AN EXPLORATORY STUDY OF THE RELATIONSHIP
BETWEEN LEARNER CONTROL PATTERNS AND COURSE COMPLETION
IN COMPUTER ASSISTED INSTRUCTION,

by

Monica Flynn Sasscer

Dissertation submitted to the Graduate Faculty
of the Virginia Polytechnic Institute and State University
in partial fulfillment of the requirements for the degree of
DOCTOR OF EDUCATION
in
Community College Education

APPROVED:

David M. Moore, Co-Chairman  Marilyn Lichtman, Co-Chairman

Maryvelle C. Keim

Jean C. Netherton  W. Robert Sullins

November, 1982
Blacksburg, VA
ACKNOWLEDGEMENTS

The present study could not have been accomplished without the assistance and support of many talented and generous people. I wish to thank the members of my committee, especially Drs. David M. Moore, Marilyn Lichtman and Marybelle Keim, who willingly gave of their time and expertise to guide me as they shifted and shared the role of chairman and co-chairman. Dr. Keim is deserving of special gratitude for her enduring help and loyalty, even from a long distance and under difficult personal circumstances.

I am sincerely appreciative of the contributions of Dr. Jean C. Netherton as mentor and friend throughout the gestation of this project. My thanks, as well, to Dr. W. Robert Sullins for his general advice and guidance.

The fact that there was any student keypress data to analyze at all and that it was in useable form is entirely due to the efforts of His knowledge and perseverance were instrumental in overcoming the many technical problems of this study. I am most grateful to him and the other members of the TICCIT operations staff for their assistance.

I am also greatly indebted to the statistician whose insight provided the key to completing the study. A very special thank you is extended to for typing "duty" far beyond the call of friendship.

Appreciation must be expressed to my colleagues in the Learning Resource Center, and most especially to the staff of the Learning Lab,
for patience, kindness and understanding as I have had to focus attention on this project.

And to my family: my parents, for inspiring and encouraging me; my husband, for lovingly bearing with me; and our children, for the years of understanding tolerance, a most loving, thank you!
TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>ii</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>vi</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>vii</td>
</tr>
<tr>
<td>CHAPTER</td>
<td></td>
</tr>
<tr>
<td>1 INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>Problem, Purpose and Hypothesis</td>
<td>3</td>
</tr>
<tr>
<td>Background</td>
<td>5</td>
</tr>
<tr>
<td>Significance of the Study</td>
<td>13</td>
</tr>
<tr>
<td>Assumptions and Limitations of the Study</td>
<td>14</td>
</tr>
<tr>
<td>Definition of Terms</td>
<td>16</td>
</tr>
<tr>
<td>Overview</td>
<td>20</td>
</tr>
<tr>
<td>2 REVIEW OF THE LITERATURE</td>
<td>21</td>
</tr>
<tr>
<td>An Overview of Computer Assisted Instruction</td>
<td>21</td>
</tr>
<tr>
<td>Literature Related to Learner Control Research</td>
<td>24</td>
</tr>
<tr>
<td>Summary</td>
<td>37</td>
</tr>
<tr>
<td>3 METHODOLOGY</td>
<td>43</td>
</tr>
<tr>
<td>The Setting</td>
<td>43</td>
</tr>
<tr>
<td>The Subjects</td>
<td>44</td>
</tr>
<tr>
<td>The Instructional Content</td>
<td>45</td>
</tr>
<tr>
<td>Design and Data Collection</td>
<td>46</td>
</tr>
<tr>
<td>The Hypothesis and Analytical Methods</td>
<td>49</td>
</tr>
<tr>
<td>Additional Research Questions</td>
<td>54</td>
</tr>
<tr>
<td>Summary</td>
<td>58</td>
</tr>
<tr>
<td>4 ANALYSIS OF THE DATA</td>
<td>60</td>
</tr>
<tr>
<td>Learner Control Patterns</td>
<td>61</td>
</tr>
<tr>
<td>Additional Research Questions</td>
<td>71</td>
</tr>
<tr>
<td>Summary</td>
<td>79</td>
</tr>
<tr>
<td>5 SUMMARY, DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS</td>
<td>80</td>
</tr>
<tr>
<td>Summary</td>
<td>80</td>
</tr>
<tr>
<td>Discussion of the Hypothesis</td>
<td>82</td>
</tr>
<tr>
<td>Conclusions</td>
<td>92</td>
</tr>
<tr>
<td>Recommendations</td>
<td>93</td>
</tr>
</tbody>
</table>
# TABLE OF CONTENTS
(continued)

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIBLIOGRAPHY</td>
<td>98</td>
</tr>
<tr>
<td>APPENDIX A -- English 110 and Math 06 Course Outline</td>
<td>105</td>
</tr>
<tr>
<td>APPENDIX B -- Questionnaire</td>
<td>115</td>
</tr>
<tr>
<td>APPENDIX C -- Sample of Log Tape Output</td>
<td>118</td>
</tr>
<tr>
<td>APPENDIX D -- Raw Data on the Number of Requests for RULES, EXAMPLES</td>
<td>120</td>
</tr>
<tr>
<td>and PRACTICES</td>
<td></td>
</tr>
<tr>
<td>APPENDIX E -- Histogram Graphs of the Number of Keypresses Accessed</td>
<td>125</td>
</tr>
<tr>
<td>by Students (Figures 1 through 6)</td>
<td></td>
</tr>
</tbody>
</table>
LIST OF TABLES

<table>
<thead>
<tr>
<th>TABLE</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Distribution of Keypress Patterns Employed by all Students in the Study</td>
</tr>
<tr>
<td>2</td>
<td>Distribution of Pattern Use by Group</td>
</tr>
<tr>
<td>3</td>
<td>Number of Rule, Example and Practice Keys Accessed</td>
</tr>
<tr>
<td>4</td>
<td>Performance of English Students on the Pre-test</td>
</tr>
<tr>
<td>5</td>
<td>Performance of Math Students on the Pre-test</td>
</tr>
<tr>
<td>6</td>
<td>Chi-square analyses of Students' Demographic Characteristics</td>
</tr>
<tr>
<td>7</td>
<td>Students' Reasons for Enrolling in Courses</td>
</tr>
<tr>
<td>8</td>
<td>Students' Long Term Academic Goals</td>
</tr>
<tr>
<td>FIGURE</td>
<td>Page</td>
</tr>
<tr>
<td>--------</td>
<td>------</td>
</tr>
<tr>
<td>1</td>
<td>53</td>
</tr>
<tr>
<td>Contingency Table of Pattern Usage</td>
<td>53</td>
</tr>
</tbody>
</table>

vii
INTRODUCTION

This study concerns the learning strategies used by community college students in computer assisted instruction. With the current advances in both instructional development and instructional delivery technologies, the question of who will control the instructional process and what dimensions of it they will control, has become an increasingly important issue (O'Neal, 1977). Toffler (1971) has said that the illiterates of the future will be those who have not learned how to learn. Merrill (1980) and his associates have expressed the belief that a truly effective instructional system is one that imparts the tools to adapt any instruction to the student's learning strategies and needs.

At least one major automated instructional system has been designed from the basic philosophical position of learner control, the TICCIT system. TICCIT (Time-shared, Interactive, Computer-Controlled, Information Television) is a time shared computer assisted instruction system, providing individualized instruction to as many as 128 learners simultaneously over color video terminals with computer generated and video tape display capabilities, as well as audio messages. It represents a departure from previous CAI systems in the important respect that the basic instructional software on the system was designed to facilitate...
learner control on many potentially important dimensions (O'Neal, 1977). TICCIT includes content control and self pacing, but emphasizes the idea of display or strategy control (Merrill, 1980). The primary use of the TICCIT system has been to deliver full courses rather than as a drill and practice supplement to more traditional instructional systems.

This investigation was designed to discover how students used the available learner control features, and whether those students who completed all the course requirements of two TICCIT delivered courses within a prescribed academic term used different strategies to work through the instructional materials, than those students who did not complete the courses. The learner control features are implemented on the TICCIT system by 15 buttons which augment the standard typewriter keyboard used to interact with the computer. The student uses these buttons, or keys, to select the next segment of material to study and/or the next instructional display within a segment. Merrill (1980) has stated that "[t]he TICCIT instructional design is based on the assumption that a given idea -- a concept, procedure or principle -- should be presented in each of three modes: rule, example and practice" (p. 77). These have been labeled primary presentation forms (Merrill & Wood, 1975). In addition to the RULE, EXAMPLE and PRACTICE displays, the learner control keys provide access to three levels of those displays: easy, medium and hard; additional elaboration of RULE, EXAMPLE and PRACTICE are found under the HELP key; an ADVICE function provides information to the student on how well he/she is performing compared to the course author's expectations, and whether or not
he should continue, or BACK up or SKIP ahead.

Learning strategies have been defined as those explicit decisions on the part of students as how to proceed through a learning episode (Elliott, 1976). In the context of TICCIT, these decisions involve the selection of each instructional display. Elliott (1976) studied the concepts of learning styles and learning strategies of adult learners and concluded that adults do exhibit "distinctive or characteristic manners of approaching learning episodes" (p.46).

The strategies he observed included characteristic approaches to sequencing, pacing and distribution of moves. He also found evidence of stability across tasks, where these were the objectives of a lesson (Elliott, 1976).

The present study sought to examine further learning strategies and their association with student success in courses characterized by learner controlled instruction. Success was defined as completion of all course objectives within a prescribed time period, an 11-week academic term. The terms successful students and completing students were used synonymously in the study since the instructional materials were designed to require mastery of each objective before proceeding to the next one.

**Problem, Purpose and Hypothesis**

The problem addressed in this study was the relationship between learning strategies and course completion rates of students in a learner controlled computer assisted instruction setting.

On the surface, the goals of increased learning effectiveness
and efficiency which many studies have concluded to be the major benefits of computer assisted instruction (Feldhusen & Szabo, 1969; Visonhaler & Bass, 1972) did not seem to be realized by the TICCIT system. An evaluation conducted by the Educational Testing Service in 1976 reported that fewer students completed the courses taught via TICCIT than those taught in a more traditional lecture-discussion mode (Alderman, 1978). The settings for this evaluation were two community colleges, Northern Virginia Community College (NVCC) and Phoenix College in Arizona. The students were enrolled in freshman English composition and pre-college level algebra courses. Follow-up studies conducted at Northern Virginia the following year reported similar findings (Sasscer, 1977).

Since TICCIT is characterized by the learner control instructional design, it was decided to explore the students' use of some of the learner control features for their relationship to course completion rates within an academic term. If TICCIT's instructional design was effective, students might be expected to use many different strategies to progress through a course. Furthermore, these strategies, or even a lack of them, might provide clues to the completion rate problem by discriminating between successful and unsuccessful students. The investigation focused on the students' use of the primary presentation forms, the displays labeled RULE, EXAMPLE and PRACTICE.

The hypothesis of the study was stated as follows:
The learning strategies or patterns developed by students in a learner control instructional design environment
discriminate between students who successfully complete all course objectives in TICCIT CAI delivered courses within one academic term, and those who do not.

Students' background characteristics, including pre-test scores and reasons for taking the courses were included as additional information and analyzed for their possible relationship to the use of learner control and/or course completion.

It was expected that all of these variables, when analyzed, would result in the following information about the TICCIT system and its learner control instructional design:

a) how students use specific learner control features;

b) the relationship, if any, between that use and completion of a TICCIT course; and

c) the relationship of student demographic characteristics, entrance ability, and long and short term goals to the completion of a TICCIT course.

Background

The TICCIT system was conceived by the MITRE Corporation as a means of bringing CAI within closer reach of the educational community. In 1971, the National Science Foundation funded a proposal by MITRE and the CAI Laboratory of the University of Texas (later transferred to the Institute for Computer Uses in Education at Brigham Young University, Utah) to design and demonstrate a small, cost-effective system dedicated to the delivery of instruction (Bunderson, 1973). TICCIT is a mini-computer system (not a micro-computer) that can handle up to 128
terminals simultaneously; it uses off-the-shelf hardware, including color television sets as display terminals, it has a built-in learner control instructional design and is based on the concept of "mainline" instruction. Detailed descriptions of the TICCIT system are available from several sources, including MITRE Corporation's An Overview of the TICCIT Program (Stetten, 1976), and ETS's Final Report of the TICCIT Evaluation (Alderman, 1978). However it is pertinent here to include a brief discussion of the learner control features of the system and the concept of mainline instruction.

In a paper listing the premises which underlie the TICCIT instructional model, Merrill (1973) explained that TICCIT represents a departure from the usual meaning of learner control as control over content in that a student is allowed to control both strategy and content. He described the options presented to the student as follows:

Not only can the student decide what he wishes to see next on a segment (individual concept or rule), lesson or unit level, but he can also decide what type of presentation mode he wishes to receive as well as to determine the sequence of presentations related to a given piece of content. At his discretion, he can terminate his instructional interaction with a given piece of content and go on or back to another place. (p.2)

In 1980, Merrill had occasion to explain the characteristics of TICCIT and its design this way:

TICCIT instruction is comprised of a very large set of displays, each of which can be retrieved by means of an appropriate learner control key. Each display contains only one kind of information, hence the displays are not the same as the pages of a book or the frames of a film strip. In TICCIT a given display may require several frames or pages. Once a learner is aware of the various types of displays that are available, the one which would best meet his/her immediate instructional needs can be selected. (p. 77)
"Mainline" instruction as a design feature for TICCIT constituted a major departure from the more frequent use of computers as a supplement to classroom instruction. Rather than serve as an adjunctive resource for traditional modes of instruction, courses on TICCIT were to be the primary source of instruction. Students would be able to study at their own pace and teachers would be free to work with individual students. Entire courses were written as part of the project and it was the intention of the developers that they be used as main-line instruction at least during the contracted demonstration period, 1974 through 1976.

The courses, two levels of basic English writing for community college freshmen and three levels of pre-college and college level mathematics were written by a combined staff of Brigham Young University authors and community college faculty members.

For a complete description of the implementation and outcomes of the TICCIT project through 1976, the reader is referred to the ETS evaluation report (Alderman, 1978). Of concern to this study are the results of the evaluation with regard to course completion rates and the success rates during subsequent implementation of TICCIT in the community colleges.

A Summary of the ETS Findings. The Educational Testing Service was contracted by the National Science Foundation to evaluate the educational impact of the TICCIT system in the community colleges during the demonstration period. Data were collected on 5000 students in nearly 200 sections of TICCIT and non-TICCIT taught courses during one
academic year (Alderman, Appel & Murphy, 1978). The design of the study included a comparison of courses taught primarily by computer with the results of conventional teaching practices. Four aspects of student performance were compared: course completion rates, student achievement, student attitudes and student activities.

Completion was defined as "the proportion of students enrolled for a course who later fulfill the course's requirements and receive grades with credit" (Alderman et al., 1978, p. 43). Significant negative effects on completion were found in the TICCIT sections in 70 percent of the analyses made. The relative standards for comparison were completions under lecture discussion conditions. The average completion rate for TICCIT Math classes in the evaluation was 16 percent, while lecture sections had a 50 percent completion rate. The English classes fared better, 55 percent for TICCIT and 66 percent for traditional sections.

Student achievement measures were higher for the TICCIT taught groups (Alderman, 1978). In mathematics courses, significant achievement gains on post-test scores were found in 83 percent of the analyses performed between TICCIT students and comparable students in lecture sections. The effects for English courses were not as strong, due in part to circumstances of the demonstration: teachers played more active roles in assigning course materials and TICCIT was used more as an adjunct in several cases. Nevertheless, positive effects were also recorded.

Student attitudes were generally favorable and could not be
found to have an effect on completion, according to Alderman (1978). He pointed out that any form of self-paced instruction is likely to exert a negative effect on the pace of student learning. When compared to completion rates in programmed and autotutorial instruction math courses at the same colleges, TICCIT math classes fared about the same.

Alderman further analyzed the completion data in an attempt to ascertain whether the differences between TICCIT and lecture sections were mainly due to the treatment, TICCIT. As correlates of student performance, data on entrance ability, grade point average, age and student status were included. His conclusion remained the same: TICCIT mainline instruction had a negative impact on course completion rates of community college students. Only entrance ability was found to have some relationship to completion in addition to the treatment.

The ETS evaluation raised some procedural questions. The developers, the NSF reviewers and the community colleges have suggested that the evaluation was premature (Sasscer, 1978). Bunderson (1977) has even suggested that the real impact of a system as innovative as TICCIT on a community college campus may best be described in evolutionary terms, over a period of ten to twenty years.

It must be noted that the ETS evaluation mentioned, but did not take into account, two other variables: the initial instability of the system itself (hardware and software), and the quality of the courseware. In the Fall of 1975, the first term of the demonstration, the system's performance was highly unstable. The attitudes which were formed then, by faculty (who were skeptical anyway) and students alike,
took many months of stable performance to change. Similarly, the
course materials were used before being subjected to a true formative
evaluation, causing innumerable frustrations for all who used them.

Even if these two factors had been absent, the influence of faculty
members on the demonstration outcomes was largely overlooked. The role
of the instructor in Computer Assisted Instruction is acknowledged as be-
ing important but very different from his traditional role (Hicks &
Hunka, 1972). While this was foreseen by all who would be involved with
the TICCIT project, there were no satisfactory guidelines available to
prepare teachers to cope with their new assignments. Some training was
attempted, but only time and experience have developed the confidence
and familiarity in the "TICCIT teachers" that they had enjoyed in
classroom teaching (Huff & Sasscer, 1982).

One other comment on the ETS design: the basis for measuring
TICCIT's success as an instructional method was the completion rates for
the traditional lecture-discussion classes. The two methods, however,
may be so different as to be not really comparable at all. For example,
students in traditional classroom courses need merely to do average C
or even D work in order to be awarded credit for the course. Further-
more, an instructor is at liberty to compensate for lost time (for what-
ever reason), in order to complete a course within the prescribed term,
even omitting less important topics, if necessary.

The TICCIT instructional strategy, on the other hand, requires
mastery level performance before allowing a student to progress. When
a student misses a class session, his course status remains where he
left it. It is important to note that Alderman did not find that it took students longer, in clock hours, to complete a TICCIT course. The actual number of hours students spent on a TICCIT course compared very favorably with the required contact hours of a traditional course (Sasscer, 1977). In other words, if a TICCIT student "attended" class the required number of contact hours and spent a modest proportion of "homework" time at the terminal as well, (since there are no outside assignments, all work must be completed on campus), the chances of completion were comparable to those in a traditional setting.

This study was prompted by the need to discriminate from among the unique aspects of TICCIT delivered instruction, a reason(s) for lower than expected success (completion) rates. In order to establish further the need for the study, some additional background information is presented in the following section.

TICCIT at NVCC Since 1976. What follows is an account of the implementation of the TICCIT instructional system at one community college, Northern Virginia Community College, since 1976.

At the close of the demonstration phase in June, 1976, the hardware and existing programs of the TICCIT system were turned over to the college by the MITRE Corporation. With the end of all use conditions imposed by the NSF grant, the college was free to use TICCIT in any way it wished. The Alexandria Campus faculty and administration chose to continue to teach courses via TICCIT and to gather additional data for further evaluation of the computer as an instructional tool.

An in-depth revision of the original Brigham Young University
courseware was undertaken. The changes were to be based on data collected during the demonstration phase and included a reconfiguration of topics to bring them more in line with the curriculum of the college. The English courseware was redefined as a grammar course, rather than a writing course, to be taught exclusively on TICCIT.

Since January 1977, three courses have been taught using TICCIT as the main source of instruction: ENGL 110, a three credit elective grammar course; MATH 06 and 07, five credit, developmental level Algebra I and II courses.

The decision to include these courses in the campus offerings was made despite the low completion record of TICCIT students. The superior achievement scores reported in favor of TICCIT by ETS prompted instructors to believe that it was worth working on the completion rate problem. They were convinced that the courses on TICCIT were of sufficient value to warrant further experience with them. The community college goal of making available alternative methods of instruction was also a factor in the decision.

Traditional sections of the mathematics courses have always been available for the students to select. It should be noted that in the Spring Quarter, 1978, only one traditional section of MATH 07 had sufficient enrollment to carry it, while seven sections of TICCIT Math were run. The ENGL 110 course continues to enroll in excess of 130 students per quarter, a healthy record for an elective course. Alternative sections in the traditional lecture mode were only added as of the Spring Quarter of 1979.
Significance of the Study

The present study was designed to contribute to the understanding of the aspects of learner controlled instruction and computer assisted instruction which might be consistent with the needs of educational institutions in general and community colleges in particular. Findings related to learner control could be considered applicable to other individualized instruction methodologies. In addition, specific recommendations were anticipated regarding possible strategies to be followed in the continued implementation of TICCIT-type instruction at Northern Virginia Community College and other TICCIT sites.

The research literature contains many studies on the use of computers and some on learner controlled instruction. However, many of the experiments have been carried out with volunteer subjects, exposed to small segments of instruction, which can be completed in two or three hours (Seidel, Wagner, Rosenblatt, Hillelsohn & Stelzer, 1975). It was the implementation of Computer Assisted Instruction in large volume settings and with whole courses that was largely untested. The present study, conducted in a real-world educational setting, attempted to contribute to this research need.

While TICCIT represents a departure from large-scale multi-purpose computer systems which have been used for delivering a variety of instructional content, its learner control logic and mainline instruction feature are adaptable to other systems (Elliott, 1976; Fredericks, 1975; Lahey, Crawford & Hurlock, 1975). Results of this study and others related to these features will be of interest to all potential users of computer assisted instruction.
Since this study involved students at an urban community college with a population generally representative of the typical community college in the United States, the findings should be of interest to a variety of instructional designers of educational materials aimed at similar adult students.

Although this research was limited to a computer assisted instruction system, the problem of low course completion rates is common to all types of self-paced instruction (Alderman, 1978). Programmed instruction of the non-mechanized variety suffers from many of the same drawbacks as found in TICCIT mainline instruction, particularly when characterized by mastery learning performance standards (e.g., the Keller plan, Sherman, 1978). It was intended that the findings of this study would be useful to other users of individualized instructional systems.

A direct outcome of this study would be the application of the findings to the improvement of TICCIT completion rates in the community colleges. It was anticipated that those variables found to be most predictive of student success, could be manipulated in order to help students complete their TICCIT courses in the given academic time-frame.

Assumptions and Limitations of the Study

This study was based on the following assumptions:

1. The sequence of keypresses made by students as they progress through an instructional episode and which are recorded on a log tape, represent learner control decisions on the part of the students.

Elliott (1976) reported some evidence of this in his study of adult
2. Once established, students tend to use the learner control patterns consistently throughout a lesson, a unit and a course. Elliott (1976) reported evidence of stability of learning styles across learning tasks where the tasks were sub-sections of a lesson. There were no studies to indicate whether or not stability of learning strategies extended across lessons. The assumption was made in this study as a point of departure in the attempt to associate learner control display options and course completion.

3. Computer assisted instruction is an effective method of delivering instruction at all levels of education. With the TICCIT system, in particular, positive achievement gains have been found in community college settings (Alderman, 1978).

4. Those students who fail to complete a course do not advance to higher level courses, and ultimately do not fulfill requirements for graduation. This, in turn, affects a school's productivity in that a proportion of students who enroll in a program of studies does not complete it. For this reason, student completion rates can be considered a direct measure of educational impact (Alderman, 1978).

The limitations of the study were:

1. Students from only one community college were involved in the study. A profile of their characteristics, however, shows that they were generally representative of urban community college students in the United States (See Chapter 3 for demographic description of subjects).
2. Data were collected during only one academic term. However, the subjects were from different populations (developmental and non-developmental) and the course contents were distinct (Math and English).

3. While the students in the study were enrolled in regular courses, for credit, their activities in only one lesson of each course were used in the analysis. For some students, this represented a few hours of instruction and for others, several weeks. This procedural choice reflected the need to include a sufficient number of subjects, in both the successful and non-successful categories, who had been exposed to the same instructional content.

4. No control or comparison group was included in the study. By definition, students who completed the courses within the given time frame constituted the base line population against which non-completers were measured.

5. Only one Computer Assisted Instruction system's approach to learner controlled instruction, TICCIT's, was used to assess the effect of learner control on student success in a course.

6. The analysis was limited by the fact that only three of the learner control options were considered, the RULE, EXAMPLE and PRACTICE options. Further, the number of keypresses was treated in a separate analysis rather than as an integral part of pattern use.

**Definition of Terms**

The terms defined in this section are those which are used in a special sense in this study, or are technical in that they have special
meanings in the context of TICCIT.

ACADEMIC TERM: In the Virginia Community College System, one quarter lasting approximately 11 weeks.

COURSEWARE: The instructional material in TICCIT that can be accessed by students. The material may be presented in some or all of the following forms: static displays, videotapes, audio messages. By extension, "courseware" includes the coding that TICCIT authors must attach to the instructional materials.

EMPLOYMENT STATUS: Information on whether a student is employed full-time, half-time, or part-time (less than half-time).

ENTRANCE ABILITY: Refers to the course content previously mastered by the student as measured by a pre-test.

EXAMPLE: A learner control display that illustrates a concept, demonstrates a procedure, or applies a principle. An example is a specific object or event which illustrates a particular RULE. This display usually presents the illustration as directly as possible with a minimum of elaboration (Merrill, 1980).

LEARNER CONTROL: A feature of an instructional system by means of which the learner can decide what type of display he will
receive next. Some details about which aspects of the TICCIT system are under learner control are given in Chapters I and II.

**LEARNING STRATEGY:** A pattern of use of learner control features which results from decisions made on the part of the learner as to how to proceed through a learning episode of TICCIT.

**LONG TERM GOALS:** Refers to a student's reason for attending college, e.g., to take a job related course, to earn a two-year degree or a four-year degree, or for enrichment reasons.

**MAINLINE INSTRUCTION:** An instructional method by which all course content, practice and tests are delivered and managed by the computer.

**PRACTICE:** A learner control display that provides an opportunity for the student to apply the rule to a specific object or event. For a concept, practice requires the student to classify a particular object or event into one or more categories. For a procedure, practice requires the student to explain a particular occurrence or set of events. A practice display usually provides minimum clues concerning the solution (Merrill, 1980).

**RULE:** A general statement which attempts to present the idea being taught as concisely and clearly as
possible. A rule may be a definition of a concept, a list of steps in a procedure, or a statement of relationship between concepts. A rule display usually contains a minimum of elaboration and seldom includes an illustration of the idea (Merrill, 1980).

**SHORT TERM GOALS:** A student's reasons for enrolling in the particular course included in this study.

**SOFTWARE:** The computer programs in TICCIT that control the operation of the computer equipment and student terminals. Software does not include the instructional material (courseware) and cannot be accessed by students.

**STUDENT STATUS:** Information on whether a student is enrolled in only one course, more than one but less than full-time, or full-time (12 or more credits).

**SUCCESSFUL STUDENT:** A student who completes all the prescribed units of a course within one academic term. On TICCIT, a student may not proceed to another unit until he has passed each lesson test at a prescribed mastery level. Completion of all units presumes mastery of course objectives.

**TICCIT:** Time-Shared, Interactive, Computer-Controlled, Information Television; a CAI system funded by the National Science Foundation and developed primarily by the MITRE Corporation and Brigham Young University. Presently, a trademark product of Hazeltine Corporation.
TIME-ON-LINE: A measure, cumulative over the duration of a course, of the time intervals between logging on the TICCIT system and logging off. It therefore includes time at the terminal for study, for testing, and for consultation with a faculty member.

Overview

The second chapter of this study includes the background literature on computers in instruction as well as a review of the pertinent literature on learner control research. In the third chapter, the design and procedures for data collection are explained. The analysis of the data is found in chapter four. The summary, conclusions and recommendations for future research are in chapter five.
CHAPTER 2
REVIEW OF THE LITERATURE

The primary concern of this study was the use of learner control options by community college students in a learner controlled, computer assisted instruction environment called TICCIT. The literature review focuses on learner control research, particularly as related to TICCIT. In order to place the study in a context, a brief overview of CAI is presented first.

An Overview of Computer Assisted Instruction (CAI)

"The educational promise of CAI lies in its ability to individualize and personalize the instructional process and to simulate experiences not readily available" (Magdison, 1978, p.5.). With this statement, Magdison provided a reason for the large volume of research which has accompanied the development of computer based educational systems. Because of its versatility and almost limitless capacity for storage of information, the computer seems to offer many solutions to the problems of the teaching/learning process. The following is a summary of several reviews of the research done on the effectiveness of computer assisted instruction.

In 1970, Dwyer reviewed over forty studies done in the late 1960's. These studies ranged from comparisons of CAI with traditional
instruction to experiments designed to assess the relationship of individual differences and CAI. He concluded: a) that although CAI showed great potential as an instructional innovation, it was a long way from actualizing its potential; b) the research showed that students learn in less time and have better attitudes; and c) that the research to date was inadequate in terms of design, number of subjects and duration of experimental treatments.

Another review led its authors to conclude that the effectiveness of CAI was substantiated by ten major studies of drill and practice applications (Visonhaler & Bass, 1972). The authors reported that the studies involved over 30 experiments of 10,000 subjects studying language arts and mathematics. However, Visonhaler and Bass cautioned that the use of the computer in those studies was limited to drill and practice of instructional materials taught in traditional settings. In other words, CAI was effective when used as a supplement to classroom teaching.

Findings that CAI was at least as effective as traditional instruction and that students were agreeable to its use were not disputed by McDougall (1975) who also reviewed the CAI literature. However, she pointed out that not enough was known about the effects of CAI on student and teacher behavior, or about the interaction of learner variables with computer assisted instruction.

Taylor and others (1974) researched the existing literature for evidence of the effectiveness of CAI and reported that they were disappointed at the lack of relevant studies. Their conclusions about
the studies they reviewed were: a) that CAI was most effective in tutorial and drill/practice situations; b) that students generally learn faster with CAI help; and c) that CAI is relatively more effective with low ability learners.

Magdison (1978) noted that published research on the effectiveness of CAI reported conflicting results, with 45 percent of the studies concluding that it was more effective than traditional instruction, and 55 percent that it was as effective as traditional instruction. He also pointed out that it was difficult to interpret the meaning of such comparisons because CAI was currently being used primarily to supplement classroom teaching.

A recent evaluation of PLATO (Programmed Logic for Automatic Teaching Operations) in community college settings emphasized Magdison's concern. Alderman et al. (1978) reported that exposure to PLATO had no appreciable impact on student performance or attrition. They wondered if there may have been too little instruction conducted on the system. "In most cases, students spent less than eight hours on the PLATO system for a course" (Alderman et al., 1978, p. 43). Faculty members were free to decide and vary the amount of CAI exposure their students should have, thereby weakening the design of the study.

The foregoing reviews suggested that after another decade, little more progress had been made in researching the impact of computers on instruction than was reported by Dwyer in 1970. His conclusions applied to the studies of the 1970's as well as to those
of the 1960's. Of particular relevance was his conclusion that the research was inadequate in terms of design and duration of experimental treatments. Furthermore, computer assisted instruction had seldom been more than traditionally designed instruction delivered by a computer. There had been few attempts to design instruction that took advantage of the unique features of computers. The learner control paradigm implemented on the TICCIT system is one example of this kind of effort.

**Literature Related to Learner Control Research**

Broadly speaking, students in higher education exercise varying amounts of control over their education by selecting a particular institution to attend, a curriculum to follow, and even some of the courses they wish to study. It is at the instructional level that the debate begins over how much control a learner can and/or should have. The basic hypothesis of learner control research is that giving the learner a more active role in the learning process by giving him varying amounts of control over his instruction will increase the efficiency and effectiveness of learning (Merrill, 1973).

Research on the various aspects of this question is limited and equivocal (Steinberg, 1977), and concentrated for the most part within the last ten years. There is a lack of consensus on which aspects of instruction are significant; terminology is ambiguous and inconsistent (Hayden, 1978). In 1972, Fry questioned the basic premise by stating that there is little evidence supporting the thesis that such
"self-direction is a motivating, satisfying or an effective mode of interacting with a learning environment" (p. 459). By 1977, though, O'Neal was able to draw implications from his review of the learner control literature that patterns emerged which pointed to the advisability of allowing learners more control on some dimensions of learner control. These dimensions were pacing, sequencing, amount of practice, difficulty level, media and program styles.

Early experimentation with learner control was limited to questions about topic sequencing within courses: could students learn better and faster by sequencing topics according to their own needs versus those imposed by the instructor? In two studies by Mager (1961) and Mager & McCann (1961), six subjects were given control over topic sequencing in an electronics course. The students accomplished the task more efficiently than their traditionally treated predecessors by developing a variety of organizational patterns that bore little resemblance to the instructor's sequence.

One of the first studies which used computer assisted instruction was by Grubb (1969) who gave 50 IBM employees two statistics lessons to learn. Five random groups were assigned combinations of two conditions: computer control over topic sequence and unit sequence, and learner control. Post-tests showed the learner control groups performed significantly better.

However, in 1971, Olivier obtained opposite results when he gave 52 students, divided into three groups, an artificial science learning task. He found that computer control of sequencing yielded better
results and that learner control students had less positive attitude measures.

These early studies were flawed by a failure to account for the effects of such variables as student ability and prior experience with self directed learning. With the exception of Olivier's study, they offered some evidence in favor of student control of topic sequencing within a learning segment.

Other studies focused on learner control of amount and type of practice problems. Dean (1969) randomly assigned fourth, fifth and sixth graders to one of two conditions for an arithmetic practice task. A significant positive effect on achievement was found for the learner control treatment among fourth graders only. The learner control group of sixth graders took significantly less time than the teacher controlled group, but the author believed the arithmetic might have been too easy for them.

Barnes (1970) used junior and senior high school students in a study contrasting various combinations of learner control over types of problems (in multiplication) and nature of remedial feedback. A finding of no differences led the author to consider that a lack of readiness to make decisions might affect learner control treatments.

In a more complex study, Brown, Hansen, Thomas and King (1970) worked with 55 university students. The focus was the level of information load of expository material: terse, medium or redundant, which could be accessed via three different delivery methods. A control group was assigned to terminals under program control at the medium level. No significant differences were found among any of the combinations. It
should be noted that students only had options at the beginning of the instruction, and could not change levels when studying different objectives.

At the University of Texas, Judd, Bunderson and Bessent (1970), found that college students who were allowed to choose module sequence and content options did slightly better on a post-test than a program controlled group. However, those students who were given the choice of studying all or some of the modules performed poorer than program controlled students who had to study all of them. There was evidence that students with lower pre-test scores faired poorly under learner control.

After 1972, interest in learner control of instruction expanded. The question no longer was whether students should be given control of their instruction, but rather, which aspects of instruction could be put under learner control and which learners could best benefit from this freedom of choice.

Two studies focused on the control of difficulty level. Fisher, Blackwell, Garcia and Greene (1975) found that elementary school children chose arithmetic problems that were either too difficult or too easy, depending on whether they were "maximizers" or "minimizers". The former chose easy items to get a good score, while the latter chose harder items to test the limits of their ability. The "minimizers" ended up with lower scores. Hartley and Sleeman (1973) also reported that many students tended to overestimate their mastery state. However, experience with learner control seemed to improve their self-perceptions as well as their efficiency. In one study, they reported significant
interactions between treatment and pre-test scores which suggested that low ability students benefited the most often from adaptive learner control programs.

In a military training task, students who were given control over the amount of practice took longer to complete the course than those given a fixed number of practice items (Lahey et al., 1975). Opposite findings were reported by Fredericks (1975) who used the same Navy setting and PLATO computer as Lahey et al.: learner control students finished an electronics practice lesson faster and had higher scores, though not significantly higher, than the control group. In another study, Motanelli and Steinberg (1976) reported that students followed suggestions on amount of practice when the problems were easy, but practiced less than the recommended amount on difficult problems.

Control over the type and number of objectives to be learned in a physics course was given to high school students by Denton and Woods (1975). No significant differences were found in achievement, but the traditionally taught control group mastered fewer objectives.

These studies suggested that while learner control of amount and type of practice was not harmful to students, it was not always the most efficient means of acquiring learning. These questions, which were further explored in subsequent studies, underlie the basic problem of this study: did the learner control features of TICCIT aid or hinder students in their attempt to complete their courses?

More complex studies added student characteristic variables
to learner control conditions. In a significant study performed in a real instructional environment, Seidel et al. (1975) related various forms of learner control to high and low performance, and to level of aspiration (self-assessment concerning mastery attained). In the study, military personnel were taught a programming language on a CAI system. The findings were that a) high and low performer groups varied from one task to another; b) low performers used three learner control options dealing with review and acceleration more frequently than high performers; c) high performers were more active and independent in choosing which topic to attempt next; and d) high performers were more realistic in their self-assessment. These results had direct implications for the present study in that they provided evidence that high and low performers could be identified by the manner in which they used the learner control options. It was not clear whether these differences were to the students' advantage or disadvantage.

Two studies which took into account learner characteristics dealt with anxiety and the number of errors made during a learning task (Leherissey, O'Neill & Hansen, 1971; O'Neill, Spielberger & Hansen, 1969). No significant differences were found as a function of anxiety trait. Anxiety was not affected by the presence or absence of objectives or type of sequencing in two studies by Tobias (1973) and Tobias and Duchastel (1974). Steinberg (1977) concluded with Tobias (1973) that "[t]he may well be that...anxiety, while useful in other areas, has limited utility in the area of individualized instruction" (p. 237).
Measures of aptitude and inquisitiveness were used by Fry (1972) to investigate a factual learning task under system and learner control. Learner control tended to improve attitude, but not learning. Students with high aptitude and low inquisitiveness did significantly better under system control. It seems that the effectiveness of the trait-treatment match was dependent on aptitude as well as inquisitiveness.

Others have explored the premise that if students have some control over their instruction, they will be more motivated and have more positive attitudes. Most of the findings showed no differences in student attitudes (Denton & Woods, 1975; Judd et al., 1970; Steinberg & Motanelli, 1977). Subjects analyzed by Fry (1972) had a more favorable attitude when allowed to select questions in order about computers. However, they performed worse than the control groups on achievement tests.

Most of the studies reported thus far were characterized by a common, limited design: a comparison of the presence or absence of some form of learner control, and its effect on one or two measures of student performance. In their reviews of the literature on learner control, Judd (1972) and Steinberg (1977) concluded that the results were contradictory, and data on which to base generalizations were inadequate. Beginning with the Seidel et al. (1975) study, however, it appears that learner control research was concerned less with comparisons to traditional instruction and more with the aspects of learner control instruction per se, and the interactions with student characteristics.

Wilcox (1979) reviewed fourteen studies related to learner
control of certain presentation forms and student characteristics. Locus of control and anxiety traits were found to have positive interactions with learner control. Students classified in lower ability groups were found to perform better under certain individualized methods as the Keller plan and the audio-tutorial method. The author concluded that learner control should not be seen as a panacea for accommodating individual differences. He suggested that student characteristics should play a role in their assignment to learner controlled instruction.

The most recent studies have focused on research concerning the effects of allowing the students the capability of selecting the sequence of primary presentation forms and number of instances for practice. Merrill and Wood (1975) categorized the components of instruction into three primary presentation forms: expository generalities or "rules", expository instances or "examples", and inquisitory instances or "practice items". Merrill, Olsen and Coldeway (1976) defined the learner-control hypothesis to include the capability to allow the student to alter efficiently his primary presentation form sequence by returning at will to previously presented forms after having studied subsequent displays.

Several studies were concerned with student performance and learner control of the sequencing of primary presentation forms. Walker, Axtell, Fletcher and Merrill (1977) studied the effect on achievement, efficiency and attitude of learner control of primary presentation forms and number of instances. Four experimental
treatment groups and a post-test only group used the TICCIT system to learn a lesson on logarithms. The students were from a traditional beginning Algebra class who were assigned to the computer laboratory for the one lesson. No significant differences among the treatment groups were found on any of the measures. Efficiency, defined as time to complete the instruction, was better for the learner control group who studied fewer instances, but the results of the post-test were not different.

In a similar study, Walker (1978) reported significantly higher post-test scores for learners without control of primary presentation form sequence. While students in the learner control treatment exercised their options, Walker concluded that they did not choose optimum sequences. Strickland and Wilcox (1978) applied regression statistical procedures to analyze data gathered from a group of students studying logarithms with no learner control, some learner control and total learner control of sequence and number of primary presentation forms. They found no significant differences in the scores of the twenty item post-test, the dependent variable.

With reference to these studies, Merrill (1980) pointed out that while no significant correlation was found between performance and students' patterns of displays, a tremendous variation in patterns was observed. Furthermore, they reported a considerable variance in the number and ratio of example items and practice items chosen by the learners. Merrill suggested that perhaps students were truly using the learner control options to adapt displays to their needs.
In 1976, Lahey and Crawford examined the patterns of behavior of forty students regarding learner control choices. There were sixteen possible strategies combining the RULE, EXAMPLE, PRACTICE options, as well as the "omit" option. They found that the rule-example-practice, example-practice and some other omit strategies were most frequently used. The number of subjects was too small for any valid conclusions, however. In another study to determine the most effective sequence of primary presentation forms, Spiller, Rogers and Merrill (1978) randomly assigned 79 students to instructional booklets which were organized in six different sequences (rule-example-practice, example-practice-rule, practice-example-rule, etc.). The dependent variables analyzed were time required to complete and score on a post-test. Two sequences were found to be superior: rule-example-practice, and rule-practice-example.

Wilcox, Richards, Merrill, Christensen and Rosenvall (1978) hypothesized that students with learner control of number of instances (examples and practices) would select the appropriate number and only the appropriate number for mastery based on an optimum number of instances arrived at in a previous study and that their attitude would be more positive. The procedure followed was the random assignment to treatments of the first day students; the second day's group was randomly paired to each first day subject. The hypotheses were not supported by the data, suggesting, according to the authors, that there was no evidence that the optimum number of instances for a particular task varies with individual differences, or that each learner is
capable of choosing his own optimum number of instances to learn.

The research of Lahey and Crawford, Spiller et al., Walker et al., and Wilcox et al., offered evidence that under some conditions, some learner control strategy patterns are more productive than others. There was little evidence that all students are capable of discovering these patterns or of doing only the necessary amount of work to attain mastery. A major limitation of these findings was that they resulted mainly from contrived treatments of relatively short duration. How would students use learner control options in a real instructional environment over a long period of time?

The primary presentation forms which are the basis of TICCIT's learner control theory can be expanded to include instructional help, i.e., additional information such as memory aids, attribute isolation or step-by-step analysis of the rule designed to facilitate the learning process either directly or indirectly. Several studies tested the general hypothesis that learning would be more efficient and more effective when helps were available for rules, examples and practice items. Hetzel (1978) was able to support the hypothesis that the percent of helps used was greater for harder lessons than for easier ones. He was not able to find evidence that the more helps are used, the more effective or efficient the lesson learning becomes, nor that the more effective lessons are more efficient. His data did not provide evidence that the more attempts required to pass a test, the more difficult a lesson and the longer students spent on treatments and tests, the more practices and examples were accessed. The setting for
this research was the same pre-calculus course taught on the TICCIT system as was used in the present study. The subjects were 35 Brigham Young University students taking the course, making it a real instructional setting where the students were more likely to make decisions of consequence to the outcome of their course grade.

Hayden (1978) assigned 90 volunteer subjects in a community college setting to three treatment groups: optional help, required help and no help. The instructional material consisted of eight mathematical-type operations. The purpose of the study was to measure the effect of the learner control of instance helps on effectiveness (test scores) and efficiency (time on line) of learning. He found no significant differences among the three treatment groups.

Axtell, Callahan, Welsh and Merrill (1978) questioned whether students were motivated differently and whether characteristically higher achievers performed differently under learner control options. Students were assigned to eight treatments involving the presence or absence of example helps, practice helps and learner control over these features. Students' self reported effort to learn the material was used in determining any aptitude-treatment interactions. No significant differences on efficiency or effectiveness were reported with the presence or absence of the helps. However, example helps were found to be beneficial in increasing the confidence and effect of highly motivated students, but detrimental for lower motivated students. Learner control over example helps and practice helps had no effect on achievement, but seemed to affect the efficiency of some students. Learner control over
example helps seemed to slow students down.

The research on the usefulness of helps when added to primary presentation forms appeared to suggest that they are of little value. Axtell et al. (1978) however, provided evidence that the use of example helps and practice helps was correlated with student motivation and student success. These findings further suggested the desirability of investigating the relationship between student characteristics, learning strategies and success in a course taught entirely on a system like TICCIT which is characterized by its learner control features.

A study directly related to the present study was done by Elliott (1976) who sought to establish an empirical basis for adult learning styles and strategies. He defined style as the characteristic manner in which a learner approaches a learning project or episode; and strategy as a careful plan or method of learning, i.e., explicit decisions on the part of the learner as to how to proceed through a learning episode. In a computer assisted instruction environment, Elliott assigned forty adult volunteers to study a lesson consisting of eight objectives on the metric system. The subjects were pre-tested and divided into two groups according to previous knowledge of the content, then post-tested and interviewed for information on their choices of strategies. The learner control options included sequencing of objectives and sequencing of the primary presentation forms, the rules, examples and practice items. Students also had access to three levels of difficulty for each of the primary presentation forms. The conclusions
of the study were as follows: 1) Learning styles exist. Eleven variables were identified in three categories: sequencing, pacing and distribution by type of move and level of difficulty. 2) There was stability across learning tasks although these were very similar. 3) No relationships were found between the learning styles and the five independent variables (pre-test, recency of schooling, level of education, age and sex). 4) There was some indication of correlations between those styles which de-emphasized practice problems and a low comprehension sub-score. The sample was too small and the post-test too easy for conclusive evidence. 5) The interviews revealed that one out of four of the subjects was conscious of making a learning strategy decision.

**Summary**

This review of the research literature related to learner control of instruction was characterized by reports of contradictory findings and equivocal terminology. Nevertheless, sufficient evidence was presented to suggest that students do select patterns of learning when given the choice (Elliott, 1976; Lahey & Crawford, 1976; Spiller et al., 1978) and that some patterns may be more successful than others (Elliott, 1976; Spiller et al., 1978). In other words, while students may use a number of different paths to complete a segment of instruction in a learner control mode, only some of the students develop strategies which lead to successful learning.

Early studies in this area sought to compare student achievement under conditions of learner control versus teacher or computer
control of such aspects of instruction as sequence of topics, number of topics, number and difficulty of practice problems (Barnes, 1970; Brown et al., 1970; Dean, 1969; Denton & Woods, 1975; Fisher et al., 1975; Grubb, 1969; Judd et al., 1970; Mager & McCann, 1961; Motanelli & Steinberg, 1976; Olivier, 1971). With the exception of Grubb, the researchers reported no differences among the treatments and, in some cases, even some evidence that system control of instruction was preferable.

The potential of learner control to improve learning efficiency (time to complete instruction) was investigated in several studies. Fredericks (1975) and Lahey et al. (1975) using the same computer system, PLATO, and the same naval school setting, reported opposite results for learner control and efficiency.

Researchers have also investigated the interaction of some learner characteristics with learner control. There was no evidence that anxiety was a factor in individualized instructional treatments (Leherissey et al., 1971; O'Neill et al., 1969; Tobias, 1973). The effect of attitude and entrance ability (pre-test) was inconclusive (Fry, 1972; Hartley & Sleeman, 1973; Judd et al., 1970). A student's ability to assess his level of mastery during instruction was positively related to high performance by Seidel et al. (1975). Student attitude did not seem to be affected by the presence or absence of learner control (Denton & Woods, 1975; Judd et al., 1970; Steinberg & Motanelli, 1977).

An improvement in the confidence and attitude of self-reported
highly motivated students when examples were expanded by means of additional explanations or mnemonic devices called "helps" was reported by Axtell et al. (1978). The addition of "helps" to practice problems had a beneficial motivational effect on lower effort students.

Most of the recent research was derived from Merrill and Wood's (1975) categorization of instructional components into three primary presentation forms: rules, examples and practice items. Reports of studies involving these components in various combinations of presence or absence of learner control concluded that no differences in achievement or attitude resulted from the treatments (Elliott, 1976; Spiller et al., 1978; Walker et al., 1977). In fact, in one study, higher post test scores were reported for students under computer control of the sequence of primary presentation forms (Walker, 1978).

In summary, a number of studies contain evidence that adult students, when given control of their instruction, selected different learning strategies. Further, it appeared that some strategies were more successful than others. It was also reported that achievement and efficiency were not generally affected by allowing students to control the sequence or amount of their instructional components. Of the student characteristics investigated, only aptitude and capability of self-assessment seemed to interact with learner control, but the research findings were contradictory.

A critical assessment of the research literature reviewed indicated that most of the studies were based on short term experiments involving small numbers of subjects, largely on a voluntary basis.
With two exceptions, Seidel et al. (1975) and Hetzel (1978), the material to be learned was limited to modules or segments to be completed in a matter of a few hours. It was questionable whether the motivation to maximize one's learning efficiency and effectiveness by using learner control options was likely to be present when one was required to volunteer time to research as part of an introductory psychology course, or when one was earning an hourly rate for participating in an experiment.

In an effort to overcome the limitations of previous research, the present study involved a larger group of students in a real educational setting, who had registered for one of two courses, taught via the TICCIT CAI system. They were expected to attain mastery of their course objectives within one academic term and receive a grade accordingly. If learner control options had any effect on learning efficiency or effectiveness, it would be more evident under these circumstances. Were the learner control features of TICCIT a major reason why so many community college students failed to complete a given course in a prescribed period of time? The basic hypothesis of this study, then, was stated as follows:

The learning strategies or patterns developed by students in a learner control instructional design environment discriminate between students who successfully complete all course objectives within a given academic term, and those who do not.

The studies of Seidel et al. (1975), Lahey and Crawford (1976), Spiller
et al. (1978), and particularly Elliott (1976), supported the hypothesis that students tend to develop different patterns of behavior in a learner control environment. Elliott offered the only suggestion that some patterns were more effective than others. This question was central to this study.

Additional information related to student characteristics was included in the study with the intent of contributing to the research with a more comprehensive profile of students who succeed or fail under learner control conditions. Data were collected on age, sex, race, employment status, student status (part-time or full-time), previous CAI experience, academic goals (long and short-term goals), and pre-test score. Judd et al. (1970) reported some evidence that lower pre-test score students fared worse under learner control conditions, whereas Hartley and Sleeman (1973), found that lower ability students benefited most from having learner control. The data from this study, collected in a realistic learning setting, may be useful in resolving these contradictions.

Axtell et al. (1978) presented evidence of the effect of "example helps" and "practice helps" on low and high motivated students, as described by their own assessment of effort exerted in learning. The present study used students' reports of academic goals and reason for enrolling in the subject courses as indications of motivation. It was anticipated that students who had definite academic goals and/or chose to study mathematics or English grammar as a result of self-perceived deficiency were more likely to be among the completing students, than
those who were vague or short-sighted about their reasons for being enrolled.
Chapter 3
METHODOLOGY

In this chapter the methods and procedures followed in the study are explained. The purpose of the study was to investigate whether the way that students used learner control features when studying courses on the TICCIT computer assisted instruction system was related to success in English and mathematics courses within a prescribed period of time, one academic quarter. Student demographics, entrance abilities and self-reported long and short range goals were also investigated for their possible contribution to the probability of success in TICCIT courses.

The chapter includes descriptions of the setting of the study, the subjects, the design and data collection procedures, and the analytical methods used.

The Setting

At the end of the National Science Foundation funded demonstration period in June, 1976, the Alexandria Campus of Northern Virginia Community College retained possession of the 128 terminal computer assisted instructional system called TICCIT. The Alexandria Campus was selected as one of two demonstration sites for the TICCIT project (the other was Phoenix College, Arizona) in 1971 because of its tradition of promoting educational innovation, its diverse student population and its desire to participate in the project. The community college was considered ideal for testing the impact of the new CAI system because
of its rapid growth and high enrollments in entry level courses (McLellen, 1975).

A five campus institution, NVCC is the largest of 23 colleges in the Virginia Community College System. In the Fall of 1978 the college enrolled a total of 31,327 students, equivalent to 15,484 full time students. The Alexandria Campus, located at the northwestern edge of the city of Alexandria, served 10,448 students in the 1978 Fall Quarter, equivalent to 4671 full time students. It is the second largest of the five campuses.

The college follows an open admissions policy. The following figures reported by the Office of Institutional Research describe the general profile of the population of the Alexandria Campus in the 1978-79 academic year. The average age of the students was 29. There were 59.2 percent females and 40.8 percent males. International students composed 11 percent of the total. Enrollment by race was 76.1 percent Caucasian and 23.9 percent minority (Black, Spanish surnamed, Oriental).

There are one hundred TICCIT terminals located in the Learning Laboratory, which is part of the Learning Resource Center. The remaining 28 are located in faculty and administrative offices. The terminals are linked by cable to an in-house, mini-computer facility. Students who register for any of three courses in English grammar or algebra receive all their instruction at these terminals.

The Subjects

The subjects of this study were the students who enrolled in MATH 06, a developmental level Algebra I course, and ENGL 110, an
English grammar course, taught on TICCIT in the 1978 Fall Quarter.

The mathematics students enroll in this course in one of two ways: 1) as a result of a campus administered placement test, a prerequisite for college level math or chemistry courses, or 2) by personal choice, perhaps on the advice of a counselor. The English course is a freshman level elective, not required in any curriculum at the college. Students enroll in ENGL 110 by personal choice or on the advice of an instructor or counselor.

The population of this study included the 148 students who, having enrolled for the TICCIT delivered sections of ENGL 110 and MATH 06 in the 1978 Fall Quarter, completed the instructional material which was the basis of this study.

All the students were informed that they would be included in a study to find out how students proceeded through courses taught on TICCIT. They were asked to complete a questionnaire about themselves in relation to the course and were given a pre-test.

Of these 148 students, 58 percent were female and 42 percent male (compared with 59 percent and 41 percent respectively of the campus population). The majority, 55 percent, were between 21 and 30 years of age.

**The Instructional Content**

The English grammar course consisted of eight units divided into 34 lessons of varying lengths. The Algebra I course consisted of five units divided into 15 lessons. Course syllabi are included in Appendix A.

The number of pertinent keypresses that were logged per student, per lesson was large: approximately 100 per English student and 195
per math student, for a total in excess of 20,000 keypresses. For this reason it was desirable to limit the data analysis to one lesson from each course. Two criteria were used in choosing the lessons to be included in the study: 1) the lesson had to be sufficiently beyond the introductory portion of the course to assure that the student was familiar with the operation of the TICCIT terminal, the structure of the course, and had established some patterns of behavior vis-a-vis the course; and 2) the lesson had to be early enough in the course to have been attempted and/or completed by a maximum number of ultimately unsuccessful, as well as successful students (to insure sufficient subjects for comparison).

An examination of the final course printouts from previous quarters resulted in the selection of the fourth lesson in English (Unit 13, Lesson 4), and the third lesson in Math (Unit 22, Lesson 3). The English lesson entitled "Verbs", contained four segments (specific objectives). The Math lesson, on the subject of "Rational Numbers", consisted of nine segments.

**Design and Data Collection**

The Learner Control instructional design used in TICCIT courses gives students more options of paths to lesson completion than more traditional methods. It was hypothesized that the study patterns which students demonstrated might be related to their ultimate success in the course. Data for the primary independent variable consisted of the keypresses made by the students.
Learner control keypress data: Every time a student requested a practice problem or a rule, needed advice or responded to a question, he did so by pressing a specific key on the TICCIT keyboard. Every keypress was recorded by the computer on a log tape, and therefore, available for further analysis. For the purposes of this study, only those keys which represented a learner control decision at the instructional segment level were selected for analysis: the RULE, EXAMPLE and PRACTICE keys.

Student characteristics: Data were collected by means of a questionnaire which the students were asked to complete. Information which was obtained included age range, sex, race, employment status, student status, previous computer experience, long range and short term educational goals.

Pre-test scores: Pre-tests for Algebra I (MATH 06) and English Grammar (ENGL 110) were developed by the Alexandria Campus faculty and piloted during the two quarters prior to the Fall Quarter, 1978. The tests were criterion referenced, using questions from a selected number of objectives in the courses. The items were randomly selected from those in the test item banks of the TICCIT courseware.

Using the Kuder-Richardson (1939) formula, reliability estimates were calculated for each of the pre-tests from three administrations, Spring, Summer and Fall, 1978. The coefficients for the English test were .79, .83, and .80 respectively. The coefficients for the Algebra test were considerably lower, .68, .64 and .67 respectively. This was probably due to the length of the test, only 15 items.
Nevertheless, the decision to continue to use the test "as is" was made by the faculty. Furthermore, they were not amenable to submitting the students to any additional testing for the purpose of this study. The data from these pre-tests were used only in a peripheral sense and were not crucial to the primary hypothesis.

The procedures to gather these data were:

1. During the first class meeting, all students who enrolled in MATH 06 and/or ENGL 110 on TICCIT were given pre-tests and asked to complete the questionnaire (Appendix B).

2. During the first and/or second class meetings, all students were introduced to the operation of the TICCIT terminal. The instruction on how to use the terminal and the learner control features was done by this investigator and one other Learning Laboratory staff member (when two classes met at the same time in adjacent rooms). The presentations were carefully prepared and coordinated to insure that all students received the same information about the instructional options available to them. The individual faculty members assisted in the presentations. Students also received a handout called "Questions & Answers About TICCIT" as an additional guide to using the computer.

3. A TICCIT system program recorded all student activity on a log tape. Every keypress made, and the sequence in which it was made, was logged. At the end of the quarter, student progress was verified on a printout which indicated the number of lessons passed, the total time on line for each student and his last date of attendance.
The Hypothesis and Analytical Methods

The design and analytical methods of the study were intended to test the hypothesis developed in Chapter I. Restated in the null form, this primary hypothesis is:

The probability of a student enrolled in TICCIT delivered courses using a particular Learner Control pattern is the same whether the student is classified as successful or unsuccessful within the prescribed academic term.

A learning strategy has been defined as a pattern of use of learner control features which results from decisions made on the part of the learner as to how to proceed through a learning episode (Elliott, 1976). There are two levels of options available to TICCIT students: a) they may choose which content to study first (including the option to challenge a lesson test) by selecting units, lessons and segments in any order, and b) within each instructional segment, they may choose the type of display to see next. These displays may be expository (the RULES), or worked EXAMPLES of the concept to be learned, or PRACTICE questions which require a response from the students. Each of these is available in four levels of difficulty: hard or concise, easy, help with worked examples, and medium or average level.

With reference to choice of content to study, in 1976 Elliott found that 65 percent of the students in his study selected the lessons in the order in which they were listed. The most common reason given by the students for this pattern was that they lacked sufficient
knowledge of the content for making other choices. Observations by faculty teaching TICCIT courses over the past five years confirmed this finding. Therefore, this study was confined to the analysis of strategy patterns \textit{within} instructional segments, i.e., the use of RULES, EXAMPLES and PRACTICES.

At the segment level, the student may exercise two kinds of options, what to see next and how many times or how many items to request. In other words, once a student knows the objective or purpose of the segment, s/he must decide whether to study the rule or see a worked example, study another version of the rule, do a practice problem, etc. The student also decides how many times to read the rule and how many examples and/or practice problems to study.

The learning strategies which a student may consciously or unconsciously develop consist of the sequence of keypresses (a rule followed by another rule, or by a practice problem, etc.) combined with the number of times each is pressed, i.e., requested. Lacking in any way to determine otherwise, it was assumed that each keypress recorded was a deliberate move and resulted in the student reading the information on the screen. While it was also recognized that sequences may be a) randomly arrived at, or b) changed according to the content of the segment, it was hypothesized that "favorite" patterns would persist in most cases.

A computer program was written to selectively print out the individual students' keypress records from the log tape. These records (see sample in Appendix C) were tabulated manually in order to identify
each pattern employed by each student.

Each segment was treated as a new learning episode, as the keypresses already indicate. As expected, nearly all the students followed the order of segments suggested by their presentation in the TICCIT lesson. In a very few instances, students began with a segment other than the one suggested or repeated a completed segment, usually at the end of the lesson.

A total of 1196 segments (21,793 keypresses) were generated by the 148 students and were then available for analysis into pattern types. These patterns became easily defineable if only the type of key was classified, rather than the number of times it was pressed. For example, student No. ENC 21 used the following sequences:

(R = RULE, E = EXAMPLE, P = PRACTICE).

Segment 4 - R₃ : E : P₉
Segment 3 - R₂ : E₁₁ : P₅
Segment 2 - R : E₈ : R : E : P₆
Segment 1 - R₂ : E₆ : P₁₀

(The subscripts indicate the number of times the key was pressed consecutively.)

The number of times students repeated a particular keypress before requesting a different display varied beyond the point of manageable analysis. But when these repetitions were "ignored" (they were counted and analyzed separately) then definite patterns emerged.

In each learning session, or segment of a lesson, the students
made a series of keypress choices that were identified as patterns. The patterns were tabulated and then grouped according to the order in which keypresses were recorded. A pattern group, then, consisted of all the segments in which students had used a particular sequence of displays, e.g., R: E: P (RULE, EXAMPLE, PRACTICE) or R: P: E, P: R, and so forth. Each of the 1196 segments was assigned to one of these groups.

The main question under investigation was whether there were differences in the ways patterns were used, primarily between successful and unsuccessful students. One way of saying that there was no difference in pattern use between two groups was by saying that the probability of a student choosing a particular pattern was the same regardless of the group s/he belonged to. Thus, a contingency table approach was used to analyze the data (Snedecor & Cochran, 1967). A cross-classification of sessions into one of the specified patterns with whether the student was a completer or a non-completer was constructed.

Figure 1 is a description of the classification. The nine patterns, symbolized by the letters A through I, formed the columns in a 2 X 9 contingency table where the rows correspond to student success. Defining the probability a successful student chose pattern \( j \) (\( j=1,2,\ldots,9 \)) to be \( P_{1j} \) and that of an unsuccessful student \( P_{2j} \), then the hypothesis of no difference was stated as:

\[
H_0: P_{1j} = P_{2j}, \quad j = 1, 2, \ldots, 9
\]

The contingency table in Figure 1 was used to test this hypo-
<table>
<thead>
<tr>
<th>Type of Student</th>
<th>Patterns</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
<td>F</td>
<td>G</td>
</tr>
<tr>
<td>Successful</td>
<td>(n_{11})</td>
<td>(n_{12})</td>
<td>(n_{13})</td>
<td>(n_{14})</td>
<td>(n_{15})</td>
<td>(n_{16})</td>
<td>(n_{17})</td>
</tr>
<tr>
<td>Unsuccessful</td>
<td>(n_{21})</td>
<td>(n_{22})</td>
<td>(n_{23})</td>
<td>(n_{24})</td>
<td>(n_{25})</td>
<td>(n_{26})</td>
<td>(n_{27})</td>
</tr>
<tr>
<td>Totals</td>
<td>(n_{.1})</td>
<td>(n_{.2})</td>
<td>(n_{.3})</td>
<td>(n_{.4})</td>
<td>(n_{.5})</td>
<td>(n_{.6})</td>
<td>(n_{.7})</td>
</tr>
</tbody>
</table>

\(n_{11}\) : number of times pattern A is used by a successful student.

\(n_{.1}\) : total number of times pattern A is used.

\(n_{1.}\) : total number of sessions by successful students.

\(n_{..}\) : the overall total by all students.

FIGURE 1
Contingency table of pattern usage
thesis (a test for homogeneity). A P value of .05 or better was considered sufficient to reject \( H_0 \).

This procedure was applied to the data in several different combinations, i.e., (a) all subjects classified as successful or unsuccessful; (b) Math students, successful versus unsuccessful; (c) English students successful versus unsuccessful; and (d) all subjects classified as English or Math. The object was to examine the data for differences in pattern use among subjects. The rejection of \( H_0 \) however, when it was indicated, did not result in information about why the null hypothesis did not hold. Therefore, further analyses were performed, as the data suggested them.

The number of times students accessed RULES, EXAMPLES, and PRACTICES was treated separately. The data was first displayed in the form of histograms. Indications were that the number of keypresses was not normally distributed, suggesting the need for a non-parametric test of equality of distributions. The Mann-Whitney \( U \) test was selected to test the null hypothesis of the keypress data being from the same distribution.

**Additional Research Questions**

The present study provided the opportunity to inquire into some related questions with regard to probability of success in TICCIT courses. The investigator was experienced with the implementation of TICCIT in a community college, and was familiar with the questions raised by the evaluation reports. It was deemed worthwhile to examine the peripheral data generated by the study for whatever
light they could shed on these related questions. It was intended that these pursuits would result in suggestions of hypotheses for future investigation. Thus the analyses discussed in this section were aimed at hypothesis generation rather than hypothesis testing.

These related questions included: 1) students' entrance ability as measured by a pre-test; 2) the students' demographic characteristics of age, sex, race, employment status, student status and previous CAI experience; and 3) students' self-reported long and short term goals.

Students' entrance ability. The literature review contained contradictory reports of the relationship between pre-test score and performance under learner control conditions. Judd, Bunderson and Bessent (1970) reported that students with lower scores fared worse than students with higher scores. Hartley and Sleeman (1973) found that students with lower abilities benefited the most from having learner control. Alderman (1978) concluded that the TICCIT instructional program may provide instructional support sufficient for students of strong entrance ability but inadequate for others.

The pre-test scores obtained for the subjects of this study were analyzed by means of independent sample t-tests.

Students' demographic characteristics. In addition to the standard demographic variables of age, sex and race, information on three other attributes was collected: students' employment status, student status and previous experience with computers.
The ETS evaluation report found no relationship between student performance on TICCIT and age or sex. Race was not included as a variable. Data were collected to confirm or contradict those findings while adding the dimension of race.

Community college students tend to be different from their four year college or university counterparts with regard to employment and student status. The community college student is usually employed (often full time) and therefore, more likely to be a part time student. What effect did these circumstances have on their probability of succeeding in courses which were flexible as to "meeting" time, but required that all work be done on a terminal at the campus? Was course completion related to the number of hours per week the student was employed? Was there a relationship with regard to the number of courses in which a student was enrolled? The data collected in the questionnaires were used to provide preliminary information on the feasibility of these questions for further research.

Finally, it was postulated that students who had been exposed to computers and computer assisted instruction might be more at ease with the method and have a higher probability of success in the courses. Throughout much of the implementation of the TICCIT system at the Northern Virginia Community College, apprehension was voiced about the possibility of students being intimidated by having to interact with a computer. This concern was raised in particular
with regard to older adults. The question of experience with computers, then, was introduced to gather preliminary data on whether this was a problem warranting further study.

The foregoing questions on the various attributes of students who completed and those who did not complete the TICCIT courses were tested using contingency table procedures. The level of significance sought for the obtained chi-square values was set at the .05 level.

**Students' long and short term goals.** There was evidence in the literature that motivation played some role in students' use of learner control options (Axtell, 1978). This further suggested that motivation might be related to success in a course characterized by learner control. Once again, the variety of goals as well as backgrounds of community college students prompted the inclusion of the subjects' self-reported reasons for being in the courses in the college as questions in the study.

In a questionnaire administered at the beginning of the course, students were asked to place check marks next to the main reason or reasons they had chosen to enroll in the course they were in (Math or English). The options were 1) as a result of a college-administered placement test; 2) to strengthen a skill; 3) the course is required for a program of studies; 4) at the suggestion of a counselor; 5) other reason. Students could mark more than one reason.

Students were also asked what their overall academic goals were, i.e., why they were enrolled in the college. The options listed were 1) for job related reasons; 2) for a two year degree; 3) for a four
year degree; 4) other. More than one reason was also permitted in this question.

It was initially expected that the analysis might indicate that students who had more immediate goals, such as a job related reward, or were motivated to take the course because of their own perceived weakness in the subject matter, might be more likely to succeed.

The resulting tabulation of the data lent itself simply to a descriptive analysis. Some tentative trends led to suggestions for future studies.

Summary

In this chapter, the design of the study, the methods used to collect data and the proposed procedures for data analysis were described. The study was designed to investigate whether the patterns developed by students as they used the RULE, EXAMPLE and PRACTICE learner control options of TICCIT were related to success in English and mathematics courses within one academic quarter.

The subjects were 148 students enrolled in TICCIT delivered algebra and grammar courses at the Alexandria Campus of NVCC. The primary data consisted of the 21,793 keypresses logged by the computer as the students progressed through a selected lesson. In addition, demographic data and students' reasons for being in the courses were gathered by means of a questionnaire. A pre-test was also administered.

The keypresses, which were printed out from a log tape, were classified into patterns by segment of instruction. There were 1196
segments generated. The pattern groups were then analyzed using a contingency table approach. The hypothesis stated that the probability of a student choosing a particular pattern was the same regardless of whether s/he was classified as successful or unsuccessful.

The number of times the RULE, EXAMPLE and PRACTICE keys were accessed by the subjects was analyzed using the Mann-Whitney U test. The student characteristics data lent itself merely to descriptive analyses.

The results of these analyses are described in Chapter 4. A discussion of the findings, followed by the conclusions and recommendations for further study are contained in Chapter 5.
Chapter 4

ANALYSIS OF DATA

The primary objective of this investigation was to determine whether students who complete the course requirements of two computer delivered courses within a prescribed academic quarter use different strategies to work through the instructional materials than those students who do not complete within one term. In order to determine whether any significant differences in the use of learner control features existed between these two groups of students, analyses were performed on combinations of keypresses recorded on a log tape as the students proceeded through their lessons. The use of the three primary presentation forms, RULE, EXAMPLE and PRACTICE were compared, as well as the total use of each of the three learner control functions.

A secondary set of research questions was analyzed to determine whether the personal characteristics, including performance on a pretest, of the two groups of students were significantly different.

Presented in this chapter are the results of the analyses performed on the data obtained from four groups of students: completers and non-completers of the Algebra I and English Grammar courses taught on the TICCIT CAI system of the Northern Virginia Community College in the Fall Quarter of 1978. As a result of decisions explained in Chapter 3, the subjects were divided into 67 completers (39 English and 28 Math students) and 81 non-completers (35 English and 46 Math students).
Learner Control Patterns

GENERAL HYPOTHESIS: The probability of a student enrolled in TICCIT delivered courses using a particular Learner control pattern is the same whether the student is classified as successful or unsuccessful within the prescribed academic term.

The analysis of the log tape data revealed that the students had developed 45 different patterns of display sequences while working through the course content. Three of these patterns accounted for 65 percent of the segments generated. They were pattern A: RULE, EXAMPLE, PRACTICE, (R:E:P), pattern D: RULE, PRACTICE (R:P), and pattern H: PRACTICE only (P). The remaining patterns were grouped according to their similarities in order to make further analysis more manageable. Six other pattern groups were thus identified. The 1196 segments completed by the subjects of the study were then classified into the nine patterns, labeled A through I. The patterns and the distribution of segments are described in Table 1.

In order to examine the relationships among learner control patterns, success in the courses and course content, the General Hypothesis was broken down into three testable sub-hypotheses.

H₀a: The probability of a student enrolled in a math or English TICCIT delivered course using a particular Learner Control pattern is the same whether the student is classified as successful or unsuccessful within the prescribed academic term.

Using the approach developed in Chapter 3, a 2 X 9 table was constructed in which the columns represented the number of segments
Table 1

Distribution of Keypress Patterns

Employed by All Students in the Study

<table>
<thead>
<tr>
<th>Pattern Label</th>
<th>Pattern</th>
<th>Number of Segments</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$R : E : P^a$</td>
<td>320</td>
</tr>
<tr>
<td>B</td>
<td>$R : E : P + \text{misc. keys}$</td>
<td>91</td>
</tr>
<tr>
<td>C</td>
<td>$R : E : R + \text{misc. keys}$</td>
<td>75</td>
</tr>
<tr>
<td>D</td>
<td>$R : P$</td>
<td>300</td>
</tr>
<tr>
<td>E</td>
<td>$R / R : P + \text{misc. keys}$</td>
<td>93</td>
</tr>
<tr>
<td>F</td>
<td>$E / E : R + \text{misc. keys}$</td>
<td>41</td>
</tr>
<tr>
<td>G</td>
<td>$E : P / P : E$ combinations</td>
<td>77</td>
</tr>
<tr>
<td>H</td>
<td>$P$ only</td>
<td>155</td>
</tr>
<tr>
<td>I</td>
<td>$P : R + \text{misc. keys}$</td>
<td>44</td>
</tr>
</tbody>
</table>

Total 1196

$^a R = \text{RULE, } E = \text{EXAMPLE, } P = \text{PRACTICE.}$
observed in each pattern classification, and the rows correspond to the students who used those patterns, the completers and the non-completers. The combined chi-square value of 12.04 (p<.25) did not support the rejection of the first null sub-hypothesis. When data for all TICCIT students, regardless of course content, were evaluated, no significant differences in pattern usage between the completers and the non-completers were observed. An analysis of differences based on course content was therefore in order.

\[ H_{0}: \text{The probability of a mathematics student in a TICCIT delivered course using a particular learner control pattern is the same whether that student is classified as successful or unsuccessful within the prescribed academic term.} \]

Using a procedure similar to the previous one, the chi-square statistic was calculated for the 74 math students (26 completers, 48 non-completers). The results (\( \chi^2 = 27.62, p<.005 \)) permitted the rejection of the second sub-hypothesis. The calculations for each pattern suggested that completing students used patterns A: RULE, EXAMPLE, PRACTICE (R:E:P), C: RULE, EXAMPLE, RULE + misc. (R:E:R+), and H: PRACTICE only (P) less than expected (patterns C and H significantly so). The remaining patterns, especially pattern E: RULE only or RULE, PRACTICE + misc. (R/R:P+), were used more frequently by completing students than expected. The single largest contributor to the value of chi-square was the significant underuse of pattern H by successful students.

In order to further explore the differences, the data for
patterns A, C and H were set aside. The chi-square test was applied to the remaining six patterns to see if these were the source of any differences between the completing and non-completing students. The value of the resulting chi-square (4.28) was not large enough to reject a hypothesis of no differences among students' use of patterns B, D, E, F, G, and I.

The question was further examined in a 2 X 2 table with the columns made up of the combination of patterns A, C, and H, versus a combination of patterns B, D, E, F, G and I. The chi-square of 16.39, p<.005, was significant evidence that the difference among the math students was concentrated in the "overuse" of patterns A, C and H by completing students. A closer look at the data suggested that pattern A (R:E:P) contributed relatively less than C (R:E:R+) and H (P only) to the differences. It seemed reasonable to consider tests with H and C, alone and combined, versus the other seven patterns. The results of these tests were significant (p<.005) thus supporting the findings that students' use of patterns H and C were the primary sources of difference.

Further confirmation was sought by testing the corresponding subgroups with each of the "significant" patterns excluded and working backwards. First, the chi-square test was applied to a 2 X 8 table from which pattern C was excluded (c2(7) =20.08, p<.01) then only pattern H was removed (c2(7) =18.54, p<.05), and finally both patterns C and H were left out of the columns (c2(6) =9.08, p<.10).

The process, therefore, confirmed the initial finding that the overall significant chi-square (27.63, p<.005) could be attributed
primarily to the difference between the use of patterns C (R:E:R+) and H (P only) by completing students and what would have been expected. Successful students in the mathematics course used these patterns significantly less than the non-successful students.

A similar set of procedures was followed in testing the sub-hypothesis referring to the students in the English grammar course.

$H_0c$: The probability of an English grammar student in a TICCIT delivered course using a particular learner control pattern is the same whether that student is classified as successful or unsuccessful within the prescribed academic term.

The data for the English sub-group were arranged in a 2 X 9 contingency table (columns = patterns, rows = successful and non-successful students). The test results $\chi^2 = 21.74, p < .01$ permitted the rejection of the third null sub-hypothesis. Examination of the data pointed to the students' use of patterns A (R:E:P), D (R:P) and H (P only) as accounting for most of the value of the chi-square. As was the case with the data for the math group, pattern A contributed relatively less than D and H to the difference.

Following the same logic used in analyzing $H_0b$, the data for the math students, the English students' use of patterns D and H was examined in juxtaposition to their use of the other seven patterns. Three 2 X 2 analyses were performed. The first combined the data for patterns D and H and contrasted that with the sum of the remaining patterns, yielding $\chi^2 = 17.78, p < .005$. Two more analyses involved the sum of all patterns except D, versus D, and except H, versus H. The
results were significant at the \( .005 \left( \chi^2_{(7)} = 10.60 \right) \) and \( .05 \left( \chi^2_{(7)} = 4.99 \right) \) levels respectively. The obtained results provided sufficient evidence to permit the rejection of \( H_0 \). There were differences in the use of patterns by completing and non-completing English students. The differences resided in the higher than expected rate of use of pattern D (R:P) and pattern H (P only) by the successful students.

The preceding analyses and respective findings prompted the formulation of an additional question: were learner control patterns content dependent? Did students in the math courses develop different strategies from those of students studying English grammar? A fourth sub-hypothesis was formulated and tested:

\( H_0^d: \) The probability of a student enrolled in TICCIT delivered courses using a particular learner control pattern is the same whether the student is enrolled in a math or an English course.

A 2 x 9 chi-square table was constructed in which the segments were arranged in nine columns, according to pattern use, and the subjects were divided into the two rows, English students and math students. The test results \( \left( \chi^2_{(8)} = 42.98, p < .0001 \right) \) provided significant evidence that students studying English had different strategies for working through a TICCIT course from those who were studying math. The English students made more use of patterns A (R:E:P) and C (R:E:R+), while math students were heavy users of patterns D (R:P) and E (R/R:P+).

Consistency of pattern use. The previous discussion of the predominant patterns employed by completing and non-completing students would be
misleading without some observations about the number of patterns employed by each student. One of the assumptions of the study was that students would exhibit preference for patterns; it was anticipated that students would be classified as "A pattern type", or "H pattern type", etc. The total number of patterns tabulated, 1196, compared to the number of subjects, 148, negated this assumption.

The math lesson studied by the subjects of the study, contained nine segments and the students generated a total of 860 pattern repetitions, or 11.5 per lesson. The English students had only four segments in their lesson. They generated 336 pattern repetitions, or 4.5 per lesson. These averages suggested that all students used a different pattern strategy for each segment of instruction they encountered.

Another approach to the data, however, presented a different picture.

In Table 2, the distribution of pattern use is grouped according to the number of subjects from each group who used one, two or more patterns per lesson. Only 11 percent (n=16) of all students used only one pattern throughout their lesson; 63 percent (n=93) of the students developed three or more patterns as they progressed through the segments. One student, in the math course, used all nine patterns in one lesson. Non-completing students tended to generate more patterns per lesson than the completing students. In the math course, 84.7 percent non-completers used three or more patterns, whereas only 71 percent of the completers needed that many patterns. Among the English students, 54 percent of the non-completers used three or more patterns, compared to 38 percent of the completing students.
Table 2
Frequencies and Percents of Pattern Use by Group

<table>
<thead>
<tr>
<th>No. of Patterns Used Per Lesson</th>
<th>Math Completers N=28</th>
<th>Math Non-Completers N=46</th>
<th>English Completers N=39</th>
<th>English Non-Completers N=35</th>
<th>Total N=148</th>
</tr>
</thead>
<tbody>
<tr>
<td>One</td>
<td>f  %</td>
<td>f  %</td>
<td>f  %</td>
<td>f  %</td>
<td>f  %</td>
</tr>
<tr>
<td>Two</td>
<td>3  11</td>
<td>0  0</td>
<td>8  21</td>
<td>5  14</td>
<td>16  11</td>
</tr>
<tr>
<td>Three</td>
<td>5  18</td>
<td>7  15</td>
<td>16  41</td>
<td>11  31</td>
<td>39  26</td>
</tr>
<tr>
<td>Four</td>
<td>8  28</td>
<td>11  24</td>
<td>13  33</td>
<td>16  46</td>
<td>48  32</td>
</tr>
<tr>
<td>Five or More</td>
<td>5  18</td>
<td>10  22</td>
<td>2  05</td>
<td>1  03</td>
<td>18  12</td>
</tr>
<tr>
<td>Five or More</td>
<td>7  25</td>
<td>18  39</td>
<td>0  0</td>
<td>2  06</td>
<td>27  18</td>
</tr>
</tbody>
</table>
Number of keypresses accessed by students. The preceding discussion of learner control patterns was limited to an analysis of observed sequences of keypresses, without regard for the number of times the keys were accessed. This section includes an analysis of the differences among the two groups of completers and non-completers as evidenced by the number of times they requested RULES, EXAMPLES and PRACTICES as they worked on their lesson.

There were 21,793 keypresses recorded on the log tape. Raw data for each key type, RULE, EXAMPLE and PRACTICE, appear in Appendix D. A summary of the data is presented in Table 3.

A preliminary examination of the raw data exposed such a wide variation in numbers of keypresses recorded by each individual to suggest that ordinary statistical procedures would be inappropriate. The data were then graphed in a series of six histograms (Figures 1 through 6, Appendix E) for the purpose of detecting whether the curves suggested the normal distribution. Concluding that these did not appear normal, a non-parametric procedure was selected for the analysis, the Mann-Whitney U test.

The number of times each successful math student accessed a RULE, EXAMPLE or PRACTICE was compared against the same information for the unsuccessful math students. The procedures were repeated with the data generated by the English grammar students. The null hypothesis for each of the six analyses was that each sample was from the same distribution as its paired sample. Since all the n's were larger than 20, the distribution of the statistic would be expected to approach the
### Table 3
Number of Rule, Example and Practice Keys Accessed

<table>
<thead>
<tr>
<th>Group</th>
<th>Key Label</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rule</td>
<td>Example</td>
</tr>
<tr>
<td>Math Completers (N=26)</td>
<td>513</td>
<td>1057</td>
</tr>
<tr>
<td>Math Non-Completers (N=48)</td>
<td>902</td>
<td>1790</td>
</tr>
<tr>
<td>Sub-Total Math (N=74)</td>
<td>1415</td>
<td>2847</td>
</tr>
<tr>
<td>English Completers (N=38)</td>
<td>299</td>
<td>1528</td>
</tr>
<tr>
<td>English Non-Completers (N=36)</td>
<td>329</td>
<td>2037</td>
</tr>
<tr>
<td>Sub-Total English (N=74)</td>
<td>628</td>
<td>3565</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Number of Keys Accessed</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
normal. Therefore, a two-tailed test to determine whether or not $H_0$ should be rejected was established. Rejection of the null hypothesis at the .05 level required that $|Z| \leq 1.96$.

Four of the $Z$ scores were smaller than $1.96$; therefore the null hypotheses could not be rejected in those cases. The number of RULES and EXAMPLES used by completing and non-completing Math students were shown to be from the same distributions. A parallel conclusion could be reached for the number of RULES and PRACTICE items accessed by the English students.

Two of the $Z$ scores proved to be significant, that of the number of PRACTICE items used by math students ($-3.199, p<.001$) and that of the EXAMPLES accessed by English students ($-1.98, p<.05$). The null hypotheses of these samples being from the same distribution, were rejected.

**Additional Research Questions**

This section contains a discussion of the findings regarding the additional information obtained in the course of the study about certain characteristics of the subjects of the study.

**Students' entrance ability.** The independent samples $t$-test was used to test the null hypothesis of no significant differences in the pre-test scores of students who completed and those who failed to complete the English and math courses on TICCIT.

The results of the analyses are displayed in Tables 4 and 5 respectively. A two-tailed $t$ value of $2.26$ ($p<.05$) was obtained for the English students. The difference in standard deviations reflects
Table 4
Performance of English Students
on the Pre-Test

<table>
<thead>
<tr>
<th>Group</th>
<th>( \bar{X} )</th>
<th>( s )</th>
<th>( t )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completers</td>
<td>67.44</td>
<td>13.69(^a)</td>
<td>2.26(^*)</td>
</tr>
<tr>
<td>( N = 39 )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Completers</td>
<td>61.38</td>
<td>8.66(^b)</td>
<td></td>
</tr>
<tr>
<td>( N = 35 )</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^a\)Scores ranged from 99.00 to 41.00.

\(^b\)Scores ranged from 83.00 to 44.00.

\(^*\) \( p < .05 \) for two-tailed test.
Table 5
Performance of Math Students on the Pre-Test

<table>
<thead>
<tr>
<th>Group</th>
<th>$\bar{X}$</th>
<th>s</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N=28</td>
<td>41.38</td>
<td>14.44</td>
<td>3.55*</td>
</tr>
<tr>
<td>Non-completers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N=46</td>
<td>29.09</td>
<td>14.43</td>
<td></td>
</tr>
</tbody>
</table>

*p < .001 for two tailed test
the wider range of test scores among the completing students (99.00 - 41.00) than among the non-completers (83.00 - 44.00). The math pre-tests reflected a more homogeneous distribution of students with $t=3.55$ ($p<.001$).

While both $t$-test values permitted the rejection of the null hypothesis, cautious interpretation is, as usual, necessary. At least two students who completed the English course scored as low and lower than the lowest scoring non-completing students.

**Students' demographic characteristics.** The null hypothesis of no differences among completers and non-completers with regard to age, sex, race, student status, employment status and previous computer experience was tested by means of chi-square analyses.

The results of the chi-square tests are displayed in Table 6. No significant differences were found among the subjects with regard to any of the variables listed. The null hypothesis could not be rejected.

**Students' long and short term goals.** Responses to the questions described in Chapter 3 about students' reasons for being in the course (short term goals) and their reasons for being enrolled in the college (long term goals) are displayed in Tables 7 and 8 respectively.

Some general observations can be made about this group of students. Students enrolled in ENGL 110 primarily to strengthen a perceived weakness in their command of a basic skill; 81 percent ($n=60$) marked this as a reason for being in the course. There was substantially no difference between completers, 85 percent and non-
Table 6
Chi-square analyses*

of Students' Demographic Characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>df</th>
<th>Math</th>
<th>English</th>
<th>All Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>2</td>
<td>1.38</td>
<td>3.45</td>
<td>1.12</td>
</tr>
<tr>
<td>Sex</td>
<td>1</td>
<td>.68</td>
<td>.03</td>
<td>.47</td>
</tr>
<tr>
<td>Race</td>
<td>1</td>
<td>.12</td>
<td>3.26</td>
<td>1.22</td>
</tr>
<tr>
<td>Employment Status&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2</td>
<td>3.37</td>
<td>1.25</td>
<td>1.36</td>
</tr>
<tr>
<td>Student Status&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2</td>
<td>1.37</td>
<td>.98</td>
<td>.81</td>
</tr>
<tr>
<td>CAI Experience</td>
<td>1</td>
<td>.25</td>
<td>.03</td>
<td>.02</td>
</tr>
</tbody>
</table>

<sup>a</sup>Includes NO employment, part-time and full-time

<sup>b</sup>Includes only one course, part-time and full-time

*None of these yielded values of the significance sought (p < .05)
<table>
<thead>
<tr>
<th>REASON</th>
<th>ENGLISH</th>
<th>MATH</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Completers N=39</td>
<td>Non-Completers N=35</td>
<td>Completers N=28</td>
</tr>
<tr>
<td>Placement Test</td>
<td>13 (.33)</td>
<td>9 (.26)</td>
<td>12 (.43)</td>
</tr>
<tr>
<td>Strengthen Skill</td>
<td>33 (.85)</td>
<td>27 (.77)</td>
<td>11 (.39)</td>
</tr>
<tr>
<td>Required</td>
<td>NA</td>
<td>NA</td>
<td>16 (.57)</td>
</tr>
<tr>
<td>Counselor Placed</td>
<td>1 (.25)</td>
<td>6 (.17)</td>
<td>6 (.21)</td>
</tr>
<tr>
<td>Other</td>
<td>6 (.15)</td>
<td>3 (.09)</td>
<td>2 (.07)</td>
</tr>
</tbody>
</table>

Numbers in parentheses are percentages of the N in that column. Percents may not add up to 1.00 because students could mark more than one reason.
Table 8

Students' Long Term Academic Goals

<table>
<thead>
<tr>
<th>GOAL</th>
<th>ENGLISH</th>
<th></th>
<th>MATH</th>
<th></th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Completers N=39</td>
<td>Non-Completers N=35</td>
<td>Completers N=28</td>
<td>Non-Completers N=46</td>
<td>N=148</td>
</tr>
<tr>
<td>Job Related</td>
<td>17 (.44)a</td>
<td>10 (.29)</td>
<td>6 (.21)</td>
<td>5 (.11)</td>
<td>38 (.26)</td>
</tr>
<tr>
<td>2 Year Degree</td>
<td>13 (.33)</td>
<td>10 (.29)</td>
<td>1 (.04)</td>
<td>4 (.30)</td>
<td>28 (.19)</td>
</tr>
<tr>
<td>4 Year Degree</td>
<td>9 (.23)</td>
<td>15 (.43)</td>
<td>25 (.89)</td>
<td>31 (.67)</td>
<td>80 (.54)</td>
</tr>
<tr>
<td>Other</td>
<td>11 (.28)</td>
<td>10 (.29)</td>
<td>1 (.04)</td>
<td>5 (.11)</td>
<td>27 (.18)</td>
</tr>
</tbody>
</table>

_a_ Numbers in parentheses are percentages of the N in that column. Percents may not add up to 1.00 because students could mark more than one reason.
completers, 77 percent, in this regard.

The students in developmental math were consistent between completers and non-completers in their reasons for enrolling: placement test, strengthen a skill and required for a program or college admission. The majority of the completers, 57 percent (n=16) said the course was required while only 37 percent (n=17) of the non-completers needed the course as a pre-requisite. The most frequent response of the unsuccessful students was to strengthen their skill; 50 percent (n=23) marked it as one of their reasons.

The college's placement test was the second most frequent reason for the successful students in math, 43 percent (n=12) and the third for their non-completing counterparts, 33 percent (n=15). It was also the second most frequent reason for all the English students, 33 percent (n=13) and 26 percent (n=9), for the completers and non-completers respectively.

English and math students differed more with regard to their long term academic goals. The majority of math students had four-year college degrees as their objective, 89 percent (n=25) of the completers and 67 percent (n=31) of the non-completers. Of the students studying English grammar, 43 percent (n=15) of the non-completers were planning to attend a four-year college, whereas only 23 percent (n=9) of the completers marked that response.

Few of these math students were enrolled in the college for job-related reasons, but over one-third of the English students gave that as their reason for being at the community college. This was also the
most frequent response among completing English students, 44 percent (n=17) versus only 29 percent (n=10) of the non-completers.

**Summary**

Chi square analyses of the four sub-hypotheses derived from the general hypothesis produced evidence that there were differences in the learning strategies developed by completing and non-completing students in the TICCIT delivered English and math courses. The differences were content dependent. There were significant differences in pattern use between English and math students. Furthermore, students appeared to develop patterns to suit the topic or segment they were studying. Only 37 percent of the students in the study used the same one or two patterns throughout the lesson analyzed.

Mann Whitney \( U \) tests comparing the number of RULES, EXAMPLES and PRACTICES accessed by successful and unsuccessful math and English students suggested that four of the six paired samples were from the same distribution. Math students' use of PRACTICE and English students' use of EXAMPLE were significantly different for completers and non-completers.

Students' entrance ability as measured by a pre-test was found to be associated with course completion. The null hypothesis of no differences among successful and non-successful students with regard to demographic characteristics could not be rejected. The descriptive analysis of students' self-reported long and short term goals did not reveal any marked differences among the groups.
Chapter 5

SUMMARY, DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

Summary

The purpose of this study was to explore the way community college students used certain learner control features of a computer system, TICCIT, to develop learning strategies, and the relationship of those strategies to course completion within a prescribed period of time, an eleven week academic term. Some demographic variables, as well as entrance ability and self reported academic goals were also investigated for their association with course completion.

The TICCIT computer system is characterized by a learner control instructional design. The research literature on learner control theory was reviewed as a prelude to the study.

Research with adult learners reported that, when given the options, these students used different learning strategies and that some of these strategies resulted in more successful performance than others. It was further reported that neither achievement nor efficiency were affected by allowing students control over the instructional variables of sequence and amount of practice. When students' aptitudes and capabilities of self-assessment were included, contradictory findings regarding their interaction with learner control were reported.

Generally, however, the literature cited suffered from the necessity for research to be so artificially controlled as to be unrepresenta-
tive of the real world of education. Most of the studies were based on short term experiments involving small numbers of subjects, largely on a voluntary basis. With two exceptions, the instruction consisted of modules or segments which could be completed in a matter of a few hours.

The review of the literature, then, did not provide sufficient information to respond adequately to the problem encountered by the community colleges using a learner control instructional computer system -- the lower than expected completion rates. The present study resulted from this need to learn more about how students used learner control options when required to exercise such options.

The design of the study was in the form of an exploratory investigation. Data were collected on the use of three learner control options, the primary display features of RULE, EXAMPLE and PRACTICE, by students who received their instruction from a computer system called TICCIT at Northern Virginia Community College. Differences in the patterns of use developed by completing and non-completing students were analyzed on the assumption that successful students devised patterns that were more likely to lead to completion, whereas the other students did not.

One hundred and forty-eight students who had enrolled in TICCIT taught courses at the Northern Virginia Community College participated in the study. Seventy-four students studied developmental level mathematics and seventy-four were taking a freshman level English grammar course.
Eighty-one subjects completed satisfactorily at the end of an eleven week quarter; sixty-seven did not meet the criteria for successful course completion within the prescribed time.

The students' use of the learner control keys RULE, EXAMPLE and PRACTICE were recorded on a log tape and then printed out for examination. The 21,793 pertinent keypresses were tabulated and analyzed for evidence of the sequences developed by students, as well as for the frequencies with which each key was accessed. Nine sequence patterns were identified. The frequency of use of these patterns by the four groups of subjects was evaluated by means of chi-square analyses. Indications of significant differences in this use were followed up by further chi-square tests on the significant patterns themselves. Significance was established at the .05 level.

The Mann-Whitney U procedure was used to expose any significant differences in the frequency of use of the RULE, EXAMPLE and PRACTICE options by the subjects.

A secondary set of questions was included in the study for the purpose of gathering additional information on the relationship between course completion and the use of learner controlled computer assisted instruction in the community colleges. The data consisted of students' entrance ability as measured by pre-tests, some demographic information and students' self-reported long and short-term goals.

Discussion of the Hypothesis

One primary hypothesis was the basis of this study. It was tested in the form of four subhypotheses to account for the general groupings
of subjects and effects possible: all completing and non-completing students, completing and non-completing English students, completing and non-completing Math students, all English and Math students. In the sections that follow, findings are summarized, discussed and compared with prior research.

The first subhypothesis tested the probability of whether learner control patterns were used in the same frequencies by all completing and non-completing students. The chi-square test indicated no significant difference (p < .2) between the groups. Based on the results, the subhypothesis could not be rejected.

The second subhypothesis tested involved only the math students and the use of learner control patterns by completers and non-completers. The results of the chi-square test indicated a significant difference (p < .005) between the two groups. The null hypothesis, therefore, was rejected. The analysis pointed to a significant under-use of patterns C (R:E:R) and H (P only) by the students who completed the course successfully. The non-completing students made greater use of these patterns, RER and P only, than the successful students. This finding might suggest that both the failure to use the PRACTICE option (pattern C) and exclusive use of PRACTICE (pattern H) were detrimental to the timely completion of a math course on TICCIT. The higher than expected use of pattern E (R/R:P + misc. keys) by completing students pointed to the combination of RULE and PRACTICE as the more successful approach to math courses on TICCIT.

The third subhypothesis concerned the frequency of use of the
various patterns by the students enrolled in the English course. The chi-square test yielded a significant value ($p \leq .01$), thus permitting the rejection of the null hypothesis. In this case, the differences resided in the more frequent than expected use of patterns D (R:P) and H (P only) by completing students. This finding partially agreed with the evidence of the math students which pointed to a pattern which emphasized RULE and PRACTICE (Patterns D (R:P) and E (R/R:P) were variations of each other) as the successful approach to course completion.

The findings related to pattern H (P only) were contradictory for math and English students. It could be concluded that using the PRACTICE option almost exclusively was beneficial to the chances of course completion in the case of English, but detrimental for math courses.

The analyses of difference between completing and non-completing students suggested an additional test based on course content. The fourth subhypothesis tested the difference in pattern use between students enrolled in English grammar and Algebra I. The results of this test indicated a significant difference ($p \leq .0001$) between the two groups, permitting the rejection of the null hypothesis. This analysis provided evidence to suggest that the use of learner control options was related to course content. Students' use of the patterns differed significantly according to the subject matter they were studying, English or mathematics. No previous research studies reported findings related to instructional content.
The differences noted were in the higher use of patterns A (R:E:P) and C (R:E:R) by English students, and the equally high use of patterns D (R:P) and E (R/R:P) by math students. In other words, English students favored the REP and RER patterns while math students preferred the RP and R only/RP combination patterns. The key difference was in the use of the EXAMPLE option. The TICCIT model provides for making available numerous examples and non-examples of the RULE being taught in a segment. The number of examples is usually equal to the number of PRACTICE items in that segment. The data in this study indicated that English students found these examples (and non-examples) useful to their learning, whereas the students in the math course chose to use them less frequently, concentrating on PRACTICE.

A comparison of the analyses of subhypotheses three and four showed that while all English students made more frequent use of patterns which included the EXAMPLE option than the math students, the difference between the successful and non-successful English students resided in the preferred use of a RULE/PRACTICE pattern by the completers.

These results were not consistent with other research on the use of RULES, EXAMPLES and PRACTICES. Elliott (1976) reported no relationship between his independent variables, which included a post-test as a measure of success, and the order in which people requested various types of moves within each objective. Half of the participants in Elliott's study were consistent in the use of an REP pattern. Of those subjects, 25 percent gave the format of the display which presented the
options available to them as the reason for following that sequence. In the present study, 34 percent of all patterns used were of the REP type.

A study by Spiller et al. (1978) found the REP and RPE sequences to be superior to other sequences in a study involving the use of instructional booklets organized in six different sequences. The present study differed significantly from theirs by allowing students to develop their own sequences in a computer assisted instruction environment. Of the total number of patterns used by the successful students, only 30 percent involved the consistent use of REP patterns. It was noted that almost 66 percent of all patterns used by subjects in this study, and 68 percent of those used by students who completed within the given term, were patterns that omitted one of the three primary presentation forms.

The previous discussion on the statistical analyses of pattern use represented one approach to investigating the relationship between learner control and course completion. This approach had as an underlying assumption the expected consistency of pattern use within a lesson by individual students. This assumption did not hold. Only 11 percent (n=16) of all students used only one pattern as they progressed through their lesson; 26 percent (n=39) used two patterns. The sum of 37 percent for two or fewer patterns per lesson was evidence that students' use of learner control options was more varied than had been anticipated. Almost two-thirds of the students in the study made use of three or more patterns in the lesson analyzed. One student used all
nine patterns. These findings had implications for the previously discussed results.

An objective of this study had been the identification of learner control patterns that were associated with student success in a TICCIT course. If identified, these patterns could be taught to future students in order to increase their chances of success in the TICCIT delivered math and English courses. The statistically significant findings reported in this study suggested that of the nine patterns analyzed, two patterns common to the successful students in both math and English made the difference between completion and non-completion of course objectives within the term. The patterns were D (R:P) and E (R/R:P). Pattern H (P only) was also important for the successful English students.

Despite the reported significance which resulted from the chi-square analyses, another approach to the data suggested that no definitive conclusions could be drawn: patterns D and E were used by 37 percent of all completers, as well as by 30 percent of all non-completers. The "successful patterns" were used by only one-third of the successful students (and almost one-third of the non-successful students). Conversely, no significant differences in learning strategies were exhibited by two-thirds of the subjects in the study. These proportions seemed to be inadequate for the purpose of identifying patterns which could be recommended to future students in learner controlled computer assisted instruction.

This variability in patterns and pattern use was consistent with
the findings of several studies reported by Merrill (1980). He wondered whether the lack of correlation between various display variables and performance meant that students were really adapting the displays to their needs and hence eliminating group differences. The results of this study seemed to provide further evidence to support Merrill's thesis.

**Number of keypresses accessed by students.** Another subset of the hypothesis tested in this study was the analysis of the frequency of use of the learner control keys by the four groups of students. Results of the Mann-Whitney U tests did not permit the rejection of four of six null hypotheses of difference between completers and non-completers. Statistically significant differences (\(Z < 1.96\)) were found for the number of PRACTICE items accessed by math students and for the number of EXAMPLES used by English students. The distributions of PRACTICE keypresses by completing and non-completing math students were significantly different: the non-completers consistently accessed more problems than the completing students. This finding did not reveal whether the non-completing students were less efficient in their use of PRACTICE, or simply required more of them to learn. In the context of a finding that these students also had significantly lower pre-test scores, it could be concluded that the TICCIT instructional design facilitated the lower ability students' need for more practice.

The difference in the distribution of EXAMPLE keypresses between completing and non-completing English students was more difficult to interpret. A value of \(Z = 1.98\) was only barely in the statistically
significant range. An examination of the graphed data indicated that while 25 percent of the unsuccessful students accessed more than 100 EXAMPLES, only 18 percent of the successful students used 100 or more. The previous finding regarding the more frequent use of a pattern which omitted the EXAMPLE option (pattern D) by the completers was consistent with the present analysis.

Some general observations on the frequency of keypress use were warranted. Math and English students differed in the ratio of PRACTICE to EXAMPLES accessed. Math students requested five PRACTICES for every EXAMPLE, while English students displayed a 1:1 ratio of use. Among the math students, the completers only accessed three problems for every EXAMPLE, while the non-completers needed seven problems for each EXAMPLE. The non-completing English students used 28 percent more EXAMPLES than PRACTICE items, whereas the completers used them with equal frequency. These observations therefore, were consistent with the findings of pattern use discussed previously.

Additional research questions. Data were gathered and examined with regard to the relationship between certain student characteristics and completion of TICCIT taught courses.

Entrance ability as measured by pre-tests was found to be associated with completion. The independent samples t-tests results yielded significant differences between completers and non-completers of the Math course (p < .001) and the English course (p < .05). Students who began the courses with less previous knowledge of the content were more likely to be among the non-completers at the end of the academic
term. This finding was consistent with the findings of Alderman (1978) and Judd et al (1970). The latter had concluded that students with lower pre-test scores fared poorly under learner control. Alderman raised questions about the effectiveness of a non-directive, self-paced machine driven instructional system for community college students with deficient academic backgrounds. However, several of the completing English students in the present study scored as low or lower than some non-completers. The learner controlled computer instruction did not harm these students' chances for success.

In 1973, Hartley and Sleeman concluded that lower ability students benefited from learner control. The findings of this study seemed to support the former studies and contradict the Hartley and Sleeman study. However, the evidence merely indicated that students with low pre-test scores tend to require more time to complete the course content than a standard academic term. Possible explanations for this were that these students spent more time in the early lessons of a course than their counterparts, perhaps because the material which may have been a review for higher pre-test students, was new and difficult for them. Lower pre-test students may have had a lower overall academic record, possibly as a result of lower mental ability or poor study habits. In any case, the pre-test data did not provide evidence that the learner control aspects of the instructional system were related to entrance ability.

The student demographic variables included in the study were found to be unrelated to course completion in TICCIT instruction. This
finding was consistent with previous studies, e.g., Hayden (1978) and Alderman (1978).

The information on students' reasons for enrolling in the English and Math courses or for being in the college did not reveal any significant insights into the motivations which might affect the likelihood of course completion. Some of the responses suggest that additional data should be collected in an attempt to have better bases for assisting future TICCIT students. For example, students who enrolled in Algebra I because it was required for some academic goal they had, were more likely to be among the completers (51 percent versus 37 percent). Similarly, more completers than non-completers had a four-year college degree as their academic goal (89 percent versus 67 percent).

Among the English students, more non-completers stated they wanted four-year degrees (43 percent versus 23 percent). This may have been due to the fact that many of the non-completers, who also had lower pre-test scores, were international students for whom English was a second language. Their handicap did not prevent them from aspiring to a college education. Over one-third of the English students were studying grammar for job-related reasons, the most frequent reason given by the completing English students (44 percent versus 29 percent).

The question of whether the problem of less than satisfactory course completion rates in TICCIT courses might be tied in some way to students' goals and motivations, was only tentatively treated by the information gathered in this study.
Conclusions

An evaluation of the results of this study led to the following conclusions.

1. Community college students did make use of the learner control options presented to them by the TICCIT computer system to develop learning strategies. There was no evidence of random keypressing. Two-thirds of the students in the study developed patterns which used only two of the three primary presentation forms, showing a consistency in the one omitted.

2. The findings of the study did not support the promotion of any specific patterns as paths to success in TICCIT delivered courses. The "successful patterns" identified in the statistical analyses were actually used by one-third of the completing and non-completing students alike.

3. There was no evidence to support the assumption that students would use a pattern consistently throughout a lesson, and by extension, a course. Students were consistent, however, at the segment level. Pattern choice seemed to be influenced by the topic to be studied.

These overall conclusions notwithstanding, the findings related to the subsets of the primary hypothesis permitted the following observations:

a. The use of learner control patterns was related to course content. Significant differences in the frequency of pattern use between the English and math students were found.
b. The findings of this study were that students in the English course used patterns which included EXAMPLES more frequently than the students studying math. The latter tended to use the RULE/PRACTICE pattern more frequently.

c. There were indications in the data that the RULE/PRACTICE pattern, omitting the use of EXAMPLES, was a successful approach to the timely completion of math and English courses on TICCIT.

d. There was evidence that the use of PRACTICE without RULES or EXAMPLES, was detrimental to the timely completion of the math course, but beneficial in the case of the English course.

e. The frequency of keypresses data indicated that mathematics courseware needed to include more PRACTICE items than EXAMPLES. The English courseware, on the other hand, would meet the needs of the students with an equal number of EXAMPLES and PRACTICE items.

f. Consistent with the findings of previous research (Alderman, 1978, Judd et al, 1970), entrance ability was found to be associated with the timely completion of courses taught with the TICCIT computer.

g. No evidence was found of a relationship between course completion and the variables of age, sex, race, employment and student status, nor previous experience with computers.

Recommendations

The present study was exploratory in nature and design. It was intended to trace the way students made use of particular learner
control options, and therefore there were no experimental controls involved. The study was further limited by the fact that it was conducted in one setting, during one academic term, and using one lesson in each of two courses for analysis. With these limitations in mind and based on the reported findings, the following recommendations were presented for the consideration of potential investigators in this area.

1. Additional research in the area of learner control patterns might well be conducted using the same courseware and computer system with similar community college students. The design might be expanded to include more lessons, perhaps at several intervals in the course. The present study was limited by the definition of unsuccessful students as those who failed to complete within a given academic term. Another approach might be to group students based on pre and post-test performance. Yet another might use time on line data, possibly as aggregate totals or at segment/lesson intervals. More data are needed on the stability of learning strategies over multiple lessons and units and their association with success in courses characterized by learner control.

2. Based on the findings that pattern use seemed to be segment (topic) dependent, further research might include a study of patterns used by successful and unsuccessful students on a segment rather than a lesson level. Do the behavioral objectives which introduce each topic lead students to develop or select a particular approach (pattern) to that segment? Are any student characteristics
associated with that choice?

3. Future studies need to take into account other learner control features of TICCIT, such as the multiple RULE forms, and the HELP options for EXAMPLE and PRACTICE. The questions related to students' use of the multiple learner control options of a system like TICCIT, as suggested by Hayden (1978), may need to be studied in the systems that are not as rich (with regard to learner control), in order to avoid the effects of redundancy: controlled experiments such as his, where one or another option is suppressed, have revealed that students compensate, for example, by treating EXAMPLES as if they were HELP versions of the problem being worked on, thereby altering the expected effect of the study.

4. With regard to the question of course completion, additional research should be done on the ultimate achievement outcomes of students in learner controlled CAI courses, without regard for traditional time limitations. Learning which took longer to master, but was mastered, as reported by Alderman (1978), may be of greater benefit to the student than learning acquired in a lock step manner in a limited time frame.

5. There is a need for additional research to determine the minimum number and types of learner control options necessary for an effective instructional system. There was some evidence, in this study and others (Hayden, 1978; Lahey & Crawford, 1976) that some features or options were consistently omitted. The implications for such studies would be in the area of courseware development, which is
extremely expensive and time consuming. The elimination of the need to write four versions of a RULE, for example, might result in a considerable savings of time and effort.

A number of practical implications can be derived from the present study. Instructors who are responsible for TICCIT delivered courses might consider the advice they give their students in light of the findings. Since there were no patterns that emerged as overwhelmingly beneficial or harmful to student success (i.e., course completion), it is probably best to refrain from promoting any single approach to using the learner control features of the system. Students should, however, be thoroughly familiarized with the options.

Math students should be alerted to study the RULES together with PRACTICE problems, i.e., to avoid the PRACTICE only pattern. The same pattern, RULE/PRACTICE, surfaced as a successful as well as efficient approach for English grammar students.

Those who might author or revise courseware in the two subject areas included in the study should consider the evidence regarding the use of EXAMPLES in both courses: these were frequently omitted by the students. This may suggest that fewer such items need to be authored. The data on the use of PRACTICE, particularly the frequency with which items were accessed suggests that there may be need for more such instances, particularly in the math courses.

With regard to the concern about course completion within an academic term, it would appear that learner control per se has little impact on the matter. Faculty may wish to follow up on the students'
self-reported long and short term goals. Cumulative data from several academic terms might yield useful insights into students' needs and perceptions. This information should be used in guiding students before and during enrollment in TICCIT courses.

This study was prompted by a need to learn why students who enrolled in courses characterized by learner control of a computer assisted instruction system had a higher probability of not completing the course than if they had enrolled in more traditionally taught, lecture-discussion courses. It was hypothesized that the learner control aspects of the instructional system were related to these problems. The learner control options which were included in the study, the RULE, EXAMPLE and PRACTICE displays, were found to have little or no relationship to a student's probability of completing a TICCIT course within a given academic quarter. Perhaps other aspects of learner control will subsequently be proven to be the obstacles to success, but this does not seem likely.
BIBLIOGRAPHY


Mager, R.F. On the sequencing of instructional content. Psychological Reports, 1961, 9, 405-413.


APPENDIX A

ENGLISH 110 and MATH 06 Course Outlines
ENGL 110: English Grammar

UNIT 18 - Introduction to the Sentence: Its Basic Structure

LESSON 3 - What a sentence is
   Segment 4. Complete and incomplete sentences
   Segment 3. Subjects and predicates
   Segment 2. Modifiers
   Segment 1. Subjects, predicates, modifiers, and complements

LESSON 2 - The words in a sentence
   Segment 2. Words, which are parts of speech, make up sentences
   Segment 1. How to recognize a part of speech

LESSON 1 - Words, phrases, and clauses as sentence components
   Segment 2. Words, phrases and clauses
   Segment 1. Sentence components can consist of words, phrases or clauses

UNIT 13 - Basic Elements of the Sentence

LESSON 4 - Verbs
   Segment 4. Verbs
   Segment 3. Forms of BE
   Segment 2. Linking verbs and action verbs
   Segment 1. Verb phrases

LESSON 3 - Basic sentence elements
   Segment 5. Nouns
   Segment 4. Pronouns
   Segment 3. Adjectives
   Segment 2. Adverbs
   Segment 1. Review of the basic elements

LESSON 2 - Phrases
   Segment 4. Prepositions
   Segment 3. Prepositional phrases
   Segment 2. Object of the preposition
   Segment 1. Noun phrases
LES SONT 1 - Subjects and predicates

Segment 3. Subjects
Segment 2. Predicates
Segment 1. Subjects and predicates

UNIT 12 - Analyzing Sentences

LESSON 4 - Sentence patterns

Segment 3. Memorizing sentence patterns
Segment 2. Identifying sentence patterns
Segment 1. From pattern to sentence

LESSON 3 - Action verb predicates

Segment 4. Direct objects
Segment 3. Indirect objects
Segment 2. Intransitive verbs
Segment 1. Review of action verb predicates

LESSON 2 - Linking verb predicates

Segment 5. Linking verbs
Segment 4. Predicate nominative
Segment 3. Predicate adjective
Segment 2. Predicate adverb
Segment 1. Review of linking verb predicates

LESSON 1 - Glossary of terms

UNIT 8 - Expanding the sentence

LESSON 4 - Glossary and the sentence in review

Segment 2. Sets and subsets of a sentence
Segment 1. Glossary of grammatical terms

LESSON 3 - Verbals and verbal phrases

Segment 4. Gerunds
Segment 3. Participles
Segment 2. Infinitives
Segment 1. Verbal phrases
LESSON 2 - Conjoining

Segment 2. Conjoining
Segment 1. Punctuation marks as conjoiners

LESSON 1 - Subjoining

Segment 6. Subordinate clauses
Segment 5. Noun clauses
Segment 4. Adverb clauses
Segment 3. Adjective clauses
Segment 2. Special cases of subordinate clauses
Segment 1. Subjoining review

UNIT 5 - Verbs and Pronouns

LESSON 7 - Verb phrases - a review of Unit 13 on verbs

Segment 8. The complete verb phrase
Segment 7. Identifying main verbs
Segment 6. Memorizing the modals
Segment 5. Recognizing the modals
Segment 4. Recognizing forms of HAVE
Segment 3. Memorizing forms of BE
Segment 2. Using forms of BE
Segment 1. Verb phrases

LESSON 6 - Irregular verbs

Segments 3-8. Irregular verbs, lists A-F
Segment 2. Verbs: regular or irregular?
Segment 1. Verb forms

LESSON 5 - Verb forms

Segment 7. Five basic verb forms
Segment 6. Using present and past
Segment 5. Building verb phrases
Segment 4. Historical present tense
Segment 3. Subjunctives
Segment 2. Illogical shifts in tense
Segment 1. Using verbs correctly

LESSON 4 - Pronoun agreement

Segment 8. Pronouns
Segment 7. Referents
Segment 6. Agreement in number
Segment 5. Agreement with indefinite referent
Segment 4. Agreement with collective referent
Segment 3. Agreement with compound referent - AND
Segment 2. Agreement with compound referent - OR/NOR
Segment 1. Pronoun-referent agreement

LESSON 3 - Pronoun case

Segment 4. Case
Segment 3. Pronouns that change form to show case
Segment 2. Formal vs. informal usage
Segment 1. Pronoun case

LESSON 2 - Unclear pronoun reference

Segment 3. Identifying unclear pronoun reference
Segment 2. Correcting unclear pronoun reference
Segment 1. Unclear pronoun reference

LESSON 1 - Subject-verb agreement

Segment 12. Number and person
Segment 11. Agreement - main verbs
Segment 10. Agreement - Auxiliary verbs
Segment 9. Compound subjects - AND
Segment 8. Compound subjects - OR/NOR
Segment 7. Subjects separated from the verb
Segment 6. Agreement - linking verbs
Segment 5. Here/there sentences
Segment 4. Indefinite pronoun as subject
Segment 3. Collective noun as subject
Segment 2. Who, which, that as subjects
Segment 1. Subject-verb agreement

UNIT 4 - Capitalization and Punctuation

LESSON 6 - Sentence fragments, and run-on, fused and spliced sentences

Segment 3. Sentence fragments
Segment 2. Spliced, fused, and run-on sentences
Segment 1. Correcting fragments, and spliced, fused and run-on sentences

LESSON 5 - Using punctuation to join sentences

Segment 4. Punctuation marks that join sentences
Segment 3. Punctuating transition markers
Segment 2. Punctuation conjoiners
Segment 1. Joining sentences with punctuation

LESSON 4 - Capitalization

Segment 3. Three easy capitalization rules
Segment 2. Capitalizing proper names
Segment 1. Capitalization

LESSON 3 - The apostrophe - possessives, contractions, & plurals

Segment 4. Using apostrophes to show possession
Segment 3. Using apostrophes in contractions
Segment 2. Using apostrophes to form plurals
Segment 1. Using apostrophes

LESSON 2 - Punctuation that separates and sets off

Segment 6. Punctuating free and bound adjectives & appositives
Segment 5. Punctuating dates, addresses, titles and time
Segment 4. Punctuating publication titles
Segment 3. Punctuating transition markers
Segment 2. Punctuating direct quotations
Segment 1. Punctuation that separates and sets off

LESSON 1 - Punctuation and capitalization

Segment 1. Punctuation and capitalization - REVIEW

UNIT 3 - Sentence Faults

LESSON 8 - Active and passive voice

Segment 2. Active and passive voice
Segment 1. Changing passive to active voice

LESSON 7 - Concise Sentences

Segment 4. Wordiness
Segment 3. Too many AND's
Segment 2. Reduction
Segment 1. Concise sentences

LESSON 6 - Dangling and misplaced modifiers

Segment 4. Dangling modifiers
Segment 3. Misleading misplaced modifiers
Segment 2. Interrupting or misplaced modifiers
Segment 1. Correcting dangling and misplaced modifiers
LESSON 5 - IS WHEN and IS WHERE problems

Segment 2. Correct and incorrect use of IS WHEN or IS WHERE
Segment 1. Correcting IS WHEN/IS WHERE problems

LESSON 4 - Parallel structure

Segment 1. Parallel structure

LESSON 3 - Shifts in construction

Segment 5. Shifts in tense
Segment 4. Shifts in voice
Segment 3. Shifts in person
Segment 2. Shifts in number
Segment 1. Shifts in construction

LESSON 2 - Sentence punctuation problems (same material as Unit 4, Lesson 6)

LESSON 1 - Identifying sentence faults

Segment 1. Identifying sentence faults (Review of Unit 3)

UNIT 7 - Multilevel Sentences

LESSON 3 - Multilevel sentences

Segment 6. Free and bound detail
Segment 5. Base clause
Segment 4. Positions of free detail
Segment 3. Levels of detail in the sentence
Segment 2. Subordinate/Coordinate
Segment 1. Diagramming multilevel sentences

LESSON 2 - Addition - expanding a sentence by the use of a detail

Segment 3. Ways to add detail
Segment 2. Absolutes
Segment 1. Adding detail to create a multilevel sentence

LESSON 1 - Reduction - reducing two or more sentences into one

Segment 1. Reduction
UNIT 23 - Arithmetic Review

LESSON 2 - Natural Numbers

Segment 4. Factors and multiples
Segment 3. Exponents
Segment 2. Primes and composites
Segment 1. Prime factorization

LESSON 1 - Integers

Segment 7. Integers
Segment 6. Absolute value
Segment 5. Addition of integers
Segment 4. Subtraction of integers
Segment 3. Multiplication of integers
Segment 2. Divisibility of integers
Segment 1. Arithmetic expressions

UNIT 22 - Rational Numbers

LESSON 2 - Rational Numbers

Segment 9. Rational numbers
Segment 8. Fundamental principle of fractions
Segment 7. Simplest form
Segment 6. Multiplication
Segment 5. Division
Segment 4. Addition
Segment 3. Subtraction
Segment 2. Order of operations
Segment 1. Complex fractions

LESSON 1 - Law of exponents

Segment 11. Meaningful integral powers
Segment 10. Zero exponents
Segment 9. Positive integral exponents
Segment 8. Negative integral exponents
Segment 7. Integral exponents
Segment 6. Products of integral powers
Segment 5. Powers of powers
Segment 4. Products of integral powers with the same exponents
Segment 3. Quotients of integral powers
Segment 2. Law of integral exponents
Segment 1. Simplifying arithmetic expressions
UNIT 20 - Linear Equations

LESSON 4 - The Real Number System

Segment 10. The real number line
Segment 9. Addition and multiplication
Segment 8. Identity laws
Segment 7. Inverse laws
Segment 6. Subtraction
Segment 5. Division
Segment 4. Commutative laws
Segment 3. Associative laws
Segment 2. Distributive laws
Segment 1. The real number system

LESSON 3 - Linear Equations in One Variable, Part 1

Segment 5. Equations and solutions
Segment 4. Solutions for \( x + b = c \)
Segment 3. Solutions for \( ax = b \)
Segment 2. Solutions for \( ax + b = c \)
Segment 1. Applications

LESSON 2 - Linear Equations in One Variable, Part 2

Segment 5. More linear equations
Segment 4. Using the distributive law to solve equations
Segment 3. Classification of equations
Segment 2. Ratio equations in one unknown
Segment 1. Applications

LESSON 1 - Applications

Segment 4. Word problems that can be solved with the equation \( A \cdot B = C \)
Segment 3. Writing expressions
Segment 2. Writing equations
Segment 1. General word problems

UNIT 19 - Linear inequalities

LESSON 3 - Absolute Value Equations

Segment 3. Absolute Values
Segment 2. Solving \( |ax + b| = c \)
Segment 1. Solving \( |ax + b| = |cx + d| \)
LESSON 2 - Linear Inequalities

Segment 5. Order relation
Segment 4. Simple inequalities
Segment 3. Solving inequalities
Segment 2. Solving inequalities
Segment 1. Solving general inequalities

UNIT 17 - Polynomial Expressions

LESSON 5 - Polynomials: Addition and Subtraction

Segment 5. Monomials
Segment 4. Addition and subtraction of monomials
Segment 3. Polynomials
Segment 2. Addition of polynomials
Segment 1. Subtraction of polynomials

LESSON 4 - Polynomials: Multiplication

Segment 3. Multiplication: Monomials in one variable
Segment 2. Multiplication: Monomials and polynomials
Segment 1. Multiplication: Polynomials in one variable

LESSON 3 - Polynomials: Division and factoring

Segment 8. Monomials divided by a monomial
Segment 7. Polynomial divided by a monomial
Segment 6. Common binomial factor
Segment 5. Long division (Part 1)
Segment 4. Long division (Part 2)
Segment 3. Factoring polynomials (Part 1) $x^2 + bx + c$
Segment 2. Common binomial factor
Segment 1. Factoring polynomials (Part 2) $ax^2 + bx + c$

LESSON 2 - Quadratic Equations

Segment 3. Solutions to quadratic equations
Segment 2. Solving quadratic equations when the right hand side equals zero
Segment 1. Solving quadratic equations

LESSON 1 - Polynomials in several variables

Segment 7. Monomials in several variables
Segment 6. Monomials: Additions and subtractions
Segment 5. Monomials: Multiplication
Segment 4. Raising monomials to powers
Segment 3. Polynomials in several variables
Segment 2. Polynomials: Addition and subtraction
Segment 1. Polynomials: Multiplication
APPENDIX B

Questionnaire
You are asked to answer the following questions about your background and your reasons for taking this course. The information will be used in helping you and in evaluating the appropriateness and effectiveness of computer delivered instruction. Your individual responses to these questions will be held in confidence by your instructors and will not affect your final grade in this course.

1. Why are you taking this course? (Please check no more than two reasons).
   a. ___ I was advised to take this course on the basis of a placement test.
   b. ___ I want to strengthen my skills in this subject.
   c. ___ This course is required for admission to my program/another college.
   d. ___ A counselor or advisor recommended the course.
   e. ___ I never studied this subject before.
   f. ___ Other. Please explain: ____________________________

2. What are your academic goals? (You may check more than one reason.)
   a. ___ I'm taking courses useful and/or related to my job.
   b. ___ I plan to complete a two-year degree.
   c. ___ I plan to complete a four-year degree.
   d. ___ Other. Please explain: ____________________________

3. What is the total number of credits you are taking this quarter (including this course)?
   a. ___ 5 or less
   b. ___ 6 to 11
   c. ___ 12 or more
4. Are you employed?  

_____ Yes  _____ No

If yes, how many hours per week:  
a. _____ less than 20  
b. _____ 20  
c. _____ 21-40  
d. _____ over 40

5. Do you have any experience with computers or computer assisted instruction?  

_____ Yes  _____ No

If yes, how much?  
a. _____ very little  
b. _____ quite a bit

6. How old are you?

a. _____ Under 21  
b. _____ 21-30  
c. _____ 31-40  
d. _____ Over 40

7. Sex:  

_____ Female  
_____ Male

8. Race:

a. _____ Caucasian  
b. _____ Black  
d. _____ Oriental  
e. _____ Other
APPENDIX C

Sample of Log Tape Output
APPENDIX D

Raw Data on the Number of Requests for RULES, EXAMPLES and PRACTICES
<table>
<thead>
<tr>
<th>Math Completers</th>
<th>STUDENT</th>
<th># RULES</th>
<th># EXAMPLES</th>
<th># PRACTICES</th>
</tr>
</thead>
<tbody>
<tr>
<td>MC 1</td>
<td>21</td>
<td>198</td>
<td>64</td>
<td></td>
</tr>
<tr>
<td>MC 2</td>
<td>10</td>
<td>50</td>
<td>88</td>
<td></td>
</tr>
<tr>
<td>MC 3</td>
<td>10</td>
<td>0</td>
<td>93</td>
<td></td>
</tr>
<tr>
<td>MC 4</td>
<td>17</td>
<td>138</td>
<td>82</td>
<td></td>
</tr>
<tr>
<td>MC 5</td>
<td>9</td>
<td>3</td>
<td>72</td>
<td></td>
</tr>
<tr>
<td>MC 6</td>
<td>15</td>
<td>4</td>
<td>166</td>
<td></td>
</tr>
<tr>
<td>MC 7</td>
<td>25</td>
<td>53</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>MC 8</td>
<td>11</td>
<td>14</td>
<td>166</td>
<td></td>
</tr>
<tr>
<td>MC 9</td>
<td>11</td>
<td>98</td>
<td>78</td>
<td></td>
</tr>
<tr>
<td>MC 10</td>
<td>50</td>
<td>96</td>
<td>354</td>
<td></td>
</tr>
<tr>
<td>MC 11</td>
<td>45</td>
<td>48</td>
<td>184</td>
<td></td>
</tr>
<tr>
<td>MC 12</td>
<td>2</td>
<td>0</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>MC 13</td>
<td>13</td>
<td>92</td>
<td>98</td>
<td></td>
</tr>
<tr>
<td>MC 14</td>
<td>13</td>
<td>10</td>
<td>124</td>
<td></td>
</tr>
<tr>
<td>MC 15</td>
<td>10</td>
<td>1</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>MC 16</td>
<td>23</td>
<td>8</td>
<td>183</td>
<td></td>
</tr>
<tr>
<td>MC 17</td>
<td>54</td>
<td>7</td>
<td>168</td>
<td></td>
</tr>
<tr>
<td>MC 18</td>
<td>13</td>
<td>52</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>MC 19</td>
<td>7</td>
<td>43</td>
<td>72</td>
<td></td>
</tr>
<tr>
<td>MC 20</td>
<td>27</td>
<td>0</td>
<td>142</td>
<td></td>
</tr>
<tr>
<td>MC 21</td>
<td>20</td>
<td>56</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>MC 22</td>
<td>24</td>
<td>2</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>MC 23</td>
<td>24</td>
<td>7</td>
<td>169</td>
<td></td>
</tr>
<tr>
<td>MC 24</td>
<td>5</td>
<td>0</td>
<td>108</td>
<td></td>
</tr>
<tr>
<td>MC 25</td>
<td>11</td>
<td>4</td>
<td>67</td>
<td></td>
</tr>
<tr>
<td>MC 26</td>
<td>13</td>
<td>20</td>
<td>183</td>
<td></td>
</tr>
<tr>
<td>MC 27</td>
<td>21</td>
<td>17</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>MC 28</td>
<td>9</td>
<td>36</td>
<td>59</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Math Non-Completers</th>
<th># RULES</th>
<th># EXAMPLES</th>
<th># PRACTICES</th>
</tr>
</thead>
<tbody>
<tr>
<td>MNC 1</td>
<td>23</td>
<td>80</td>
<td>108</td>
</tr>
<tr>
<td>MNC 2</td>
<td>11</td>
<td>119</td>
<td>68</td>
</tr>
<tr>
<td>MNC 3</td>
<td>31</td>
<td>68</td>
<td>87</td>
</tr>
<tr>
<td>MNC 4</td>
<td>17</td>
<td>57</td>
<td>179</td>
</tr>
<tr>
<td>MNC 5</td>
<td>42</td>
<td>54</td>
<td>171</td>
</tr>
<tr>
<td>MNC 6</td>
<td>18</td>
<td>73</td>
<td>230</td>
</tr>
<tr>
<td>MNC 7</td>
<td>39</td>
<td>60</td>
<td>187</td>
</tr>
<tr>
<td>MNC 8</td>
<td>57</td>
<td>2</td>
<td>191</td>
</tr>
<tr>
<td>MNC 9</td>
<td>8</td>
<td>52</td>
<td>174</td>
</tr>
<tr>
<td>MNC 10</td>
<td>14</td>
<td>117</td>
<td>189</td>
</tr>
<tr>
<td>MNC 11</td>
<td>9</td>
<td>15</td>
<td>120</td>
</tr>
<tr>
<td>MNC 12</td>
<td>32</td>
<td>57</td>
<td>189</td>
</tr>
<tr>
<td>MNC 13</td>
<td>11</td>
<td>1</td>
<td>111</td>
</tr>
<tr>
<td>MNC 14</td>
<td>22</td>
<td>44</td>
<td>218</td>
</tr>
<tr>
<td>MNC</td>
<td>6</td>
<td>11</td>
<td>102</td>
</tr>
<tr>
<td>------</td>
<td>-----</td>
<td>-----</td>
<td>------</td>
</tr>
<tr>
<td>MNC</td>
<td>8</td>
<td>3</td>
<td>81</td>
</tr>
<tr>
<td>MNC</td>
<td>14</td>
<td>2</td>
<td>99</td>
</tr>
<tr>
<td>MNC</td>
<td>28</td>
<td>62</td>
<td>111</td>
</tr>
<tr>
<td>MNC</td>
<td>11</td>
<td>10</td>
<td>106</td>
</tr>
<tr>
<td>MNC</td>
<td>17</td>
<td>1</td>
<td>82</td>
</tr>
<tr>
<td>MNC</td>
<td>14</td>
<td>31</td>
<td>121</td>
</tr>
<tr>
<td>MNC</td>
<td>9</td>
<td>28</td>
<td>106</td>
</tr>
<tr>
<td>MNC</td>
<td>13</td>
<td>2</td>
<td>206</td>
</tr>
<tr>
<td>MNC</td>
<td>7</td>
<td>22</td>
<td>110</td>
</tr>
<tr>
<td>MNC</td>
<td>41</td>
<td>82</td>
<td>373</td>
</tr>
<tr>
<td>MNC</td>
<td>32</td>
<td>19</td>
<td>100</td>
</tr>
<tr>
<td>MNC</td>
<td>17</td>
<td>0</td>
<td>117</td>
</tr>
<tr>
<td>MNC</td>
<td>6</td>
<td>1</td>
<td>143</td>
</tr>
<tr>
<td>MNC</td>
<td>39</td>
<td>11</td>
<td>268</td>
</tr>
<tr>
<td>MNC</td>
<td>26</td>
<td>4</td>
<td>155</td>
</tr>
<tr>
<td>MNC</td>
<td>4</td>
<td>1</td>
<td>214</td>
</tr>
<tr>
<td>MNC</td>
<td>29</td>
<td>6</td>
<td>264</td>
</tr>
<tr>
<td>MNC</td>
<td>44</td>
<td>71</td>
<td>154</td>
</tr>
<tr>
<td>MNC</td>
<td>12</td>
<td>56</td>
<td>204</td>
</tr>
<tr>
<td>MNC</td>
<td>8</td>
<td>62</td>
<td>234</td>
</tr>
<tr>
<td>MNC</td>
<td>23</td>
<td>56</td>
<td>113</td>
</tr>
<tr>
<td>MNC</td>
<td>37</td>
<td>50</td>
<td>152</td>
</tr>
<tr>
<td>MNC</td>
<td>9</td>
<td>2</td>
<td>99</td>
</tr>
<tr>
<td>MNC</td>
<td>14</td>
<td>2</td>
<td>104</td>
</tr>
<tr>
<td>MNC</td>
<td>12</td>
<td>151</td>
<td>79</td>
</tr>
<tr>
<td>MNC</td>
<td>22</td>
<td>103</td>
<td>137</td>
</tr>
<tr>
<td>MNC</td>
<td>10</td>
<td>0</td>
<td>91</td>
</tr>
<tr>
<td>MNC</td>
<td>10</td>
<td>21</td>
<td>128</td>
</tr>
<tr>
<td>MNC</td>
<td>39</td>
<td>100</td>
<td>85</td>
</tr>
<tr>
<td>MNC</td>
<td>4</td>
<td>8</td>
<td>380</td>
</tr>
<tr>
<td>MNC</td>
<td>3</td>
<td>13</td>
<td>167</td>
</tr>
</tbody>
</table>

**English Completers**

<table>
<thead>
<tr>
<th>EC</th>
<th>9</th>
<th>74</th>
<th>93</th>
</tr>
</thead>
<tbody>
<tr>
<td>EC</td>
<td>15</td>
<td>30</td>
<td>27</td>
</tr>
<tr>
<td>EC</td>
<td>8</td>
<td>0</td>
<td>34</td>
</tr>
<tr>
<td>EC</td>
<td>1</td>
<td>0</td>
<td>45</td>
</tr>
<tr>
<td>EC</td>
<td>6</td>
<td>0</td>
<td>54</td>
</tr>
<tr>
<td>EC</td>
<td>18</td>
<td>32</td>
<td>23</td>
</tr>
<tr>
<td>EC</td>
<td>9</td>
<td>112</td>
<td>26</td>
</tr>
<tr>
<td>EC</td>
<td>4</td>
<td>17</td>
<td>43</td>
</tr>
<tr>
<td>EC</td>
<td>4</td>
<td>80</td>
<td>51</td>
</tr>
<tr>
<td>EC</td>
<td>12</td>
<td>0</td>
<td>39</td>
</tr>
<tr>
<td>EC</td>
<td>17</td>
<td>4</td>
<td>35</td>
</tr>
<tr>
<td>EC</td>
<td>12</td>
<td>2</td>
<td>34</td>
</tr>
<tr>
<td>EC 13</td>
<td>8</td>
<td>6</td>
<td>25</td>
</tr>
<tr>
<td>EC 14</td>
<td>4</td>
<td>0</td>
<td>33</td>
</tr>
<tr>
<td>EC 15</td>
<td>4</td>
<td>102</td>
<td>25</td>
</tr>
<tr>
<td>EC 16</td>
<td>4</td>
<td>80</td>
<td>26</td>
</tr>
<tr>
<td>EC 17</td>
<td>3</td>
<td>104</td>
<td>18</td>
</tr>
<tr>
<td>EC 18</td>
<td>11</td>
<td>38</td>
<td>26</td>
</tr>
<tr>
<td>EC 19</td>
<td>2</td>
<td>15</td>
<td>24</td>
</tr>
<tr>
<td>EC 20</td>
<td>1</td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>EC 21</td>
<td>2</td>
<td>28</td>
<td>5</td>
</tr>
<tr>
<td>EC 22</td>
<td>19</td>
<td>114</td>
<td>67</td>
</tr>
<tr>
<td>EC 23</td>
<td>7</td>
<td>30</td>
<td>34</td>
</tr>
<tr>
<td>EC 24</td>
<td>18</td>
<td>169</td>
<td>17</td>
</tr>
<tr>
<td>EC 25</td>
<td>9</td>
<td>0</td>
<td>35</td>
</tr>
<tr>
<td>EC 26</td>
<td>8</td>
<td>39</td>
<td>51</td>
</tr>
<tr>
<td>EC 27</td>
<td>0</td>
<td>0</td>
<td>122</td>
</tr>
<tr>
<td>EC 28</td>
<td>5</td>
<td>37</td>
<td>43</td>
</tr>
<tr>
<td>EC 29</td>
<td>4</td>
<td>0</td>
<td>26</td>
</tr>
<tr>
<td>EC 30</td>
<td>2</td>
<td>0</td>
<td>40</td>
</tr>
<tr>
<td>EC 31</td>
<td>5</td>
<td>34</td>
<td>68</td>
</tr>
<tr>
<td>EC 32</td>
<td>7</td>
<td>9</td>
<td>89</td>
</tr>
<tr>
<td>EC 33</td>
<td>7</td>
<td>130</td>
<td>43</td>
</tr>
<tr>
<td>EC 34</td>
<td>1</td>
<td>22</td>
<td>34</td>
</tr>
<tr>
<td>EC 35</td>
<td>10</td>
<td>145</td>
<td>37</td>
</tr>
<tr>
<td>EC 36</td>
<td>18</td>
<td>70</td>
<td>56</td>
</tr>
<tr>
<td>EC 37</td>
<td>12</td>
<td>0</td>
<td>47</td>
</tr>
<tr>
<td>EC 38</td>
<td>9</td>
<td>3</td>
<td>43</td>
</tr>
<tr>
<td>EC 39</td>
<td>4</td>
<td>0</td>
<td>32</td>
</tr>
</tbody>
</table>

**English Non-Completers**

| ENC 1 | 24 | 25 | 32 |
| ENC 2 | 35 | 173| 62 |
| ENC 3 | 9  | 63 | 29 |
| ENC 4 | 8  | 15 | 18 |
| ENC 5 | 2  | 1  | 29 |
| ENC 6 | 1  | 9  | 59 |
| ENC 7 | 4  | 43 | 29 |
| ENC 8 | 16 | 1  | 60 |
| ENC 9 | 13 | 57 | 50 |
| ENC 10| 9  | 0  | 56 |
| ENC 11| 5  | 39 | 37 |
| ENC 12| 11 | 50 | 31 |
| ENC 13| 7  | 219| 22 |
| ENC 14| 16 | 134| 51 |
| ENC 15| 8  | 110| 30 |
| ENC 16| 3  | 18 | 34 |
| ENC 17 | 6 | 1 | 52 |
| ENC 18 | 21 | 6 | 52 |
| ENC 19 | 33 | 3 | 93 |
| ENC 20 | 7 | 107 | 70 |
| ENC 21 | 9 | 27 | 30 |
| ENC 22 | 7 | 127 | 66 |
| ENC 23 | 4 | 10 | 23 |
| ENC 24 | 5 | 10 | 45 |
| ENC 25 | 8 | 68 | 25 |
| ENC 26 | 4 | 109 | 15 |
| ENC 27 | 6 | 0 | 38 |
| ENC 28 | 4 | 77 | 86 |
| ENC 29 | 7 | 108 | 49 |
| ENC 30 | 16 | 92 | 60 |
| ENC 31 | 5 | 67 | 30 |
| ENC 32 | 4 | 59 | 21 |
| ENC 33 | 4 | 22 | 24 |
| ENC 34 | 4 | 111 | 38 |
| ENC 35 | 4 | 45 | 21 |
APPENDIX E

Histogram Graphs of the Number of Keypresses Accessed by Students (Figures 1 through 6)
Figure 1

Number of RULES Accessed by English Students
Figure 2

Number of RULES Accessed by Math Students
Figure 3

Number of EXAMPLES Accessed by English Students
Figure 4

Number of EXAMPLES Accessed by Math Students
Figure 5

Number of PRACTICES Accessed by English Students
Figure 6

Number of PRACTICES Accessed by Math Students
The two page vita has been removed from the scanned document. Page 1 of 2
The two page vita has been removed from the scanned document. Page 2 of 2
AN EXPLORATORY STUDY OF THE RELATIONSHIP
BETWEEN LEARNER CONTROL PATTERNS AND COURSE COMPLETION
IN COMPUTER ASSISTED INSTRUCTION
by
Monica Flynn Sasscer

ABSTRACT

The study was designed to discover how community college students used the available learner control features of the TICCIT computer assisted instruction system, and to determine whether those students who completed all the course requirements of two TICCIT delivered courses within an eleven week academic term used different strategies to work through the instructional materials than those students who did not complete the courses. One hundred and forty eight students who enrolled in a developmental level Algebra I course and freshman level English grammar course participated in the study. Sixty-seven students met the criteria for course completion; 81 were non-completers. A log tape record was kept of the keypresses made by the subjects as they progressed through the topics of the lesson selected for the study. The sequences of keypresses resulted in the classification of nine different strategy patterns which were analyzed by means of chi-square contingency tables.
The findings were that community college students made use of the learner control options presented to them by TICCIT to develop learning strategies. While "successful patterns" were identified in the statistical analyses, these were actually used by an equal proportion of completing and non-completing students and could not be considered as paths to success for future TICCIT students. No evidence was found that students used a pattern consistently throughout a lesson. There was significant evidence that pattern choice was influenced by the subject matter studied and, specifically, by the topic of the segment. Students in the English course used more patterns which included EXAMPLES, whereas the students in the math course favored the RULE/PRACTICE combination. With regard to timely completion, however, the RULE/PRACTICE pattern was a successful option for both math and English course completers. The use of PRACTICE without reference to RULES or EXAMPLES was detrimental to the timely completion of math coursework, but beneficial in the case of the English course.