THE UNIVERSITY OF CALGARY

Lesson Control and Prior Notification of Lesson Control Type in a Computer-Aided Lesson.

by

William Douglas Murray

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR

THE DEGREE OF MASTER OF SCIENCE

DEPARTMENT OF EDUCATIONAL PSYCHOLOGY

CALGARY, ALBERTA

AUGUST, 1998

National Library
of Canada

Acquisitions and
Bibliographic Services

395 Wellington Street
Ottawa ON K1A 0N4
Canada

Bibliothèque nationale
du Canada

Acquisitions et
services bibliographiques

395, rue Wellington
Ottawa ON K1A 0N4
Canada

Your file Votre référence

Our file Notre référence

0-612-34981-0

Canada

ABSTRACT

Post-test performance, student attitude, prior knowledge, navigation log data were analyzed using two groups, one learner control focus (LCF) and the other program control focus (PCF). On entering the lesson, half of each group was notified of the correct lesson control focus, and half we incorrectly notified. Prior knowledge was determined by pre-testing and self-rating. There was a significant gain ($p < .05$) between pretest and post-test across conditions. There were no significant differences by group or subgroup in attitude, prior knowledge, post-test performance, or due to prior notification of control type. PCF group participants were more likely to rate their program as higher in program control, as there were no differences in the LC ratings. There were differences in navigation patterns for some LCF students. Significant is the lack of correlation between participant interactivity rating and learner control rating on the survey. Participants with both higher prior knowledge and higher post test scores spent less time in the simulation and problem modules. The instructional design of the program may have contributed to results that are largely inconsistent with other research.

ACKNOWLEDGMENTS

I appreciate the support and help of Dr. John Mueller, my supervisor, Dr. Tak Shing Fung for demystifying statistics and helping me with SPSS, and to the members of my committee.

I would like to acknowledge the loving support of my wife, Angeline Fitch, Ph.D., for all her help, understanding, emotional and financial support and to our son, Berkeley, for tolerating my hermit periods, when I was shut away in my office.

Thanks and appreciation go to CDI College of Business & Technology, especially Terry Allam for providing space and volunteer participants for my project. Appreciation is extended to all participants: I couldn't have done it without you.

A special thanks to LCDR Pete Casalegno, USN, for providing the initial support and encouragement back in 1980 necessary to start my exploration of advanced education.

Also an extra special thank you goes to the faculty and staff of the Department of Educational Psychology and The Faculty of Graduate Studies for their ongoing support and help throughout my course of studies.

DEDICATION

In memory of my beloved sister,

Sarah Gridley-Eubank

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Technology and educational psychological theory together provide the basis for lesson control in computer-aided instruction (CAI). We are now in the third generation of lesson control theory and research. This does not mean that the first two generations are invalid, only that we have more, and, in many cases, better options than we had in the past. The three generations each may be said to have an accompanying learning theory. The three generations are Behaviourist/Empirist -- Main-Frame Era, The Cognitive/Rationalist-Personal Computer Era, and the Situative/Pragmatist/Sociohistoric-Multimedia Era. The learning theory categories are suggested by Greeno, Collins and Resnik (1996). The era categories do not indicate the relevance of any of the eras, but rather a stage along a single timeline in the progress of technology and education theory. In fact, there is strong support for all three educational theories in any given learning situation.

Behaviourist/Empiricist-Mainframe Era

In the main-frame computer era, computers were expensive, and difficult to program. Only large institutions could afford the technology. At the same time, the prevailing educational psychological view was focused on the acquisition of knowledge and skills. Computers could support the acquisition of knowledge through structured, objective-oriented and individualized training. (Greeno et al., 1996). Learners could, in theory, schedule and monitor their own progress. Progress was measured against objectives, and was measured often by testing for the completion of objectives. Learners

could make mistakes free of criticism. Lessons were primarily Drill and Practice or Tutorial in nature.

The Cognitive/Rationalist-Personal Computer Era

When Apple, Commodore, and Tandy introduced personal computers in 1977, cognitive educational theory was becoming the dominate learning model. Greeno et al. (1996) describe the interactive learning environments which focus on the construction of understanding. "Learning environments can be organized to foster students' constructing understanding of concepts and principles through problem-solving and reasoning in activities that engage students' interest and use of their initial understand[ing]s and their general reasoning and problem-solving abilities" (p. 27).

Students were given more control over their own learning, including computer-aided instruction (CAI). With increased control, students could control the sequence and amount of lesson they wanted. Research concentrated on student choice in lesson sequencing, number of practices, and amounts reviewed. At the same time, personal computer and technological advances were providing greater capability for the lesson designer. A computer-controlled videodisc was a common melding of computer and technology. This era saw less emphasis on drill and practice, and more on the development of simulations (though some would argue that some simulations are behaviourist), problem solving programs, and educational games.

Situative/Pragmatist-Sociohistoric-Multimedia Era

While cognitive/rationalist theory is still widespread, situative/pragmatist-

sociohistoric theory is adding new dimensions to our understanding of how people learn. The learning environment includes participation in the social practices of inquiry and learning. Greeno et al. (1996) described the learning environment of this era, as follows:

> Learning environments can be organized to foster students' learning to participate in practices of inquiry and learning to support the development of students' personal identities as capable and confident learners and knowers. These activities include formulating and evaluating questions, problems, conjectures, arguments, explanations, and so forth, as aspects of social practices of sense-making and learning. (p. 27)

Research in this era was concerned with computer support in cooperative and group learning, modeling and cognitive overload. Multimedia provides for multi-modal learning. Learner control research begins to focus on the learners' understanding of the concepts and models used by the programmer and how they affect the learner, and how CAI can fit into cooperative and group learning.

Today, research continues in these domains, research where technology no longer limits the integration of learning theory into computer-aided lesson design. As computer-aided learning research matures, our understanding increases in some areas, while new technologies and their applications, coupled with learning theory advances, provide new opportunity for research.

Prior to the availability of personal computers, lesson control generally consisted of allowing students to have flexible lesson hours and the freedom to make errors without criticism. This limited view of learner control was due to the prevailing pedagogical

practice and the limitations of technology. In this behaviourist era, computers were large, expensive, and difficult to program. The prevailing educational psychological thought centered on meeting the individual users' need (the acquisition of knowledge) through highly structured programs. Many of these programs, in the Skinnerian model, would vary program path in response to student progress, but otherwise the student had little direct control over the program. Borsook (1991) would argue that these and all computer-aided lessons have some degree of learner control, but it seems very minimal here.

The introduction of personal computers came at a time when educational psychologists were taking a more cognitive approach to lesson development. This cognitive approach saw the student as an active partner in learning, whereby the student builds his/her own reality. Lesson control was beginning to include more learner control. Technology and educational psychology theory had moved beyond the limitations of the mainframe era. With the enhanced capabilities inherent in current technology, we can move past technology-driven computer-aided instruction (CAI) to educational-principle based CAI. That is, the technology no longer limits the application of educational psychological principles in instructional design.

In the past few years, learner control has begun to take on new meanings, in that the lesson design itself is a form of control (Sims & Hedberg, 1995). Students' success can depend on their ability to grasp what concept or metaphor the designer used in program development. This research did not explore this aspect of learner control in detail; instead it concentrated on the second era, the Cognitive/Pragmatist Era.

Borsook and Higgenbotham-Wheat (1991) outline this second era of lesson

control. Although acknowledging lesson control is complex, they state that the concept is simple: when students are given greater control over their learning, they can approach a lesson in a manner more appropriate to their needs which "... enhanc[es] the efficacy and efficiency of learning. Furthermore, this greater freedom should motivate students, thus enhancing learning even more" (p. 13).

This view has been further enhanced by third-era research. The student first must understand the structure and functions contained in the program (Jih & Reeves, 1992), especially if the model, structure, or metaphor used by the program is unfamiliar to the learner. Students' problems in achieving lesson goals or completing interactions may indicate structural problems within the program. Inappropriate control functions may interrupt instructional transactions (Sims & Hedberg, 1995).

In cognitive-based learning theory, meaning is seen as rooted in, and indexed by experience (Duffy & Jonassen, 1991). What students already know concerning a subject has impact on how they will approach a lesson.

Significance of Research

Lesson control includes both learner control focus (LCF) and program control focus (PCF). The use of the terms LCF and PCF suggest a bi-polar relationship between two methods of control. Research suggests that the relationship is not bipolar, but a matter of degree of learner control. Borsook (1991) places all software somewhere along a continuum between total learner control and total program control. In this view, LCF lessons provide a greater degree of student control than is found in PCF lessons. The term "learner control" refers to allowing the learner some control in an individualised

lesson. The learner may control lesson pace, sequence, content (and/) or feedback. This is in contrast to program control, where the computer controls the flow of the lesson (Milheim, 1989). Interactive software hands over some degree of control of the learning experience to the learner, and it is this interactivity that gives CAL such potential (Borsook, Higginbotham-Wheat, 1991). An alternative, although not necessarily opposing, view is found in the Generative Theory of Multimedia Learning (Mayer, 1997). In this model, "the learner is viewed as a knowledge constructor who actively selects and connects pieces of visual and verbal knowledge" (p. 4). These views seem to indicate a learner control approach to lesson design, yet a review of research fails to support a learner control approach for all learners or in all situations. Research concerning lesson control generally supports learning benefits from greater learner control for experienced learners, but relatively more structure is best for novice learners, those learners without a prior subject matter knowledge base. Experienced learners tend to learn from PCF lessons as well as novice learners do, but they experience higher self-efficacy when they are given more lesson control.

Objectives of the Research Question

The purpose of this research project is to revisit lesson control focus to determine the relationship between prior knowledge and the focus of lesson control, as measured by lesson grades and student attitude assessment. A second objective is to determine whether prior notification of the lesson control focus will affect these same measurements. That is, will the prior notification of control focus (i.e. LCF or PCF) prime the student to look for indications of the primed control type or control focus in general?

Question: Will prior domain knowledge, lesson control focus, and/or prior notification of control type significantly impact student performance or attitude in a lesson, as measured by post-test scores, navigation log analysis, and survey results? With an alpha level of .05, post-test scores are expected to be significantly higher than pretest scores, significant group or subgroup mean differences are expected in test scores.

CHAPTER 2

LITERATURE REVIEW

Previous research into lesson control has produced mixed results. This includes research into the program structure, options, sequence, and feedback. Williams (1993a), in a comprehensive review of lesson control research, found that LCF lessons produced inconsistent results when compared to PCF lessons. The inconsistency has been attributed to a number of factors, including learning differences, prior knowledge, type of material being covered, and lesson context.

Relan (1991) argues that students can frequently make the appropriate decision within the context of a CAI lesson. In particular, he argues that students should be given the choice of how many items they need to complete a concept. He concludes, " . . . the unique needs of students may be more efficiently met by providing individuals with control of their activities that comprise instruction" (p. 8). However, frequently students are unable to make appropriate decisions in LCF lessons. Subject-matter novices report confusion and frustration over choice making, and/or made poor choices when using learner control programs (Atkinson, 1972; Fisher, Blackwell, Garcia, & Greene, 1975; Park & Tennyson, 1980).

Ross and Rokow (1981) reported higher test score results for PCF math fact lessons compared to LCF and lecture lessons. Of the three, the LCF means were the lowest. The advantage of the PCF lesson increased across retention intervals and as prior knowledge decreased. These researchers attributed the unexpected performance to the lack of domain-specific meta-cognitive skills, or to the lack of meta-cognitive skills in

general. While the technology available when the previous studies were competed was less sophisticated than today's, the trend continues.

Young (1996) was more specific when discussing why LCF students did not do as well as PCF students. He found that students with low self-regulated learning strategies (SRLS) performed less well in the LCF lesson than they did in the PCF lesson, whereas students with high SRLS performed equally well in both lessons, but high SRLS Students liked the LCF lesson more. Self-regulation refers to the students' systematic use of meta-cognitive, motivational and behavioral strategies to complete the lesson (Zimmerman, 1990). Relan (1991) found that LCF increases learners' feelings of perceived control and self-efficacy, consistent with this argument.

Studies Supporting a Learner Control Focus (LCF)

Simsek (1993) found a significant effect for learner-control students working in a group environment. The LCF groups had significantly higher scores on the post-test and a two week delayed post-test, and he reported better time spent on task, verbal interaction, and attitudes. Gray (1987) compared a group taking a linear lesson with a group who had to make branching decisions on every screen. She found that the latter group did significantly better in a comprehension measure, was no better on a retention measure, and formed a more negative attitude toward the lesson. Other studies also report significant gains for LCF lesson users, such as Park and Tennyson (1980), and Tennyson and Rothen (1977).

Studies Supporting a Program Control Focus (PCF)

Temiyakarn (1995) found that PCF learners of high-ability improved their

cognitive learning strategies through generative learning activities, compared to the high-ability LCF students. Other studies have indicated greater improvement for low-ability students using PCF. Lee and Lee (1991) reported that PCF produced significantly better results than LCF for the acquisition of new knowledge, and that LCF was superior to PCF for the review of familiar material. However, they found no significant differences in perceived self-efficacy. " . . . the operational efficiency of the LC(F) strategy is contingent on the extent to which learners know the target knowledge " (p. 496). Shin, Schallert, and Savenye (1994) found that low prior knowledge students had better performance in a limited-access (PCF) lesson, while high prior knowledge students preferred advisement when using a unlimited access (LCF) program. These other studies also show a significant gain for PCF lesson users: Lee and Wong (1989); Gay (1986); Tennyson, Park, and Christensen (1985); and Goetzfried and Hannafin (1985).

Group Learning and Lesson Control

Simsek (1993) conducted a study indicating that individualized instruction (perceived as a major advantage of learner control) may not be appropriate for all situations. This study examined the effects of lesson control and aptitude (general abilities) on performance, interaction, and attitudes during a computer-aided science lesson. Grouping variables included focus of lesson control (LCF or PCF), ability (high or low), and group composition (homogeneous or heterogeneous). The results showed significant gains for learning, time on task, verbal interaction, and attitudes for the LCF and heterogeneous groups. Research by Hooper and Hannafin (1988) showed similar results.

The authors pointed out that other studies in group work do not always support their results. Hooper and Temiyakarn (1993) found that LCF and PCF groups of all abilities did better when working in groups. These studies used elementary students whose group dynamics may be very different from those for adults and teenagers. Yet they suggest that group or team-work may overcome some of the reported disadvantages of LC lessons for low prior knowledge, lower ability students. Simsek (1993) points out that the research is not consistent in this arena, as some studies show higher gain for low-ability students and/or homogeneous groupings and others argue against them.

Prior Notification of Research Control Focus

Lee and Lee (1991) conducted lesson control focus research where students were notified of lesson control focus type before commencing their lessons. Learner control students were told they "had total control" over their lessons. Program control students were informed "about the lockstep sequencing of the tasks." Primed by the knowledge of lesson control focus type, the question was whether student expectations of the lesson had any effect on performance. Unfortunately, Lee and Lee (1991) did not comment on this issue, nor did they indicate why notification was given.

Observations

The results of other lesson control focus research have been inconclusive. Park (1991) summed up the problem when he wrote: " . . . the instructional principle of 'learner-control' has been an appealing issue in education because of its potential possibility to increase students' motivation, to develop self-learning ability, and, thus to yield the best learning achievement. However, many researchers who have investigated

the instructional effects of 'learner-control' have failed to provide empirical evidence for its positive effect" (p. 24). Borsook and Higgenbotham-Wheat (1991) concluded: "Research suggests that allowing all but the brightest and most knowledgeable free rein at controlling sequencing, pacing, amount of practice, and level of difficulty results in disappointing performance" (p. 13); and they continued concerning the apparent failure of LCF strategies to produce meaningful results: "The reason for disappointing results may be that learner control simply shifts the locus of control from the computer to the learner. As locus of control shifts from one party to another, true interactivity is diminished. Indeed, the very term locus of control implies an imbalance that is the antithesis of interactivity" (p. 13).

However, many researchers do agree on a few principles. A summary of the research suggests that (1) novice learners require more structure in CAI lessons, and (2) that experienced learners do equally well in LCF or PCF lessons, but prefer greater control. Temiyakarn (1995) reached the same conclusion in her research and literature review. Further, there is a complex array of variables interacting with focus of lesson control concerns: prior domain knowledge, competency in cognitive and meta-cognitive skills, self-regulation skills, learning styles, and a lack of standards as to what constitutes a learner controlled or a program controlled lesson. Other factors include: lesson context, purpose, group characteristics (homogeneous vs. heterogeneous), and learner expectations. Lee and Lee (1991) reported that PCF produced significantly better results than LCF for the acquisition of new knowledge. They also reported that LCF was superior to PCF for the review of familiar material. This would indicate the lesson intent

is also a factor in lesson control, in that a lesson designed for review would have a different focus on learner control.

> Burwell (1991) summarises the research in terms of instructional design: "Some students can optimize learning when they control the pace, sequence, or style of instruction. Other students function better in a learning situation where control decisions are made for them by others and they follow a predetermined path through the instruction" (p. 37).

The research reported here further investigates the effect of lesson control focus and prior notification of the lesson control focus on student performance and attitude towards the lesson. The research has two groups each representing a different focus of lesson design. Group one will use a lesson with a learner control focus (LCF), while group two will use a lesson with a program control focus (PCF). It is expected that the students in the LCF group with greater prior knowledge will like the program more than the low prior knowledge students, whereas the students in the PCF group will express an opposite opinion.

The students will rate their perception of lesson focus of control using a Likert scale questionnaire. One question will ask the student to rate their perception of lesson learner control (variable LC), and another will ask them to rate their perception of how much control the computer had (variable PC). It is expected that the students using the PCF lesson will rate their lesson higher in program control (PC variable) and lower in learner control (LC variable). While the students taking the LCF lesson are expected to rate their lesson as being higher in learner control (LC variable) and lower in program

control (PC variable).

Each group will be divided into two groups, one subgroup will be informed they will be using a PCF program, and the other subgroup will be informed they are taking a LCF program. It is expected that some students will report a lesson control focus that is in agreement with the prior notification that they received. Table 1 shows the groups and subgroups, and illustrates their relationships.

Table 1

Research Groups and Subgroups

	LCF Group	PCF Group
Prior Notification of LCF	LCF-LCF Subgroup	PCF-LCF Subgroup
Prior Notification of PCF	LCF-PCF Subgroup	PCF-PCF Subgroup

CHAPTER 3

METHODOLGY

The research study was conducted entirely on a computer. The software included a pretest, three lessons, a simulator, problem, post-test, and a Likert scale survey. The software tracked student progress throughout the program, providing navigation details, times, test scores, and survey results in the form of an ASCII log file. Information from the log file was printed and data were analyzed using SPSS 8.0. In addition participant navigation paths through the program were analyzed manually.

Computer Program Design

The program was designed as a stand alone tutorial for adult learners, so that the tutorial would have been followed by laboratory experimentation using theory and relationships introduced in the lesson. In this context, the program was designed to provide structure and context for experimentation. Otherwise, the tutorial would be used by students who missed scheduled class, needed additional time on a topic, or else students could use the lesson for review.

There were two basic versions of the program: lesson control focus (LCF) and program control focus (PCF). The programs contained the same screens, differing only in available navigation choices. Interactivity consisted of optional elaboration pop-up screens, intra-lesson questioning with feedback, and an interactive simulation. No feedback was given in the pretest or post-test as these were used for measurement. The simulator and the problem were identical in both treatments, and these were free-formed,

containing no correct path or screen order. Students could exit the simulator and problem at will. The two programs differed in that the LC program was menu driven, while the PC program required the participants to complete the three lessons, the simulator, and the problem in a fixed order. Once all modules were completed the PC participants gained access to the LC menu-driven program.

Learner Control Program (LC) Navigation (Figure 1)

The LC program allowed the participant to select modules at will, as each module had its own menu. In addition, students could move between pages. Subjects were not permitted to return to the pretest nor to go back to the modules from the post-test. Because of this, the first page of the post-test asked students if they had finished all lessons, and gave them a chance to return to the menu.

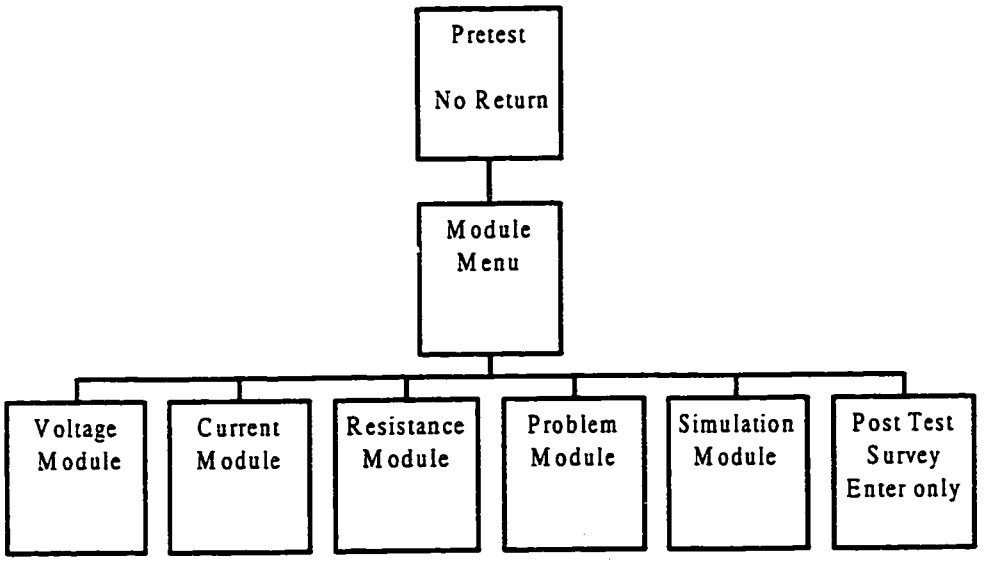


Figure 1. LC Lesson flow chart - without pop-up pages

Program Control (PC) Navigation (Figure 2)

The PC program allowed students to move back and forth within a lesson, and at the end they were allowed to repeat the lesson. The simulation and problem modules were the same as the LC program, except that the student had to do them in order. Once all modules were completed the LC menu was available.

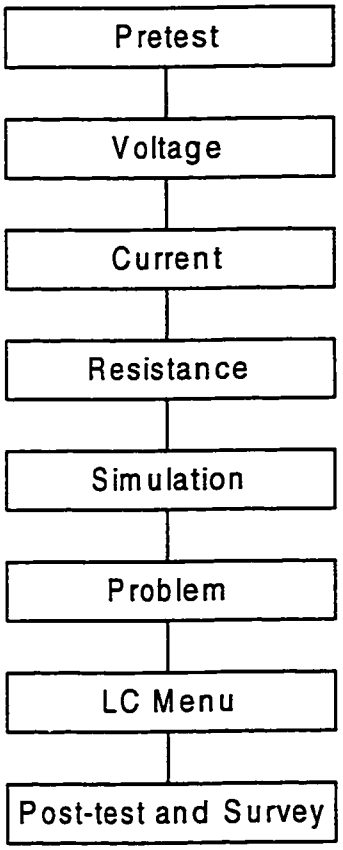


Figure 2. PC Lesson Flowchart - Pop-up pages and LC Menu Choices not shown

The lessons were basic electronic lessons on voltage, current and impedance.

Intra-lesson selectable pop-up pages provided optional amplifying information, analogies, or mathematical calculations. Occasionally, students were questioned and feedback was given by the program. In the simulations, students were asked questions such as "If you had doubled the resistance, what effect would that have on current?" The simulation required the student to select various combinations of voltage and resistance and then predict what the resulting current would be. The student was given four choices in each category from which to choose. The problem required the students to select a combination of resistance and voltage to provide for a current flow within a given range, the range required for a reading lamp to function properly. The lessons contained some sound and voice narration.

Upon completion of the five modules, the student could either select the post-test or review a module. As during the pretest, the post-test did not allow the student more than one attempt at the correct answer. In other words, the program did not provide feedback or knowledge of correct response, as this feature was removed from the program for this phase. The program simply moved on to the next question after an answer on the pretest and post-test. At the completion of either test, students could click a button and their score would appear on the screen. Test questions and their distracters were randomized for each participant. The survey immediately followed the post-test to conclude the session.

Survey

The survey (Appendix B) was a 12-item Likert scale. Subjects were asked to rate

aspects of the program with emphasis on lesson control focus, interactivity, and lesson sequence. Students were also asked to rate their prior knowledge of the subject matter; this, along with the pretest scores, would be used to determine prior knowledge. Other items included in the survey asked the students to rate their computer knowledge and their attitudes concerning the lesson humour and sound, as well as their attitude towards the inclusion of humour and sound in CAI in general.

Two final survey variables asked the students to rate the focus of control for the program from 1 (rarely) to a 5 (all of the time). Specifically, they were asked how much control they had (LC) and how much control was maintained by the computer program (PC). Then these PC and LC variables were also combined into a global variable called "control." The variable "control" reflected the overall amount of perceived learner control. If a student rated their program a 3 (some of the time) on LC and a 3 on PC, then the variable control would be a 3, whereas a rating of 2 on LC and 2 on PC would be 3. A high rating on the PC variable equates to low perception of learner control (see Table 2), whereas a low rating implies high learner control, the reverse being true for the LC variable.

Therefore the ratings for PC scores were inverted (1 converted to a 5, for example) and averaged with the LC rating to produce a combined "control" variable.

Table 2

Genesis of the Variable "Control."

How much was the computer in control?	How much was the learner in control?
1 (rarely) becomes a 5	5 (all of the time)
2 (occasionally) becomes a 4	4 (most of the time)
3 (some of the time) remains a 3	3 (some of the time)
4.(most of the time) becomes a 2	2 (occasionally)
5 (all of the time) becomes a 1	1 (rarely)

Rather than simply asking students to rate the amount of learner control, I used the LC, PC and "control" variables to overcome any ambiguity concerning the meaning of learner control. All three variables are examined in the data analysis. The intent for the variables LC, PC, "control," lesson sequence, interactivity and "enjoy the lesson" was to determine student attitude toward the lesson in general, and the focus of lesson control in particular. By way of defining labels, LC and PC are variables, LCF and PCF are group names.

Subjects and Design

The research was conducted using two groups, LCF and PCF, each with two

subgroups. One subgroup was told, on screen, that they were doing an LCF lesson; the other subgroup was told they were doing a PCF lesson. The subjects were six adults from CDI College of Business & Technology and 26 adults from The University of Calgary. The students were randomly assigned to one of the subgroups, labeled A-D. The subjects were assigned a password consisting of the group letter (A-D) and a number. The password was only used to track their progress through the program, there being no correlation between student name and password in the log file.

Subjects read a letter describing the research, and signed a waiver (Appendix A), and were given a copy of each. The subjects entered their password and then worked on the program, most finishing in about an hour.

Statistics and Data Analysis

The data were analyzed using multiple measures. For group mean achievement a repeated-measures MANOVA was completed using pretest and post-test dependent variables with subgroup as the grouping variable. Another MANOVA was done using the group variable. Independent samples t-tests were done for the various "time spent in module" variables and the survey response variables, using the LCF-PCF groups as the independent variables. To test these same independent variables by subgroup, univariate ANOVAs were calculated using Tukey and Scheffe post hoc measures. All statistics were considered significant relative to the $p < 0.05$ level.

Table 3

List of Main Variables

Independent Variables	Survey Variables	Time in Module Variables
Group 1 (LCF)	Prior knowledge (PK)	Pretest (tpre)
Group 2 (PCF)	Enjoy lesson (enjoy)	Voltage (tvol)
Subgroup 1 (PCF-PCF)	Sequencing (seq)	Current (tamp)
Subgroup 2 (PCF-LCF)	PC (PC)	Resistance (tohm)
Subgroup 3 (LCF-PCF)	LC (LC)	Simulator (tsim)
Subgroup 4 (LCF-LCF)	Interactivity (int)	Problem (tpro)
	Computer knowledge (cpukn)	Total (ttotal)

Actual data variables and their abbreviations are shown in parentheses in Table 3. The difference between the subgroups was that subgroups 1 and 4 were notified of the correct focus of lesson control, whereas subgroups 2 and 3 were told the opposite. Other survey variables concerned sound and humour in the lesson, and sound and humour in CAI in general.

Repeated Measures MANOVA

Repeated measures MANOVAs were conducted to see if the program was effective in teaching basic electronics theory. Since there were groups and subgroups, it was decided to do two MANOVAs instead of a single more complex design. The purpose of these tests was to determine if there was improvement for both the PCF and LCF groups, and for the four subgroups as well, and to see if there were any group differences. It was expected that post-test scores would be significantly higher than pretest scores.

Group and Subgroup Mean Differences for Post-test

An independent t-test was used to determine if there were significant mean differences between the group post-test scores, and an ANOVA tested the subgroups. Post hoc Scheffe and Tukey analysis was done as required.

Independent t-tests were done on time variables and survey response variables. Time variable data were derived from the log file generated as the participant worked through the program. The literature review suggested that LCF students would spend more time on the lesson, that higher PK students should enjoy the LCF lesson more, and that lower PK students will prefer the PCF lesson.

Correlation and Regression Analysis

Correlation and regression analysis was done on specific variables to determine what additional relationships, if any, exist between these variables. Relationships analyzed included: pretest, prior knowledge, LC, PC and "control" with post-test and attitude

towards the lesson (variable "enjoy"), and sequencing and interactivity, with LC, PC and "control."

Expected results of Correlation and Regression: It was expected the prior knowledge would predict test scores; that LC, control, interactivity, sequencing, and attitude ("enjoy" variable) would directly correlate. It was expected that PC would inversely correlate with interactivity and sequencing.

Navigation Path Evaluation

The log file was examined to determine navigation patterns: did students in any group or subgroup revisit modules, and, if so, which one(s) and for how long? Were pop-up pages used, and were there any patterns to the use? Did students select a correct answer the first time in the problem module? Did they select more than one correct answer, when the first answer was correct? Did they try again when the first answer was incorrect? Did the students use the "what ifs" questions in the simulator, or did they simply move on to the next screen?

CHAPTER 4

RESULTS

The following chapter reports the results from both the quantitative and qualitative analyses of the research, including the survey, navigation data, computer data generated by student interaction with the program, pretest and post-test. Tables and figures summarizing these findings are at the end of the chapter.

Survey Results

All participants (n =32) completed the survey (Appendix B) as it was part of the computer lesson. Survey results will be presented, and group or subgroup differences will be noted. Only variables showing significance at the p = .05 level or less will be reported. (The label shown on the lower left corner of the graphs is the variable name as used in data collection, and as shown in Table 3).

How Much did You Enjoy the Lesson? (Figure 3)

Participants could rate their enjoyment of the lesson from 1 (not at all) to 5 (a lot), and the mean rating was 3.4 An independent t-test found no significant group mean differences at the $p < .05$ level. An ANOVA found no significant subgroup mean differences at the $p < .05$ level. There was a moderate Pearson correlation of $r = .449$, df = 32, significant at $p < .05$, between survey variable "humour" in the lesson and the "enjoy" value.

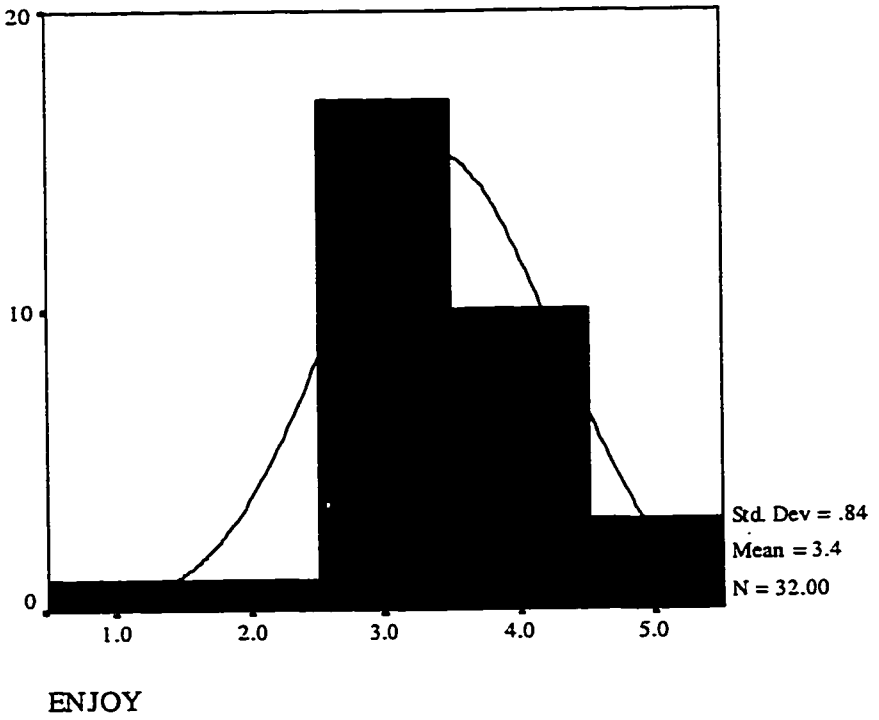


Figure 3. Distribution of "enjoy the lesson"

I Liked the Humour in the Lesson. (Figure 4)

Students could rate this variable from 1 (strongly disagree) to 5 (strongly agree), and the mean rating was 3.4. There was a moderate Pearson correlation of $r = 0.449$, significant at $p < .05$, with the survey variable "enjoy lesson ." An independent t-test found no significant mean differences for the variable "humour in the lesson" between groups (LCF and PCF) at the $p < .05$ level. An ANOVA found no significant mean differences for the variable "humour in the lesson" between any subgroup (LCF-LCF, LCF-PCF, PCF-PCF, and PCF-LCF) at the $p < .05$ level.

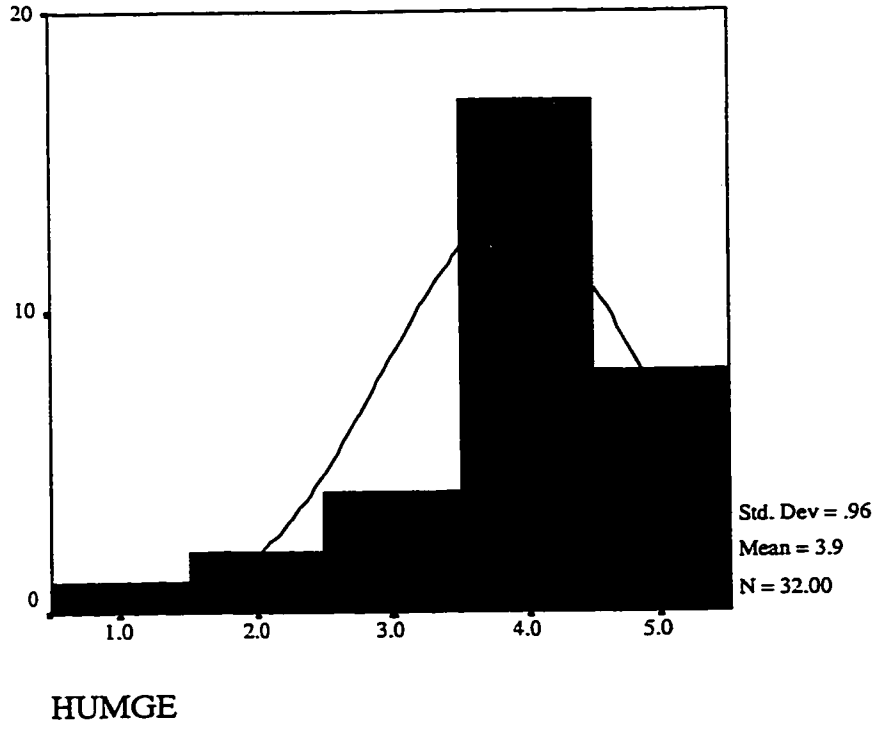


Figure 4. Distribution of humour in the lesson rating

Prior to This Project How Much Did You Know About the Subject? (Figure 5)

Participants could rate prior domain knowledge from 1 (nothing) to 5 (a lot), and the mean rating was 1.9. There were no significant group differences. A one-way ANOVA revealed no significant subgroup differences. There was a high correlation with pretest scores, $r = .595$, post-test scores, $r = .611$, and a moderate correlation with time in problem, $r = .350$, at the $p < .05$ level of significance. Prior knowledge was a predictor of post-test scores, $r = .632$, adjusted r-squared .358.

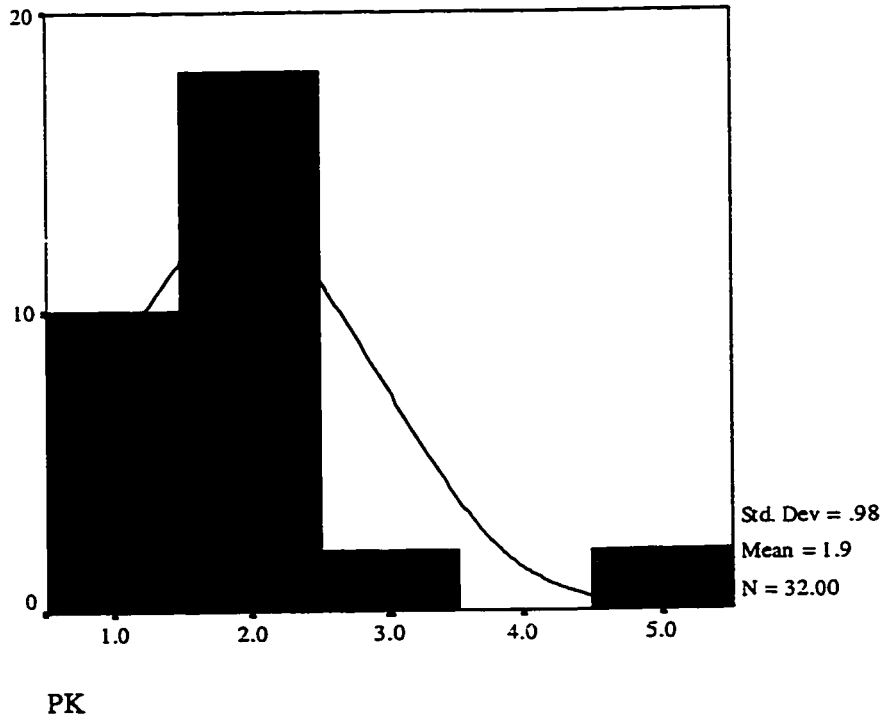


Figure 5. Distribution of prior knowledge rating

I Felt I was in Control of the Lesson -- Variable LC (Figure 6)

Ratings for LC ranged from 1 (rarely) to 5 (all of the time), with a mean rating of 3.9. An independent t-test showed no significant mean differences by group, and an ANOVA showed no mean differences by subgroup (LCF-LCF, LCF-PCF,PCF-PCF, and PCF-LCF) for LC, at the $p < .05$ significance level. There was a significant correlation between LC and the variable "lesson sequencing," $r = .463$.

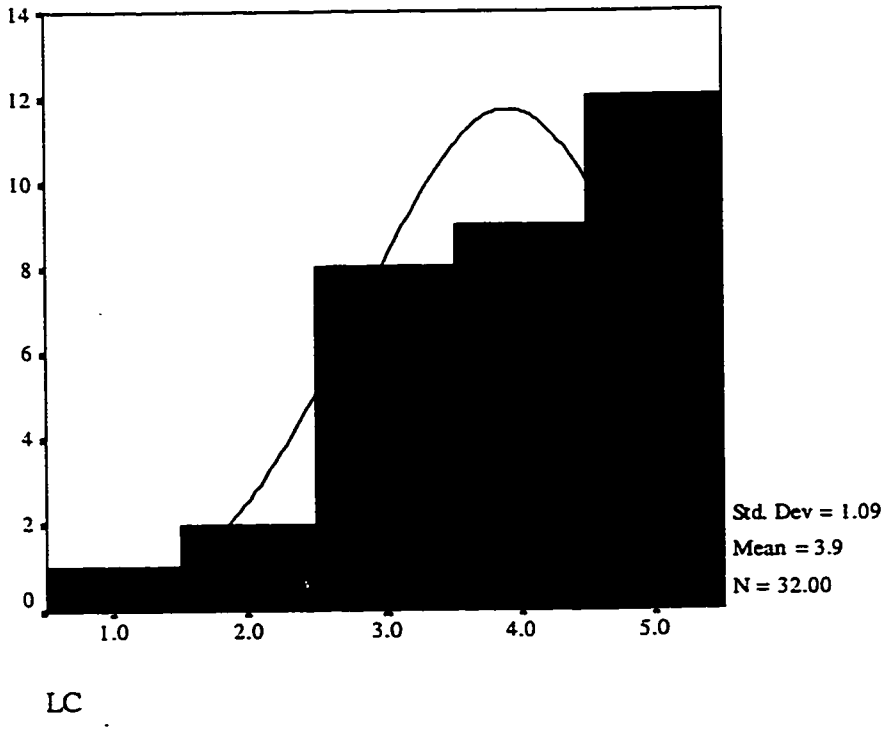


Figure 6. Distribution of LC ratings.

The Computer Was in Control of the Lesson -- Variable PC (Figure 7)

Ratings for PC could vary from 1 (rarely) to 5 (all of the time), with a mean of 2.7. Independent t-test showed significant ($p < .05$ level) mean differences on the PC rating between the PCF subjects ($m = 3.63$) and the LCF subjects ($m = 2.56$) (Table 4). An ANOVA indicated significant subgroup mean differences, $F(3,28) = 3.69$, $p < .05$, and a post hoc Tukey analysis showed a significant mean difference between both PCF subgroups and the LCF-LCF group at the $p < .05$ level (Table 5. There was a significant inverse correlation between the variables sequencing and PC, $r = -.556$.

Table 4

Mean Group Ratings for Variable PC

Group	N	Mean	SD
LCF	16	2.56	1.209
PCF	16	3.63	0.885
Total	32	3.09	1.174

Table 5

Mean Subgroup Ratings for Variable PC

Subgroup	N	Mean	SD
LCF-LCF	8	2.13	0.991
LCF-PCF	8	3.00	1.309
PCF-LCF	8	3.63	0.916
PCF-PCF	8	3.63	0.916
Total	32	3.09	1.174

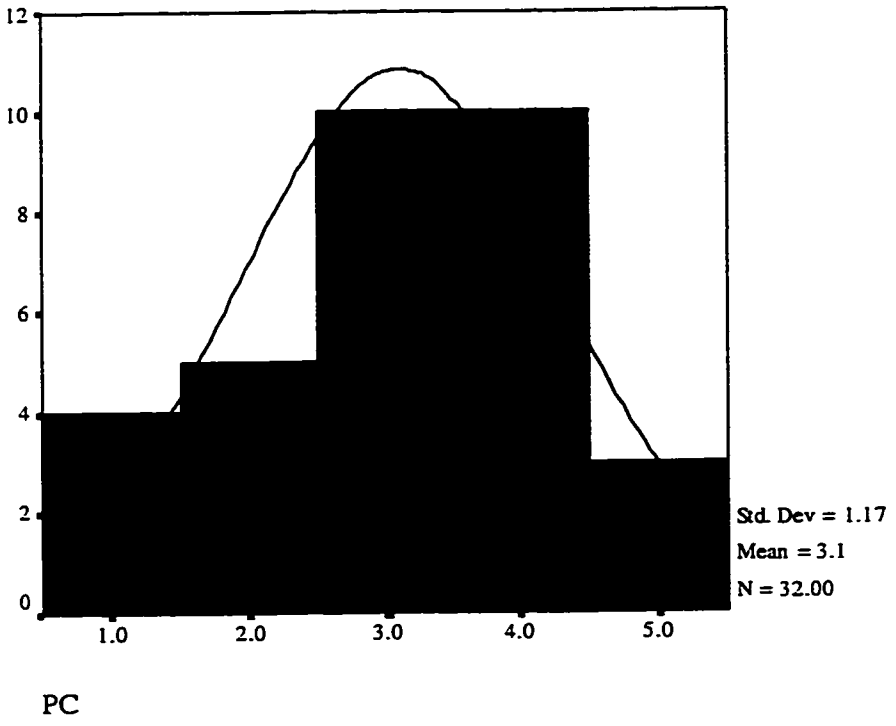


Figure 7. Distribution of the PC Rating

Variable "Control" (Figure 8)

The global variable "control" was developed using the LC and PC questions on the survey, so it is no surprise that the Pearson correlation for "control" with LC was r = .835 and the correlation for "control" with PC was r = -.873. Therefore, a high rating on the variable "control" represents a high degree of perceived learner control. The mean for "control" was 3.4.

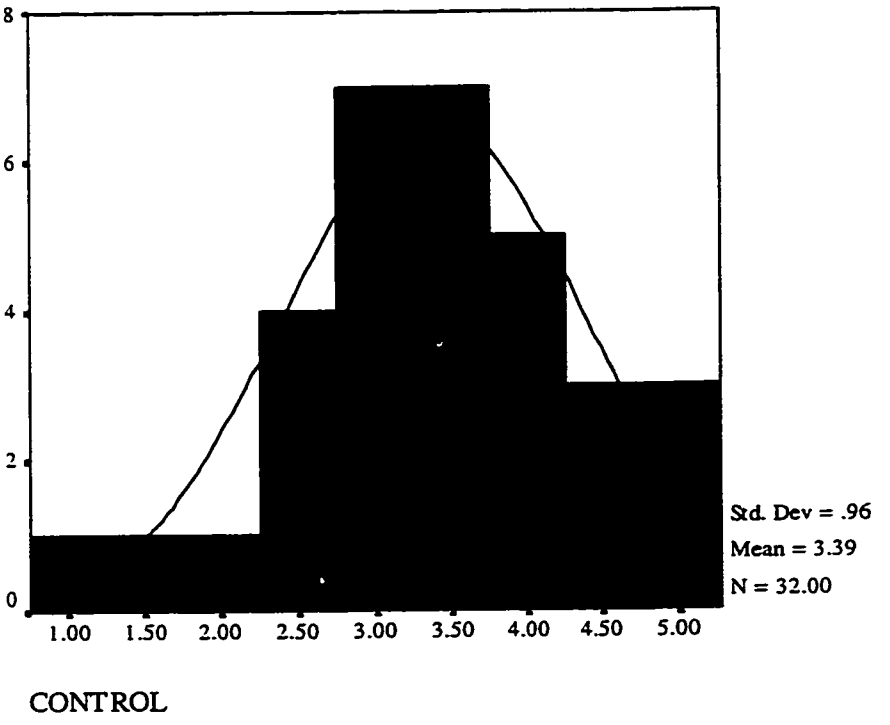


Figure 8. Distribution of Variable Control

An independent t-test found significant mean differences for the variable "control" at a level of p = < .05, with a PC mean of 2.96 and an LC mean of 3.81.

Based on ANOVA, subgroup means showed significant mean differences, $F(3,28) = 3.14$, $p < .05$, and a post hoc Tukey test found significant differences between both PCF subgroups and the LCF-LCF subgroup, Table 6. It appears that the PC variable rating is responsible for most of the differences, because the LC variable fails to show significant differences by subgroups (LCF-LCF LCF-PCF, PCF-PCF, and PCF-LCF). The global variable "control" was a combination of the PC and LC variables' ratings. Subjects in the PCF group and its subgroups (PCF-PCF and PCF-LCF) rated the program significantly lower in learner control than the LCF group or subgroups. This means that PC ratings had a significant effect on student attitude towards lesson learner control, as the PC variable was significant, whereas the LC was not significant.

Table 6

Subgroup Means for the Variable "Control"

Subgroup	N	Mean	SD
LCF-LCF	8	4.13	0.641
LCF-PCF	8	3.5	1.102
PCF-LCF	8	3.0	0.535
PCF-PCF	8	2.94	1.084
Total	32	3.39	0.965

Correlations for the global variable "control" included a moderate correlation with

sequencing, $\underline{r} = .574$, a moderate correlation with humour in the lesson $\underline{r} = .353$, and an inverse correlation with variable 'time in survey", $\underline{r} = -.372$, all significant at the $\underline{p} < .05$ level or beyond. Interestingly absent was any significant correlation between "control" and "interactivity," $r = .142$.

The Programs Level of Interactivity was Just About Right (Figure 9)

The rating for the level of program interactivity could vary from 1 (strongly disagree) to 5 (strongly agree), and the mean was 3.5. There were no significant mean differences between groups or subgroups at the $p < .05$ confidence level. Correlations for the variable "interactivity" included a moderate correlation with "humour in the lesson," $r = .438$, a moderate correlation with "lesson sequencing," $r = .425$, and a negative correlation with variable "computer knowledge," $r = -.362$, all significant at $p < .05$.

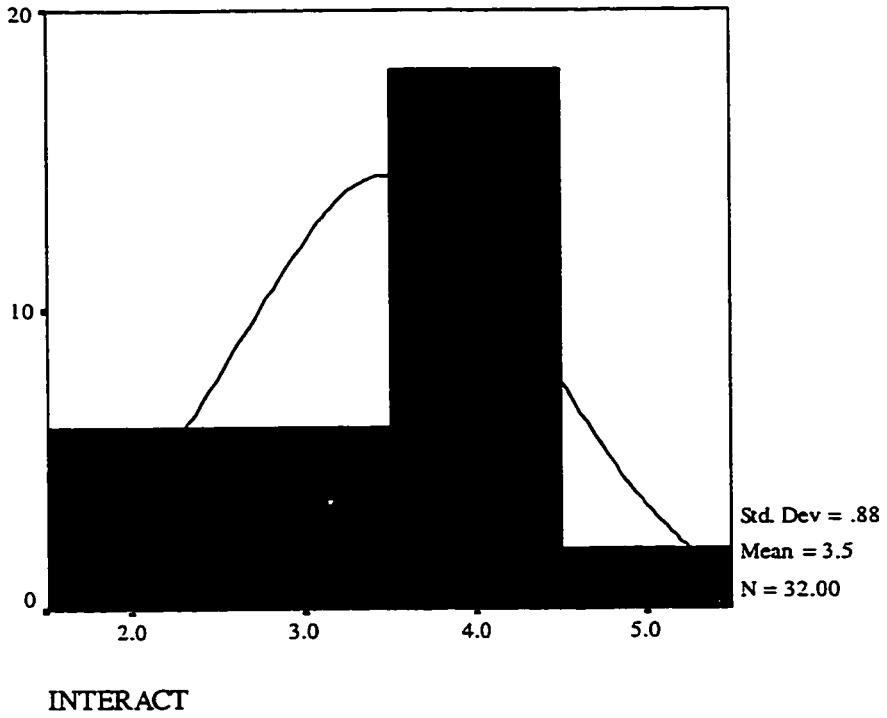


Figure 9. Distribution of Interactivity Ratings

The Sequencing of the Lesson was Appropriate (Figure 10)

The survey question on the appropriateness of lesson sequencing had a range of responses from 1 (strongly disagree) to 5 (strongly agree), with a mean of 4.03. There were no significant mean differences by group or subgroup. Pearson correlations for the "lesson sequencing" variable included a moderate correlation between "lesson sequencing" and "control," $r = .574$, "humour in the lesson," $r = .523$, and "interactivity," $r = .425$, all significant at $p < .05$ or beyond.

Note: there were no ratings below 3.0, indicating no negative attitude toward lesson sequencing by any participant.

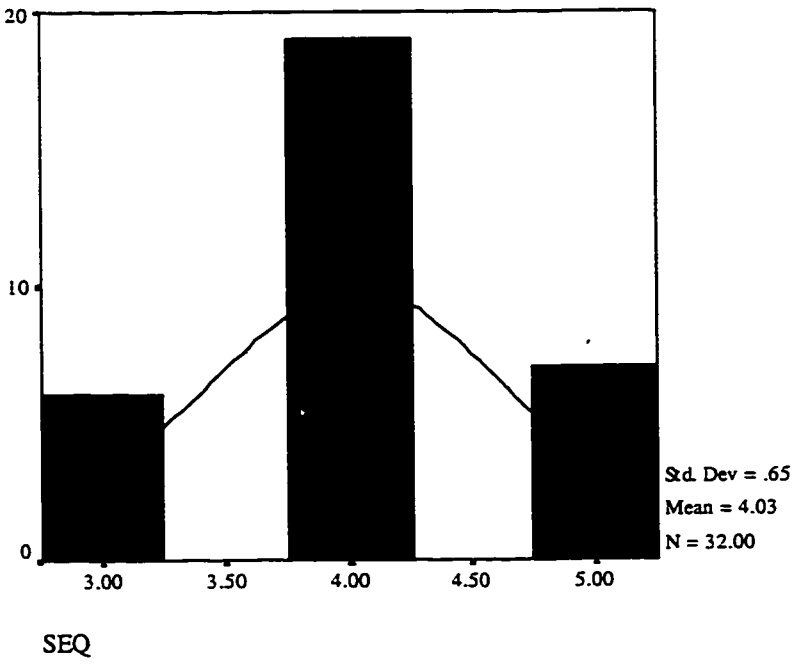


Figure 10. Distribution of sequencing ratings (note: there where no ratings below 3.0)

How Would You Rate Your Computer Knowledge (Figure 7)

The rating for computer knowledge could vary from 1 (none) to 5 (expert), and the mean rating was 3.1. An independent t-test showed no group mean differences, and the ANOVA showed no subgroup differences for the variable "computer knowledge." There was a negative correlation between "computer knowledge" and "interactivity," r = -.363, indicating that students with high computers skills rated the program less interactive than other participants.

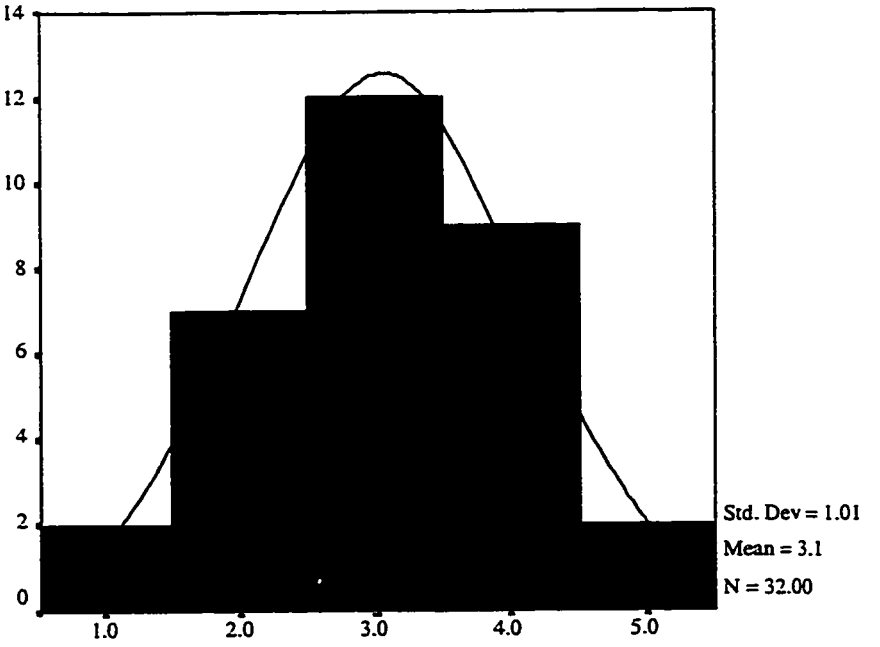


Figure 11. Distribution of Computer knowledge ratings.

Navigation Path Analysis

The program created a log file as the students moved through the program. Log

details included times for each screen, time in module, screens and pop-ups viewed, and test and survey responses.

Order of Module Completion for LCF Students

Students taking the LCF program could select any module, yet with only two exceptions they completed the lessons in the same order as the PC students, who had no control. In other words, even with personal control, they simply followed the menu in order.

Module Revisits or Skipped

Three students moved about the lesson in no apparent pattern, one of these leaving out an entire module. These three had an average change (loss), pretest to post-test, of -7 points, and spent slightly more time than the average in the program, 2460 seconds versus a mean time of 2402 seconds.

Three other students revisited modules, but completed all modules in the same order as the other LCF students before reviewing, and showed a pretest to post-test improvement average of 40 points.

Interactive Pop-up Usage

An analysis of how many students used the pop-up pages showed no significant differences between groups or subgroups, and revealed pop-up usage of 89%.

Log file time analysis

One way ANOVAs revealed no significant differences by group, in any module, for the time measurement. Independent t-tests showed no significant mean differences in any module time measurement. There was a significant inverse correlation between

number of tries in simulator module, r = -.378, number of tries in problem module, r = -.538, and post-test scores. There was also an inverse correlation between number of tries in simulator module, r = -.239, number of tries in problem module, r = -.400, and prior knowledge ratings; however, only the latter was significant at the $p < .05$ level. There was a significant inverse correlation between time in simulation, r = -.384, time in the problem, r = -.420, with post-test scores at the $p < .05$ level. A review of navigation paths through the simulator and problem showed that students who spent more time in the module still tended to find fewer correct answers.

Repeated-Measures MANOVA Results

Repeated-measures MANOVAs were completed to test for improvement by group and subgroups over time using pretest and post-test scores. No significant group or subgroup mean differences were discovered. However, a significant time effect was noted, $F(1,30) = 69.99$, $p < .05$, for groups and, $F(1/28) = 82.13$, $p < .05$, for subgroups. The mean gain from pretest to post-tests was 25 points.

Regression

Pretest and prior knowledge were determined to be predictors of post-test scores. SPSS 8.0 regression analysis showed only PK as a predictor when both variables were entered in the same analysis. When analyzed separately both PK, r = .632, and pretest, r = .532, were significant.

Summary of Results

A summary of research findings displayed in diagrams and tables follow. While statistically significant variables are shown, on occasion non-significant variables are included for contrast, and will be identified as such.

Summary of Means

The PC variable and the global variable "control" show significance mean differences by group (LCF and PCF) and for the same three subgroups (LCF-LCF, PCF-PCF, and PCF-LCF). The LC variable shows no significant mean differences. Table 6 shows the means and standard deviations for subject variables, significant mean differences are shown in italics. When viewing Table 6 it is helpful to recall that a negative correlation existed between "control" and PC, so that the means for the PC variable will be lower than the means for the global variable "control."

Table 7

A Comparison of Significant Mean Differences

	GROUPS (t-test)		SUBGROUPS (ANOVA)			
Variable	LCF	PCF	LCF-LCF	LCF-PCF	PCF-PCF	PCF-LCF
PC M	2.56	3.62	2.13	3.00	3.63	3.63
SD	1.2	0.88	0.99	1.31	0.92	0.92
LC	4.19	3.63	4.38	4.00	3.63	3.63
	0.91	1.2	0.74	1.07	1.06	1.06
CONTROL	3.81	2.97	4.13	3.50	2.94	3.00
	0.92	0.82	0.64	1.10	1.08	0.53

Correlation Summary

The diagram in Figure 12 displays the relationships between variables, solid lines show significant positive correlation, while dashed lines show significant negative correlation. The diagram clearly shows the importance of sequencing on student perception of the program, as it correlated with 5 of the 7 variables. Lesson humour also affected student perception of the lesson's structure, as it correlated with interactivity, sequencing and control. Also, the lack of correlation between control and interactivity is surprising. Table 8 displays correlation in a tabular form.

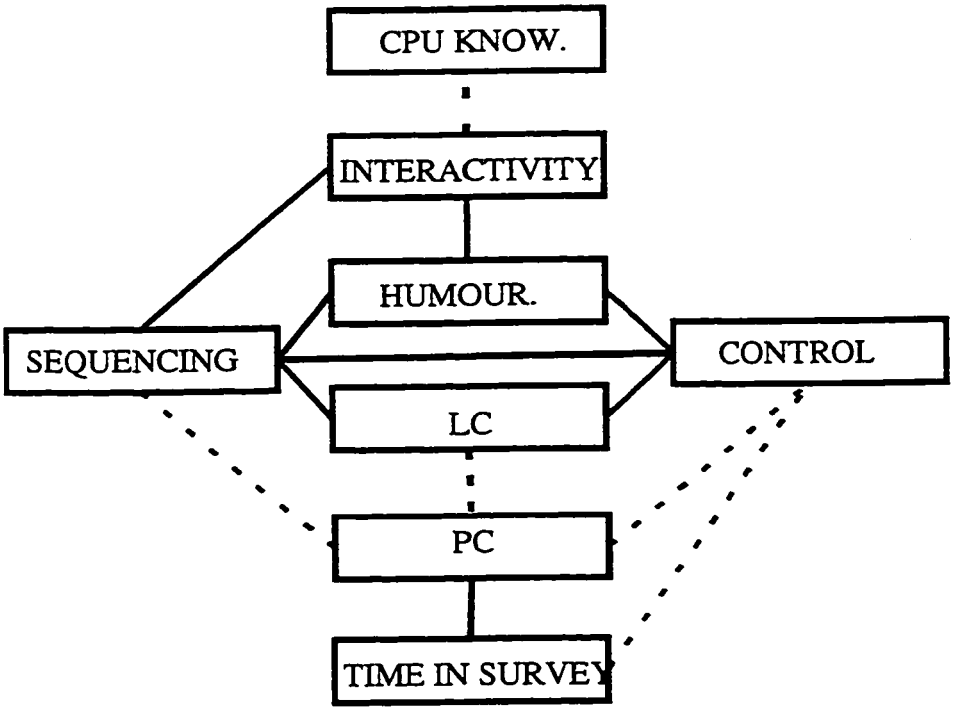


Figure 12. Significant Correlations -- Dashed lines indicate negative correlation

Table 8

Summary of Correlation -- Significance is Underlined

	INT	CPUK	LC	PC	SEQ	CONT	TSY	HUM
INTER-ACTIVITY	1.000	-.362	.152	-.108	.425	.142	.074	.438
CPU KNOW-LEDGE	-.362	1.000	.152	-.086	.095	.139	.073	.039
LC	.152	.152	1.000	-.473	.463	.835	-.253	.330
PC	-.109	-.086	-.473	1.000	-.556	-.873	.377	.306
SEQUENCE	.425	.095	.463	-.556	1.000	.574	-.167	.523
CONTROL	.142	.139	.835	-.873	.574	1.000	-.372	.353
TIME IN SURVEY	.074	.073	-.253	.377	-.167	-.372	1.000	-.238
LESSON HUMOUR	.438	.039	.330	.306	.523	.353	-.238	1.000

CHAPTER 5

DISCUSSION AND CONCLUSIONS

The survey, test scores and navigation log analysis provided a great deal of information concerning lesson control and perception of lesson control. This chapter initially returns to the questions posed in Chapter One, and then discusses the findings in terms of those questions. Limitations of the research will be noted, followed by suggestions for future research, and implications for lesson design. The conclusions will revisit the major areas of previous research in terms of findings.

Discussion of Research Questions

Will prior domain knowledge affect either student performance or attitude in the tutorial?

Prior knowledge (PK) in a particular domain is assumed to provide the structure from which we construct an understanding of new information. The nature of a tutorial is to provide new learning, so often prior domain knowledge is weak. In this project the mean (1.9) for the self-reported variable prior knowledge had a positive skewness of 1.84 (Figure 13). However, this may not have been an accurate description of actual domain knowledge in that 85% of the participants were college students, and as such they should have had Physics classes in the past. The students may not have equated the lesson topic, basic electronics theory, with Physics. In contrast, many students entering post-secondary technical institutions in the United States have not studied Physics. The pretest variable provides added insight into actual prior knowledge as it had only a small positive skewness of .384 (Figure 13). PK and pretest variables were highly correlated ($r = .611$) and can both be used as a measure of prior knowledge.

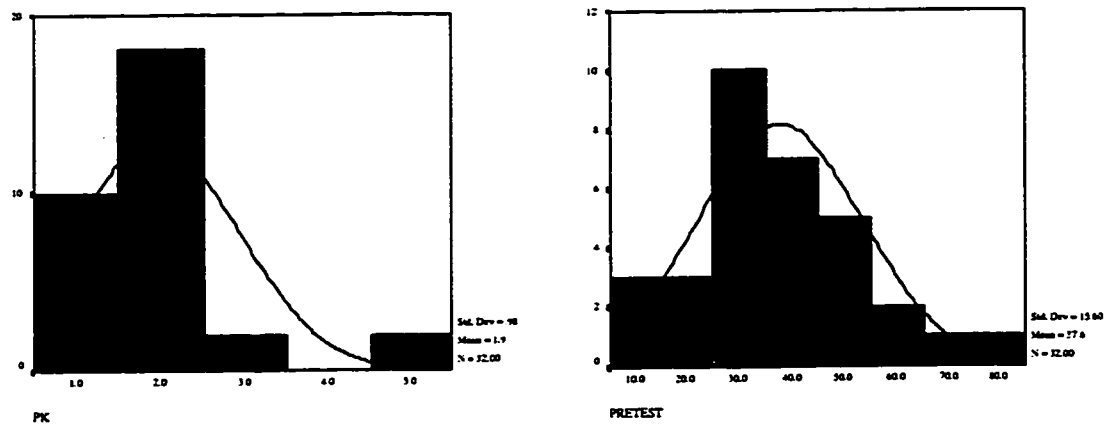


Figure 13. Comparisons of positive skewness for PK (on left) and pretest (on right) mean ratings.

Participants who had higher prior knowledge tended to do better on the post-test, as PK and pretest scores were predictors (r = .632 and r = .532 respectively) of post-test performance. There was no effect on student attitude as defined by the "enjoyed the lesson" variable. However students who did better in the pretest tended to rate the program as more PCF-oriented. The literature review indicated a preference for LCF lessons in those students with higher domain knowledge. This is consistent with the inverse correlation between prior knowledge and variable learner control.

Participants who had lower pretest and PK scores tended to spend more time in the simulator problem module, whereas the opposite was true for the high prior knowledge students. An analysis of the path taken within the problem module showed many tries and few correct answers. This could indicate frustration or uncertainty on the part of low prior knowledge students. It is important to remember that the simulator and problem modules had the same free-form design for both the LCF and PCF groups.

Previous research reported frustration or poor choice making for low prior knowledge students in LCF designs.

An alternative explanation is that the subjects experienced cognitive overload, that is, the students were asked not only to provide data (voltages and resistances), but had to understand the model of what the program designer expected of them, including the actual frame design used in the program; in this case, a pushbutton was used to move on to the final frame. Although the students were asked to push the clearly labeled button, they had not seen the button before, thus, processing the unfamiliar button may have used enough resources to create some overload and frustration. Jih and Reeves (1992) assert the learners' understanding of structure and functions will have an impact on their navigation behaviour and learning. Hedberg and Sims (1998) suggest, "[p]roblems in accessing content items, achieving goals or completing interactions are potential indicators of poorly structured mental models" (p. 1).

High prior knowledge students spent less time in the problem module and went more directly to a correct answer. Although the simulator module results were similar, the correlation was not significant at the $p < .05$ level.

Will prior notification of lesson control focus affect either student performance or attitude to the tutorial?

Post-test Scores The repeated-measures multivariate analysis showed an average gain in test score of 25 points between pretest and post-test. There were no significant differences between the various subgroups.

Enjoy Lesson There was no significant effect for "enjoy lesson" by group or

subgroup. Enjoy lesson did correlate with humour in the lesson, as students who rated the lesson as more enjoyable also tended to like the lesson's humour.

Variable "Control" While there were mean group and subgroup differences for the variable "control," none of these correlated with prior notification of lesson control focus.

Program Control (PC) There were significant group mean differences between the PCF group (3.63) and LCF group (2.56), and both PCF subgroups had a significant mean difference when compared to the LCF-LCF group. It appears that the PCF students had a more definite opinion concerning the type of lesson control. There was no empirical evidence of significant mean differences between the PCF or LCF subgroups.

Prior notification of lesson control focus had little effect on the students' performance and attitude. It is possible that the notification at the beginning of the lesson was not noticed or remembered, or that most of the students were education majors and had had classes that included software evaluation. There is a third alternative, to be discussed later, of a lack of understanding as to what learner/program control is.

Group and Subgroup Mean Differences for Post-test.

No significant mean differences were expected for post-test scores and none were found. This is in line with previous research that sometimes shows a higher score for LCF lessons and sometimes for PCF lessons.

Repeated Measures MANOVA -- For Pretest vs. Post-test

There was significant gain between pretest and post-test for all groups and subgroups. There were no significant mean differences for group (PCF and LCF) or subgroup (LCF-LCF, LCF-PCF, PCF-PCF, AND PCF-LCF). Three students failed to

improve over time, two of whom actually produced lower post-test scores.

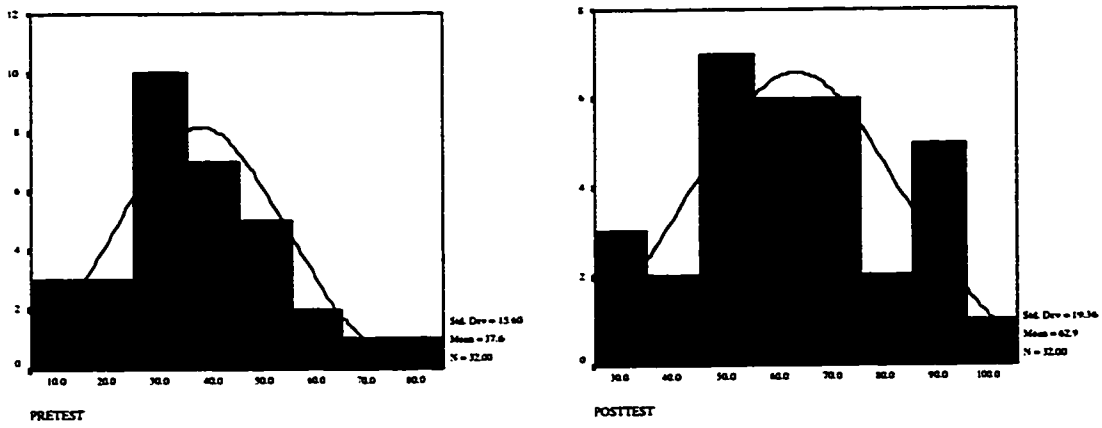


Figure 14. Distribution of the difference between pretest and post-test scores.

Measures of Lesson Control - Sequencing, Interactivity, and Navigation.

Sequencing of material, interactivity and navigation are all important aspects in lesson control. The results of the present study are interesting, in particular the lack of correlation between the variable of global control and interactivity

Lesson Control and Sequencing. The LC lesson ratings correlated directly with the variable lesson sequencing, while the PC ratings were inversely correlated. The mean for the variable lesson sequencing for all students was 4.03, with no ratings below the mid-mark of 3. This seems to indicate that the PC students were more sensitive to sequencing, but were pleased with the sequencing.

Lesson Control and Navigation. Navigation ratings were not significant at the $p < .05$ level for this project.

Lesson Control and Interactivity. Although Borsook (1991) and others equate learner control with interactivity, the participants in this study did not. There was no significant correlation between interactivity and the variable "control", PC ratings or LC ratings. However, interactivity did correlate with sequencing and humour in the lesson. Some of the lesson humour was interactive in nature. The correlation between interactivity and humour is due to the interactive nature of the lesson's humour.

Computer Knowledge.

The computer knowledge variable had a mean of 3.1 (Figure 12). Computer knowledge produced no significant group or subgroup rating differences. There was a small correlation, $r = -.363$, with interactivity, indicating that some higher computer knowledge students perceived less interactivity than most other participants.

Navigation Path Analysis

This study also examined information derived from analyzing the navigation log file. The log file included the order of module completion, modules revisited, interactive pop-up usage, and time analysis.

Order of Module Completion. Only the LCF students could control the lesson sequence, yet all but three LCF students completed the modules in the same order as the PCF students. It was apparent that the menu acted as advisement to the LCF students. Advisement has been seen as an effective tool in LCF software, because it can reduce confusion in choice making for low prior knowledge students (Shin, Schallert, & Savenye, 1994). Apparently the mere inclusion of the menu was enough to convince the LCF students that they had more control.

Modules Revisited or Skipped. The three students who appeared to roam through the modules revisited three modules (one student skipped an entire lesson). The three subjects participated on April Fool's day, sadly a possible explanation for their behaviour. They had an average gain pretest to post-test of –7 points, adding to this suspicion. However, these students' times in lessons and survey ratings were not significantly different from the means.

Pop-up Usage. Interactive pop-up usage was 89%, indicating that most students used them. The pop-ups provided interaction between the program and students, allowing those who wanted additional explanation, an analogy, or mathematics support for the concepts under discussion a means of accessing them. In addition, some of the lesson humour was accessed by user interaction with the interface. Interestingly, the correlation between lesson humour and interactivity may be because of the interactive nature of the humour.

Time/Tries Analysis. There were inverse correlations between times/tries in the simulator and problem modules, and prior knowledge and post-test scores. Since prior knowledge correlates to post-test scores, it seem that the students with high post-test scores tended to spend less time in the problem and simulation modules. The correlations were not high for any except time in problem, yet the trend was obvious. Gay (1986) reported that high prior knowledge students spent less time in the program. While the students here spent less time in the simulation and problem modules, the tendency for them to spend less time in the program was not significant at the $p < .05$ level. It may be

that the students felt competent enough to skip the simulation and problem modules.

General Conclusions and Implications

This section provides conclusions and implications by reviewing the major variables of the study: prior knowledge, prior notification, focus of lesson control, and navigation paths. Program design may have influenced the outcomes of this study in that the simulation and problem models were learner controlled in design. This may have increased the cognitive load for some of the students, especially the low prior knowledge students.

Prior Knowledge

Prior knowledge was an important factor in this research as it was a reliable predictor of post-test scores, and inversely correlated to the amount of time spent in the simulator and problem module. Prior knowledge did not make a difference in group or subgroup attitudes or performance. The positive skewness of the prior knowledge distribution curve may have made the emergence of group or subgroup differences difficult. Lesson design also called on prior knowledge by using an analogy of a flashlight to introduce a basic electronics circuit. For the lowest PK students, the flashlight provided a mental image upon which they could build. Yet, the flashlight example may not have enabled students to make lesson navigation decisions. Another form of prior knowledge is related to understanding the programmer's models and ideas as expressed in the program. If the student has not experienced them before, he/she must expend cognitive resources to understand them (Jin & Reeves, 1992), but this was not explored in this research.

Focus of Lesson Control

The lack of group or subgroup effect for post-test is consistent with the inconsistency of the research. It is also understandable here, in that the LC students completed the lesson in the same order as the PC students. Also, the LC lessons in this project featured fewer learner control features than some of the researched studies, many of which had many more optional screens. Research by Hicken, Sullivan and Klein (1992) had 78 optional screens in their lesson design. The simpler approach was chosen to keep the amount of information constant between groups; this desire may have led to the lack of significant differences for focus of lesson control.

Participant attitude to the program indicates that the students considered the program to have an LCF focus, rating the LC variable 3.9 and PC variable 3.1, even though the program featured less learner control than many of those in the research. The enjoy the program rating of 3.4 is further evidence that the students affect was good. Further, the emphasis Borsook (1991) and others give to interactivity and the lack of a correlation between interactivity and focus of control in this program is another indication that there is a gap between researcher and participant perception. I believe that it may be more fruitful to look at the various confounds in learner control research, such as self-regulation, cognitive loading, prior knowledge (domain specific and other), meta-cognitive skills, rather than pursue the LCF-PCF line of research. There are many new studies that look at ways to increase student performance with computer-aided instruction. One such study examines group composition, recommending heterogeneous

grouping for using CAI (Simsek, 1993).

Navigation Path Analysis

One of the best features of ToolBook is the automatic generation of a navigation log. The navigation log indicated when it appeared the students had lost focus or were confused. In terms of this research project, the log showed that some students skipped the simulation and problem section, while others never found a correct combination to solve the puzzles. The data obtained from the log pointed to some pedagogical problems with the simulation. In the simulation, the student is asked to select a value of resistance and a value of current, then he/she is asked to speculate on the resulting current, and finally his/her speculation is affirmed or not by the following screen. This process would be called an instructional transaction (Tx), (Sims & Hedberg, 1995). A Tx is more than a frame; it is an instructional event that should not be interrupted. The simulation asks the students to speculate on how a different choice of resistance would have changed the problem. This second question comes before he/she has learned if his/her original speculation was correct. I suspect this interruption increases the learner's cognitive load and may lead to frustration.

Limitation of the Research

There are several limiting factors to this research including subject demographics, survey reliability, and the number of subjects. Some of the problems stem from deviation from original design due to loss of corporate sponsorship. The small number of participants reduces the power of the research and makes it difficult to determine significance because statistical outriders play a larger role in the statistical analysis. A

small number of participants also reduces the generalizability of the research.

The low level of learner control, compared to other research, may have confounded the research in the area of focus of lesson control. A conscious decision was made to limit the choices so as not to set up a research situation where one group covers more information than another, as was the case in Shin et al. (1994). The inclusion of the same simulation and problem in the PCF lesson, instead of a more linear approach, may have further skewed the focus of control results.

Implications for Future Research

The concepts, results and insights developed during this project present opportunities for further exploration. Implications for future research exist in the area of student performance, and in the integration of software into lesson plans or courses.

Opportunities for research in areas concerning how students work together on a computer (Simsek, 1993), or how students could work in groups to overcome the lesson design problems, such as , to much learner control for a low prior knowledge student.

In a computer-aided lesson on the basic electrical light circuit, an example of a flashlight is useful; would an actual flashlight -- one the student could handle and explore -- enhance the learner's understanding? What is the benefit of computer-aided just-in-time learning? Could it be implemented in, say, an electronic laboratory, and would the students benefit? Just-in-time learning may be the ultimate in learner control, in that the learner gets the information when he/she needs or wants it.

Other lines of research include exploration into cognitive resources and load, and under what circumstance cognitive overload develops. Research along the lines of Mayer

(1997) into multi-modal learning seems promising. How do we take advantage of limited mental processing capacity through the use of multimedia? What is the role of humour and sound in CAI?

Technology has finally caught up with the promise; the challenge is to use the technology in concert with sound educational principles.

REFERENCES

Asymetrix Learning Systems (1995). Multimedia ToolBook 4.0, (CBT Edition)[Computer software]. Bellevue, WA: Asymetrix Learning Systems.

Atkinson, R. C. (1972). Ingredients for a theory of instruction. American Psychologist, 27, 921-931.

Borsook, T. (1991). Harnessing the power of interactivity for instruction. In M. R. Simonson & C. Hargraves (Eds.), Proceedings of the 1991 Convention of the Association for Educational Communications and Technology (pp. 103-117). Orlando, FL: Association for Educational Communications and Technology.

Borsook, T. & Higgenbotham-Wheat, N. (1991). Interactivity: What is it and what can it do for computer-based instruction? Educational Technology Research and Development, 31(10), 11-17.

Burwell, L. (1991). The interaction of learning styles with learner control treatments in an interactive videodisc lesson. Educational Technology 31(3), 37-43.

Duffy, T., & Jonassen, D. H. (Eds.) (1992). Constructivism and the Technology of Instruction: A Conversation. Hillsdale, NJ: Lawrence Erlbaum Associates

Fisher M. D., Blackwell, L. R., Garcia, A. B., & Greene, J, C. (1975). Effects of student control and choice on engagement in a CAI arithmetic task in a low-income school. Journal of Educational Psychology, 67, 776-783.

Gay, S. H. (1987). The effect of sequence control on computer assisted learning. Journal of Computer-Based Instruction, 14(2), 54-56.

Goetzfried, L. & Hannafin, M. J. (1985). The effect of locus of CAI control strategies on the learning of mathematical rules. American Educational Research Journal, 22, 273-278.

Gray, S. H. (1987). The effect of sequence control on computer assisted learning. Journal of Computer-Based Instruction, 14, 54-56.

Greeno, J. C., Collins, A. M., & Resnik, L. B. (1996). Cognition and learning. In D. C. Berliner & R. C. Calfee (Eds.), Handbook of Educational Psychology. New York, NY: Simon & Schuster Macmillian.

Hicken, S., Sullivan, H. & Klein, J. (1992). Learner control modes and incentive variations in computer-delivered instruction. Educational Technology Research and Development, 40(4), 15-26.

Jin, H. J. & Reeves, T. C. (1992). Mental models: A research focus for interactive learning systems. Educational Technology Research and Development. 40(3), 39-53.

Jonassen, D. H. (1988). Integrating learning strategies into courseware to facilitate deeper processing. In D. H. Jonassen (Ed.) Instructional Designs for Microcomputer Courseware.. Hillsdale, NJ: Lawrence Erlbaum Associates.

Lee, S. & Lee, Y. H. K. (1991). Effects of learner-control versus program-control on computer-aided learning of chemistry problems: For acquisition or review. Journal of Educational Psychology, 83, 491-498.

Lee, S. S. & Wong, S. C. H. (1989). Adaptive program vs. learner control strategy on computer aided learning of gravimetric stolchiometry problems. Journal of Research on Computing in Education, 21, 367-379.

Mayer, R. E. (1997). Multimedia learning: Are we asking the right questions? Educational Psychologist, 32(1), 1-19.

Milheim, W. D. (1989). Perceived attitudinal effects of various types of learner control on an interactive video lesson. Paper presented at the meeting Association for Educational Communication and Technology, Dallas, TX..

Park, O. C. (1991). Hypermedia: Functional features and research issues. Educational Technology Research and Development, 31(8), 24-35.

Park, O. C., & Tennyson, R. D. (1980). Adaptive design strategies for selecting number and presentation order of examples in coordinate concept acquisition. Journal of Educational Psychology, 72, 362-370.

Relan, A. (1991). The desktop environment in computer-based instruction: Cognitive foundations and implications for instructional design. Education Technology 31 (1), 7-14.

Ross, S. M., & Rakow, E. A. (1981). Learner control versus program control as adaptive strategies for selection of instructional support on math rules. Journal of Educational Psychology, 73, 745-753.

Shin, E. C., Schallert, D. L., & Savenye, W. C. (1994). Effects of learner control, advisement, and prior knowledge on young students' learning in a hypertext environment. Educational Technology Research and Development, 42 (1), 33-46.

Sims, R., & Hedberg J. (1995). Dimensions of learner control a reappraisal of interactive multimedia instruction. Available as Adobe Acrobat document at http://ascilite95.unimelb.edu.au/SMTU/ASCILITE95/abstracts/Sims.html.

Simsek, A. (1993). The effects of learner control and group composition in computer-based cooperative learning. Proceedings of Selected Research and Development Presentations at the Convention of the Association for Educational Communications and Technology. (ERIC Document Reproduction Service No. ED 362 205)

SPSS Inc. (1997). SPSS for Windows (Version 8.0) [Computer software]. Chicago, IL: SPSS Inc.

Temiyakarn, C. (1995). Effects of generative learner and program controlled hypermedia instruction on learning results of students at high school level. Research paper presented at the annual conference of the Association for Educational Communications and Technology, February 1996, Indianapolis, IN.

Temiyakarn, C., & Hooper, S. (1993). The effects of cooperative learning and learner control on high and low achievers. (ERIC Document Reproduction Service No. ED 362 208)

Tennyson, R. D., Park, C., & Christensen, D. L. (1985). Adaptive control of learning time and content sequence in concept learning using computer-based instruction. Journal of Educational Psychology, 77, 481-491.

Tennyson, R. D., & Rothen, W. (1977). Pretask and on-task adaptive design strategies for selecting number of instances in concept acquisition. Journal of Educational Psychology, 69, 586-582.

Williams, M. D. (1993). Interactions among attributional style, attributional feedback and learner control in computer-based instruction. Proceedings of selected research and development presentations at the convention of the Association for Educational Computers and Technology. (ERIC Document Reproduction Service No. ED 363 271)

Young, J. D. (1996). The effect of self-regulated learning strategies on performance in learner controlled computer-based instruction. Educational Technology Research and Development, 44(2), 17-27.

Zimmerman, B. J. (1990). Self-regulated learning and academic achievement: An overview. Educational Psychologist, 25(1), 3-17.

APPENDIX A

DATA COLLECTION PACKAGE

Dear Student:

My name is Will Murray. I am a graduate student in the Department of Education Psychology at the University of Calgary, conducting a research project under the supervision of Dr. John Mueller. This research is a partial requirement towards a MSc degree in Computer Applications. I am writing to provide information regarding my research project Computer-Aided Lesson
so that you can make an informed decision regarding your participation.

The purpose of the study is to determine the effectiveness of a simple tutorial on basic electronic theory. As part of the study you will be asked to:

* Sign consent form for research participation
* Complete a computer-aided tutorial, including quiz, your path through the lesson and all responses and scores will be saved in an encrypted format in computer filesfor latter analysis.
* Fill out a short questionnaire

You should be aware that even if you give your permission you are free to withdraw at any time or for any reason without penalty. Participation in this study will involve no greater risk than those ordinarily experienced in daily life.

Data will be gathered in such a way as to ensure anonymity, that is, you will not be required nor asked to enter your name by the program. You will be asked to enter a code. There will be no record linking you to your code. Once collected the data will be kept in strict confidence, in secured files. Data will be destroyed two years after the completion of the study. Dissemination will be in the form of a short report. Only myself and my supervisor, Dr. Mueller, will have access to the data. I will disseminate copies in Calgary. You may request a copy by circling YES on the appropriate space on the consent form.

If you have any problems feel free to call me 402.289.9373, my supervisor for this project in Dr. John Mueller 403.220.5664, the Office of the Chair, Faculty of Education Joint Ethics Committee at 403.220.5626, or the Office of the Vice-President (Research) at 403.220.3381. Two copies of the consent form are provided. Please return one signed copy to me and retain the other copy for your record.

Thank you for your cooperation.
Sincerely,

William D. Murray

* Email: wmurray@acs.ucalgary.ca
Internet http://www.ucalgary/~wmurray/ http://www.4imago.com/
* Voice 403.289.9373 Fax 403.244.2018

CONSENT FOR RESEARCH PARTICIPATION

I the undersigned, hereby give my consent to participate in a research project entitled Computer-Aided Lesson.

I understand that such consent means that I will take part in the following:

* Complete a computer-aided tutorial, including a pretest and post test, and that, all responses and scores will be recorded by the computer for latter analysis by me..
* Compete a computer monitored questionnaire

All together the whole process takes about 60 minutes.

I understand that participation in this study may be terminated at any time by my request or at the request of the investigator. Participation in this project and/or withdrawal from this project will not adversely affect me in any way.

I understand that the responses will be obtained anonymously and kept in strictest confidence.
I understand that only group data will reported for this project and that the data will be available to my supervisor Dr. J. Mueller, and Dr. J. Melott who is assisting in data collection. A report on research results will be forwarded to Dr. Melott for dissemination to participants. I will provide reports for Calgary participants. Please indicate below if you would like a copy of the report.

I would like a copy of the research report [circle one] YES NO. University of Calgary participants, If you indicated YES provide address or location to send report in the space below.

I have received a copy of this consent form for my records

I understand that if I have any questions I can contact the researcher at 403.289.9373, his supervisor 403.220.5664, the Office of the Chair, Faculty of Education Joint Ethics Committee at 403. 220.5626, or the Office of the Vice-President (Research) at 403.220.3381

_____ _____

Date Signature

_____

Participant's Printed Name

http://www.4imago.com

APPENDIX B

QUESTIONS FROM COMPUTER MODERATED QUESIONNAIRE

1. How would you rate your computer knowledge?

Expert Some more Some A little None

2. It was easy to navigate through the lesson.

Strongly agree Agree Neutral Disagree Strongly disagree

3. I liked the sound used in the lesson

Strongly agree Agree Neutral Disagree Strongly disagree

4. The sequencing of the lesson was appropriate.

Strongly agree Agree Neutral Disagree Strongly disagree

5. The computer was in control of the lessons.

All of the time Most of the time Some of the time Occasionally Rarely

6. I felt I was in control of the lesson

All of the time Most of the time Some of the time Occasionally Rarely

7. How much did you enjoy the lesson?

A lot Some more Some A little Not at all

8. There should be more sound in the lesson.

Strongly agree Agree Neutral Disagree Strongly disagree

9. There should be more humour in computer-aided lessons -- in general

Strongly agree Agree Neutral Disagree Strongly disagree

10. I like humour in the lesson.

Strongly agree Agree Neutral Disagree Strongly disagree

11. Prior to participation in this project how much did you know about the subject?

A lot A little more A little Very little Nothing

12. The programs level of interactivity was just about right.

Strongly agree Agree Neutral Disagree Strongly disagree

APPENDIX C

SAMPLE LOG FILES

Sample PCF-PCF Log File

This student completed a program control focus (PCF) module. Analysis of the log modules would have been easier if page naming had been done more carefully. Annotations to log file are in bold font.

```
10:45:41 AM : a012{student id]              1998  02    04 {date]
pretest D:\EET_CD\PRETEST.EXE {module name]      10    45
10:45:43 AM  Page Title
11:09:13 AM  Page Q5
11:09:44 AM  Page Q12
11:09:46 AM  Q5          "Voltage" {answer selected]
11:10:01 AM  Page Q13
11:10:03 AM  Q12         "Current"
11:10:22 AM  Page Q8
11:10:24 AM  Q13         "Decrease R"
11:10:28 AM  Page Q14
11:10:30 AM  Q8          "Voltage"
11:10:35 AM  Page Q6
11:10:37 AM  Q14         "Voltage"
11:10:49 AM  Page Q2
11:10:51 AM  Q6          "very little resistance."
11:10:59 AM  Page Q11
11:11:00 AM  Q2          "Impedance"
11:11:07 AM  Page Q4
11:11:09 AM  Q11         "Resistance"
11:11:28 AM  Page Q7
11:11:30 AM  Q4          "Insulating"
11:11:38 AM  Page Q15
11:11:40 AM  Q7          "Resistance"
11:11:48 AM  Page Q10
11:11:49 AM  Q15         "Current"
11:11:56 AM  Page Q1
11:11:58 AM  Q10         "Coulomb"
11:12:23 AM  Page Q9
11:12:24 AM  q1          "Amps = V/R"
11:12:35 AM  Page Q3
11:12:36 AM  Q9          "Voltage"
```

11:13:16 AM Page Quiz Summary
11:13:18 AM Q3 "Insulators"
11:13:20 AM Q5 Locked! "Voltage"
11:13:21 AM Q12 Locked! "Current"
11:13:21 AM Q13 Locked! "Decrease R"
11:13:21 AM Q8 Locked! "Voltage"
11:13:22 AM Q14 Locked! "Voltage"
11:13:22 AM Q6 Locked! "very little resistance."
11:13:23 AM Q11 Locked! "Resistance"
11:13:23 AM Q4 Locked! "Insulating"
11:13:24 AM Q7 Locked! "Resistance"
11:13:24 AM Q15 Locked! "Current"
11:13:24 AM Q10 Locked! "Coulomb"
11:13:25 AM q1 Locked! "Amps = V/R"
11:13:25 AM Q9 Locked! "Voltage"
11:13:26 AM Q3 Locked! "Insulators"
11:13:26 AM Q=Group a : E=ShowScore! : S=0.4,15

SESSION END SUMMARY 00 28 31

Question	Score	Max Score	Locked	Tries used		Max Tries	Time used
	Max Time	Last response					
Q5	1	1 TRUE 1	1	0	0	"Voltage"	
Q12	0	1 TRUE 1	1	0	0	"Current"	
Q13	1	1 TRUE 1	1	0	0	"Decrease R"	
Q8	0	1 TRUE 1	1	0	0	"Voltage"	
Q14	1	1 TRUE 1	1	0	0	"Voltage"	
Q6	1	1 TRUE 1	1	0	0	"very little resistance."	
Q2	0	1 FALSE1	0	0	0	"Impedance"	
Q11	0	1 TRUE 1	1	0	0	"Resistance"	
Q4	0	1 TRUE 1	1	0	0	"Insulating"	
Q7	1	1 TRUE 1	1	0	0	"Resistance"	
Q15	0	1 TRUE 1	1	0	0	"Current"	
Q10	0	1 TRUE 1	1	0	0	"Coulomb"	
q1	1	1 TRUE 1	1	0	0	"Amps = V/R"	
Q9	0	1 TRUE 1	1	0	0	"Voltage"	
Q3	0	1 TRUE 1	1	0	0	"Insulators"	

11:14:01 AM a012 1998 02 04
VOI D:\EET_CD\P_VOLT.EXE 11 14
----- ----- -----
11:14:03 AM Page PC **{PCF Prenotification page]**
11:14:09 AM Page Title Page **{no menu page indicates PCF focus lesson]**

11:14:23 AM Page Chapter 1
11:14:45 AM Page c1 p1
11:14:58 AM Page c1 p2
11:15:24 AM Page c1 p3
11:16:02 AM Page c1 p3a
11:16:19 AM Page c1 p4
11:17:07 AM Page c1 p5
11:17:34 AM Page c1 p6
11:17:51 AM Page answer01
11:18:29 AM Page Current? **{pop-up page]**
11:18:57 AM Page vreview
11:19:23 AM Page end PC
SESSION END SUMMARY 00 05 35
Question Score Max Score LockedTries used Max Tries Time used
Max Time Last response

11:19:37 AM a012 1998 02 04
VOI D:\EET_CD\P_AMP.EXE 11 19
----- ----- -----
11:19:39 AM Page Title Page
11:19:51 AM Page Chapter 1
11:19:57 AM Page c1 p1
11:20:01 AM Page c1 p2
11:20:18 AM Page c1 p3
11:20:44 AM Page penny
11:21:15 AM Page shocking
11:21:43 AM Page c1 p3
11:22:05 AM Page pwnny **{analogy pop-up]**
11:22:17 AM Page c1p3a
11:22:32 AM Page c1 p4
11:23:37 AM Page c1 p5
11:23:47 AM Page answer01
11:25:25 AM Page Mathextra **{pop-up for math formula manipulation]**
11:25:29 AM Page value for R
11:25:34 AM Page c1 p5
11:25:37 AM Page C1 p6
11:25:46 AM Page C1 p7
11:26:03 AM Page C1 p8
11:26:47 AM Page C1 p9
11:27:06 AM Page C1 p10
11:27:17 AM Page end of amps
SESSION END SUMMARY 00 07 48

Question	Score	Max Score	Locked	Tries used	Max Tries	Time used
	Max Time	Last response				

11:27:27 AM a012 1998 02 04
VOI D:\EET_CD\P_OHM.EXE 11 27

11:27:29 AM	Page	Title Page
11:27:54 AM	Page	What is circuit
11:28:53 AM	Page	requirements_c
11:29:41 AM	Page	c1 p2
11:30:43 AM	Page	c1 p2
11:31:23 AM	Page	6of24
11:32:11 AM	Page	valence
11:32:33 AM	Page	conductor
11:33:15 AM	Page	insulator
11:33:28 AM	Page	semiconductor
11:33:45 AM	Page	3atoms
11:34:05 AM	Page	3atomquiz
11:34:10 AM	Page	c1 p4
11:34:12 AM	3atomquizchoice	""
11:35:02 AM	Page	c1 p5
11:35:19 AM	Page	R_circuit sym
11:35:35 AM	Page	Rev_1
11:36:21 AM	Page	Rev_2
11:36:37 AM	Page	Menu

SESSION END SUMMARY 00 09 20

Question	Score	Max Score	Locked	Tries used	Max Tries	Time used
	Max Time	Last response				

11:36:48 AM a012 1998 02 04
VOI D:\EET_CD\P_SIM.EXE 11 36

11:36:49 AM	Page	Title Page
11:37:11 AM	Page	sim01
11:37:25 AM	Page	start
11:37:35 AM	Page	2r?v
11:37:47 AM	Page	8r?vans
11:38:02 AM	Page	16v4r
11:38:18 AM	Page	16V4Rdo
11:38:21 AM	Page	start
11:38:24 AM	Page	8V?R

11:38:32 AM Page 8v8r
11:38:35 AM Page 8v8rdo
11:38:39 AM Page start
11:38:41 AM Page 4r?v
11:38:43 AM Page 16v4r
11:38:46 AM Page 16V4Rdo
11:38:48 AM Page start
11:38:51 AM Page 16V?R
11:38:52 AM Page 16v2r
11:38:55 AM Page 16v2rdo
11:38:59 AM Page start
11:39:00 AM Page 16V?R
11:39:02 AM Page 16v8rdo
11:39:07 AM Page 16v8rcf
11:39:21 AM Page start
11:39:24 AM Page menu
SESSION END SUMMARY 00 02 42
Question Score Max Score LockedTries used Max Tries Time used
Max Time Last response

11:39:32 AM a012 1998 02 04
VOI D:\EET_CD\P_PROB~1.EXE 11 39
----- ----- -----
11:39:33 AM Page start
11:39:55 AM Page 01
11:40:10 AM Page 8V?R
11:40:12 AM Page 8v2r
11:40:22 AM Page start
11:40:29 AM Page menu
SESSION END SUMMARY 00 01 09
Question Score Max Score LockedTries used Max Tries Time used
Max Time Last response

11:40:43 AM a012 1998 02 04
voi quiz D:\EET_CD\VOI_QUIZ.EXE 11 40
----- ----- -----
11:40:44 AM Page Title
11:40:56 AM Page Q9
11:41:07 AM Page Q15
11:41:08 AM Q9 "Impedance"
11:41:08 AM Q9 Locked! "Impedance"

```
11:41:11 AM  Page Q12
11:41:13 AM  Q15            "Current"
11:41:13 AM  Q15    Locked!      "Current"
11:41:19 AM  Page Q8
11:41:21 AM  Q12            "Resistance"
11:41:21 AM  Q12    Locked!      "Resistance"
11:41:25 AM  Page Q7
11:41:27 AM  Q8             "Current"
11:41:27 AM  Q8     Locked!      "Current"
11:41:38 AM  Page Q3
11:41:39 AM  Q7             "Resistance"
11:41:39 AM  Q7     Locked!      "Resistance"
11:41:47 AM  Page Q2
11:41:48 AM  Q3             "Conductors"
11:41:48 AM  Q3     Locked!      "Conductors"
11:41:57 AM  Page Q1
11:41:59 AM  Q2             "I"
11:41:59 AM  Q2     Locked!      "I"
11:42:12 AM  Page Q6
11:42:13 AM  q1             "Amps = V/R"
11:42:13 AM  q1     Locked!      "Amps = V/R"
11:42:23 AM  Page Q13
11:42:25 AM  Q6             "very little resistance."
11:42:25 AM  Q6     Locked!      "very little resistance."
11:42:41 AM  Page Q11
11:42:42 AM  Q13            "Decrease R"
11:42:42 AM  Q13    Locked!      "Decrease R"
11:42:59 AM  Page Q10
11:43:01 AM  Q11            "Impedance"
11:43:07 AM  Page Q5
11:43:08 AM  Q10            "Coulomb"
11:43:08 AM  Q10    Locked!      "Coulomb"
11:43:11 AM  Page Q4
11:43:13 AM  Q5             "Voltage"
11:43:13 AM  Q5     Locked!      "Voltage"
11:43:33 AM  Page Q14
11:43:35 AM  Q4             "Insulating"
11:43:35 AM  Q4     Locked!      "Insulating"
11:43:42 AM  Page Quiz Summary
11:43:43 AM  Q14            "Voltage"
11:43:43 AM  Q14    Locked!      "Voltage"
SESSION END         SUMMARY  00      03      17
```

Question	Score	Max Score	Locked	Tries used		Max Tries	Time used
	Max Time	Last response					
Q9	1	1	TRUE	0	0	0	"Impedance"
Q15	1	1	TRUE	0	0	0	"Current"
Q12	1	1	TRUE	0	0	0	"Resistance"
Q8	1	1	TRUE	0	0	0	"Current"
Q7	1	1	TRUE	0	0	0	"Resistance"
Q3	1	1	TRUE	0	2	0	"Conductors"
Q2	1	1	TRUE	0	0	0	"I"
q1	1	1	TRUE	0	0	0	"Amps = V/R"
Q6	1	1	TRUE	0	2	0	"very little resistance."
Q13	1	1	TRUE	0	0	0	"Decrease R"
Q11	1	1	FALSE	0	0	0	"Impedance"
Q10	1	1	TRUE	0	0	0	"Coulomb"
Q5	1	1	TRUE	0	0	0	"Voltage"
Q4	0	1	TRUE	0	2	0	"Insulating"
Q14	1	1	TRUE	0	0	0	"Voltage"

11:44:05 AM a012 1998 02 04

voi quiz D:\EET_CD\SURVQUIZ.EXE 11 44

11:44:06 AM	Page Title	
11:44:18 AM	Page Question 9	
11:44:27 AM	Page Question 7	
11:44:29 AM	lesson sound	"Agree"
11:44:35 AM	Page Question 13	
11:44:37 AM	interactivity	"Agree"
11:44:44 AM	Page Question 5	
11:44:45 AM	comp know	"Some"
11:44:49 AM	Page Question 12	
11:44:51 AM	lc	"All of the time"
11:44:57 AM	Page Question 6	
11:44:59 AM	sound_les	"Neutral"
11:45:04 AM	Page Question 8	
11:45:05 AM	enjoy less	"A lot"
11:45:11 AM	Page Question 2	
11:45:12 AM	humour_gen	"Strongly Agree"
11:45:30 AM	Page Question 11	

11:45:31 AM computer control "Some of the time"
11:45:40 AM Page Question 1
11:45:41 AM gen humour "Neutral"
11:45:46 AM Page Question 4
11:45:47 AM navig "Strongly Agree"
11:45:52 AM Page Question 3
11:45:54 AM seq "Strongly Agree"
11:46:02 AM Page Quiz Summary
11:46:03 AM prior know "very little"

SESSION END SUMMARY 00 02 12

Question	Score	Max Score	Locked	Tries used		Max Tries		Time used
Max Time		Last response						
lesson sound	0	5	FALSE	0	0	0	0	"Agree"
interactivity	0	5	FALSE	0	0	0	0	"Agree"
comp know	0	5	FALSE	0	0	0	0	"Some"
lc	0	5	FALSE	0	0	0	0	"All of the time"
sound_les	0	5	FALSE	0	0	0	0	"Neutral"
enjoy less	0	5	FALSE	0	0	0	0	"A lot"
humour_gen	0	5	FALSE	0	0	0	0	"Strongly Agree"
computer control	0	5	FALSE	0	0	0	0	"Some of the time"
gen humour	0	5	FALSE	0	0	0	0	"Neutral"
navig	0	5	FALSE	0	0	0	0	"Strongly Agree"
seq	0	5	FALSE	0	0	0	0	"Strongly Agree"
prior know	0	5	FALSE	0	0	0	0	"very little"

LCF-PCF Sample Log File

The Pretest, Post-test and Survey have been removed for this sample, they are the same for all treatments. This student completed the program in menu order but repeated modules.

3:43:56 PM b16 1998 04 01

VOI D:\EET_CD\VOLT_TUT.EXE 15 43

3:43:58 PM	Page PC	**{Pre-notification of a PCF lesson page]**
3:44:05 PM	Page Menu	**{menu page indicates actual LCF lesson]**
3:44:12 PM	Page Title Page	
3:44:25 PM	Page Chapter 1	
3:44:51 PM	Page c1 p1	
3:45:06 PM	Page c1 p2	
3:45:43 PM	Page c1 p3	
3:46:22 PM	Page c1 p4	
3:47:11 PM	Page c1 p5	
3:47:32 PM	Page c1 p6	
3:47:47 PM	Page answer01	
3:48:12 PM	Page c1 p5	
3:48:14 PM	Page c1 p4	
3:48:17 PM	Page c1 p5	
3:48:19 PM	Page c1 p6	
3:48:27 PM	Page Current?	
3:48:39 PM	Page vreview	
3:48:43 PM	Page c1 p6	
3:48:45 PM	Page vreview	
3:49:21 PM	Page Chapter 1	
3:49:23 PM	Page Title Page	
3:49:26 PM	Page Menu	
3:49:29 PM	Page Title Page	
3:49:32 PM	Page Menu	

SESSION END SUMMARY 00 05 41

Question Score Max Score LockedTries used Max Tries Time used Max Time Last response

---

3:49:40 PM b16 1998 04 01

VOI D:\EET_CD\AMP_TUT.EXE 15 49

3:49:41 PM	Page Title Page
3:49:45 PM	Page Chapter 1
3:49:51 PM	Page c1 p1
3:49:55 PM	Page c1 p2
3:50:03 PM	Page c1 p3
3:50:37 PM	Page penny
3:51:00 PM	Page shocking
3:51:30 PM	Page c1 p3
3:51:46 PM	Page c1 p3
3:52:02 PM	Page c1p3a
3:52:15 PM	Page c1 p4
3:52:44 PM	Page c1 p5
3:52:57 PM	Page answer01
3:54:21 PM	Page Mathextra
3:54:41 PM	Page value for R
3:54:51 PM	Page c1 p5
3:54:53 PM	Page C1 p6
3:55:14 PM	Page C1 p7
3:55:40 PM	Page C1 p8
3:56:32 PM	Page C1 p7
3:56:34 PM	Page C1 p6
3:56:34 PM	Page c1 p5
3:56:39 PM	Page Mathextra
3:56:49 PM	Page value for R
3:56:52 PM	Page c1 p5
3:56:55 PM	Page C1 p6
3:56:57 PM	Page C1 p7
3:56:58 PM	Page C1 p8
3:57:02 PM	Page C1 p9
3:57:28 PM	Page C1 p10
3:57:36 PM	Page Menu

SESSION END SUMMARY 00 08 03

Question	Score	Max Score	Locked	Tries used	Max Tries	Time used	Max Time	Last response
3:57:45 PM	b16	1998	04	01				

VOI D:\EET_CD\OHMS.EXE 15 57

3:57:46 PM	Page Title Page
3:57:48 PM	Page What is circuit

3:58:41 PM Page requirements_c
3:59:19 PM Page requirements_c
3:59:25 PM Page c1 p2
4:00:28 PM Page c1 p2
4:00:42 PM Page c1 p2
4:00:45 PM Page c1 p2
4:00:47 PM Page 6of24
4:01:03 PM Page valence
4:01:19 PM Page conductor
4:01:45 PM Page insulator
4:02:02 PM Page semiconductor
4:02:15 PM Page 3atoms
4:02:28 PM Page 3atomquiz
4:02:35 PM Page c1 p4
4:02:37 PM 3atomquizchoice ""
4:03:14 PM Page c1 p5
4:03:28 PM Page R_circuit sym
4:03:36 PM Page Rev_1
4:04:02 PM Page Rev_2
4:04:27 PM Page Menu feeding parking meter break
SESSION END SUMMARY 00 12 56
Question Score Max Score LockedTries used Max Tries Time used
Max Time Last response

4:10:43 PM b16 1998 04 01
VOI D:\EET_CD\SIM.EXE 16 10
---- ---- ----
4:10:44 PM Page sim01
4:11:31 PM Page start
4:11:45 PM Page start
4:11:58 PM Page 8r?v
4:12:21 PM Page 8r?vans
4:13:24 PM Page 16V8R
4:13:43 PM Page 16v8rdo
4:13:51 PM Page 16v8rcf
4:14:06 PM Page start
4:14:09 PM Page 4r?v
4:14:14 PM Page 8r?vans
4:14:21 PM Page 8v4r
4:14:25 PM Page 8v4rdo
4:14:31 PM Page start
4:14:33 PM Page 4v?r

4:14:39 PM Page 4v?rans
4:14:56 PM Page 4v2r
4:15:01 PM Page 4v2rdo
4:15:05 PM Page start
4:15:06 PM Page 2r?v
4:15:15 PM Page 8r?vans
4:15:20 PM Page 16v8rdo
4:15:24 PM Page 16v8rcf
4:15:26 PM Page start
4:15:31 PM Page menu
SESSION END SUMMARY 00 04 58
Question Score Max Score LockedTries used Max Tries Time used
Max Time Last response

==========

4:15:42 PM b16 1998 04 01
VOI D:\EET_CD\SIMPRO.EXE 16 15
----- ----- -----
4:15:44 PM Page start **{returned to module]**
4:15:45 PM Page menu
SESSION END SUMMARY 00 00 06
Question Score Max Score LockedTries used Max Tries Time used
Max Time Last response

==========

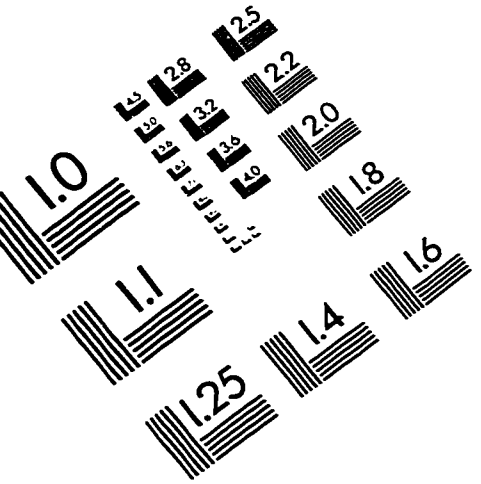
4:15:50 PM b16 1998 04 01
VOI D:\EET_CD\OHMS.EXE 16 15
----- ----- ----- **{returned to module]**
4:15:51 PM Page Title Page
4:15:54 PM Page What is circuit
4:16:01 PM Page requirements_c
4:16:06 PM Page c1 p2
4:16:08 PM Page c1 p2
4:16:10 PM Page 6of24
4:16:18 PM Page valence
4:16:20 PM Page Menu
SESSION END SUMMARY 00 00 35
Question Score Max Score LockedTries used Max Tries Time used
Max Time Last response

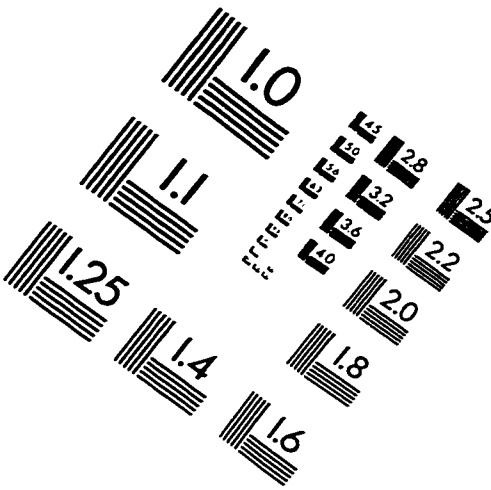
==========

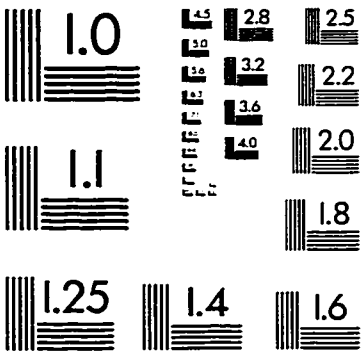
4:16:27 PM b16 1998 04 01
VOI D:\EET_CD\SIMPRO.EXE 16 16 **{returned to module]**

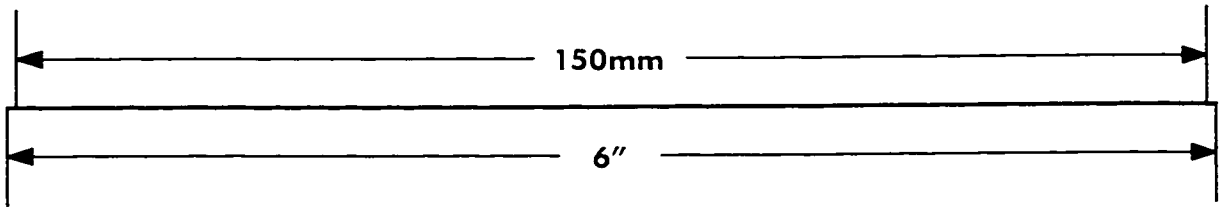
4:16:28 PM	Page start	
4:16:48 PM	Page 01	
4:17:07 PM	Page 8r?v	
4:17:13 PM	Page 4v8r	
4:17:16 PM	Page 4v8rdo	
4:17:21 PM	Page start	
4:17:32 PM	Page 01	
4:17:38 PM	Page 4v?r	
4:17:42 PM	Page 4v4r	
4:17:51 PM	Page start	
4:17:53 PM	Page 01	
4:17:55 PM	Page 2r?v	
4:17:57 PM	Page 4v2r	
4:18:06 PM	Page start	
4:18:11 PM	Page 01	
4:18:13 PM	Page 8r?v	
4:18:14 PM	Page 16V8R	
4:18:24 PM	Page start	
4:18:26 PM	Page 01	
4:18:28 PM	Page 8r?v	
4:18:29 PM	Page 4v8r	
4:18:31 PM	Page 4v8rdo	
4:18:35 PM	Page start	
4:18:37 PM	Page 01	
4:18:39 PM	Page 2r?v	
4:18:40 PM	Page 4v2r	
4:18:47 PM	Page start	
4:19:00 PM	Page 01	
4:19:06 PM	Page menu	
SESSION END	SUMMARY	00 02 45

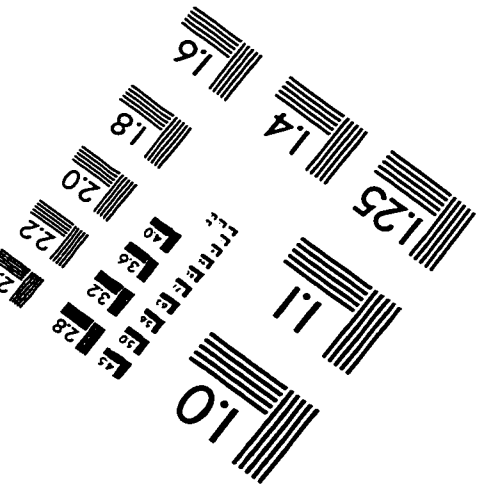
IMAGE EVALUATION
TEST TARGET (QA-3)

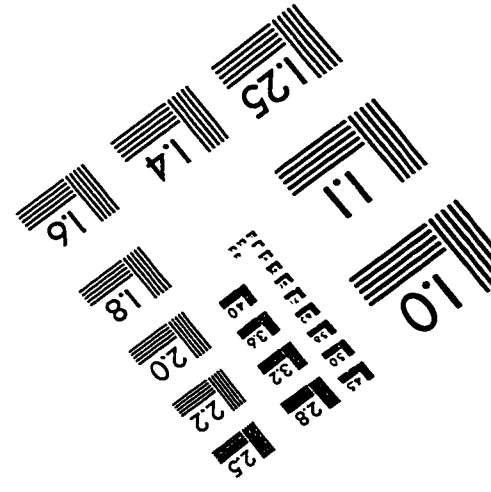












APPLIED IMAGE, Inc
1653 East Main Street
Rochester, NY 14609 USA
Phone: 716/482-0300
Fax: 716/288-5989