aptitude Treatment Interaction (ATI)

Succinctly defined, ATI is the attempt to evaluate individual student differences (aptitudes) and subsequently develop specific instructional strategies (treatment) to accommodate these differences (Driscoll, 1987). ATI research has uncovered that certain media may be beneficial learning tools for some, and adversive for others; hence, an interaction effect can be observed.

Cognitive Learning Styles

This section presents literature in the area of cognitive learning styles. The *Gregorc Style Delineator* is defined and salient literature pertaining to the measure is examined. Furthermore, studies discussing issues relating to CAL's role in education are analysed.

The *Gregorc Style Delineator*

The *Gregorc Style Delineator* is a self-scoring battery based on mediation ability theory which states that the human mind has channels through which it receives and expresses information most efficiently and effectively (Gregorc, 1982b). According to Gregorc (1982b), the term "mediation abilities" describes a person's capacity to use these channels.

Mediation Abilities

The *Style Delineator* focuses on two types of mediation abilities in adult individuals: perception (the means through which one is able to grasp information) and ordering (the means in which one arranges, systemizes, and disposes of information). The two dimensions of ordering are referred to as sequential and random; the two qualities of perception are known as abstractness and concreteness (Gregorc, 1982a).

According to Gregorc (1982c), there are countless other individualities that are not measured by the battery, but which, nonetheless, impact human behavior. For example, a person can have an inductive or deductive reasoning preference, be a separative or an associative, and operate as an introvert or extrovert. For ease of administration, however, The *Style Delineator* focuses on perception and ordering as two of the more salient measures of learning style.

Abstractness allows the individual to comprehend that which is not visible to the senses. Data can be mentally visualized, grasped, and conceived through the faculty of reason. Individuals who are strong in concreteness use the physical senses to comprehend and mentally register data.

Sequential individuals perceive and organize data in a linear, methodical fashion, and can express themselves in a precise manner. Furthermore, discrete pieces of information can be categorized naturally. In contrast, randomness disposes the mind to organize information in a nonlinear and multidimensional fashion. This quality enables individuals to deal with, and process, multiple data simultaneously.

Gregorc combines these abilities to create four mediation channels of mind styles: concrete sequential (CS), concrete random (CR), abstract sequential (AS) and abstract random (AR). Gregorc believes that individuals have, to a certain degree, characteristics of each category, but most individuals tend to show a stronger orientation toward specific channels.

Style Delineator scores are obtained by ranking four words at a time ('1' indicating "least like me", '4' indicating "most like me"). Ten categories of four words determine the scores for each of the four mind-styles. Each word corresponds to a particular mediation channel, and when summed, give a measure of a person's propensity for operating within specific learning channels.

Gregorc (1982a) divides the scores received on The *Style Delineator* into three levels: 1) Strong orientation towards qualities associated with the particular channel (or pointy-headedness), indicated by a score of 27-40; 2) Moderate ability, indicated by a score range of 16-26 on any one mediation channel; and 3) Minimal capacity (stubby pointedness), indicated by a score of 10-15 in a specific channel. According to Gregorc (1985) approximately 60 % of the channel's characteristics are observed in people with a score of 27 or over; hence, 27 has been selected as the cut-off point for "pointy-headedness". Another major cut-off point, 15, has been identified as an indication of "stubby pointedness" because very few of the channel's characteristics are observed in people with scores below 15 (Gregorc, 1982a).

Learner Characteristics

(Unless otherwise stated, information presented in this section is cited from Gregorc's book "An Adult's Guide to Style", 1982b.)

People who are dominant CS are usually practical, thorough, well-organized and prefer quiet, structured environments. CS individuals tend to perceive reality as the concrete world of the physical senses, and think in a sequential and orderly fashion. The CS can detect the most minute details, working with the exactitude of a machine (Gregorc, 1982a). The CS student is a perfectionist and prefers being told what to do (Butler, 1984). These learners do not like to go against the norm, view work as a job assignment, and enjoy being physically involved and active in lessons.

AS people consider themselves as evaluative, analytical, and logical individuals with a preference for mentally stimulating, orderly, and quiet environments. The AS has an academic-type mind which is driven by a thirst for knowledge. To an AS knowledge is power, and the ability to synthesize and relate concepts enables the AS to transmit ideas (both through the spoken and written word) intelligibly and eloquently. AS learners thrive on teachers who are experts in their area of interest, learning well through lecture-style teaching (Butler, 1984).

AR individuals are highly focused on the world of feeling and emotion and are sensitive, spontaneous, attuned, person-oriented people. Thought processes of AR individuals tend to be nonlinear, multidimensional, emotional, perceptive, and critical. AR people prefer active, free, and colorful environments. ARs thrive on building relationships with others and, as learners, dislike extremely structured assignments (Butler, 1984).

Finally, CR individuals process information in three-dimensional patterns and think intuitively, instinctively, impulsively, and independently. CR people prefer competitive, unrestricted, and stimulus-rich environments. CRs can be risk-takers and can easily jump to conclusions, often correctly. Such individuals are divergent thinkers, thriving in environments which engender exploration. The CR learner does not need many details to solve a problem, instead operating according to personally constructed standards (Butler, 1984).

Overall, everyone has the capacity to learn within each of the above channels; no one is a "pure type" (Gregorc, 1982b, p 41). Therefore, The *Style Delineator* is a tool which:

> provides an individual with a key to understand better the subtle and potent qualities of the mind, (their) behavior, the behavior of others and the demands placed upon individuals by their environment (Gregorc, 1982b, p.41).

Research on The *Gregorc Style Delineator*

Numerous studies have been conducted to investigate The *Gregorc Style Delineator*'s efficacy as a learning styles inventory (Joniak & Isaksen, 1988; O'Brien, 1990; Bokoros, Goldstein & Sweeney, 1992; Drummond & Stoddard, 1992). This section will delineate findings from these studies.

Bokoros et al. (1992) reviewed five measures of cognitive style: The *Myers-Briggs Type Indicator*, *Gregorc*

Style Delineator, Decision Style Indicator, Kolb's *Learning Style Inventory* and *Lifescripts*. It was found that The *Delineator* corresponded to the other measures of learning style. The researchers used intercorrelations to examine the relationship between the common assessment tools. A high correlation between The *Gregorc Style Delineator* and batteries such as The *Myers-Briggs Type Inventory* emerged (e.g., CS was significantly correlated with Introversion and AR was correlated with Extroversion). Findings also indicated that all learning style batteries could, and should, be combined into three basic dimensions: a thinking/feeling dimension, an information-processing dimension, and an attentional-focus dimension.

That the *Gregorc Style Delineator* is correlated with similar instruments was shown by a study conducted by Drummond and Stoddard (1992). Results indicated that The *Style Delineator* and *Myers-Briggs Type Inventory* measure many of the same qualities, but use different labels, even through The *Style Delineator* uses four scales as opposed to 16 combinations measured by *Myers-Briggs*.

In terms of the validity and reliability of The *Style Delineator*, Gregorc (1982a) reported an alpha coefficient of 0.85 to 0.88, indicating a strong test-retest correlation. In addition, Gregorc (1982a) published internal consistency reliability coefficients ranging from 0.89 for the AS scale to 0.93 for the AR scale, and predictive validity correlations ranging from 0.55 to 0.76. (All figures are significant at the $p < 0.001$ level. Results were based on a sample size of 110 participants.)

However, studies conducted by O'Brien (1990) and Joniak and Isaksen (1988) report somewhat lower internal-consistency estimates. Joniac and Isaksen (1988) examined the internal consistency of The *Style Delineator*. The data revealed alpha coefficients raging from 0.23 to 0.66, figures below those which were reported by Gregorc (1982a). O'Brien (1990) found similar results. Using a sample size of 263 undergraduate students, O'Brien reported alpha coefficients ranging from 0.51 for the AS scale to 0.64 for the CS scale.

Unlike Gregorc's studies in which a sample was drawn from a general population, neither O'Brien (1990) nor Joniac and Isaksen (1988) used a varied sample of subjects. O'Brien (1990) collected a sample 263 Faculty of Education students enrolled in a specific course. Joniac and Isaksen used a fisrt-year University sample size of 325. Furthermore, both research studies failed to publish cell sizes for the learning style groups. Large disparities between group cell sizes may have adversely affected results.

Issues in Learning Styles and CAL

The Issue of Matching

Much attention has been directed to the significance of learning styles in education (Brudenell & Carpenter, 1990; O'Brien & Wilkenson, 1992; Richardson & Fergus, 1993;

O'Brien, 1994; Cavanagh, Hogan & Ramgopol, 1995).

A study conducted by O'Brien (1994) investigated the effects of cognitive learning styles (as measured by The *Style Delineator*) on academic achievement in high school students. It was found that CS students had a significantly higher mean cumulative GPA of the four cognitive style groups.

Results from the study conducted by O'Brien are not surprising, considering that most primary and secondary school classroom teachers create learning environments which cater to concrete-styles of thinking (O'Brien, 1994; Butler, 1984). Those students who think using a different mediation channel must style "flex" in order to adapt to the demands of the environment (Gregorc, 1985). Gregorc (1979) writes: "Every environment places demands upon individuals for adaptation" (p.234). Hence, "matching", a term Gregorc (1982a, 1982b, 1985) uses to describe learning environments which are consistent with a student's particular learning style, may be necessary in order for students to attain desired learning goals. Some degree of style flexing is desirable, as learners need to develop proficiency adapting to a variety of forms of instruction (Butler, 1984). Style flexing over a long period of time, however, may have deleterious effects on learners, leading to emotional stress and quite possibly physical ailments such as headaches and ulcers (Gregorc, 1985).

The Computer as a Matching Tool

Although the idea of matching instruction to students' learning styles has been supported in the literature (e.g., Butler, 1984; Hettiger, 1988), it can be difficult for educators to accommodate all learning styles in the traditional classroom. It has been argued that effective CAL can correct for many teachers' inability to meet the needs of all learners (Schlechter, 1991). Yet, CAL may not be the preferred mode of learning for all students. According to Gregorc (1985), sequential students (CS and AS) tend to prefer CAL because the computer is seen as an extension of the sequential person's mind. Random individuals (CR and AR) require environments which are flexible and provide opportunities for multidimensional thinking (Butler, 1984). AR individuals, in particular, are inherently social and enjoy learning with others (Butler, 1984). It is apparent that traditional CAL does not always provide such an environment for this group of learners.

Unlike the teacher who may be able to troubleshoot and modify lessons to meet the specific learning needs of the student (see Fischer & Fischer, 1979), the computer is only as good as the program that has been created for it; and, as Gregorc (1985) warns:

> Students who cannot adapt to the demands of the medium are 1) denied access to the content and goals, and 2) are vulnerable to possible psychological damage if they cannot free themselves of the medium...Children can therefore become victims of a medium which is offensive to them. They are at the mercy of the machine (p.168).

Moreover, because a computer requires sequential thinking in order to gain access to its content (Gregorc 1985), many CR and AR individuals may become flustered and agitated when problems arise with the medium. Gregorc (1985) warns that problems such as "burnout" and other mental and physical ailments can arise if individuals are made to accept certain media which are seen as adversive.

In an effort to ensure that all learners can benefit from computer technology, Gregorc (1985) recommends that leaders (e.g., teachers, administrators, employers, professors) provide human mediators who can correct for matching problems that may arise from using an inappropriate and potentially invasive learning medium.

Further support for the notion of instructional matching was voiced by Burger (1985). In her opinion, CAL may be overused to a certain degree:

> Requiring all students to use CAI [Computer-Aided Instruction] may not be in the best interest of the student. The matching of the teaching style of the specific computer program and the learning style of the student must be considered (p. 21).

Inasmuch as the computer can be a powerful learning medium, the machine is limited in its capacity to modify instruction to meet individual needs (Gregorc, 1985). While there have been advances in the area of intelligent tutoring and adaptive interfaces (see Steinberg, 1992; Mills & Ragan, 1994), some of the software interfaces that are currently available are unintuitive and unnecessarily complex (Mitta &

Packebusch, 1995). Wallace and Anderson (1993) explain "designing good computer interfaces has proven a formidable challenge" (p. 259).

Hence, many students may be forced to adapt and harmonize with the computer (i.e., style flex) in order to attain desired learning goals. Gregorc (1985) writes:

> These inanimate objects lack empathy. Machines cannot sense the opportunities, qualifications, fears or problems. Nor can they sense the pressures from the forced intimacy we demand between learners and the media. Without compassion, there are no adjustments or alternative approaches offered. There is no sense of harm or restraint as the frozen medium makes its learning demands for sympathetic resonance. School personnel must recognize these facts when purchasing machines (p. 168).

Butler (1984) elucidates the notion of mismatching learning styles and media discussed by Gregorc (1985). "Instructional technology biases the way information is presented, and demands, to varying degrees, that we use certain mediation channels" (p. 237). In other words, the use of technology may systematically discriminate against certain learners who are unable to match learning styles with the medium. Just as the lecture approach in education is best suited to AS learners (Gregorc 1982b), so the computer may be better suited to certain learning styles.

Support for the need to match learning styles with computer-aided learning was voiced by Cosky (1980). In his paper, Cosky details the importance of providing individualized computer-based instruction to learners. However, because there is a dearth of research in the area of interface design and learning styles, Cosky explains that it may be some time before research can support the creation of truly adaptive interfaces.

CAL and Learner Profiles

A study conducted by Friend and Cole (1990) discovered that sensing-thinking individuals (dimensions correlated with CS and AS) responded more favorably to CAL than did intuitive-feeling types (dimensions which are correlated with AR). Friend and Cole postulated that intuitive-feeling types require more human interaction to achieve desired learning outcomes, and that CAL may not be suitable for all learners.

Enochos Handley and Wollenberg (1985) found that concrete learners (as determined by Kolb's *Learning Style Inventory*) learned more from a CAL session than did abstract learners. Pritchard (1982) gives further support for the claim that CAL may not accommodate all learning styles equally. In his essay on educational computing, Pritchard explains that CAL is suited best for individuals with an affinity for accuracy and attending to detail. Moreover, the researcher claims individuals with certain learning styles may be more partial to learning from computers than would others, and that people who have a preference for CAL usually enjoy working alone.

In keeping with CAL and learner profiles, Hoffman and Waters (1982) state that CAL is best suited for individuals who: "...have the ability to quietly concentrate, are able to pay attention to details, have an affinity for memorizing facts, and can stay with a single track until completion" (p.51).

Dunn and Dunn (1979) report that certain students may only achieve through selected instructional methods (e.g., CAL, whole-group instruction, etc.) and that matching can significantly improve academic achievement. Dunn and Dunn assert that students who are motivated, require specific instructions, are sequential, and enjoy frequent feedback generally do well with programmed learning such as CAL. However, students who are kinesthetic, peer-oriented learners (i.e., AR learners) may not be engaged adequately by the same method of instruction.

Quantitative Studies Examining CAL and Learning Styles

Several quantitative studies focusing on learning styles and computer-aided instruction have been conducted. This section will detail results from these studies.

In an investigation examining the effects of learning styles (as measured by The *Gregorc Style Delineator*) and performance in a CAL university course, Davidson et al. (1992) postulated that abstract individuals would have an affinity for CAL more so than would concrete students. Abstractness, it was thought, would enable students to understand the workings of the computer and lead to higher motivational levels. The researchers also hypothesized that sequential learners would fare better with programming skills--skills that require linear step-by-step execution of procedures--than would random learners.

Using a sample of 68 Faculty of Education learners, course assignments such as a mid-term and a programming assignment were used as measures of achievement levels. It was found that AS learners showed higher skill and knowledge scores than did AR dominant learners. A significant negative correlation between level of AR and achievement was reported, indicating poor learning outcomes for dominant AR students. Findings revealed significant differences between the random/sequential dimensions more so than that which existed between the concrete/abstract dimensions measured by The *Gregorc Style Delineator*.

In contrast to findings reported by Davidson et al. (1992), Burger (1985) found no significant differences to exist between learning style groups (field dependent/ independent) and achievement in a computer application undergraduate course. However, those who showed a preference for using computer technology (measured by a questionnaire devised by the researcher) performed significantly better in the final exam than those who showed more negative views.

Liu and Reed (1994) investigated the effects of learning styles on human-computer interaction and found no significant differences to exist between learning style groups and achievement levels. The *Group Embedded Figures Test* (*GEFT*) was used to separate ESL university subjects into field dependent/independent categories. The researchers used patterns of behaviors (e.g., use of video, text and time taken to complete the CAL program) as dependent measures. A hypermedia language tutorial program was used to collect data.

Results indicated that hypertextual, multimedia-rich environments allowed learners to modify instruction to meet their needs. Learners, regardless of being field dependent or field independent, performed equally well on tests measuring learning outcomes. Although learning style groups achieved comparably, there were significant correlational differences between human-computer interactional behaviors and learning style groups. In other words, learning style groups interacted differently with the program, but achieved comparably.

Dahl (1991) investigated the effects of learning styles on human-computer interaction. Eighty-four subjects were administered the *GEFT* test for determining field dependence/ independence. Subjects were then randomly assigned to either a simulation group or a drill-and-practice group. Data revealed a significant three-way interaction between gender, CAL strategy and learning style. Female field dependent students in the simulation group performed significantly poorer than did field independent female students in the same group. The researcher noted that results illustrate the importance of matching learning styles to computer-aided learning.

A study conducted by Cordell (1991) sought to determine the influence of learning styles (as measured by Kolb's *Leaning Style Inventory*) on achievement in a CAL lesson. Two hundred undergraduate subjects were randomly assigned to either a branching or a linear program. Although results did not indicate a significant difference in overall learning outcomes, data suggested disparities in post-test results between treatment groups. Assimilators and Divergers performed better with the branching program, whereas Accommodators and Convergers performed better with the linear program.

Results from the post-treatment questionnaire indicated that about half of the subjects from each group encountered difficulties with the program (Cordell, 1991), a figure which is to be expected considering half of each group was comprised of individuals with mismatched learning and instructional styles (Butler, 1984). Cordell stressed the importance of providing supplementary classroom instruction for learners to compensate for mismatching that may occur with CAL.

Wood, Ford, Miller, Sobczyk, and Duffin (1996) argue that students need to become aware of their learning style in order to achieve success. Results from their study indicated that learning style affected the quality of university student searches in CD-ROM information retrieval tasks. Wood et al. stress the importance of having students adopt alternative strategies when approaching computer-based instruction that does not match their prominent learning style. Such strategies require students to 1) be aware of mismatching incidences, and 2) have a repertoire of strategies available to employ (Wood et al., 1996). The authors also expressed the need to design CAL packages which can accommodate individual learning styles.

Hence, courseware designers who create educational technology should consider carefully the need to create interfaces that can accommodate all learners. As well, educators who implement the technology need to be aware of individual differences that exist in the classroom. Studies such as Cordell's (1991) show the need for further research in the area of interface design to engender style matching.

Section Summary

Although little research has been conducted in the area of cognitive learning styles as measured by The *Gregorc Style Delineator* and CAL, it would appear that sequential students fare better with most CAL applications than do random students (Gregorc, 1985; Davidson et al., 1992; see Butler, 1984 for an in-depth description of learning styles and learning preferences).

Yet, in any given classroom, 50 % (or more) of students have a propensity for learning best in the random mediation channel (O'Brien, 1994). When coupled with the fact that the use of hypermedia information systems with little or no teacher guidance is increasing in education (Small & Grabowski, 1992), the need for more research becomes apparent. Specifically, research in the area of learning styles and human-computer interaction is needed in order to understand better the influences of individual differences and CAL.

The next section of the literature review will explore briefly other dimension of individual differences.

Other Individual Differences

Learning styles should not be considered in isolation when examining individual differences and CAL. Computer anxiety levels, motivation, domain knowledge possessed, and prior experience with CAL can also impact achievement.

Attitudinal Considerations

According to Bloom (1971), the method of instruction employed may affect learners' attitudes towards the instructional situation and its desired outcomes. Such a finding becomes more germane when using computer technology (Neil, 1985). It can be difficult for the teacher to monitor student attitudes and levels of performance which may falter as the CAL session progresses. Especially if a student has had a negative experience with a poorly designed program, attitudes towards CAL may be adversely affected (Neil, 1985).

Marcoulides (1988) reported findings from Loyd and Gressard (1984) suggesting that as many as one-quarter of students have anxiety towards computers and related computer technology. In her study, Marcoulides found that the higher the level of computer anxiety, the lower the achievement levels observed in her sample of university-aged students.

Liu and Reed (1995) conducted a study investigating the effects of individual differences on human-computer interaction. Subjects were given the *GEFT* to determine learning styles as well as a survey to determine computer anxiety and computer attitudes. The data revealed that achievement levels were negatively correlated with anxiety levels; that is, participants who had higher levels of anxiety performed poorer than did those who had lower levels of computer anxiety. Liu and Reed posit:

> Learner performance has much to do with students' degree of computer anxiety, their attitudes towards computers...and their learning styles (p. 162).

Gaston and Arndt (1991) conducted a study to investigate the influences of learning style (as measured by Kolb's *Learning Style Inventory*) and attitudes towards CAL. It was found that no significant correlation existed between learning style and attitudes towards CAL. What seemed to influence attitudes was prior experience with CAL.

The results from the study conducted by Gaston and Arndt (1991) are consistent with findings from a study published by Brudenell and Carpenter (1990). The *Attitude Toward CAI Semantic Differential Tool* was administered to 40 registered nurses pre and post CAI treatment. The Kolb's *Learning Styles Inventory* was used to group subjects according to the following categories: Accommodator, Assimilator, Converger, and Diverger. The researchers discovered that experience with computers significantly affected attitudes towards CAL more so than did cognitive learning styles.

It should be noted that *all* participants who took part in the study conducted by Brudenell and Carpenter (1990) showed a decrease in attitudes towards CAL after moving through the tutorial program. Convergers and Assimilators showed the largest decrease in scores. The researchers attributed decreases in attitudes to defects in the CAL program's interface.

In keeping with interface design, James and Gardner (1995) suggested that it is futile and potentially harmful to use technology alone without considering individual differences such as attitudes towards technology. Moreover, the authors point out interface design is of paramount importance when relying on technology as the sole basis of instruction (as is the case with CAL).

Motivational Levels

Mills and Ragan (1994) believe that adaptive interfaces, which match content presented to the learner's level of functioning, can provide learners with individualized instruction and improve learning outcomes.

Adaptive systems allow the user to control the way the content is presented and the pacing of lessons. Insofar as such independence may facilitate learning for some students, Keller (1968) warns that giving the learner control presupposes that students can make valid decisions about how they will achieve the stipulated learning objectives. Keller found that using his Personalized System of Instruction (PSI), many underachieving students chose too little computer support (in the form of learning resources, feedback and time to complete lesson objectives) whereas high achievers chose too much computer support. Keller attributed the differences to student motivation levels and warned of the dangers of leaving important instructional decisions to students.

According to Small and Grabowski (1992) there is a lack of data regarding how user motivation affects movement through CAL programs, attitudes towards CAL, and learning outcomes. Keller and Suzuki (1988) offer some insight into the problem of motivation. ARCS Model of Motivational Design identifies four factors which influence motivation to learn: **A**ttention, **R**elevance of instruction to individual needs, **C**onfidence for achieving learning success, and **S**atisfaction with the learning experience. If any one of these identified areas is deficient or not present, students' motivational levels can falter.

Domain Knowledge and CAL

Another area where individual differences exist is the level of domain knowledge possessed by learners. Learners who approach a CAL task will undoubtedly possess different levels of content knowledge. Some will be content experts, while others will be relative novices with the presented material. Domain knowledge, therefore, is of significant importance to the field of HCI, and is an area under investigation for the purposes of this study.

According to Alexander (1992), the term "domain knowledge" includes that which is declarative, procedural and conditional. Domain knowledge can also operate at a tacit or explicit level. Alexander suggests that the term "domain knowledge" has been used inappropriately in many studies, and therefore, she attempts to reconceptualize it:

> Taking a systematic perspective, one finds that domain knowledge is an individual's prior knowledge. It is that segment of an individual's existing conceptual knowledge that is related to a specific studied area (p. 35).

<u>The Expert/Novice Paradigm</u>

One of the most pervasive themes to emerge from domain literature is the expert/novice dichotomy (Chi, Feltovich & Glasser, 1981; Bereiter & Scardamalia, 1986; Hannisch, Kramer, & Hulin, 1991). The paradigm will be discussed briefly to clarify differences in the way the two learning groups approach learning tasks.

Simply stated, an expert can be defined as an individual with formal training and experience in the area under investigation, whereas a novice can be defined as having little or no formal training/experience in the area examined (Simmons & Lunetta (1993).

Simmons and Lunette (1993; p. 154) differentiate further the two groups using prior research in the area to formulate a list of common behaviors. According to the researchers, domain experts:

1. Analyse the task carefully
2. Approach the problem-solving task in a hierarchical fashion
3. Describe the main components of the problem before considering the details
4. Plan more completely before solving the problem
5. Frequently check the consistency of answers

In contrast, domain novices:

1. Sort problems based on surface features
2. Use more trial and error approaches
3. Use backward working processes

Literature has explored the influences of domain knowledge as it pertains to such areas as bridge, baseball and physics problem solving (Zeits, 1994). Regardless of the content area, experts are generally found to have better domain-specific memory skills than do novices (Zeits, 1994; Bjorklund & Schneider, 1992. Benysh, Koubek and Calvez (1993) report that domain-experts cluster domain-relevant concepts, and that such clusters serve as building blocks from which more elaborate knowledge representations can be constructed. Ye and Salvendy (1994) posit that experts, because of their ability to chunk for long-term memory storage, show better performance than do novices in recalling meaningful pieces of information. Priest and Lindsay (1992) suggest that experts are more likely than novices to plan solutions at a meta-level.

What remains unclear from the literature is how a novice moves to becoming an expert (Alexander, 1992; Elio & Scharf, 1990). Alexander argues that the developmental process observed in school-aged children is most informative in studying the shift to expertise. In addition, one of the most influential and integral factors in aiding a person in the shift from novice to expert is interest in the subject (Bereiter and Scardamalia, 1986). Bereiter and Scardamalia theorise that human beings have a natural propensity for moving from being a novice to being an expert. The researchers report that individuals who master a procedure do not continue to practice it and refine their skills; rather, once expertise is attained, attention is turned to the procedure itself, revising its sophistication and degree of complexity.

Expertise may not necessarily be associated with making fewer human-computer interaction errors, though (Prümper, Zapf, Brodbeck & Frese, 1992; Gillan, Breedon & Cooke, 1992). Prümper et al. found that experts made just as many errors in performing a computerized office task as did novice workers. However, experts spent less time *handling* the errors than did the novice group.

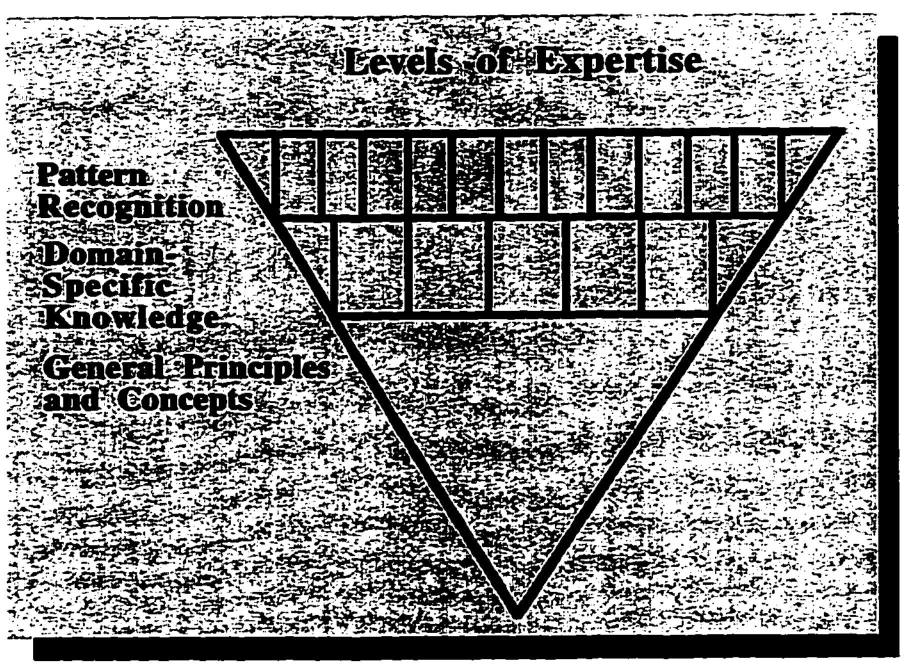
Expert/Novice Studies

Ye and Salvady (1994) undertook a study to investigate the way experts and novices chunked computer software knowledge. Using a sample of ten experts and ten novices in C programming language, 23 common programming concepts were given to each subject. Participants were asked to rate the relatedness of each concept pair. Results indicated that experts and novices differed in their overall knowledge structure. Cluster analysis suggested that experts had fewer,but more elaborate, knowledge chunks than did novices. Data revealed that the depth of each chunk, not the breadth of chunks in long-term memory, led to better performance by experts.

This view is consistent with Estes (1993) who theorizes that expertise has a number of levels.

Figure 1

Conceptualizing Levels of Expertise



adapted from Estes, 1993

According to Estes, at the most superficial level of information processing (the top level of Figure 1), the individual is able to recognize patterns which exist between concepts and information presented. The second level concerns mastery of domain-specific knowledge. One of the most significant differences between experts and non-experts is the vast amount of knowledge experts possess about the given field. Such knowledge, however, is unable to be transferred to other areas. At the lowest--or deepest--level of expertise, concepts can be generalized across domains.

A study conducted by Simmons and Lunetta (1993) examined differences in the way domain experts and novices used a simulation program called CATLAB. Three Ph.D. experts and ten secondary school novices participated in the genetics simulation experiment. It was found that the expert/novice dichotomy was too limiting in describing problem-solving performance. Instead, three groups of problem-solving behavior emerged: successful performance (two experts and two novices fell into this category), less successful performance (one expert and three novices exhibited behaviors consistent with this category), and least successful performance (five novices were placed into this category).

Results from the study should be interpreted cautiously, however. The methodology was flawed in that developmental differences may have existed between the expert and novice groups (Ph.D. and high school level). This may have confounded results, leading to differences in performance. Furthermore, no entry level pre-test or measure of knowledge level was administered; thus intra-group knowledge disparities may have existed, leading to further contamination of results.

Nonetheless, findings from the study conducted by Simmons and Lunetta (1993) indicate that the expert/novice paradigm may be, in some cases, too constraining (also see results from Tanaka & Taylor, 1991). Human knowledge levels may not fall discretely into two categories.

Aptitude Treatment Interaction and Individual Differences

Background

ATI first became prominent in the late 60's when Cronbach, a pioneer in the area, published a theoretical paper explaining the rationale for such research (Briscoll, 1987). ATI seeks to identify characteristics of a learner (such as learning styles, motivational levels and attitudes/anxiety levels) and then create instruction that can accommodate the learner's needs (Chan & Cole, 1986).

After decades of ensuing research in the area, it remains unclear as to what types of instructional methods are best for certain types of students (Driscoll, 1987). Some of the problems with current and past research have been a dearth of theoretical research in the area, a lack of agreement as to what aptitude means, studies which take a indiscriminate approach to data analysis, and problems with adequately defining instructional methods (Driscoll, 1987). Driscoll explains that current research has begun to consider entry level familiarity with content presented as being a significant contributor to ATI.

ATI and CAL

CAL offers the possibility of individualized instruction (Toh, 1996), and has received attention in ATI research (e.g., Snow, 1968). Many in the field of Educational Technology are predicting that CAL will become the dominant way of delivering instruction, not just in schools, but in universities as well (Keller, 1968; Marshall & Hurley, 1996). However, as Snow (1968) warns:

> The development of new media and instructional technologies is rapidly expanding the variety of educational experiences with which to confront learners and is permitting individualization of many learning situations...The advertised value of individualized multimedia instruction is an empty promise. Individualization implies classification in schools, and these require disordinal interactions...The concept of a single best method of instruction for everyone is like the search for the Holy Grail (p. 67).

As with the introduction of film and television into the classrooms during the period between 1960 and 1970, initial promises with CAL and revolutions that would take place have yet to materialize (see Postman, 1984; Postman, 1992). Part of the reason for this stems from unrealistic expectations placed on the medium (Schlechter, 1991).

Geisert and Dunn (1991, p. 47) found that CAL, when implemented properly, has the inherent ability to provide individualized instruction. In the researchers' opinion, CAL can give students the ability to:

- Work alone or in groups
- Work in varying environments (e.g., dim/ bright, cool/warm, quiet/noisy etc.)
- Respond to information in a variety of ways (e.g., speak, type or draw)
- Take regular breaks and work with or without teacher supervision
- Work at different times of the day or night

Despite CAL's ability to provide a number of learning environments, the technology is not for every learner. Clark (1982), in studying ATI research, found that some students preferred the instructional method from which they learned the least (e.g.,use video when one learns best from reading). In other words, students may not always make the best decisions about their learning (see Ellis, 1996). Hence, modification of instruction may be more successful if matched to one's individual learning profile (e.g., learning style, domain knowledge level, anxiety level, etc.) prior to engaging in the CAL lesson (Hettiger, 1988). This would require interface designers to build software that could be modified based on the learning profile of the user.

Snow (1984) reported in a study by Hettiger (1986) believes treatment that is mathemagenic (i.e., fostering learning) for one learner, may be mathemathanic (i.e., detrimental in nature) for another kind of learner. Hettiger uses this finding to stress the need for CAL programmers and educators to identify and engender mathemagenic approaches.

Recently, a number of efficacy studies have been conducted exploring individualized CAL and its ability to meet the needs of learners. Riding, Buckle, Thompson and Hagger (1989) claim that the majority of CAL instructional programs ignore differences in learning style--a problem which could have a detrimental effect on learning. The researchers designed a computer-based learning styles measure which individualized the way content was presented. Results indicated that a mismatching of instruction, especially for lower-ability students, resulted in lower post-test scores. It was recommended that CAL designers develop adaptive interfaces in order to effectively mediate learning.

A study by Carver, Howard and Lavelle (1996) found that using adaptive hypermedia interfaces based on students' entered learning style profiles helped learners stay on task and traverse through the plethora of content without feeling overwhelmed. Some learners were given mostly visual images, whereas other learners were give textual information with opportunities to follow hypertextual links. The authors of the study note:

> Adaptive hypermedia based on student learning styles provides the ability to individually tailor the presentation of course material to each student. The underlying idea of adaptive hypermedia based on learning styles is quite simple: adapt the presentation of course material so that it is most conducive to each student learning the course material. To a certain extent, each student is taking a different course based on what material is most effective for each student (from ED-Media CD-ROM, Article No. 486).

Section Summary

In addition to cognitive learning styles, individual differences such as motivation, anxiety levels, and domain knowledge possessed have been shown to affect the way learners approach CAL lessons. ATI research has identified the importance of instructional matching to maximize learning.

Chapter Summary

It is evident, from the research examined in this chapter, that more inquiry is needed to understand further the influences of individual differences and their effects on CAL. Learning styles do affect certain human-computer interaction behaviors, and while some studies have shown learning outcomes to differ significantly according to learning style, others have not. The *Gregorc Style Delineator* mediation channels indicate AS and CS learners may have a natural propensity for working well with computers; AR and CR students may find the same technology adversive (Gregorc, 1985).

In addition to learning styles, other individual differences have been shown to impact CAL learning outcomes. Individuals who have low motivation levels may not always select the most appropriate method of instruction, and learners with high anxiety levels may suffer from cognitive interference when using CAL. As was illustrated with the discussion of expert/novice paradigm, differences in entry-level domain knowledge can affect the behavior of learning.

ATI research has affected significantly the way educators plan and implement instructional programs. To maximize learning, educators should make an attempt to match instruction to meet the leaner's individual needs. It would appear that adaptive interfaces offer possibilities for accommodating students' with different needs. Further research is needed to help developers of educational software design more effective adaptive interfaces.

CHAPTER FOUR

METHODOLOGY

Problem

Based on the literature reviewed in the previous chapter, it would appear that computer technology has limited ability to accommodate users with varying learning styles (e.g., Cosky, 1980; Butler, 1984; Gregorc, 1985; Davidson et al., 1992; Cordell, 1995). Although a number of studies have been conducted in the area of cognitive learning styles and CAL (e.g., Liu and Reed, 1995), previous studies have not investigated learning styles as determined by The *Gregorc Style Delineator* and their influence on CAL.

Research Questions

Since this appears to be the first study to investigate the Gregorc mediation channels and their impact on learning from, and interacting with, a CAL program, no hypotheses have been made. The researcher will, instead, explore the following research questions:

1. Will learning outcomes differ significantly based on student cognitive learning styles as measured by The *Gregorc Style Delineator*?
2. Will human-computer interaction behaviors (i.e., time

spent on program, navigation, events recorded, video, tools and lesson preference) differ significantly based on student cognitive learning styles as measured by The *Gregorc Style Delineator*?

3. Will individual differences (i.e., entry level domain knowledge, CPR background/confidence levels and computer comfort level) affect learning outcomes?

Subjects

Seventy University of Calgary undergraduate volunteers (26 males, 44 females) participated in the study. University students were chosen for the following reasons:

1. Knowledge of computers was necessary for the purposes of this study. It can be argued that the majority of university students possess some computer knowledge (e.g., how to use a mouse and a keyboard) (Lee-Sing, 1996).
2. University students represent a relatively homogeneous group of learners. In this way, differences in attributes such as reading and developmental levels should not significantly confound achievement or patterns of learning variables.
3. University students are, in general, more familiar with the computer as a learning tool and, as a result, should not be subject to the novelty effect as may be seen in

younger children or older adults (Lee-Sing, 1996).

4. University students were relatively easy to recruit.

Since the researcher was interested in the effects of entry-level content knowledge on human-computer interaction, it was imperative that some of the participants had background knowledge of CPR principles and practises. Participants were sampled primarily from Nursing and Kinesiology because both Faculties require yearly CPR recertification from their students. To obtain subjects with limited CPR backgrounds, the researcher sampled from University Faculties with no such certification requirements: Education, Management, and Engineering.

According to recent figures collected by the University of Calgary's Teaching Development Office, the majority of students in Nursing and Education are either Concrete Sequential or Abstract Random learners (Schulz, 1993). For data analysis it was imperative that the learning style *between group* sample size be relatively equal; thus the researcher recruited students from Faculties such as Engineering, Science and Management--Faculties with a higher proportion of Abstract Sequential and Concrete Random learners (Schulz, 1993).

The researcher offered subjects a free CPR recertification course in return for participating in the study. Recertification courses were scheduled for April and September, 1997.

Treatment

The primary purpose of this study was to determine the effects of learning styles on human-computer interaction. To investigate differences between participants, subjects received the same treatment.

The researcher has produced a CD-ROM which is being marketed internationally. Entitled *Adult Cardiopulmonary Resuscitation,* the CD-ROM is part of a ten set series for Nursing schools. For the purposes of this study, a single section of the six section program, one-rescuer CPR, was used to collect data (see pocket insert for CD-ROM program used in the study). Created by the researcher, content for the CD-ROM was vetted for accuracy and validated by a three member committee comprised of experienced CPR Instructor Trainers.

The following is a breakdown of the interface learning tools and features (see Appendix A for sample program screens):

- an on-line glossary-- that is complete with definitions and narrated pronunciation for each word
- a note pad feature-- where students can write, and have the option to print, important information learned from the program
- a search tool-- that enables the user to conduct a text search by typing a word to be found or by clicking on any hypertextualized word
- video control buttons-- such as pause, stop, rewind and play
- an index tool-- that allows the user to move quickly to a step within a certain procedure
- a quick quiz feature-- that allows the user to test knowledge of a procedural step
- a further information feature-- which provides guidelines, legal information, common questions, problems and tips in addition to supplementary

information on a given step
- a summative quiz-- comprised of 20 randomly generated multiple choice questions

Experimental Set-up

The researcher duplicated 14 copies of the program on CD-ROMs and preinstalled the instructional software prior to participants' arrival. Each computer station was outfitted with a set of headphones (to reduce interference due to extraneous noise), a copy of The *Gregorc Style Delineator*, two copies of consent forms and a CPR gift certificate (redeemable for a free CPR course conducted by the researcher).

The Faculty of Nursing's microcomputer lab, the location of the study, was equipped 14 Power Macintosh computers. Each computer had 16 megabytes of Random Access Memory (RAM) and ran at 66 Mhz. All monitors were 14 inches, running millions of colors. Volume controls were preset to '6' (out of a maximum of '10') for each computer; however, participants could change the volume during the lesson.

Participants were scheduled to attend one of five experiment days. Sessions were conducted over the course of one week in early February (February 3-7, 1997). An average of 12 participants participated in the experiment each day. The remaining ten subjects participated in make-up days over the course of the next week. The researcher made every effort to conduct the make-up data collecting sessions in a way which was commensurate with the original research sessions.

Logistics of CAL Session

The entire experimental session took two hours to complete. Approximately one hour was devoted to assessing and understanding learning style scores. The second hour was dedicated to the CAL session.

After signing the consent form (Appendix B), the researcher introduced the workshop facilitator(s). A 45-minute workshop, conducted by Dr. Robert Schulz and Dr. Michael Martin, enabled students to explore and contextualize their particular learning style. In the researcher's opinion, construct validity and reliability measures were strengthened by having these *Gregorc Style Delineator* "experts" administer and interpret the inventory's results. Topics covered in the 45 minute workshop included personal learning preferences, how to become a more effective student, what learning styles mean, and how students can become aware and tolerant of other's learning styles. In no way were students provided with information which would bias the way in which they interacted with the program (e.g., Abstract Sequential students learn better using computers, or Concrete Sequential students prefer to move through CAL programs in a sequential way).

Participants were asked to enter their four mediation scores into the computer for later analysis and coding by the researcher.

Following completion of the workshop, the researcher explained the program interface to the participants to familiarize learners with the features and options available to them during the CAL session. Participants then were free to complete the on-line questionnaire and begin the 20-question pre-test.

No time restriction was imposed on the learners, as this could have potentially contaminated the results. In addition, time was a variable under investigation. It was imperative that learners did not feel rushed to complete their learning in a stipulated time limit; similarly, a time restriction may have forced quicker learners to stretch out the CAL session to meet the time limit.

After completing the session, participants were asked to click on the print function. This allowed the audit trail records to be printed to the local network printer (Appendix C). Learners could also view their test results if they so desired. Participants were free to leave at any time.

Learning Style Instrument

As a measure of cognitive learning styles, The *Gregorc Style Delineator* was administered to participants. The self-scoring inventory (described more fully in Chapter Three) creates individual profiles based on four mediation channels: Concrete Sequential (CS), Concrete Random (CR), Abstract Sequential (AS), and Abstract Random (AR). A score over 27 in any one mediation channel reflects strength in that area.

A standard alpha coefficient measuring The *Delineator's* reliability ranges from 0.89 to 0.93 (Gregorc, 1982b). Although his findings have not been supported by other research studies (see Chapter Three), The *Gregorc Style Delineator* is in wide use today as a measure of cognitive learning style (O'Brien, 1992).

The Gregorc Style Delineator was selected, in part, for the following reasons (adapted from Schulz, 1993, p.3):

1. Easy to administer
2. Easy to interpret
3. Self-scoring battery
4. Relatively quick to administer and complete
5. Inexpensive (funding and direction provided by Dr. Robert Schulz and the Teaching Development Office)
6. Discrete, easily reportable scales
7. Validity and reliability measures have been partially supported by research (e.g., Gregorc, 1982a)

For analysis purposes, the researcher used the subjects' highest scores as an indicator of their dominant learning style. (Four subjects had equal high mediation scores. In these cases, the computer randomly selected one of the scores as an indication of dominance.) In addition, the subjects' lowest score was used as an indicator of their least preferred learning style. (No subjects had tied low scores.) Gregorc (1982a) explains that the lowest score attained in The *Gregorc Style Delineator* is a valuable measure. Although not as potent as the highest score, the lowest value can illustrate the individual's least preferred method of learning.

Test Instruments

According to Bloom (1964) a well-constructed test should measure a student's ability to recall, comprehend, apply, analyse, synthesise, and evaluate information being tested. Bloom's taxonomy refers to a hierarchical system of categorizing test questions. The ability to answer questions becomes increasingly more difficult as one moves up the taxonomic layers. Furthermore, correct responses to higher-level questions reflect a deeper understanding of the content being evaluated (Violato et al., 1992).

Both the pre-test and the post-test were comprised of ten knowledge-type questions, five comprehension questions, and five application questions (Appendix D). Questions covered one-rescuer Cardiopulmonary Resuscitation (CPR) guidelines and procedures as stipulated by the *Heart and Stroke Foundation of Canada*'s Emergency Cardiac Care Committee. Construct validity for the test items was determined by a three member CPR instructor trainer review committee. Furthermore, the researcher who created the test items is an experienced CPR instructor and holds a Bachelor's degree in Education.

Although the pre-test and post-test were comprised of differently worded questions, the content being tested was related (e.g., 3+2 for pre-test, 2+3 for post-test). The tests were differently constructed to reduce the pre-test effect. Since less than 30 minutes separated the two tests, it would have been difficult to measure achievement strictly due to the tutorial effect.

On-Line Survey

A questionnaire was developed to measure individual differences and to obtain demographic information (Appendix E). Presented on-line, several questions used a Likert-type scale to ascertain CPR confidence, background, and computer comfort level. The researcher did not include an extensive measure for assessing attitudes towards CAL (e.g., Computer Attitudes Scale), as the subjects had a number of other tasks to complete in the relatively short time period.

Independent Measures

1. Learning Styles

For the purposes of this study, subjects' high and low learning style scores were treated as two independent variables.

2. Domain Knowledge

The pre-test score (out of 20) was used as a covariate to examine the effects of pre-test measured knowledge on learning outcomes.

In addition, subjects' CPR background (number of CPR courses taken in the last five years) was also used as a covariate indicating background knowledge.

3. <u>Computer Comfort Level</u>

The subjects' self-perceived level of computer comfort was used as a covariate for examining the effects of this individual difference on learning outcomes.

Dependent Measures

The term "patterns of learning" (referred to in a study by Liu and Reed, 1994) was used in this study to describe human-computer interaction indices. These indicators are listed below:

- **Total time (in minutes) to complete the tutorial**-- Participants were given no time restriction to move through the tutorial program; hence, time scores varied from subject to subject.
- **Navigation trend**-- Participants' patterns of movement through the tutorial were determined by a numerical score. The tutorial consisted of 15 instructional screens detailing the discrete steps in performing CPR. The audit trail recorded navigation by assigning a '+1' value when the next screen button was selected, and a '-1' value when the previous screen button was selected. For example, if a subject were to move through the procedures in a linear fashion, a score of 14 would be assigned (14 'next screen' selections x 1). If a subject were to go back three screens while covering all 14 steps, a net score of +11 would be assigned by the

audit trail file ({14 'next screen' selections x 1} + {3 'back screen' selections x -1}).

Use of the index tool to essentially jump from one step in the instructional sequence to another would decrease the navigational score as well. For instance, a learner who skips from step one to step ten, and then exits the tutorial would receive a score of +2 indicating non-linear movement.

It is important to note that a negative score could be recorded (e.g., if a learner were to move to a specific step in the sequence using the index tool and then backtrack at least two screens). Similarly, a score over 14 could be recorded (e.g., if a learner were to move linearly through the tutorial, use the index tool to jump back to step 5, and then move forward through the tutorial again).

- **Total Number of Tools Used**-- The frequency with which the subject accessed the program tools (note pad, search tool, index tool and glossary) was reflected by this measure.
- **Total Number of Video Events**-- The number of times the user accessed video controls 'Play', 'Pause', 'Rewind', and 'Volume' was indicated by this total. It is important to note that the video, by default, played automatically upon moving to a new screen; hence, the score reflected in this category indicated the number of video events above and beyond the standard score of 15

(or 15 video play options).

- **User Preference for Instructional Sequence**-- The tutorial program was comprised both of a 15 step tutorial sequence and a video review section. The video review section summarized all video steps covered in the tutorial. Learners could choose to watch the review video prior to, or following, the tutorial. A code of '1' was assigned to those participants who chose the 'Review Video' option first; an indicator of '2' was assigned for learners who chose to move through the tutorial first.
- **Total Number of Events**-- This measure indicated the level of user interaction. This number was derived by adding the total number of tools used, video accessed, and navigational events. A low number reflects user passivity.

In addition, learners were evaluated with a 20-question multiple-choice post-test. The results from the post-test were used as a dependent variable for the purposes of achievement analysis.

Audit Trail File

A program audit trail file was created for the purposes of this study to track participants' patterns of learning (Appendix C). Together with the pre-test score, learning style scores, and the preliminary survey information, the audit trail file also stored detailed information (e.g., which tools and video options were accessed on which screens, continuous time reports, etc.).

The following chapter deals with the analysis of data collected from the study's participants.

CHAPTER FIVE

RESULTS

This chapter is divided into two parts. The first part will delineate descriptive statistics collected from independent and dependent variables. Using inferential statistics, the second part will explore the research questions postulated.

Descriptive Statistics

The audit trail file collected data from subjects' learning style profiles (as measured by The *Gregorc Style Delineator*), preliminary survey responses, tutorial patterns of learning, and pre/post-test results. Results from the audit trail are revealed below.

1. Dominant Learning Style

Table 2 details the learning style distribution of the participants.

Table 1
Frequency of Subjects Grouped According to Dominant Learning Style

Learning Style	Number	Percent
Concrete Sequential	20	28.6
Concrete Random	20	28.6
Abstract Sequential	14	20.0
Abstract Random	16	23.0

The majority of the subjects were dominant CS or dominant CR learners.

2. Degree Route

The following table displays a breakdown of students by Faculty.

Table 2
Distribution of Participants by Faculty

Faculty	N
Nursing	18
Kinesiology	20
Other	32

Students were fairly evenly distributed across Faculties. Crosstabs indicated that the majority of Nursing students were AR or CS (61 %), a figure that is consistent with results reported by Schulz (1993). Overall, subjects in each faculty were distributed fairly evenly according to dominant learning style groups. (See Appendix G).

3. Gender of Participants

The majority of participants (44 or 63 %) were female. This is not surprising considering that subjects were primarily sampled from Nursing and Education faculties.

Crosstabs indicated that a higher percentage of females than males were random rather than concrete learners (55 % of females as opposed to 46 % of males). Only 14 % of females were AS as opposed to 31 % of males.(See Appendix G.)

4. Year of Degree Program

Table 3 provides a summary of the participants' year of program.

Table 3

Subjects' Year of Program

Year	Number	Percentage
1	12	17.1
2	16	22.9
3	17	24.3
4	25	35.7

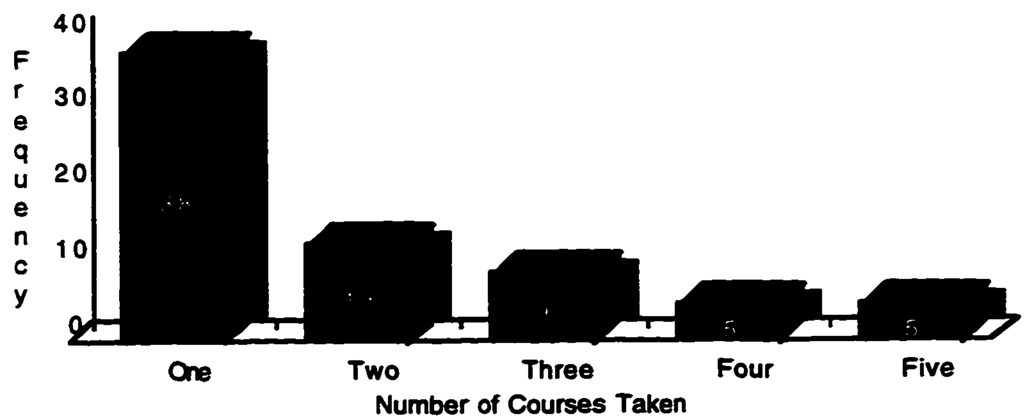
Over 35 % of subjects were fourth-year students, while under 20 % were in the first-year of their program routes.

5. CPR Course Background

Participants were asked to indicate their CPR course background (measured by the number of certification/ recertification courses taken). The researcher limited the period of time to five years so that a relatively current participant profile could be ascertained. Figure 2 depicts the subjects' CPR course background over the last five years.

Figure 2

Subjects' CPR Course Background



Although the majority of participants were fourth year students, only 27 % had recertified their CPR between three to five times over the last five years (though for some, it was required every year). Fifty-four percent of subjects possessed limited knowledge of CPR, completing one CPR course over the last five years.

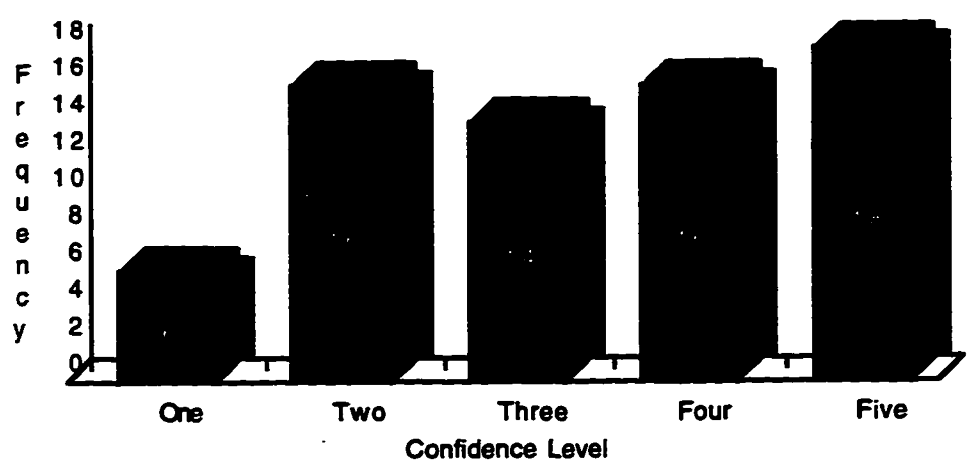
Over 80 % of CR subjects and close to 72 % of AS subjects have taken one CPR course in the last five years, as opposed to only 12.5 % of AR subjects. (See Appendix G).

6. CPR Confidence

Measured using a Likert-type Scale from 1 to 5 (1 being 'Very Confident', 5 being 'Not Confident at All'), CPR confidence indicates the participants' perceived level of CPR competence. Confidence levels could vary according to the time elapsed between recertification courses, the number of courses taken, the quality of the CPR course(s) taken, and whether the skill has ever been used in a real emergency situation.

Figure 3 illustrates subjects' confidence in their CPR skills.

Figure 3.
Subjects' Perceived Level of Confidence in CPR Skills



Close to 50 % of participants (48.6 %) were not confident with their CPR skills, as indicated by a '4' or a '5' response in the survey. This figure is not surprising, considering the high number of subjects who have taken only one CPR course in the last five years.

The majority of AS subjects (65%) were not confident with their CPR knowledge as opposed to 75 % of CS subjects and 65% of CR subjects who reported being confident with their knowledge levels. Forty-five percent of AR subjects reported being confident with their level of knowledge. (Appendix G).

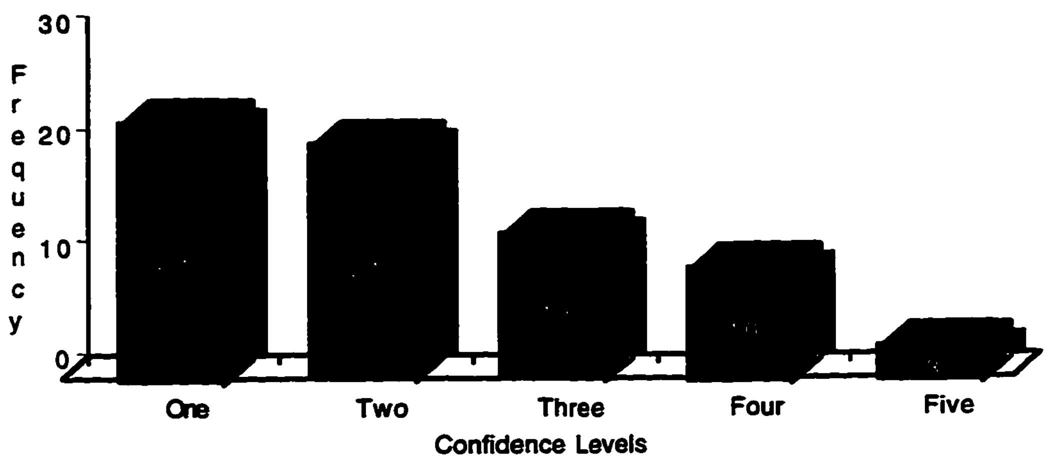
7. Computer Comfort Level

Research discussed in Chapter Three has shown that attitudes and views towards CAL impact the way in which the user interacts with the computer. This study focused on learning from the computer; thus, it was essential that a measure be included which ascertained computer comfort level. Since participants had a number of other tasks to perform in addition to the tutorial, and because the preliminary survey was already quite involved, the researcher limited the measure of computer comfort level to one question.

Figure 4 details participants' computer comfort level (using a Likert-type Scale where 1 indicates 'Very Comfortable' and 5 indicates 'Not Comfortable at All'):

Figure 4.

Subjects' Perceived Computer Comfort Level



It would appear that the majority of subjects (63 %) were either very comfortable or quite comfortable with using the computer.

A breakdown by dominant learning styles indicated that close to 60 % of AS subjects reported being comfortable with using the computer. In contrast, only 36 % of AR subjects felt comfortable with computer technology. Over 50 % of CS subjects and 55 % CR subjects felt comfortable with using the computer (Appendix G).

8. Human-Computer Interaction Indicators

Table 4 includes mean scores for human-computer interaction indicators (patterns of learning) based on a sample size of 70 subjects.

Table 4

Mean Scores for Patterns of Learning

Patterns of Learning	Mean	Std. Deviation	Std. Error
Pre-test	12.1	3.4	0.41
Post-test	13.4	2.5	0.30
Time in Program	27.4	9.8	1.17
Navigation Trend	12.6	4.3	0.52
Number of Events	54.9	25.5	3.04
Number of Tools Used	5.4	6.4	0.76
Number of Video Events	11.1	14.0	1.68
Instructional Sequence Pref.	1.4	0.50	0.06

a) *Pre-test versus Post-test:* As indicated in Table 4, participants recorded a mean achievement score of 1.3. Even though the average amount of time spent in the instructional program was less than 30 minutes, subjects' post-test scores reflect a more than one point increase from pre-test results. This indicates that subjects, as a group, learned from interacting with the computer program.

b) *Tutorial Time:* Overall, learners spent just under one half of an hour in the instructional sequence. While some participants diligently moved through the program, taking over one hour to do the tutorial (66 minutes), others spent less than ten minutes (9.6 minutes) to review the same content. These discrepancies in time could be due to differences in participant learning rates, motivation or domain knowledge levels.

c) *Navigation Trend:* A mean trend score of 12.6 suggests that overall, subjects moved through the program in a linear fashion. This statistic is to be expected considering the inherent nature of the instructional program. CPR is a psychomotor skill which requires a specific sequence of events to be performed. There is little room for deviation from the sequence; thus, it follows that learners would take a mostly linear approach to learning the content.

d) *Number of Events:* A mean score of 54 indicates that learner interaction with the program was quite high. Upon closer examination of the data, it became apparent that some learners were not very involved in the tutorial, while others were highly involved. One subject recorded only two events (playing the review video twice and then exiting the program), while another recorded 115 (playing the video on each screen more than once and using tools such as the glossary and note pad on a frequent basis). Such variance is responsible for the high Standard Deviation of 25.5.

e) *Number of Tools Used:* The mean score of 5.4 illustrates that users did not make full use of the program tools (note pad, search feature, glossary and index). This could stem from the study's time constraints which may have restricted subjects from utilizing the tools. For example, the note pad tool allows the learner to access a box where notes can be made for later retrieval or printing. Learners may not have needed to make such notes because they were not using the program for future studying. As was the case with the varying time scores, the low tool score could be due to differences in participant learning rates, motivation, or domain knowledge levels.

f) *Number of Video Events:* As was mentioned in Chapter Four, video in the program played automatically upon moving to a new screen (which is not reflected in the score for this variable). Learners could choose to stop the video while reading the text, or they could watch the movie first and then review the text information. As is indicated by the relatively low mean score of 11 (in addition to the default score of 15, or 15 automatic video play events) the majority of the learners did not need to access frequently the video features such as play, rewind and pause.

g) *Instructional Sequence Preference:* Described more fully in Chapter Four, a value of '1' was assigned for starting the tutorial with the review movie, while a value of '2' was designated for learners who went straight to the 15-step instructional sequence. Thus, a mean score of 1.4, reveals that subjects preferred to start the lesson with the three minute review movie slightly more than starting in the tutorial sequence.

Section Summary

1. Participants were fairly distributed according to dominant learning style scores.
2. The majority of participants reported taking under three

CPR courses in the last five years. It follows, then, that CPR confidence levels were low.

3. The majority of participants reported being comfortable with using the computer.
4. The one point difference between pre-test and post-test means suggests that participants learned from the program.
5. It is apparent that the tutorial program features were not used to their fullest potential. Subjects may not have found the need to use tools such as the search feature or the note pad, considering the nature of the learning environment.
6. The majority of participants completed the study well within the expected time period of one hour. The researcher did not impose a time restriction on the learners, so it was up to the individual to effectively manage time.

Exploration of Research Questions

This part of the chapter deals with exploration of the research questions posed in the previous chapter. The alpha level representing statistical significance was set at the $p < 0.05$ level. Results that have lower or higher p values will be reported as such. Data was analysed using SPSS 6 and BMDP IV.

1. Learning Outcomes

Will learning outcomes differ significantly based on student cognitive learning styles as measured by The *Gregorc Style Delineator*?

Analysis by Dominant Learning Style Score

To explore whether learning outcome were influenced by dominant learning style groups, a two-way ANOVA (2 X 4 factorial analysis) was conducted. The variable 'Time' was created to measure the tutorial effect (or difference between the pre-test and post-test) for the four learning style groups. Results are reported in Table 5.

Table 5

ANOVA Summary Table for Dominant Learning Styles Group by Learning Outcome

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F. Prob
Within Cells	66	156.40	2.37		
Time	1	57.91	57.91	24.44	0.001***
Style by Time	3	142.95	47.65	20.11	0.001***

***Significant at the $p < 0.001$ level

The data in Table 5 reveal significant differences in the pre-test and post-test means over time ($F_{(1,66)} = 57.91$, $p < 0.001$). There was also a significant interaction between learning style and learning outcome ($F_{(3,66)}$=20.11, $p < 0.001$).

The mean scores from the pre and post-tests are reported in Table 6.

Table 6

Pre/post-test Mean Scores by Dominant Learning Style Group

				95% Confidence Interval for Mean	
Dom Learning Style	N	Mean	Std. Deviation	Lower Bound	Upper Bound
Pre-test					
CS	20	11.85	2.32	10.76	12.94
CR	20	11.45	3.67	9.73	13.17
AS	14	10.29	3.17	8.45	12.19
AR	16	14.75	3.23	13.03	16.47
Post-test					
CS	20	13.90	1.94	12.99	14.81
CR	20	13.15	2.78	11.85	14.45
AS	14	13.93	2.92	12.24	15.62
AR	16	12.56	2.45	11.26	13.87

The mean test scores reveal that three of the four dominant learning style groups showed gains from the pre-test to the post-test. The AS group increased an average of 3.64 (or 18 %), displaying the highest gain of the three groups. CS and CR groups increased an average of about 2 points (or 10 %). Interestingly, the AR group decreased from pre-test to post-test an average of just over 2 points (or 10 %).

Figure 5 depicts the interaction between dominant learning style and learning outcome.

Figure 5

Interaction between tutorial effect and dominant learning style groups

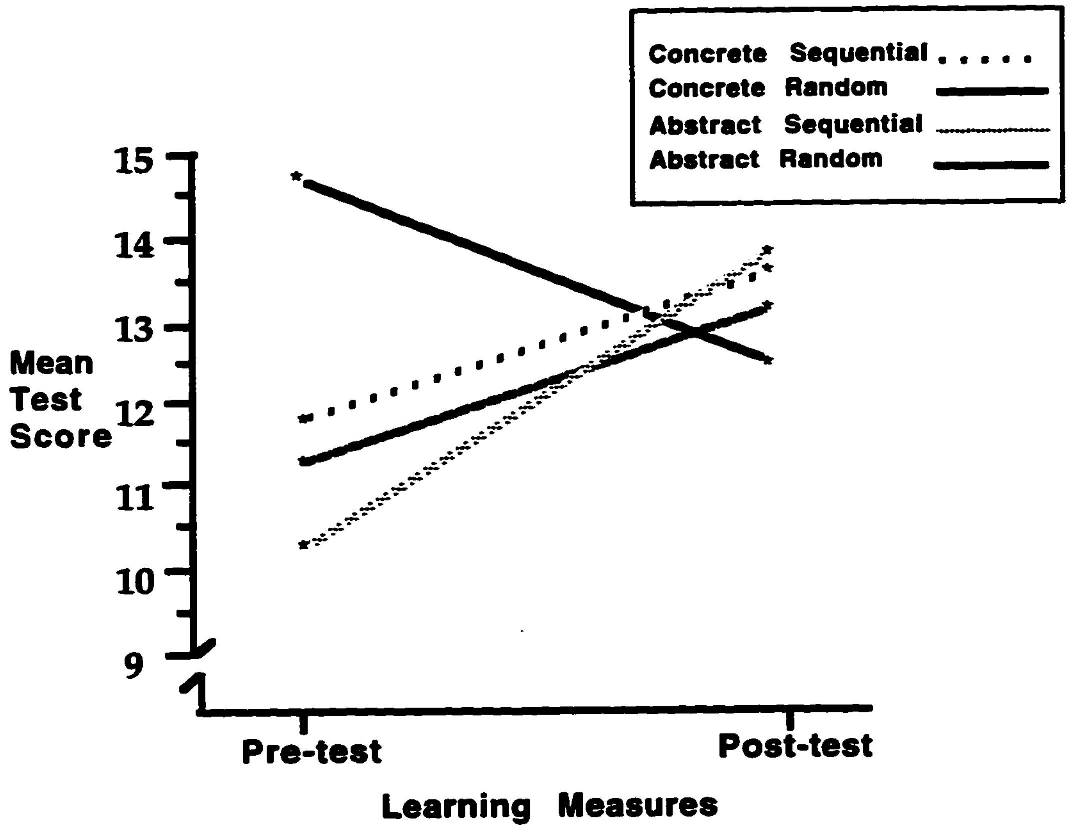


Figure 5 clearly shows the interaction between achievement levels and dominant learning style group.

In summary, the results indicate that there were significant differences in achievement between the four dominant learning style groups. Dominant learning styles, it would appear, affected the magnitude and direction of the differences in the pre-test and post-test results.

Analysis by Least Dominant Learning Style Score

Analysis was conducted using subjects' least dominant learning style as an indicator of achievement. As with dominant learning styles, a 2 X 4 factorial analysis was conducted; this time, however, subjects' *lowest* learning style score was compared with achievement on the post-test.

Results from the two-way ANOVA appear in Table 7.

Table 7

ANOVA Summary Table for Least-Dominant Learning Styles Group by Learning Outcome

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F. Prob
Within Cells	66	226.61	3.43		
Time	1	55.62	55.62	16.20	0.001***
Low by Time	3	72.74	24.25	7.06	0.001***

***Significant at the $p < 0.001$ level

Results indicate that the subjects' lowest learning style score significantly affected learning style outcomes at the $p < 0.001$ level. Table 8 illustrates the differences in means according to pre-test and post-test.

Table 8

Pre/Post-Test Mean Scores by Least Dominant Learning Style Group

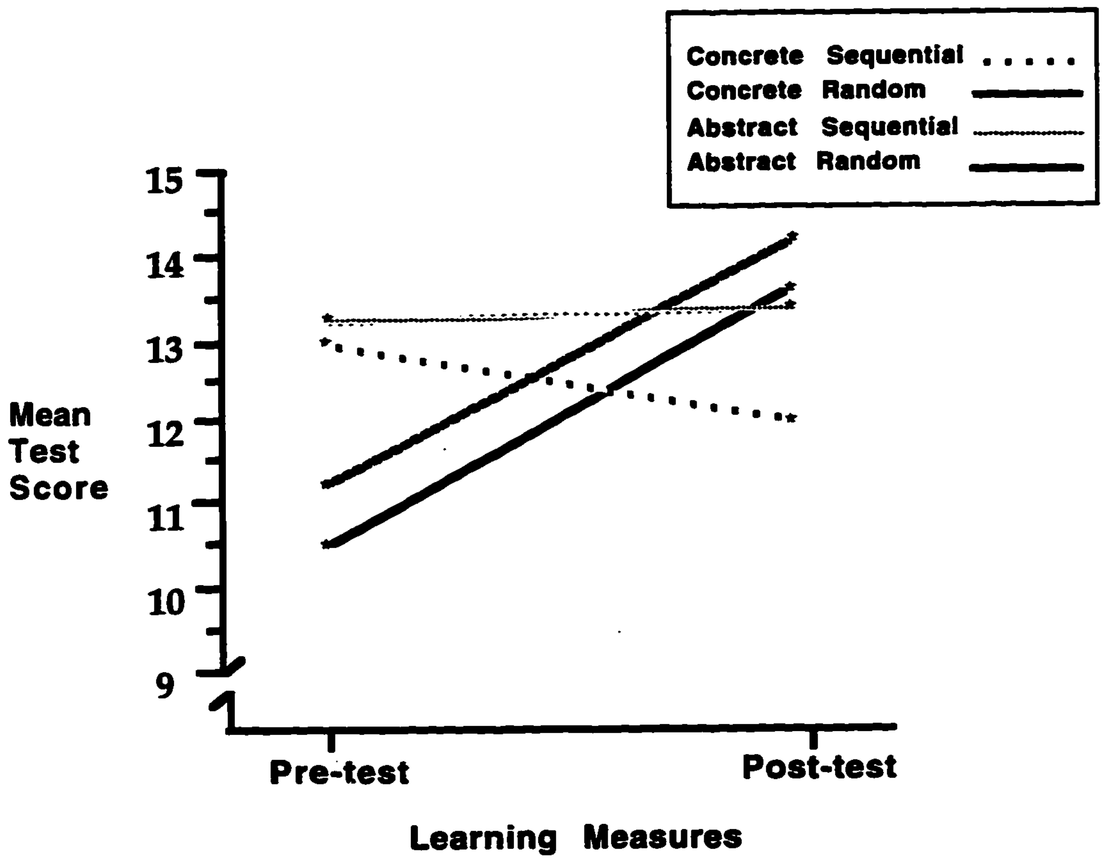
Least Dominant LS	N	Mean	Std. Deviation	95% Confidence Interval for Mean Lower Bound	Upper Bound
Pre-test					
CS	13	13.00	3.49	10.82	12.94
CR	19	11.21	2.86	9.83	12.59
AS	23	13.35	3.10	12.01	14.69
AR	15	10.47	3.87	11.27	12.91
Post-test					
CS	13	12.54	2.73	10.89	14.18
CR	19	14.11	2.51	12.41	14.54
AS	23	13.48	2.46	12.43	14.42
AR	15	13.39	2.52	12.78	13.99

As is shown in Table 8, participants who had low AR and low CR scores achieved the greatest pre-test to post-test change, indicated by increased test scores of close to three points. Subjects with low CS scores decreased from pre-test to post-test by half of one point. Finally, participants with low AS ability stayed the same from pre-test to post-test.

Figure 6 illustrates the interaction between least dominant learning style and learning outcome.

Figure 6

Interaction between tutorial effect and least dominant learning style groups



Results illustrated in Figure 6 indicate an almost inverse effect of the least dominant learning style score on achievement. It would appear that subjects' least dominant learning style, measured by The *Gregorc Style Delineator*, had an impact on learning outcomes.

Conclusion

The data suggest that learning styles (either dominant or least dominant) significantly affected the magnitude and direction of achievement. Hence, the research question "*Will learning outcomes differ significantly based on student cognitive learning styles as measured by The Gregorc Style Delineator?*" should be answered in the affirmative.

2. Human-Computer Interaction

Part one of this chapter indicated that significant achievement differences existed using dominant and least dominant learning style groups as independent measures. In this section, user interaction is investigated to ascertain whether patterns of learning differed based on dominant learning style categories.

The proceeding research question will be explored:

> Will human-computer interaction behaviors (time spent in program, navigation, events recorded, video, tools and lesson preference) differ significantly based on students' dominant cognitive learning styles measured by The *Gregorc Style Delineator*?

To investigate the way dominant learning styles affect human-computer interaction, a MANOVA was conducted using six patterns of learning as the dependent variables and dominant learning style as the independent variable. Results indicated that there was not a significant effect for patterns of learning by dominant learning style ($\lambda = 0.66$, $F_{(3,66)} = 1.51$, $p = 0.09$). Despite the fact that results were not significant at the $p < 0.05$ level, results from the MANOVA appear in Table 9.

Table 9

MANOVA Examining the Effects of Dominant Learning Styles on Patterns of Learning Indices

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F. Prob
Time	3	468.65	156.22	1.68	0.18
Navigation	3	22.32	66.77	4.06	0.01**
Events	3	3031.05	1010.35	1.60	0.20
Tools	3	72.14	24.05	0.58	0.63
Video	3	984.16	328.05	0.17	0.17
Lesson Preference	3	0.92	0.31	1.26	0.30

**Significant at the $p < 0.01$ level

The data suggest that only one pattern of learning, navigation style, differed significantly at the $p < 0.05$ level.

For the purposes of further exploration, table 10 presents descriptives from the MANOVA conducted.

Table 10

Descriptives from Dominant Learning Style by Patterns of Learning MANOVA

Learning Style	N	Mean	SD	Learning Style	N	Mean	SD
Time				Lesson Preference			
CS	20	28.95	7.06	CS	20	1.35	0.49
CR	20	26.85	9.27	CR	20	1.35	0.49
AS	14	30.64	13.37	AS	14	1.64	0.50
AR	16	23.31	9.10	AR	16	1.37	0.50
Navigation				Tools			
CS	20	11.95	3.56	CS	20	5.10	5.92
CR	20	14.05	3.87	CR	20	5.80	7.43
AS	14	14.42	4.14	AS	14	7.00	8.18
AR	16	10.06	4.74	AR	16	4.00	3.06
Events				Video			
CS	20	53.70	20.86	CS	20	8.00	8.78
CR	20	60.60	32.27	CR	20	16.65	21.64
AS	14	60.71	28.00	AS	14	11.57	10.97
AR	16	44.06	15.08	AR	16	7.81	6.97

A post-hoc Scheffé test was conducted to examine where differences in navigation occurred. Results indicated that the AS and CR group means were significantly different from the AR group mean. Data indicated that the AR group was the least linear of the four dominant learning style groups, recording a mean score of just over 10 points (See Chapter Four for further information on patterns of learning and their functions).

It appears that high standard deviation scores resulted in non-significant differences for the indicators time, events, and video. Results suggest that AR participants spent less time in the program, used less video, and made fewer interactions with the computer than did the other three dominant learning style groups. In contrast, AS subjects spent more time with the tutorial program, used a higher number of tools, and interacted more with the computer than did the other three groups. Although not statistically significant, mean scores do suggest some interesting differences between dominant learning style to be explored further (See Chapter Six for a detailed explanation).

Conclusion

The overall lack of significant differences between dominant learning style and patterns of learning measures of time, total events, tools, video, and lesson preference suggests that learning styles as measured by The *Gregorc Style Delineator* did not significantly affect the way in which learners interacted with the computer-aided instructional software. The question: "*Will human-computer interaction behaviors (time spent in program, navigation, events recorded, video, tools and lesson preference) differ* *significantly based on student cognitive learning styles as measured by The Gregorc Style Delineator?"* should, therefore, be answered in the negative. Five of six patterns of learning indicators did not differ significantly between dominant learning style groups.

3. Individual Differences and Learning Outcomes

The research question under investigation is:

> Will other individual differences (i.e., entry level domain knowledge, CPR background and computer comfort level) affect learning outcomes?

Examination was conducted to ascertain whether dominant learning style group post-test differences retained significance when controlling for entry-level content knowledge differences. An ANCOVA was conducted to identify the influences of learning style on post-test scores while controlling for pre-test variation in scores. (The ANCOVA procedure assumes equality of slopes. The null hypothesis for equality of slopes was not rejected for each ANCOVA. Hence equality of slopes was met for each of the following procedures.)

Table 11 delineates data results from the pre-test ANCOVA conducted.

Table 11

ANCOVA Learning Outcome Results Controlling for Pre-Test Knowledge Disparities

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F. Prob
Within Cells	65	199.80	3.07		
Regression	1	219.42	219.42	71.38	0.001***
Dom	3	108.31	36.10	11.75	0.001***
Model	4	240.79	60.20	19.58	0.001***
Total	69	440.59	6.39		

***Significant at the $p < 0.001$ level

The ANCOVA showed a significant effect for pre-test (β= 0.79; t = 8.4; sig t = 0.001). However, learning styles still retained a significant influence on post-test scores ($F_{(4,65)}$ = 19.58, $p < 0.001$). Furthermore, the adjusted r^2 value of 0.52 suggests that dominant learning styles alone explained 52 % of the variance in post-test scores after controlling for the influences of pre-test scores.

Further analysis was conducted using CPR background and computer comfort level as covariates. Results indicate that, when controlled for, neither computer comfort level ($F_{(4,65)}$ = 15.82 $p < 0.001$) nor CPR course background ($F_{(4, 65)}$ = 12.22 p < 0.001) significantly impacted learning outcomes. ANCOVA results showed significance between dominant learning style and learning outcome to remain at the $p < 0.001$ level.

Conclusion

Based on the results from the ANCOVAs conducted, it would appear that the question "*Will individual differences (entry level domain knowledge, CPR background and computer comfort level) affect learning outcomes?*" should be answered in the negative.

Section Summary

1. *Learning Outcomes:* Collectively, results indicated that the tutorial program led to significant gains in knowledge from pre-test to post-test. It is only when groups were distilled by learning style groups that differences in performance became apparent.

In addition, data analyses uncovered significant differences in learning outcomes between the four dominant learning style groups, and between the four least dominant learning style groups.

2. *Patterns of Learning*: It would appear that learning styles had no significant impact on human-computer interaction, although one pattern of learning indicator, navigation style, was significant at the $p < 0.01$ level. Results from the MANOVA indicated that collectively, patterns

of learning were not significant at the $p < 0.05$ level. However, time and number of events indices, while not showing statistically significant differences, did seem to differ from group to group.

3. *Other Individual Differences:* ANCOVA results controlling for pre-test knowledge disparities, computer comfort levels, and CPR course backgrounds showed that learning style groups contributed most significantly to learning outcomes.

Chapter Six will discuss the significance of the findings elucidated in this chapter.

CHAPTER SIX

DISCUSSION

This exploratory study sought to determine the effects of cognitive learning styles on human-computer interaction. After an extensive review of the literature, it would appear that this study is the first to examine the influences of Gregorc's learning style model on human-computer interaction. In this chapter, results will be discussed and linked to the few educational studies that have used The *Style Delineator*. In addition, learning style profiles constructed by Gregorc (1982b;1985) and elucidated by Butler (1984) will be used to build a theoretical framework around which results will be analysed and discussed.

The discussion chapter will focus on three areas of interest: learning outcomes, patterns of learning as indicators of human-computer interaction, and anecdotal notes.

Learning Outcomes

In terms of learning outcomes, the data suggested that, as a group, participants showed an increase from pre-test to post-test. This increase was found to be statistically significant at the $p < 0.001$ level. This would suggest that the tutorial program led to significant gains in Cardiopulmonary Resuscitation (CPR) knowledge.

Once subjects were distilled into their dominant (and least dominant) learning style groups, however, the data revealed a significant interaction effect between learning style group and achievement levels. In short, learning styles significantly affected both the magnitude and direction of achievement levels. Significance was found using dominant and least dominant learning style scores. Using the AR dimension as an example, participants who were high on the AR mediation channel decreased from pre-test to post-test by over two points; those subjects who recorded their *lowest* score as being AR were found to achieve significantly higher (a mean increase in almost three points from pre-test to post-test).

Table 12

Summary of Net Achievement Outcomes According to Dominant and Least Dominant Learning Style Groups

Learning Style	**CS**	**CR**	**AS**	**AR**
Dominant	2.05	1.7	3.6	-2.19
Least Dominant	-0.46	2.9	0.13	2.92

The AR group decreased an average of more than two points from pre-test to post-test, a result which has significant implications for CAL if supported by future studies. The dominant AS group moved from a pre-test score of ten points to a post-test score of almost 14. Considering that the group spent on average only 30 minutes interacting with the program (the highest of the four learning style groups), a gain of four points is quite drastic. The dominant CS and CR groups made modest gains of about two points from pre-test to post-test.

Theoretical Explanations for Achievement Differences

According to Gregorc (1982b) individual learning styles influence preference for method of instruction. As was discussed in Chapter Three, Butler (1984) and Gregorc (1985) believe that dominance in CS and AS mediation channels predisposes the individual to having a preference for working with computers (be it in the capacity as a computer programmer, or as a learner using CAL software). Randoms are said to find working with computers frustrating (see Gregorc 1985, pp. 202, 203). In particular, AR individuals prefer human contact throughout the learning process, and prefer engaging in tasks requiring verbal and multidimensional responses (Butler, 1984).

Results from the present study are consistent with results found by Davidson et al. (1992). As was discussed in Chapter Three, the researchers found that AR individuals enrolled in a computer applications university course showed significantly lower achievement levels than did the other three *Delineator* learning style groups. AS individuals showed the highest gains in the course, indicating their ability to work well with computer technology. The only differences in methodology between the studies is that Davidson et al. utilized course assignments as a measure of success, whereas this study used pre-tutorial and post-tutorial results as an indicator of achievement levels.

The Influence of Other Individual Differences

It can be argued that there were obvious background disparities between the four groups upon entering the study. While it is true that groups did differ based on their pre-test scores, the ANCOVA showed that groups still differed significantly on the post-test when *controlling* for pre-test differences in knowledge. Two additional ANCOVAs were conducted controlling for computer comfort levels and CPR course background. Both analyses showed that, when controlled for as independent measures, these individual differences had no significant impact on learning outcomes.

Hence, it would appear that achievement in the CAL session was affected most significantly by cognitive learning styles. Although three of the four dominant learning style groups learned from the CAL lesson, one group, AR, consistently did not (two dominant AR subjects increased scores from pre-test to post-test, nine decreased scores and four showed no change). Further research needs to be conducted in this area to verify results from this study--results that could have significant implications for the field of CAL.

Further Exploration:Differences in Pre-Test Group Scores

It is interesting to note that the pre-test means were different between the four learning style groups. While the AS group had a mean pre-test score of just 10, the AR group had a mean pre-test score of 15. Such a sharp contrast may be explained by a number of factors.

A) Varied CPR Background

It appears that the CPR course background varied between the four learning style groups (CS = 2, CR = 1.4, AS = 1.5, and AR = 2.8). An ANOVA was conducted to investigate whether the differences between groups were significant. Results from the ANOVA indicate that differences in CPR course backgrounds were statistically significant ($F_{(3,66)} = 5.16$, $p < 0.01$). A post-hoc Scheffé test was used to ascertain which groups were significantly different. The AR group's mean CPR course background score was deemed significantly different from the other three groups. Such differences in course background may explain the variances in pre-test scores.

B) CPR Confidence

The data suggest that the four dominant learning style groups differed in CPR perceived confidence. The preliminary survey asked participants to rate their CPR level of confidence (using a Likert-type Scale; 1 being very confident, 5 being not confident at all). Group mean scores (CS = 3.3, CR = 3.4, AS = 4.1, AR = 2.7) were significantly different ($F_{(3,66)} = 2.71$, $p < 0.05$) indicating differences in CPR confidence by learning style groups. Scheffé post-hoc analysis showed that the AS group mean was significantly different from the three other groups.

It is not surprising, then, to see that there were differences in the mean pre-test scores across groups. The AS group had taken the least number of CPR courses of the four groups, and had the lowest confidence level in their skills. This group also displayed the lowest pre-test score. Similarly, the AR group recorded taking the most number of CPR courses of the four groups, and had the highest CPR confidence level.

Patterns of Learning

Patterns of learning, indicating human-computer interaction behaviors, were not significantly different between dominant groups. Although five of six patterns of learning were not significant at the $p < 0.05$ level, three indices showed some interesting between-group differences. High standard deviation scores contributed to the high p values and thus, to the non-significant λ value of 0.66.

The mean scores revealed in Table 11 of the previous chapter show some interesting differences between groups. It would appear that the AR group spent, on average, less time in the program, used less video, and recorded fewer events than did the other three dominant learning style groups. The AS group showed diametrically opposite behaviors, spending more time in the program, interacting to a higher degree, and using more video than did the other three groups.

Furthermore, the AR group recorded a significantly different mean navigation value (significant at the $p < 0.001$ level) from the other groups. AR participants, on average, recorded a mean value of around ten points, indicating some degree of non-linear movement (either moving backward to review previous screens, or using the index tool to jump from step to step). The other learning style groups showed values which hovered around the expected level of 14.

Patterns of Learning as Indicator of Achievement

Upon closer inspection of the audit trail print-outs, it would appear that many AR participants missed entire screens while traversing from step to step. One participant missed five screens, jumping from step 3 to step 9, moving through the remaining six steps, and then finishing back with step 8. It is not known if the subject knew the content covered by the missed screens; however, it is clear that such an approach to learning CPR--a procedure that requires a linear movement through the sequence--may interfere with current learning, and may very well interfere with previous learning.

One test question, for example, asked participants to put the steps of CPR in order. A correct response for this question required the learner to have moved through the program in a linear fashion. Skipping steps and moving to previous screens may have interfered with learning required for a correct answer to these types of questions.

When teaching CPR in the traditional classroom setting, it would be detrimental for the instructor to move from step 1 to step 12 and then back to step 2. Regardless of the type of learning style one has, certain materials require sequential processing. Excessive and inappropriate use of the index tool--a tool that allows the user to jump from any given step to another--may have contributed to cognitive interference in many of the AR subjects.

According to Milheim and Azbell (1988) cited in Small and Grabowski (1992), systems that give the user control over the learning process are empowering for some and destructive for others. Small and Grabowski warn that too much user control can lead to navigation decisions resulting in either skipping pertinent content or leaving the tutorial program before all content has been thoroughly covered (also see Schroeder, 1994). Castelli, Colazzo and Molinari (1996) discovered that many users of hypermedia "get lost" in hyperspace. The notion of becoming disoriented due to incessant "jumping around" is consistent with findings from Hammond (1989).

The overall lack of interaction recorded by AR subjects (based on low events score, video use and time in program) may have resulted from a lack of interest in the CAL session. Motivation is key to any type of self-paced CAL session, according to findings from Keller (1968). Keller, in his essay on computers in the school, warned of the dangers of leaving important instructional decisions to students. Students may neither have the metacognitive abilities nor the motivation to select appropriate paths for achieving desired learning goals. Small and Grabowski (1992) found that high motivation levels led to subjects spending more time with the computer program and subsequently contributed to higher learning outcomes. Low motivation levels had an inverse effect.

In direct contrast to the AR group, the data revealed that AS subjects were highly engaged in the CAL lesson. All patterns of learning indicated that these subjects interacted to a high degree with the program. Such enthusiasm and diligence may have contributed to the higher achievement levels observed.

In terms of patterns of learning, Liu and Reed (1994) also found that, overall, human-computer interaction measures were not significantly affected by learning styles under investigation in their study. However, field independence (a propensity for thinking analytically and logically) was linked to using the index tool, and field dependence (thinking in a more global way) was correlated with using more video. In addition, field dependent subjects used the courseware significantly more than did field independent participants. (It should be noted that comparisons cannot be made between field dependence/independence and Gregorc's mediation channels. There is no research to support relationships between these dimensions of learning styles.)

Chapter Summary

To conclude, one of six patterns of learning was statistically significant (i.e., navigation); three others (video, events and time) showed a margin of difference between learning style groups. Navigation trend (the only significant pattern of learning) was used to explain why AR subjects performed so poorly on the post-test.

CHAPTER SEVEN

STUDY'S LIMITATIONS AND OPPORTUNITIES FOR FURTHER RESEARCH

Results from the present exploratory study have some significant implications for computer-aided learning if supported by further research. If replicated, a number of considerations should be followed to improve the generalizability of the results.

1. The present study used the traditional goals--tutor--test approach to gather data from participants. A study should be conducted with a computer program adhering to a different learning model (e.g., discrimination learning, simulation, intelligent tutoring system, etc.). If results prove to be consistent with those of this study, then it can be more conclusively argued that CAL may not sufficiently accommodate all learners equally.

2. This study found significant results with a limited sample size of 70 subjects. It is recommended that this study be conducted with a larger sample size (100 subjects or more with an ideal learning style cell size of 25 subjects). A higher number of participants could significantly reduce sampling error.

3. A formal exit survey should have been conducted to obtain participant's comments and concerns with the CAL session. Although follow-up phone sessions were conducted with a limited number of participants, a formal measure should have been incorporated into the study.

4. The present study used content that was familiar to most, if not all, subjects (as indicated by the relatively high pre-test mean). Inasmuch as it was desirable to have subjects who had varying levels of domain knowledge for the purposes of exploring one research question (namely, domain knowledge as a measure of individual differences), further research should be conducted using a subject area that is unfamiliar to all participants. In this way, learning outcomes could be more accurately measured.

5. Subjects were expected to interact with the CAL tutorial program for a relatively short period of time. Further research should explore the effects of learning styles and other individual differences on CAL using a one week to one month study time frame.

6. The present study used a psychomotor skill tutorial to collect data. Such a program requires the learner to move though content in a linear way. This may have

contributed to the differences in learning outcomes. This study should be replicated using a program with content that can be learned in a non-linear manner.

7. Further research should explore the impact of adaptive interfaces on human-computer interaction. The user would be able to enter his or her dominant learning style, and the interface would adapt to meet the needs of the learner. For such a system to be successful, studies need to be conducted to ascertain the types of interfaces preferred by the different learning style groups.

8. An experimental study should be conducted exploring achievement outcomes and learning styles. The experimental group would receive a CAL program to learn material; the control group would receive traditional instruction. The groups' learning outcomes could be compared using dominant learning styles as the independent measure. In this way, each learning style group could be compared with a similar control group.

9. This study should be replicated using a sample from a different population (e.g., high school students).

10. If findings from this study are supported by further research, specific intervention programs should be

formulated to help AR learners adapt to computer technology.

The previous recommendations for future research have a common theme: there remains a need for more research in the area of learning styles and human-computer interaction. The literature suggests that there are definite learning preferences which are consistent with learning style profiles. It follows, then, that CAL may not be suitable for all learners. Unfortunately, the relationship between learning styles and computer-mediated learning needs to be explored in greater detail before more conclusive statements can be made.

CHAPTER EIGHT

CONCLUSIONS AND RECOMMENDATIONS

This exploratory study examined the effects of cognitive learning styles on human-computer interaction. Results indicated that learning styles had a significant impact on the level of achievement attained. Specifically, AR subjects appeared to suffer from cognitive interference as a direct result of the CAL tutorial program. Scores in this group decreased significantly from the pre-test to the post-test. The AS group clearly benefited from the CAL session, increasing by almost four points from test one to test two. Analysis by least dominant learning style scores added further evidence of differences in achievement levels.

Although only one of six patterns of behaviors was statistically significant, there appeared to be some interesting differences in the way the four learning style groups approached the CAL lesson. While dominant AS individuals recorded a higher degree of interaction with the program, the dominant AR group showed a lower degree of involvement with the same program. CS and CR groups appeared to be fairly equal in both learning outcomes and patterns of learning observed.

Hence, it would appear that the sequential/random dimension had more of an influence on both learning outcomes and patterns of learning than did the abstract/concrete mediation channel. The disparities between AS and AR subject performance gives evidence to this conclusion.

***

Many technology enthusiasts espouse the notion that computers will soon replace teachers-- a notion that was discussed over 30 years ago (see Keller, 1968). The current pervasiveness of the computer in education can be likened to the advent of the motion picture (and thus instructional film) in the early 1900's. According to Thomas Edison (quoted in the Seattler newspaper, 1968, p.98):

> Books will soon be obsolete in the schools. Scholars will soon be instructed through the eye. It is possible to teach every branch of human knowledge with the motion picture. Our school system will be completely changed in the next ten years (in Lee-Sing, 1996, p. 6).

Computers should continue to be thought of as a learning aid, a *tool* to supplement teacher-directed learning (Greenberg & Pengelby, 1989) not supplant it. Computers are only as good as the programs that have been created by programmers, and currently there appears to be no consistency between CAL software packages (Wallace and Anderson, 1993). Some programs are extremely beneficial, significantly facilitating the learning process, while others have flaws which could jeopardize achievement.

Although computer-aided learning is rapidly becoming one of the most influential media of instruction in educational environments (Schlechter, 1991), CAL may not be suitable for all learners as an instructional methodology. Studies continue to support the need to critically evaluate this ubiquitous tool which has permeated the classroom and homes more quickly than most other technologies have in the past (see Schlechter, 1991).

Computer-aided learning has tremendous potential to provide teachers and industry with a powerful educational tool; however, educators must continue to be cognizant of inherent differences which exist between learners--differences such as cognitive learning styles. Results from this exploratory study show that some learners (AR learners in particular) may have difficulty adapting to certain forms of CAL.

It remains essential, then, that the computer continue to be used a tool for supplementing classroom instruction. Some learners may need greater support and guidance from the teacher, while others may be able to learn from the computer relatively independently. Thus, teachers should not assume every student will automatically benefit from computers in the classroom. There remains the need for interpersonal contact and guidance to ensure that all students attain their learning potential.

Recommendations for the Use of Computer Technology in Education

(**N.B.** Although this study is exploratory in nature, the researcher believes that results indicate the need to be aware of individual differences when planning for computer use in the classroom.)

The following recommendations are meant to be used as guidelines for the successful classroom implementation of computer technology and are based on findings from this study. It remains essential for a clearly stated list of recommendations, outlining proper computer use, to be published. In this way, all students are guaranteed the right to learn in the way that suits them best.

1. Educators should closely monitor--and mediate where necessary--all computer instruction. Students should have clear and identifiable tasks to complete, and learning outcomes should be measured periodically. This is consistent with views expressed by Greenberg and Pengelby (1989).
2. Students should be asked to express their views towards CAL through the use of a teacher-constructed survey. Furthermore, if teachers have an interest, they should ascertain the learning styles of their students, and provide insight on how learning styles influence

students' preferences for instruction. Learning style scores could be used in conjunction with preference surveys to identify potential matching problems.

3. Opportunities for group work should be given to those students who are hesitant to work on the computer alone. Research shows that AR students enjoy working with others and sharing ideas during the learning process (Butler, 1984). Since the focus shifts from being intimate with a machine to working collaboratively with a group, the potentially negative effects of CAL for these individuals may be masked and/or lessened.
4. Government Departments of Education should remain cautious with sweeping decisions to convert entire curricula onto electronic media (as was mentioned in the article by Dwyer, 1996). The goals of such a process should be weighed against the potential problems (e.g., alienating certain learners).
5. To avoid alienating a certain learning style group, educators should continue to incorporate a number of different teaching strategies into their lessons. If a particular student is unable to learn from the computer, instructors should provide alternative ways for content to be delivered.

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Search Process: The researcher used the following key words to search the ERIC and Psych Lit databases (both on CD-ROM) and CARL UNCOVER database (on Internet): Gregorc, learning styles and computer, individual differences and computer, motivation and computer, attitudes and computer, domain knowledge, expert-novice, Aptitude Treatment Interaction, ATI and computer.

In addition, the researcher obtained a number of sources from the Ed-Media/Ed-Telecom conference proceedings, article reference lists, as well as from professors and other colleagues.

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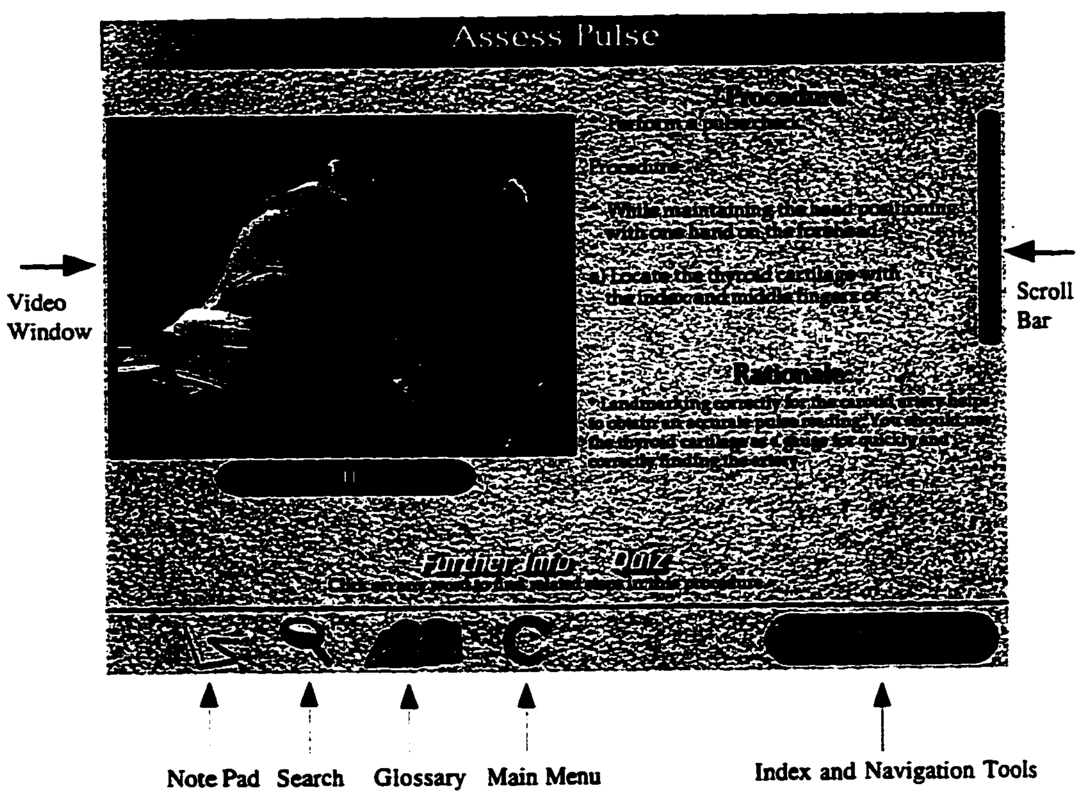
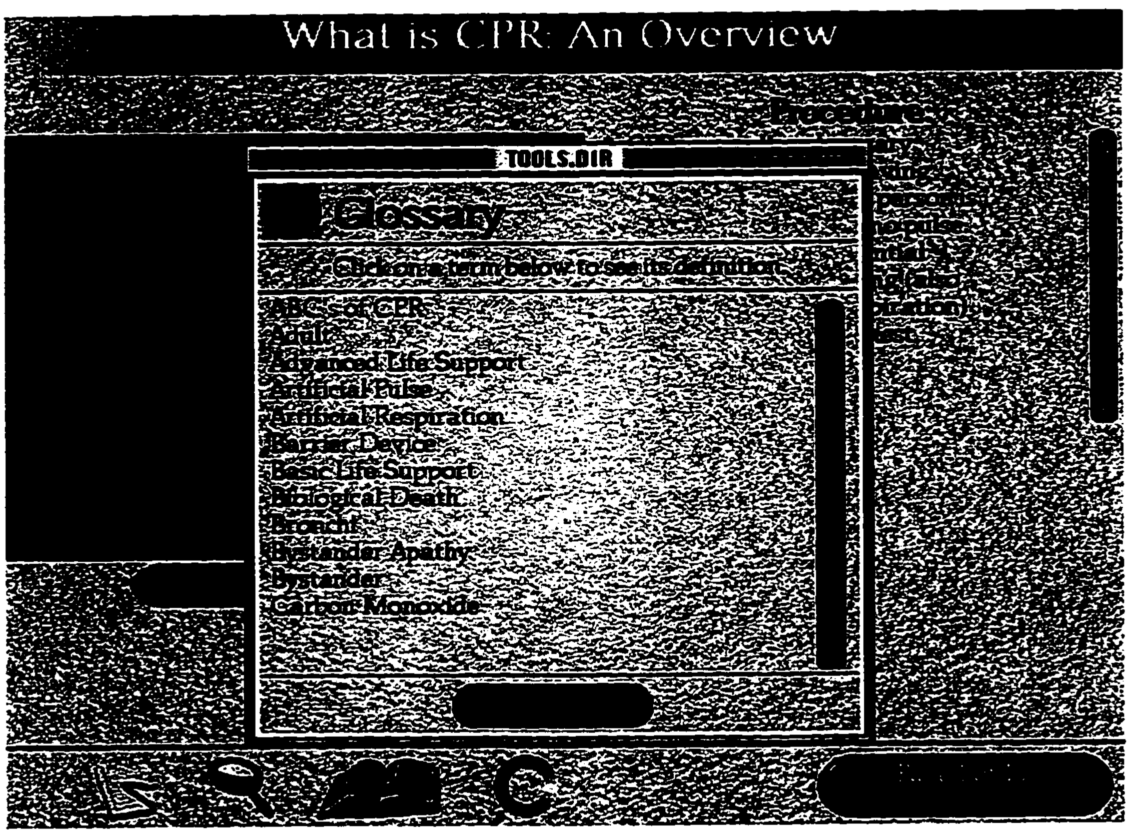
APPENDIX A: SAMPLE PROGRAM SCREENS

The next several pages contain screen shots of the tutorial program. This has been included to help the reader become familiar with the program interface. To obtain further information regarding the interface and the experiment in general, please use the accompanying CD-ROM.

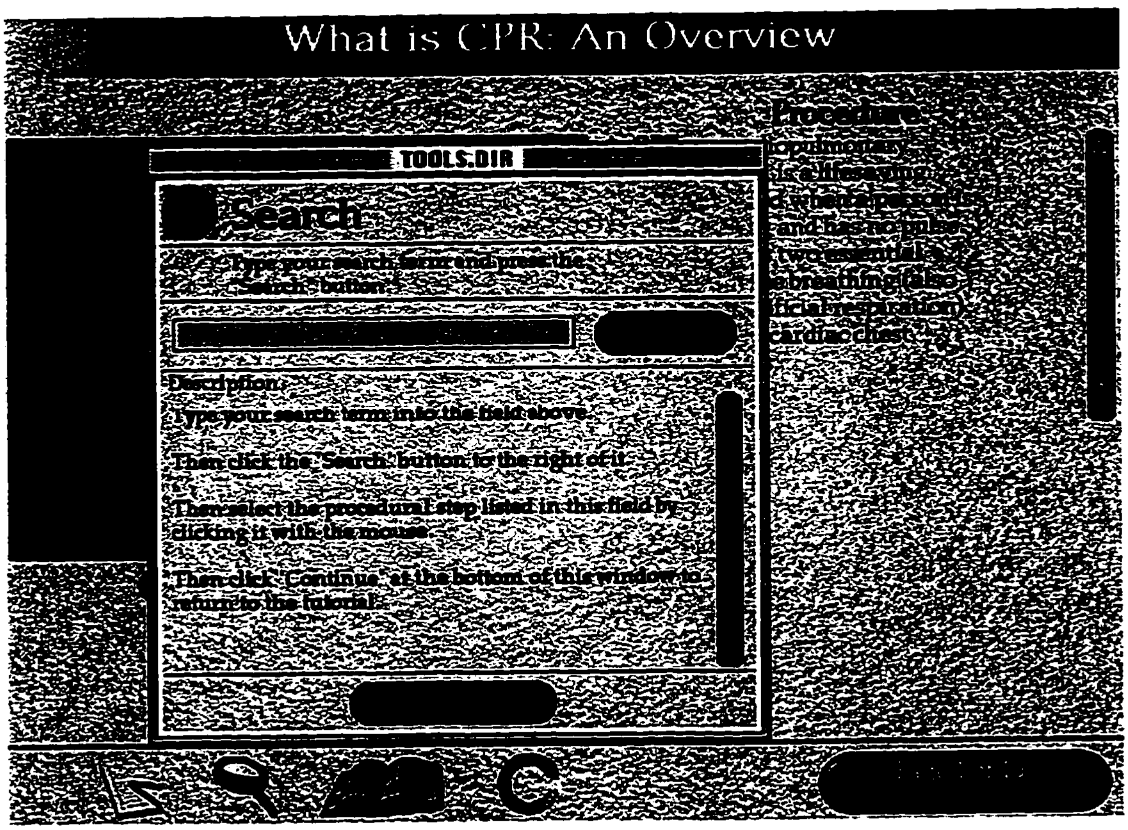
A: A sample tutorial program screen:



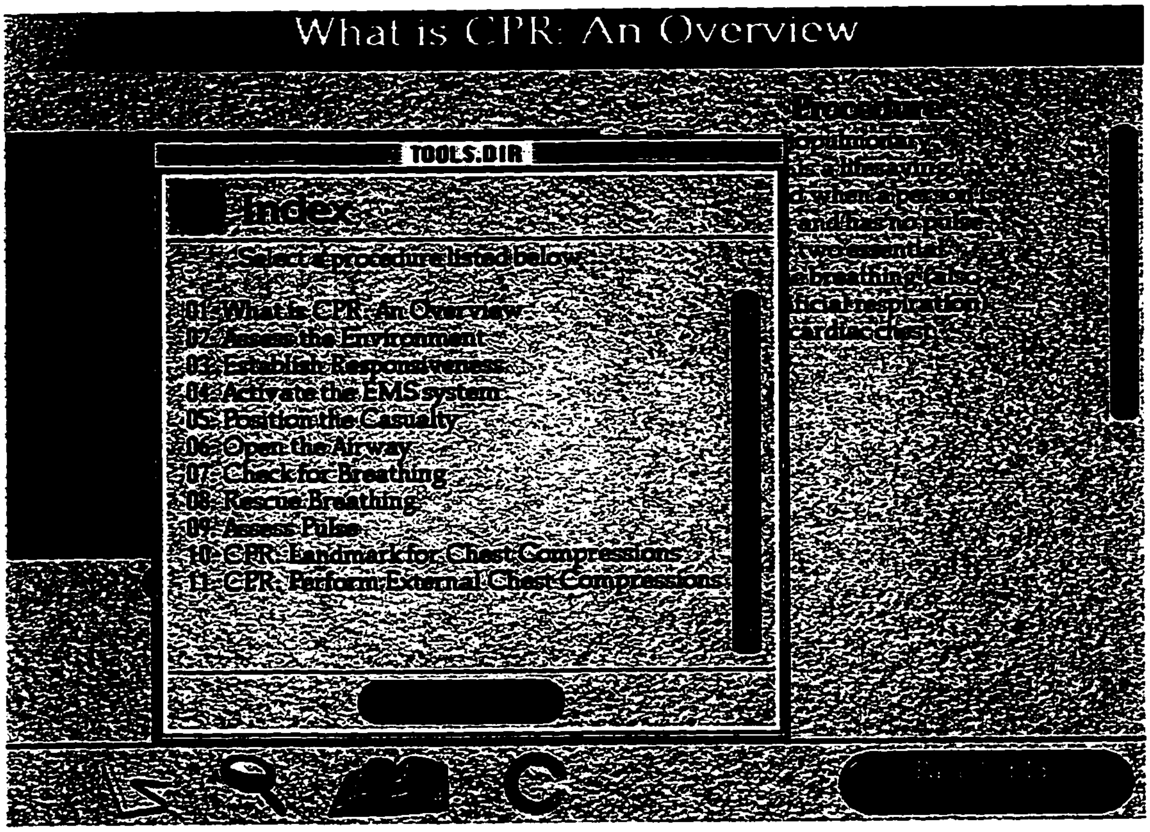
B: The glossary tool feature:



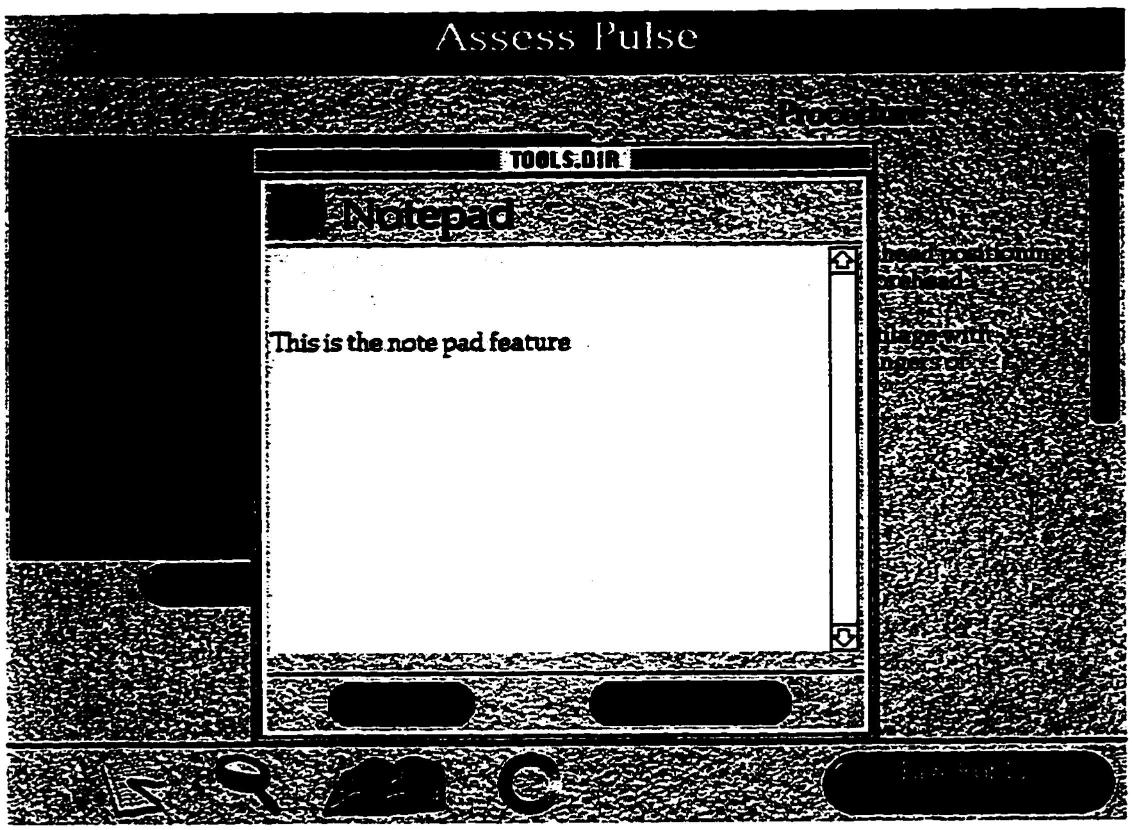
C: The Search tool feature



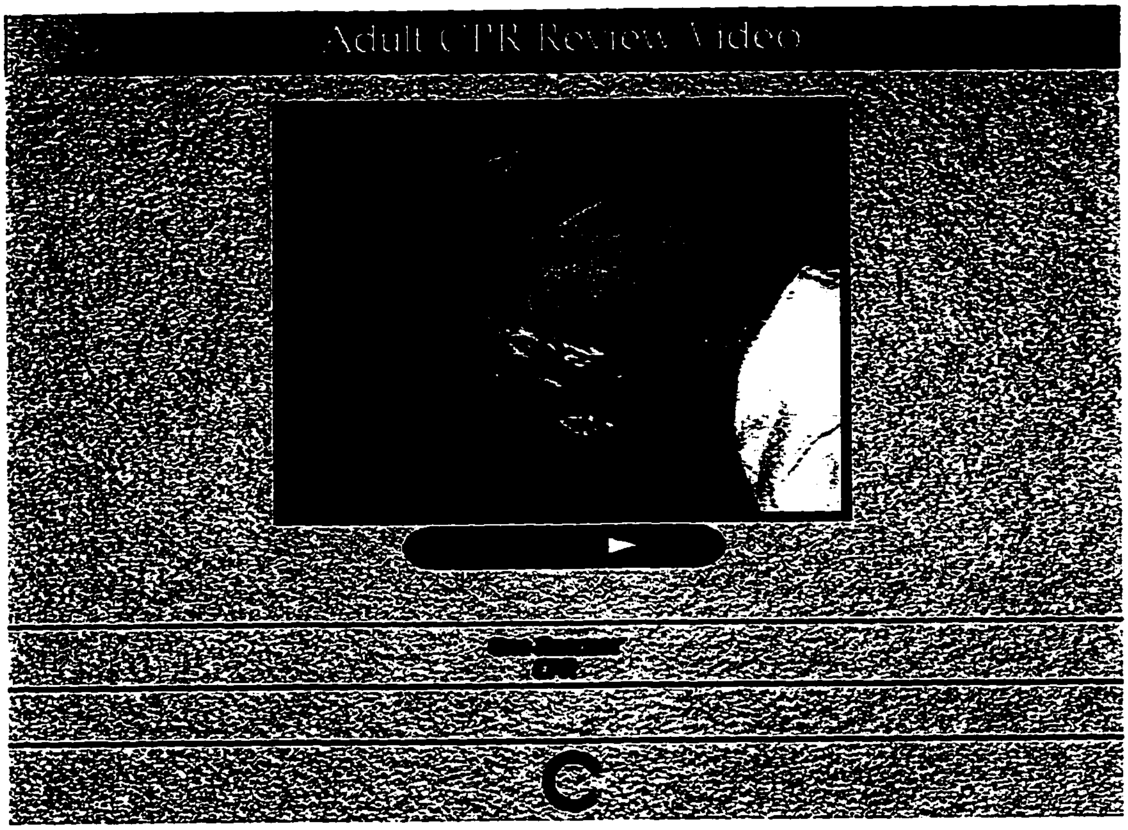
D: The Index tool feature



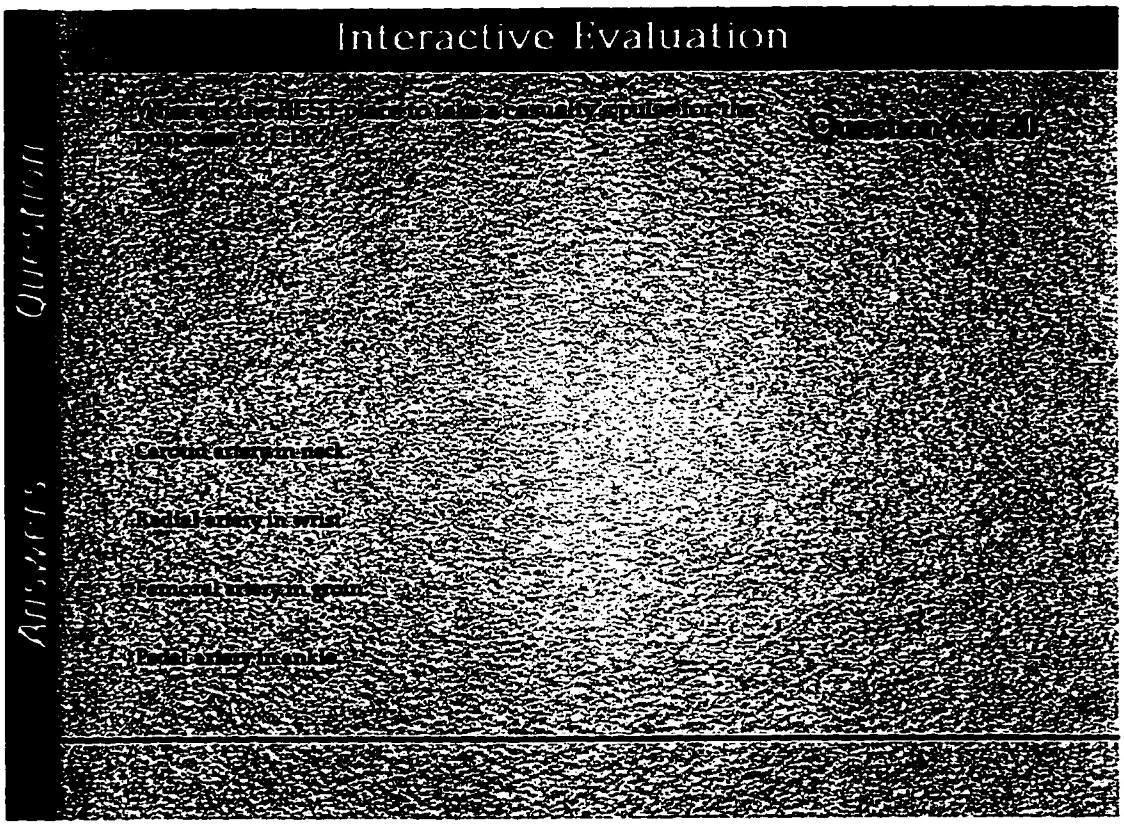
E: The Note Pad tool feature:



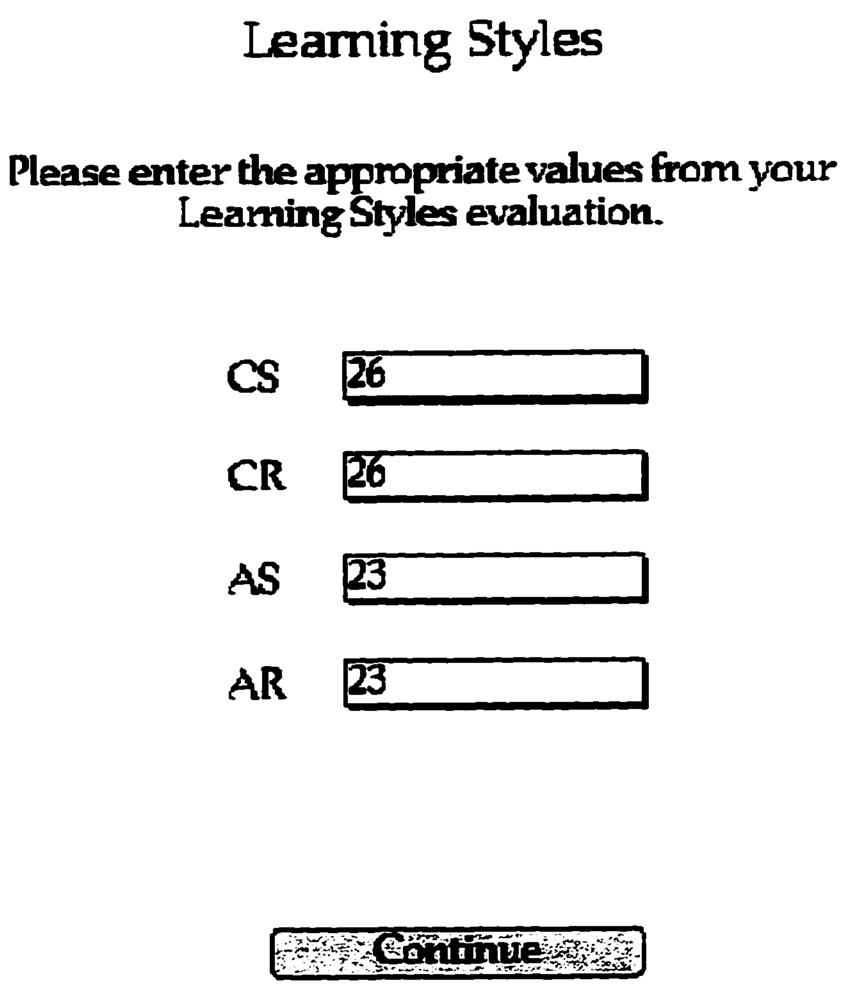
F: The Review Video section



G: A sample test screen:



H: The preliminary learning style entry screen



APPENDIX B: SAMPLE LETTER OF CONSENT

Letter of Consent

This form confirms the consent of ______________________ to participate in the research project entitled 'The effects of learning styles on human-computer interaction: Implications for computer-aided learning'. This study will be conducted by Jonathan Ross under the supervision of Dr. Ian Winchester in the Graduate Division of Educational Research.

I have been informed, to the appropriate level of understanding, about the purpose and methodology of this research project, the nature of my involvement and any possible risks to which I may be exposed by virtue of my participation.

I agree to participate in this project by doing the following:

- Complete the Gregorc Style Delineator learning styles assessment
- Complete the on-line questionnaire
- Interact with the CPR CD-ROM program
- Compete two multiple choice quizzes

I understand and agree that

- My participation is voluntary and that I have the right to withdraw from this research at any time without penalty
- The researcher has a corresponding right to terminate my participation in this research at any time
- All data will be kept in a secure place inaccessible to others
- Data will be disposed of three years after the completion of the project
- Confidentiality and anonymity will be assured through the assigning of a number to each participant

The benefits of participation include a free CPR Basic Rescuer course conducted by the researcher.

The risks involved in partaking in this study are no greater than those experienced in daily life.

I have read the consent form and I understand the nature of my involvement. I agree to participate within the above parameters.

Name:______________________________

Date: ____________________

Signature of Participant: ________________________________

APPENDIX C: SAMPLE AUDIT TRAIL REPORT

CPR CD-ROM STUDY REPORT

Trial completed at 6:39 PM on Wednesday, February 5, 1997

LEARNING STYLES:

CS: 38
CR: 22
AS: 26
AR: 14

PRELIMINARY SURVEY RESULTS:

GENDER: male
YEAR OF PROGRAM: 4
FACULTY: Other
# of CPR COURSES: 1
CPR CONFIDENCE: 5
COMPUTER CONFIDENCE: 2

SUMMARY REPORT OF ACTIVITY

TOTAL TIME IN PROGRAM: 8 minutes (5902 seconds)
PRETEST SCORE: 12
POSTTEST SCORE: 14
GENERAL TREND OF NAVIGATION (+/- score): 7
TOTAL NUMBER OF EVENTS: 72

NUMBER OF MENU EVENTS: 4
NUMBER OF NAVIGATION EVENTS: 47
NUMBER OF TOOL EVENTS: 7
NUMBER OF VIDEO EVENTS: 14

DETAILED REPORT OF ACTIVITY:

events are listed as seconds: event description.

MENU EVENTS:
3828: Theatre
4225: Tutorial
4229: topic:Two Rescuer CPR
5902: quit

NAVIGATION EVENTS:
4231: change page: chapter 1 page 1
4336: next page
4336: change page: chapter 1 page 2
4377: next page
4377: change page: chapter 1 page 3
4398: next page

4398: change page: chapter 1 page 4
4471: next page
4472: change page: chapter 1 page 5
4541: next page
4541: change page: chapter 1 page 6
4591: next page
4591: change page: chapter 1 page 7
4638: next page
4638: change page: chapter 1 page 8
4765: next page
4765: change page: chapter 1 page 9
4815: next page
4815: change page: chapter 1 page 10
4858: next page
4858: change page: chapter 1 page 11
4913: next page
4914: change page: chapter 1 page 12
4945: previous page
4945: change page: chapter 1 page 11
4984: next page
4984: change page: chapter 1 page 12
4998: next page
4998: change page: chapter 1 page 13
5024: next page
5024: change page: chapter 1 page 14
5079: next page
5080: change page: chapter 1 page 15
5181: previous page
5181: change page: chapter 1 page 14
5227: previous page
5227: change page: chapter 1 page 13
5258: previous page
5258: change page: chapter 1 page 12
5279: previous page
5279: change page: chapter 1 page 11
5355: previous page
5355: change page: chapter 1 page 10
5400: previous page
5400: change page: chapter 1 page 9
5429: previous page
5429: change page: chapter 1 page 8

TOOL EVENTS:
5138: quiz
5184: quiz
5230: quiz
5260: quiz
5282: quiz
5359: quiz
5403: quiz

VIDEO EVENTS:
3874: change volume
3874: change volume
3875: change volume
4128: rewind

4129: rewind
4135: play
4220: pause
4247: change volume
4247: change volume
4248: change volume
4955: change volume
4958: change volume
4958: change volume
4960: change volume

TOTAL EVENT REPORT:
3828: menu,Theatre
3874: video,change volume
3874: video,change volume
3875: video,change volume
4128: video,rewind
4129: video,rewind
4135: video,play
4220: video,pause
4225: menu,Tutorial
4229: menu,topic:Two Rescuer CPR
4231: navigation,change page: chapter 1 page 1
4247: video,change volume
4247: video,change volume
4248: video,change volume
4336: navigation, next page
4336: navigation,change page: chapter 1 page 2
4377: navigation, next page
4377: navigation,change page: chapter 1 page 3
4398: navigation, next page
4398: navigation,change page: chapter 1 page 4
4471: navigation, next page
4472: navigation,change page: chapter 1 page 5
4541: navigation, next page
4541: navigation,change page: chapter 1 page 6
4591: navigation, next page
4591: navigation,change page: chapter 1 page 7
4638: navigation, next page
4638: navigation,change page: chapter 1 page 8
4765: navigation, next page
4765: navigation,change page: chapter 1 page 9
4815: navigation, next page
4815: navigation,change page: chapter 1 page 10
4858: navigation, next page
4858: navigation,change page: chapter 1 page 11
4913: navigation, next page
4914: navigation,change page: chapter 1 page 12
4945: navigation, previous page
4945: navigation,change page: chapter 1 page 11
4955: video,change volume
4958: video,change volume
4958: video,change volume
4960: video,change volume
4984: navigation, next page
4984: navigation,change page: chapter 1 page 12
4998: navigation, next page

4998: navigation,change page: chapter 1 page 13
5024: navigation, next page
5024: navigation,change page: chapter 1 page 14
5079: navigation, next page
5080: navigation,change page: chapter 1 page 15
5138: tool,quiz
5181: navigation, previous page
5181: navigation,change page: chapter 1 page 14
5184: tool,quiz
5227: navigation, previous page
5227: navigation,change page: chapter 1 page 13
5230: tool,quiz
5258: navigation, previous page
5258: navigation,change page: chapter 1 page 12
5260: tool,quiz
5279: navigation, previous page
5279: navigation,change page: chapter 1 page 11
5282: tool,quiz
5355: navigation, previous page
5355: navigation,change page: chapter 1 page 10
5359: tool,quiz
5400: navigation, previous page
5400: navigation,change page: chapter 1 page 9
5403: tool,quiz
5429: navigation, previous page
5429: navigation,change page: chapter 1 page 8
5902: menu,quit

APPENDIX D: SAMPLE TEST QUESTIONS

(**N.B.** Subjects were to click on the appropriate answer
* indicates correct answer)

For an adult casualty, each breath should last ____to _____seconds in length.

0.5 to 1
1 to 1.5
1.5 to 2 *
2 to 2.5

After which step should EMS be called for an adult casualty?

Establishing unresponsiveness. *
Opening the airway.
Checking for breathing.
One minute of CPR.

A rescuer finishes her last cycle of CPR with the fifteenth compression. She then proceeds to check the carotid artery for 5 seconds. After finding that the casualty has no pulse, she begins her next set of CPR with 15 compressions. What (if anything) did the rescuer do wrong?

The rescuer:

Did not finish the last cycle of CPR with one slow breath.
Failed to activate the EMS system after her first set of CPR.
Did everything according to procedure.
Did not finish the CPR cycle with two slow breaths.*

Where is the BEST place to take a casualty's pulse for the purposes of CPR?

Carotid artery in neck. *
Radial artery in wrist.
Femoral artery in groin.
Pedal artery in ankle.

Where is the BEST place to take a casualty's pulse for the purposes of CPR?

Carotid artery in neck. *
Radial artery in wrist.
Femoral artery in groin.
Pedal artery in ankle.

For a breath check, you should place your____over the casualty's ________.

hand, mouth and nose
ear, chest
ear, mouth and nose *
hand, chest

You find that a casualty is not responsive so you send your friend to call EMS. You then open the casualty's airway and check for breathing for 5 seconds. The casualty is not breathing so you give her 2 breaths lasting 1.5 seconds.

What (if anything) was performed incorrectly?

Everything was performed correctly.*
You should have called EMS yourself.
Each breath should last 2 seconds in length.
You should have checked for breathing before calling EMS.

In which of the following situations should you use the recovery position?

A casualty is unconscious. He is breathing and there is no possibility of a spinal injury. *
A casualty is not breathing, and there is no possibility of spinal injury.
A casualty is unconscious. He is breathing and there is possible abdcminal and chest injuries.
In each of the above situations should you use the recovery position.

How many cycles of CPR should be performed for an adult casualty before reassessing pulse?

One
Two
Three
Four *

8. Which step in the following list is out of order?

1) Assess environment
2) Check responsiveness
3) Open airway
4) Check breathing
5) Give 2 breaths
6) Check pulse
7) Perform 4 cycles of CPR
8) Call EMS

No steps are out of order.
Step 5
Step 8 *
Step 7

Place the following steps in order:

1) Open airway
2) Check scene
3) Call EMS
4) Check responsiveness
5) Look listen and feel for breathing

1,2,3,4,5
2,4,1,3,5
2,1,4,3,5
2,4,3,1,5 *

What should you do if you find your first ventilation attempt unsuccessful?

Attempt to ventilate again.
Readjust the airway and attempt to ventilate once again.*
Readjust the airway and check for breathing for 3-5 seconds.
Readjust the airway and perform 5 abdominal thrusts.

APPENDIX E: PRELIMINARY SURVEY QUESTIONS COLLECTED ON-LINE

Gender

______M
______F

Year of Degree Program

______1
______2
______3
______4

Faculty

______ Kinesiology
______ Nursing
______ Other

How many CPR Basic Rescuer courses/refreshers have you taken within the last 5 (five) years?

_____0
_____1
_____2
_____3
_____4
_____5

How confident are you with your CPR skills? (1=very confident, 5 = not confident at all)

______1
______2
______3
______4
______5

How comfortable are you with using computers ? (1=very comfortable, 5 = very uncomfortable)

______1
______2
______3
______4
______5

Appendix F: ANECDOTAL NOTES

Follow-up telephone interviews were conducted with two individuals who decreased from pre-test to post-test by three points or more; similarly, interviews were conducted with two participants who increased from pre-test to post-test by three or more points. The researcher knew the four interviewees and asked permission to follow-up with telephone interviews. Two of the four interviews conducted will be examined in detail below.

Subject One

Background

A strong Abstract Sequential (33), subject 1 had a limited CPR background, taking one course over the last five years. CPR confidence levels were extremely low (5) and computer comfort level was moderately high (2). Spending close to 30 minutes in the CAL program, subject 1 recorded a high number of events (72), indicating a moderate to high level of interaction with the program. He relied heavily on video as a source of learning recording 31 video events. Upon closer examination of the audit trail, the subject rewound and played video at least two times per screen. His navigation score was 14, indicating linear movement through the program.

Subject 1 recorded a pre-test score of 6 points, a figure that is commensurate with the level of CPR knowledge expected. The post-test score of 12 indicates a substantial gain in achievement.

Interview Findings

Subject 1 indicated that he has used CAL programs to learn subject areas such as Anatomy and Physiology (citing the A.D.A.M. program as being a "lifesaver" during his first year of Kinesiology studies). He enjoys the freedom and flexibility that CAL offers the learner. He also enjoys learning with text, video and graphics, features subject 1 comments that textbooks do not offer.

The CAL session went very well according to this subject. His audit trail file shows a consistently high level of engagement.

> I really feel that I learned something. I liked the way the steps were broken down with video and text. It really helped me learn the steps.

Clearly, subject 1 found the CAL session to be highly beneficial. The gain of six points from pre-test to post-test shows how well this dominant AS person learned from the computer.

Subject 2

Background

A strong Abstract Random (point value = 32), subject 2, a female who has graduated from University over ten years ago, recorded having one CPR course in the last five years. She rated her CPR and computer confidence levels at '3'. Subject 2 spent 26 minutes in the program and showed a three point decrease in post-test score (from 13 to 10). Navigation was somewhat linear (12), and interaction with the program was moderate (events = 40). Subject 2 used only one tool and recorded eight video events.

Interview Findings

Subject 2 was not surprised that her achievement score decreased. Here is a portion of the interview session:

> I have never really taken to the computer. I have been almost forced to work with them at work. Many of my colleagues also cannot stand them. I cannot imagine why anyone would go out of their way to learn from a computer program.

When asked why she thought her post-test score was lower than her pre-test score, subject 2 could not respond. She just "knew" that it (the session) did not feel natural. This appears to be a clear case of what Gregorc (1982b) labelled as "mismatching". The medium did not match this individual's preferred way of learning, and, as a result, she did not achieve to expected levels.

Appendix G: CROSSTAB PRINT-OUTS

1. Dominant Learning Style by Degree Route

DOM	Count / Row Pct	Kines 1	Nursing 2	Other 3	Row Total
Conc-Seq	1	4	6	10	20
		20.0	30.0	50.0	28.6
		20.0	33.3	31.3	
Conc-Ran	2	7	3	10	20
		35.0	15.0	50.0	28.6
		35.0	16.7	31.3	
Abs-Seq	3	3	4	7	14
		21.4	28.6	50.0	20.0
		15.0	22.2	21.9	
Abs-Rand	4	6	5	5	16
		37.5	31.3	31.3	22.9
		30.0	27.8	15.6	
	Column Total	20	18	32	70
		28.6	25.7	45.7	100.0

2. Dominant Learning Style by Gender

Style	Row Pct	Male 1	Female 2	Row Total
Conc-Seq	1	6	14	20
		30.0	70.0	28.6
		23.1	31.8	
Conc-Ran	2	7	13	20
		35.0	65.0	28.6
		26.9	29.5	
Abs-Seq	3	8	6	14
		57.1	42.9	20.0
		30.8	13.6	
Abs-Rand	4	5	11	16
		31.3	68.8	22.9
		19.2	25.0	
	Column Total	26	44	70
		37.1	62.9	100.0

3. Dominant Learning Style by CPR Confidence (1 = very confident, 5 = not confident at all)

DOM	Row Pct / Col Pct	CPR Confidence 1	2	3	4	5	Row Total
1		3	4	4	2	7	20
Conc-Seq		15.0	20.0	20.0	10.0	35.0	28.6
		50.0	25.0	28.6	12.5	38.9	
2		2	5	2	6	5	20
Conc-Ran		10.0	25.0	10.0	30.0	25.0	28.6
		33.3	31.3	14.3	37.5	27.8	
3			2	1	5	6	14
Abs-Seq			14.3	7.1	35.7	42.9	20.0
			12.5	7.1	31.3	33.3	
4		1	5	7	3		16
Abs-Rand		6.3	31.3	43.8	18.8		22.9
		16.7	31.3	50.0	18.8		
	Column Total	6	16	14	16	18	70
		8.6	22.9	20.0	22.9	25.7	100.0

4. Dominant Learning Style by Computer Confidence (1 = very confident, 5 = not confident at all)

DOM	Row Pct / Col Pct	Computer Confidence 1	2	3	4	5	Row Total
1		5	6	5	4		20
Conc-Seq		25.0	30.0	25.0	20.0		28.6
		21.7	28.6	38.5	40.0		
2		6	6	5	2	1	20
Conc-Ran		30.0	30.0	25.0	10.0	5.0	28.6
		26.1	28.6	38.5	20.0	33.3	
3		8	5			1	14
Abs-Seq		57.1	35.7			7.1	20.0
		34.8	23.8			33.3	
4		4	4	3	4	1	16
Abs-Rand		25.0	25.0	18.8	25.0	6.3	22.9
		17.4	19.0	23.1	40.0	33.3	
	Column Total	23	21	13	10	3	70
		32.9	30.0	18.6	14.3	4.3	100.0

5. Dominant Learning Style by CPR Course Background (Number of Courses)

DOM	Row Pct / Col Pct	CPR Course Background 1	2	3	4	5	Row Total
Conc-Seq	1	10	3	4	1	2	20
		50.0	15.0	20.0	5.0	10.0	28.6
		26.3	23.1	44.4	20.0	40.0	
Conc-Ran	2	16	2	1		1	20
		80.0	10.0	5.0		5.0	28.6
		42.1	15.4	11.1		20.0	
Abs-Seq	3	10	2	1	1		14
		71.4	14.3	7.1	7.1		20.0
		26.3	15.4	11.1	20.0		
Abs-Rand	4	2	6	3	3	2	16
		12.5	37.5	18.8	18.8	12.5	22.9
		5.3	46.2	33.3	60.0	40.0	
	Column Total	38	13	9	5	5	70
		54.3	18.6	12.9	7.1	7.1	100.0

6. Dominant Learning Style by CPR Course Background

CPRBGN	Row Pct / Col Pct	Kines. 1	Nursing 2	Other 3	Row Total
	1	8	4	26	38
		21.1	10.5	68.4	54.3
		40.0	22.2	81.3	
	2	7	3	3	13
		53.8	23.1	23.1	18.6
		35.0	16.7	9.4	
	3	1	6	2	9
		11.1	66.7	22.2	12.9
		5.0	33.3	6.3	
	4	1	4		5
		20.0	80.0		7.1
		5.0	22.2		
	5	3	1	1	5
		60.0	20.0	20.0	7.1
		15.0	5.6	3.1	
	Column Total	20	18	32	70
		28.6	25.7	45.7	100.0