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CAI in pharmacology: student academic performance and instructional interactions

University — Université

University of Alberta

Degree for which thesis was presented — Grade pour lequel cette thèse fut présentée

Ph. D.

Year this degree conferred — Année d'obtention de ce grade

1981

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THE UNIVERSITY OF ALBERTA

CAI in Pharmacology: Student Academic Performance and Instructional Interactions

by

© Louis Anthony Pagliaro

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF Doctor of Philosophy

IN

Educational Psychology

Faculty of Education

EDMONTON, ALBERTA

Fall 1981

THE UNIVERSITY OF ALBERTA

RELEASE FORM

NAME OF AUTHOR: Louis Anthony Pagliaro

TITLE OF THESIS: CAI in Pharmacology: Student Academic Performance and Instructional Interactions

DEGREE FOR WHICH THESIS WAS PRESENTED: Doctor of Philosophy

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled CAI in Pharmacology: Student Academic Performance and Instructional Interactions submitted by Louis Anthony Pagliaro in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Educational Psychology.

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DEDICATION

This thesis is dedicated to my loving wife Ann without whose encouragement, help and support this research and this thesis would not have been done.

ABSTRACT

This research project was designed to measure the effect of computer aided instruction (CAI) in the content area of pharmacology upon student academic performance and to document the occurrence of significant correlations and instructional interactions. The subjects for this study were pharmacy students enrolled in an undergraduate pharmacology course at the University of Alberta during the 1979-1981 academic years. The subjects were randomly divided into three different treatment groups (CAI alone, CAI concurrent with lecture, lecture alone) and proceeded through a series of CAI programs in a variety of topics in pharmacology. Data was collected on a variety of demographic and psychological variables and on academic performance in a selected pharmacology topic. This data, analyzed by means of correlation and analysis of variance techniques, provided an objective analysis of the effect of CAI on academic performance in pharmacology and attitude toward CAI. In addition, specific demographic and psychological variables obtained from student records and the California Psychological Inventory were correlated with CAI usage and attitude toward CAI. Variables which correlated significantly with academic performance when using CAI in pharmacology were identified. Several instructional interactions were observed and discussed.

ACKNOWLEDGEMENTS

I would like to thank the following individuals for their time and assistance during the conduction of this research and in the preparation of this thesis:

Stephen M. Hunka, my thesis supervisor, for his help and guidance and for providing me with a better understanding of and appreciation for the process of analytical research.

Ann M. Pagliaro, my wife, for her help in typing, editing and proofreading this thesis and for her encouragement and support.

Dominant Chung, my technician, for his help in retrieving copies of the references for this thesis and for his assistance in putting this thesis into textform.

Garry R. Van Petten and John A. Bachynsky, Deans of the Faculty of Pharmacy and Pharmaceutical Sciences, for their permission and assistance in conducting this research.

Justin Elbrink, Eugene W. Romaniuk, John E. Seger, Leonard L. Stewin, Michael Szabo, and Marvin L. Westrom, the individual members of my candidacy and supervisory committees for their constructive questions, comments and suggestions during this entire process.

This study was conducted in coordination with a three year research project, "Development of Computer-Assisted Instruction in Pharmacology", submitted by Charles Heath, director, Louis A. Pagliaro, David A. Cook, Charles M.

Bidwell, (Rhóderic J. Reiffenstein, acting director), and supported by Alberta Advanced Education and Manpower grant #IPF 670-1022.

Computer funds for this research project were supplied by the Department of Educational Psychology, Faculty of Education, Department of Pharmacology, Faculty of Medicine, and the Faculty of Pharmacy and Pharmaceutical Sciences.

Table of Contents

List of Tables

List of Figures

CHAPTER I

INTRODUCTION

Computer aided instruction (CAI) - problem or panacea? This question has plagued educators for the past two decades, yet the answer has continued to avoid elucidation.

It is often observed that individuals either fear or worship that which they do not understand. Educators are no different in this regard and their fear of or worship for CAI has often been clearly visible in the hundreds of articles which have been devoted to the initially posed question. Some educators see CAI as a totally dehumanizing force which has no place in the classroom, while other educators bestow upon CAI the personification of saviour of the educational system (Bork, 1977; Bozeman, 1979; Brittin, 1972; Hallworth & Brebner, 1980; Norris, 1978; Seidel, et al, 1974; Suppes, 1966). Caught in this schizophrenic dilemma, CAI would almost certainly have died an ignominious death if its fate had relied solely upon educators. However, rapid technological changes and advances in the last two decades have sustained CAI's existence and have again catapulted this technology into the limelight of the educational arena in the 1980's.

Deja vu? It would certainly appear so, as this cycle occurred at the beginning of the 1960's, repeated itself first at the beginning of the 1970's and again at the beginning of the 1980's, and seems likely to repeat itself again at the beginning of the 1990's unless it is somehow broken. The dichotomous stereotype of "CAI as Archfiend" or "CAI as Archangel" must now be replaced with a realistic view of CAI. Neither friend nor foe, CAI is a highly sophisticated, yet essentially neutral technology which has the potential to interact within the educational milieu in either a positive or a negative manner. The key word here is "interact" and it is believed that in order to be properly and impartially represented, CAI must be viewed in the context of instructional interactions (II) [1].

Before an attempt is made to integrate the notions of "CAI" and "instructional interactions" a brief review of the literature of instructional interactions will be presented.

The concept that individuals differ in learning styles and that each "learns" in highly specific and individual ways is the basis for the occurrence of instructional interactions. This has probably been recognized for as long as there have been teachers and students, as is evidenced in the following quotations:

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[1] Instructional interactions (II) (Pagliaro, 1979) is used here as a generic term for interactions which occur in actual and simulated instructional settings and which account to a great extent for individual preferential differences in learning. It is a general form of what has been referred to on a somewhat more limited basis as "Aptitude Treatment Interactions (ATI)" (Cronbach & Snow, 1977), "Attribute Treatment Interactions (ATI)" (Tobias & Abramson, 1971), "Trait Treatment Interactions (TTI)" (Berliner & Cahen, 1973), and "Achievement Treatment Interactions (ATI)" (Tobias, 1976).

> Each particular activity can best be performed [learned] by methods which to an important degree are peculiar to that activity . . . to a degree varying with the individual (Woodrow, 1946, p. 157).

> One thing we can all be quite certain of: Wherever in the vast realm of human learning we wish to look for individual differences, we surely will find them (Jensen, 1967, p. 117).

> No single instructional process provides optimal learning for all students (Bracht, 1970, p. 627).

The concept that learning could be related to specific variables has also been known for some time:

> Even the group factors involved in learning are not unique to learning, but consist of abilities which can be measured by tests given but once (Woodrow, 1946, p. 149).

> But we do find that a person learns more easily from one method than another, that this best method differs from person to person, and that such between-treatments differences are correlated with tests of ability and personality (Cronbach, 1957, p. 681).

It was in an address to the American Psychological Association in 1957 that Cronbach first formally introduced the concept of instructional interactions[2] (Cronbach, 1957). Lubin (1961) quantified and named three types of interactions which occur: none, i.e. the interaction lines, which relate academic achievement (learning) to some other independent variable, are parallel; "ordinal, where the rank order of a treatment is constant but the quantitative effect may vary", i.e. the interaction lines are nonparallel but do not intersect; and "disordinal, where the rank order of the treatment changes with the value of another classifying variable", i.e. the interaction lines intersect. The concept of disordinal interactions was further refined by adding a dimension of statistical significance to the definition (Bracht & Glass, 1968).

In spite of these developments, Cronbach noted ten years after his address that educational adaptation to individual differences had not yet integrated the concept of instructional interactions but still followed four "traditional" models: (1) adaptation within a predetermined program, i.e. every child should go as far in school as his or her abilities warrant; (2) adaptation by matching goals to the individual, i.e. "algebra" taught to college preparatory students and "general mathematics" for others; (3) adaptation by erasing (ignoring) individual differences, i.e. teaching the same unaltered course with the same

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[2] Cronbach (1957) used the term "aptitude - treatment interaction" in his address, however, for the sake of clarity and consistency this thesis uses the more comprehensive term "instructional interaction" which was introduced by Pagliaro (1979) (See Figure 6).

demands for all students; and (4) adaptation by altering course design, i.e. telling one student to "look it up" in order to promote independence and helping another student "find it" in order to minimize possible frustration (Cronbach, 1967). It is evident that none of these "adaptive" models satisfactorily use instructional interactions as a basis for adaptation of instruction to individual differences. Even the fourth model, which used the concept of instructional interactions, falls far short because, as noted by Cronbach, it is an informal procedure that requires the teacher to act as a clinician (Cronbach, 1967).

DiVesta, several years later, echoed the same frustration with the lack of rational adaptation to individual differences: "A major source of our dissatisfaction has roots in a philosophy of education based on objectives which imply that the child must adapt to education" (DiVesta, 1974, p. 357).

DiVesta further optimistically stated that: "Improvements in instruction during the 1970's will come from adapting education to the child" (DiVesta, 1974, p. 358). However, as noted by Tobias this has not come to pass:

> There are few systematic attempts to adapt method of instruction to student characteristics; existing adaptations generally consist of varying instructional rate to student needs rather than instructional method (Tobias, 1976, p. 61).

The question must now be asked, "Why have instructional interactions not made a major impact on educational practice?" The complete answer is complex and multifarious, but a preliminary answer may be found in a statement from Cronbach and Snow's (1977) comprehensive text on instructional interactions: "No aptitude X [by] treatment interactions are so well confirmed that they can be used directly as guides to instruction" (p.492).

This answer, however, gives rise to other more basic questions. "Do instructional interactions indeed exist? Why have they not been better documented and confirmed?" As the previous discussion implies, the answer lies not in inherent errors in the concept or existence of instructional interactions but in the inability of researchers to properly study and interpret instructional interactions. As Salomon (1972) has noted, "ATI [aptitude treatment interaction] research still seems to work on the basis of trial and error" (p. 327). Several other researchers have noted this problem and have suggested the need for a theory of instruction which would accommodate the concept of instructional interactions (Berliner & Cahen, 1973; Cronbach, 1967; DiVesta, 1974; Snow, 1977).

The Mega Interactive Model of Instruction [3] (Pagliaro, 1979) has been designed to help fill this need for a comprehensive theory of instruction by providing a

----

[3] A more complete description and discussion of this model is found in the "Materials" section of Chapter IV.

conceptual framework in which instructional interactions can be studied and interpreted. This framework provides a model for investigating and interpreting the results of instructional interaction studies and may thus facilitate transfer of this information to the instructional setting.

The research project discussed in this thesis is one of the first to provide an in-depth examination of CAI in the context of instructional interactions. As such, it hopes to demonstrate that the answer to the question, "Computer aided instruction--problem or panacea?", is found in the context of CAI use. Thus, it would be expected that CAI will be effective, perhaps optimal, for some teachers, learners, and content, but not for others. This idea will be developed in this thesis by an examination of the effect of CAI in the content area of pharmacology. The specific questions to be answered in this regard are found in the first part of Chapter III.

The presentation of the remainder of this thesis is divided into six additional chapters. Chapter II provides an overview of the development of CAI from a historical perspective. A statement of the specific problems addressed in this study and a review of related CAI literature is presented in Chapter III. A comprehensive description of the procedures and methodology used in this study is detailed in Chapter IV. Chapter V presents the results of the study. Discussion of the results is found in Chapter VI. Final concluding remarks and recommendations for future research are addressed in Chapter VII. Appendices and bibliography follow the last chapter.

CHAPTER II

DEVELOPMENT OF CAI

CAI: 1926 - 1981

Early Teaching Machines

The history of computer aided instruction (CAI) is inextricably mixed with and related to the histories of both education and computers. Because of this and the fact that these two histories developed independently and at different rates, the history of CAI does not easily lend itself to a straight forward didactic discourse. However, a brief chronological overview, which focuses upon significant individuals and programs in this area, will be presented.

This overview begins in the mid 1920's with Pressey. As the title of his first article "A Simple Apparatus Which Gives Tests and Scores - and Teaches" (Pressey, 1926) suggests, Pressey was interested in designing mechanical devices which could automatically provide drill and practice items to students in order to:

> lift from her [the teacher's] shoulders as much as possible of this burden [drill and "information-fixing"] and make her freer for those inspirational and thought-stimulating activities which are, presumably, the real function of the teacher (Pressey, 1926, p. 373).

Pressey did not only have an interest in saving time for the teacher, but was also keenly interested in delivering "individualized" instruction as can be noted in the instructional paradigm he "programmed" into his machine:

> . . . an apparatus for teaching drill material which (a) should keep each question or problem before the learner until he finds the correct answer, (b) should inform him at once regarding the correctness of each response he makes, (c) should continue to put the subject through the series of questions until the entire lesson has been learned, but (d) should eliminate each question from consideration as the correct answer for it has been mastered (Pressey, 1927, p. 552).

It should be noted that some may object to even including Pressey's teaching machines in the history of CAI because these machines were mechanical in nature and computers, by definition, are electronic. However, the early contribution Pressey made by integrating the notions of machines and learning, as well as his introduction of a mastery learning paradigm into his "teaching machines", are the major reasons for beginning the overview of the history of CAI with Pressey.

Many individuals experimented with several types of teaching machines over the next two decades, but it was not until the 1950's that the next significant contribution to the history of CAI occurred. Skinner's experimental work in the area of stimulus-response and reinforcement was the next major development which further contributed to an understanding of the usefulness and the application of teaching machines. In a paper presented at a psychology conference in 1954 Skinner noted that the relationship and importance of reinforcement to learning had been well documented, yet the classroom environment was relatively devoid of its use. He further noted that the teacher, because of class sizes and the styles of teaching and grading being used, was not likely to succeed in properly implementing increased reinforcement (Skinner, 1954). Skinner then stated that:

> If the teacher is to take advantage of recent advances in the study of learning, she must have the help of mechanical devices.
>
> The technical problem of providing the necessary instrumental aid is not particularly difficult. There are many ways in which the necessary contingencies may be arranged, either mechanically or electrically. An inexpensive device which solves most of the principal problems has already been constructed . . . The important features of the device are these: Reinforcement for the right answer is immediate. The mere manipulation of the device will probably be reinforcing enough to keep the average pupil at work for a suitable period each day, provided traces of earlier aversive control can be wiped out. A teacher may supervise an entire class at work on such devices at the same time, yet each child may progress at his own rate, completing

> as many problems as possible within the class period. If forced to be a[illegible]om school, he may return to pick up where he left off. The gifted child will advance rapidly, but can be kept from getting too far ahead either by being excused from arithmetic for a time or by being given special sets of problems which take him into some of the interesting bypaths of mathematics.
>
> The device makes it possible to present carefully designed material in which one problem can depend upon the answer to the preceding and where, therefore, the most progress to an eventually complex repertoire can be made (Skinner, 1954, p. 95).

In conclusion, Skinner advocated that mechanized instruction should be integrated into all schools, not as a replacement for, but as an adjunct to the teacher.

Research in the "Teaching Machine Project" at the IBM research center during the late nineteen-fifties led to the development and application of an IBM 650, a high-speed digital computer, as a teaching machine. A typewriter was interfaced to the IBM 650 and this configuration was known as the "IBM 650 Inquiry Station".

> The IBM 650 Inquiry Station is a typewriter and a console which is capable of transmitting typed information to the computer and receiving information from the computer. The student sits at

the Inquiry Station. The program of instructions in the computer presents the problem to the student by way of the typewriter. The student, in turn, types his answer, which is transmitted to the computer for checking (Rath, et al, 1959, p. 126).

The subject matter taught by this early CAI system was binary arithmetic. It should be noted that this system required "running one S [student] in real time with the computer", however, the authors noted that the computer spent most of its time waiting for the student to respond and could probably be multiplexed in order to "present and score problems for several students who sat at different inquiry stations" (Rath, et al, 1959, p. 129).

Needless to say, other educational technologies had also been invented and developed during the twenties, thirties, fourties and fifties. In addition, diverse and physically different types of "teaching machines" had been developed, but as different from one another as they may have appeared physically, the teaching machines maintained several unifying and identifying characteristics.

In the review, "Teaching Machines and Self-Instructional Materials", Lumsdaine (1959) identified three major properties which distinguished the teaching machines from films, television, and other audio-visual media:

> First, continuous active student response is required, providing explicit practice and testing of each step of what is to be learned.
>
> Second, a basis is provided for informing the student with minimal delay whether each response he makes is correct, leading him directly or indirectly to correction of his errors.
>
> Third, the student proceeds on an individual basis at his own rate--faster students romping through an instructional sequence very rapidly, slower students being tutored as slowly as necessary, with indefinite patience to meet their special needs. (p. 164)

Thus by the beginning of the 1960's, the knowledge, understanding and potential application of CAI had been fairly well identified and subjected to preliminary testing by both engineers and psychologists. However, in spite of the progress made by engineers and psychologists in designing teaching machines and analyzing their effect on learning, Pressey's "hope" and Skinner's "encouragement" were not generally heeded by educators, and by 1960 "teaching machines" still had not found a niche in the classroom.

Dick (1965) noted that "computer instruction offers an almost unlimited area of research into individual differences" (p. 44). He further, perhaps optimistically, stated that "Skinner has said that cultural inertia blocked the use of Pressey's teaching machines in the twenties. Our culture is apparently ready for Skinner's machines in the sixties" (p. 53).

Dedicated CAI Systems in the 1960's

CAI was attempted in a variety of subject matter on virtually every type of computer in use in the 1950's and 1960's (for example: Lickider, 1962; Morrison & Adams, 1968; Schurdak, 1967; Stolurow, 1967). However, two major systems in particular, the IBM 1500 and PLATO, were developed specifically for CAI in the early 1960's and contributed significantly to its use.

Early collaborative work between the Institute for Mathematical Studies in the Social Sciences (IMSSS) at Stanford University, under the direction of Richard Atkinson and Patrick Suppes, and the International Business Machine (IBM) Corporation led to the development of the IBM-1500 Instructional System. The system consisted of: a central process computer; a disc storage unit; a magnetic tape unit; a card read-punch unit; a printer; an audio control unit; two proctor stations; and sixteen student stations. Each student station consisted of: a cathode ray tube display screen; a picture projector with rear image screen; a modified typewriter keyboard with certain added function keys; a light pen; and an audio system. The proctor stations were similar to the student stations except that they did not contain the audio or film projector units (Atkinson, 1968).

Initially, the IBM 1500 Instructional System was used to teach reading (AtKinson & Hansen, 1966) and mathematics (Suppes, 1966) to primary school students. Other programs and courses, however, rapidly developed including college and university level courses, i.e. Russian (Suppes & Morningstar, 1969).

At about the same time that the IBM 1500 Instructional System was being developed another coorperative research group was at work on a different CAI system. This group, consisting of members from the University of Illinois, under the direction of Donald Bitzer, the Control Data Corporation (CDC), and the National Science Foundation, began work in the early 1960's on the PLATO System.

PLATO (Programmed Logic for Automatic Teaching Operations) was developed to deliver CAI via a large mainframe or macro-computer system as opposed to a mini-computer (i.e. the IBM 1500). By utilizing this larger computer system it was possible to: have a much larger library of programs immediately available for student use; more easily utilize sophisticated programs to automatically keep track of an individual student's progress in a series of CAI programs; and provide access to many times more students than was possible with a mini-computer system (i.e. a ten to fifty fold increase in the potential number of simultaneous users).

The early PLATO II System ran on the ILLIAC I computer at the University of Illinois. This system had a "high speed electrostatic memory of 1024 40-bit words and an auxiliary magnetic drum storage of 10,240 words" (Bitzer, et al, 1962, p. 206). Students communicated with the system by means of a keyboard which contained alphanumeric characters and a special set of function keys (i.e. continue, help, aha). Feedback and new material or questions were presented to each student via closed circuit television. Slides and alphanumeric characters could be simultaneously superimposed on the students' screen. A major feature of this system was that it could instruct a number of students concurrently, while the PLATO I originally had only one student terminal connected to it.

The next PLATO System, also developed in the 1960's, consisted of a large CDC 1604 mainframe computer and a number of remote student terminal stations. Each station consisted of: a plasma terminal display screen capable of detecting areas which were touched (as in pointing to an answer on the screen); a modified typewriter keyboard with certain added function keys; and a computer-controlled electronic slide selector. Other peripheral devices (i.e. film projectors, audio units) could be interfaced to the student terminal station and placed under computer control if necessary. An added feature of the system was the ability to have communication between the various terminals transmitted via the central computer.

Despite the advances made by the IBM 1500 Instructional System and PLATO, as well as numerous other individual achievements and developments in the area of CAI, the role of the computer in education, contrary to Dick's (1965) prediction, was minimal in the 1960's. Were then the 1970's to become the "Age of CAI"? Certainly many leading authorities in the field of CAI (Bitzer & Bitzer, 1973; Suppes, 1966) thought so: "Within the next decade teachers and computers will become educational partners" (Hicks & Hunka, 1972, p. 20).

Application of Microcomputers in the 1970's

The major development during the 1970's which bode well for CAI were the development of: the TICCIT System; and educationally oriented microcomputers.

During the early 1970's another co-operative research effort between a University based group and a private corporation yielded a significant contribution to the field of CAI. The groups involved were a group from Brigham Young University, under the direction of Victor Bunderson, and a group from the MITRE Corporation. The result of this co-operative effort was the Time-shared, Interactive, Computer-Controlled, Information Television (TICCIT) System of CAI (Suppes & Macken, 1978).

TICCIT was originally a 32 terminal minicomputer based CAI system which used the television as the display device by which it delivered CAI programs to student users. The original subject matter consisted of English and mathematics programs intended for students at the junior or community college level (Suppes & Macken, 1978).

A major contribution made by the TICCIT System to CAI was not in the hardware or courseware which it used per se, but in its application of a theory for instruction as its base. The hardware as well as the courseware which ran on the system, was based on a theory for instruction developed by M. David Merrill (Merrill, 1980; Reigeluth, 1979). This theory for instruction was primarily concerned with strategies for teaching a single concept or principle. According to this theory:

> Any particular instance of a complex cognitive instructional presentation must always feature some combination of presentation mode and content. The qualitative values are expository (E), inquisitory (I), generality (G), and instance (eg). Combining them into a two-way table will produce the following presentations: expository generality (EG), expository instance (Eeg), inquisitory generality (IG), and inquisitory instance (Ieg). In an expository-generality (EG) presentation, S [student] is presented definitions or rules and directed to study or read these generalities. In an expository-instance (Eeg) presentation, S is presented exemplars or nonexemplars of a given concept along with some indication of appropriate

class membership or a sample of the application of a rule to a particular problem. This presentation may be in the form of questions, if the answer is given at the same time. In an inquisitory-generality (IG) presentation, the student is asked to reproduce or deduce the definition or rule . . . In an inquisitory-instance (Ieg) presentation, S is presented an exemplar or nonexemplar of a concept and asked to indicate class membership, or he is given a problem and asked to apply the rule (Merrill & Boutwell, 1973, pp. 106-107).

TICCIT applied this theory to an instructional paradigm with the assumption that "a given idea concept, procedure, or principle - should be presented in each of three modes: rule, example, and practice" (Merrill, 1980, p. 77).

This was the first time, since the application of Pressey's simple mastery paradigm and Skinner's immediate reinforcement to the early teaching machines, that CAI formally and rigorously attempted to base its operations in instructional theory. TICCIT thus became the first CAI system to be extensively based in instructional theory (Reigeluth, 1979).

The other major CAI development during the 1970's was the development of microcomputers. Microcomputers are basically a scaled down or unit version of large computers. They are relatively small and possess stand alone computer facilities with a minimum amount of hardware. Basically this includes a microprocessor with a display screen and a keyboard for data entry.

Micro-electronic and silicon chip technology, developed in the early 1970's, resulted in the development of microprocessors, which possessed the power of the older and physically several hundred fold larger computer processors, but at a cost several hundred fold less (Vacroux, 1975; Wagner, 1976). This opened the door for the development of microcomputers and by 1975 the first commercially available microcomputers, the Altair 8800, the Intellec-8, and the Motorola Microcomputer, were released in kit form ready for the consumer to assemble. Others (i.e. Heathkit, SOL) rapidly became available at lower and lower costs. However, because of the expertise and time necessary to properly assemble one of these units few educators took advantage of them to deliver CAI, although use was made of these kits in vocational education, electronics, and computer science courses.

This changed in 1977 with the appearance of the PET 2001 microcomputer by Commodore. This was a fully assembled and tested microcomputer which could appeal to the general consumer or educator without the necessity of computer or electronics knowledge. Others which appeared at about the same time in ready to run form included: Apple, Compucolor, Datapoint, Exidy Sorcerer, IMSAI, SOL (by Processor Technology), and TRS-80 (by Radio Shack).

The microcomputer did much to promote CAI, both directly and indirectly. Because of the microcomputer's attractive features (i.e. portability, self-containment, low cost), it produced a wider interest in the use of CAI among educators than had any of the previous types of CAI delivery systems. Thus, many schools had their first, and perhaps only, contact with CAI because of and by means of the microcomputer.

Indirectly, the microcomputers contributed to CAI both within and outside of the educational community by making CAI technology available at an affordable price to lay individuals and educators alike. This in turn resulted in: the desire of interested individuals to learn more about microcomputers and their potential applications, including CAI; and a need for vehicles by which this information could be communicated.

In response to this need, numerous publications, clubs, and organizations devoted primarily to microcomputers and/or CAI were developed in the 1970's. The journals included titles such as: Byte, Dr. Dobb's Journal, Interface Age, Kilobaud Microcomputing, and Personal Computing. The clubs, primarily lay or hobbyist oriented, produced newsletters and publications and sponsored "personal computer conferences" and "computer fairs". Many professional organizations which were started or expanded during the 1970's (i.e. Association for the Development of Computer-Based Instruction Systems [ADCIS], Association for Educational Data Systems [AEDS]) owe a great deal to the interest in CAI generated by the development of microcomputers.

A further, perhaps larger and more important, "ripple" effect, which the microcomputers have had on CAI, was that of increasing public awareness of computers in general. This ultimately will probably be the most significant contribution which the microcomputers will have in promoting CAI, that is: to decrease the "societal inertia" which had hitherto hindered the growth of CAI.

Despite these advances CAI continued to be the exception, rather than the rule, in the classroom during the 1970's. This situation certainly was not expected, as witnessed by earlier predictions, nor can it be easily explained. The technology and instructional psychology of CAI had developed sufficiently to warrant its wide spread use and societal (especially student user) inertia seemed to be minimal. Educational funding cutbacks during the 1970's certainly may have contributed to the situation. A tempting speculation is that educators themselves were primarily responsible for this situation (Norris, 1978).

Current Status

What of the 1980's? It is still too early to predict whether or not this decade will see CAI become widely and routinely integrated into the instructional system. The first two years have seen both advances and retreats for CAI.

The current state of affairs for CAI in the 1980's will begin with a review of the progress and status of two major dedicated CAI systems, the IBM 1500 Instructional System and Plato.

The IBM 1500 Instructional Systems were extensively used and tested by educators and researchers from the mid-1960's through the 1970's. Major centers of application and development included: Stanford University, Florida State University, Pennsylvania State University and the University of Alberta. Despite the 1500's ability to deliver highly sophisticated CAI, the IBM Corporation discontinued support for the system and the last one was removed from service at the University of Alberta in 1980. This system was not replaced by IBM with another dedicated CAI system.

The PLATO system, on the other hand has continued to develop since its inception in the early 1960's. Since that time it has shown steady increases in the quality and variety of CAI courses available on it. The 1981 catalog of published PLATO courses contained over seven hundred entries in disciplines ranging from astronomy to veterinary science. In addition, many times this number of programs exist in an unpublished form, available on a restricted basis at the various universities and centers which utilize the PLATO system.

Various central computers have been utilized by the PLATO system including the CDC 1604, the CDC 6400, the CDC CYBER 74, the CDC CYBER 170, and the CDC CYBER 172. PLATO hardware and software changes, now entering their fifth generation, have enabled the system to keep pace with growing numbers of student users so that from an early capacity of 20 simultaneous student users, the maximum system configuration is now capable of supporting over six-hundred terminals simultaneously at an acceptable performance level, and can theoretically support over one-thousand simultaneous users. Major centers which now have PLATO computer or terminal facilities include: the Universities of Alberta, Arizona, Belgium, Colorado, Delaware, Finland, Florida State, Illinois, Minnesota, Quebec, and Western Cape (South Africa); learning centers in over one-hundred cities throughout North America; and several North American secondary school districts. In total 15 central computers and over two thousand terminals are currently dedicated to PLATO use. Currently under development is also a microcomputer version of PLATO.

Microcomputers are by far the most widely used "systems" for CAI. Some, such as the SOL, have not survived into the 1980's. However, most of the major original microcomputers have survived into the 1980's and are now into their second or third generation of machine modifications.

Microcomputers have continued to decrease in cost while improving features, such as increasing memory space. Peripherals and microelectronic boards are now available for most microcomputer systems which permit: data storage and retrieval on floppy disks; use of several computer and authoring languages; interfacing with a printer; sound recognition and synthesis; use of color; generation of dynamic (animated) graphics; and the ability to create special characters.

This discussion of microcomputers and CAI would be incomplete and perhaps misleading, however, if mention at least was not made of microcomputer's significant limitations. The application and use of microcomputers in CAI currently has three major limitations: 1) lack of high quality, manufacturer produced, courseware; 2) general inability to readily transfer material from one system to another; and 3) general inability to centrally collect and record individual student and class responses automatically for data analysis. These limitations have not been sufficiently addressed by educators.

> . . . there is a real danger that microcomputers wll be purchased by schools and shortly, relegated to a cupboard for most of the time. The danger is especially acute where CAI is concerned: unless sufficient high quality programs are available, there is no possibility that a microcomputer can be used sufficiently to justify its cost (Hallworth & Brebner, 1980, p. 115).

Perhaps the question for the 1980's is not whether CAI will be used, but whether it will be used wisely. For as Braun (1980) has noted: "Computers will move into our homes and our schools whether or not anyone does anything to ensure their effective use" (p. 110).

CAI in Pharmacology and Related Fields

CAI in pharmacology began in the early 1970's primarily under the impetus of the "Computer Assisted Teaching System" (CATS) at the University of Kansas (Norton, Doull & Walaszek, 1972) and PLATO at the University of Illinois (Bitzer & Bitzer, 1973). Since that time many departments of pharmacology have increasingly turned to CAI. This trend toward CAI has been due to a combination of factors including: rapid increase of both knowledge and complexity in the area of pharmacology; progressive increase in the number of students enrolled in pharmacology courses; increased emphasis on the rapid and continuously changing area of clinical pharmacology; greater availability and accessibility of pharmacology CAI programs; and the apparent ability of CAI to make learning individualized and self-paced (Doull & Walaszek, 1978; Kreeft, 1977; Madsen & Bell, 1977; Ruedy, 1977; Vanselow, 1975).

A search of the literature revealed surprisingly few publications dealing with CAI in pharmacology. Most of the published literature (i.e. Doull & Walaszek, 1978; Florenz, et al, 1975; Madsen & Bell, 1977; Pagliaro, et al, 1979; Ruedy, 1977; Vanselow, 1975) concerning CAI in pharmacology consisted of descriptions and reports of various CAI applications and systems. Only four publications were found which contained quantitative data concerning the effect of CAI in pharmacology on either academic performance or attitude (Bitzer & Bitzer, 1973; Essex, et al, 1977; Kornberg, 1979; Pagliaro & Burkhalter, 1979). None of these studies, however, satisfactorily answer the question of whether or not CAI in pharmacology significantly affects student learning and/or attitude.

The Bitzer and Bitzer (1973) study examined CAI administered to nursing students in the content areas of maternity nursing and pharmacology. It was stated that the students who used CAI generally had favorable attitudes toward CAI and evaluated it highly. It was also stated that students could learn the same material and save one-third to one-half the time by using CAI. However, the data presented was either for the the subject matter of maternity nursing alone or combined with pharmacology. No data was available for the pharmacology lessons alone. In addition, research design flaws involving sampling and measurement of effect (i.e. use of gain scores) made the results obtained tenuous at best.

The study by Essex, Sorlie and Jones (1977) was actually a comprehensive evaluation report of the PLATO computer-based education project in basic medical sciences at the University of Illinois from 1973 to 1976. Opinions were collected from the medical student users on a variety of course and CAI related items. In addition, comparison of user and non-user performance on selected segments of the medical students year end clinical diagnostic examinations were also performed and analyzed. The student users were highly consistent in their opinion that "more lessons should be developed" and that PLATO lessons serve primarily "as a resource which supplements textbooks and lectures". Data was collected from 72 medical students (users = 26, i.e. 36%; nonusers = 46, i.e. 64%) on their diagnostic examinations in relation to the content "pharmacology of respiratory disease". The results were analyzed, utilizing a t-test for the difference between independent means, and found not to be significantly different. Major problems with this study included: data based on only 72 of 97 medical students at Urbana because of lack of written consent; low CAI use rate (i.e. 36% of available respondents); tenuous, at best, equation of clinical (applied) pharmacology oriented responses with CAI in basic (pure) pharmacology; lack of description of typical examination questions used; use of a variety of nonstandardized opinion gathering questionnaires; use of lessons, some of which had been specifically developed for the medical students at Urbana and some of which had been verbatim translations from the University of Kansas; and use of a post-test only design. A subsequent paper (Sorlie & Essex, 1978) claimed that 3 of 19 similar analyses performed in 1976-1977 showed significant differences favoring CAI users (two of which involved pharmacology content) with the remaining analyses showing no statistically significant differences, however, no data was presented in this paper.

Kornberg's (1979) study compared computer based education (CBE), a written booklet of programmed instruction and lecture presentation (the control group) in the content area of pharmacology with second year medical students. Subjective attitude measurements (i.e. evaluation forms) were also obtained. The results indicated that although most students (93%) liked CBE, the differences in learning observed were either not practically significant or not statistically significant. Kornberg concluded that CBE is not an effective method of instruction in this content area. The major criticisms of this study included: use of a posttest only design; lack of quantitative data on student use of the computers (i.e. number of hours of use); high percentage of subjects who dropped out or for whom incomplete data was available (greater than 50 percent); and no measurement of specific demographic or psychological variables.

The Pagliaro and Burkhalter study (1979) attempted to determine whether or not CAI could affect pharmacy students' attitudes when used in conjunction with traditional modalities of pharmacology instruction (i.e. lecture and laboratory). The results of this study indicated that although students (93%) favored the development and use of more CAI programs in pharmacology (as assessed by means of a course evaluation form), student attitudes (as assessed by an attitude questionnaire) were not significantly influenced by CAI use in the content area of pharmacology. The major criticisms of this study include: small sample size; low participation rate (46 of 90 students - i.e. 51%); and no measurement of either demographic or psychological variables with which to correlate the observed results.

Thus, the situation currently exists where an increasing number of students are being taught with a technique (CAI) which has yet to be carefully examined in an objective manner and determined to be effective in the content area of pharmacology.

From an examination of CAI use and evaluation in a variety of other basic medical science disciplines [anatomy (Jones, et al, 1978); microbiology (Essex, et al, 1977); and physiology (Myer & Beaton, 1974; Thies, et al, 1969)] it is obvious that mixed results have been obtained with CAI; however, when compared to more traditional modes of instruction (i.e. lecture, laboratory), CAI appears to be equivalent to these other modes in relation to student achievement.

CHAPTER III

THE PROBLEM

Statement of the Problem

One of the basic motivating factors in conducting this research was the opinion that the results observed to date in studies of CAI in the basic medical sciences , that of no significant difference, should have been expected due to individual learner preferences and the notion of instructional interactions. Past studies have focused upon trying to find the one best form of instructional delivery (i.e. CAI or lecture) instead of trying to determine specific learner characteristics which would enable the identification of those individuals who perform optimally with CAI and those who perform optimally with other modes of instruction.

With this in mind, the present study was designed and executed in order to objectively answer the following four series of questions:

1. What effect does CAI have on student academic achievement in pharmacology? If CAI is used in addition to lectures is student achievement increased in comparison to either lectures or CAI alone?

2. If CAI is used prior to lectures is student retention of learned material increased in comparison to CAI used either during or following lectures?

3. Does the use of CAI affect student attitude toward CAI? If attitude toward CAI changes, is this change

correlated with academic achievement in relation to the use of CAI in pharmacology?

4. Can a significant correlation or instructional interaction be found between specific student demographic and/or psychological variables and academic performance in relation to the use of CAI in pharmacology?

Review of Related Literature

CAI and Achievement

As noted in the last section of the previous chapter, application of CAI in the basic medical sciences has yielded mixed results. Can this observation be generalized to other post-secondary applications of CAI? This section will attempt to answer this question by: summarizing four review articles which described the relationship between CAI and achievement up to 1975; and then examining in detail individual reports, from 1975 to date, which were performed to measure the effect of CAI upon student achievement in five different post-secondary contexts.

Feldhusen and Szabo (1968), in an early review, summarized CAI studies and reports, mostly unpublished, from 1960 to 1968. In their summary, they noted that " . . . the evidence clearly indicates that CAI will teach at least as well as live teachers or other media . . . students can learn from CAI when taught didactically and inductively" (p. 271).

Vinsonhaler and Bass (1972) summarized ten major studies on CAI drill and practice in the content area of language arts and mathematics. They concluded that CAI is effective and further that "the effectiveness of CAI over traditional instruction seems to be a reasonably well-established fact . . . " (p. 31). However, they also stated that: "there are indications that the effects obtained with CAI might be obtained through less expensive means" (p. 31) (i.e. programmed instruction). Vinsonhaler and Bass went on further in this regard: "Studies have shown that CAI may actually prove inferior to programmed instruction under certain circumstances" (p. 31.). This last statement supports the notion that CAI must be evaluated in terms of instructional interactions.

In the report, "The effectiveness of alternative instructional media: a survey", Jamison and his colleagues (1974) examined the effectiveness of instructional radio, instructional television, programmed instruction, and CAI in comparison to traditional classroom instructional (TI). After analyzing several studies which related CAI and achievement at the secondary and post-secondary levels they concluded that: "At the secondary school and college levels, a conservative conclusion is that CAI is about as effective as TI when it is used as a replacement" (Jamison, et al, 1974, p. 55).

The next major review of the effectiveness of CAI (Edwards, et al, 1975) differentiated between CAI used alone and CAI used as an adjunct to traditional teaching modalities. In relation to the latter application of CAI, they noted that "all studies have shown normal instruction supplement by CAI to be more effective than normal instruction alone" (p. 147). However, CAI used alone appeared to be less efficacious in relation to retention than traditional teaching. "Even though students may learn more or may learn more quickly through CAI, there is some evidence that they may not retain as much as traditionally taught students" (Edwards, et al, 1975, p. 151). Here again, however, no clear cut statement could be made by the authors and it is highly likely that the observed mixed results were due to instructional interactions.

Thus, at least until 1975, there appeared to be the same pattern of mixed CAI results, as noted in the basic medical sciences, occurring in other disciplines.

A search of the literature from 1975 to date, excluding references to applications in the basic medical sciences, revealed six published studies which were primarily concerned with determining the effect of CAI upon achievement in post-secondary settings.

In the first of these studies Chizmar and colleagues (1977) assessed the effect of CAI upon student achievement in an economics course at Illinois State University. Using a statistical procedure to control for the contributory effects of the user characteristics (age, grade point average, sex), they found that "the effect of CAI is negative but small" (p. 45). Major limitations of this study include: use of statistical, as opposed to experimental, controls in the design and analysis; self-selection of group membership (i.e. CAI or non-CAI) by the students; and incomplete reporting of data (i.e. no presentation of raw scores or means).

Dixon and Judd (1977) reported the results of an experiment designed to compare computer managed instruction and lecture mode in a statistics course at the University of Texas at Austin. No significant difference was found between groups in either the posttest or retention test measures. They state, however, that the results of their study "support the contention that for some student populations and some topics CMI [computer managed instruction] can be as effective as an experienced instructor . . ." (p. 25). The qualifier "some", which they used, again tends to support the implication of instructional interactions in relation to CAI. The major limitation of this study was the use of a posttest only design which ignored the potential for initial achievement differences among the test groups.

Paden, et al (1977), assessed the effect of CAI in the content area of economics. After three years of study they noted that: ". . . although content material was transmitted as effectively by the computer as by more conventional means, student performance was not significantly improved by doing so" (p. 18). They further concluded that "expectations of greatly improved student performance . . . seem to be unrealistic . . ." (p. 18).

Tsai and Pohl (1978) studied the effect of three different teaching techniques: lecture, CAI, and lecture supplemented with CAI, in a computer programming course at the University of Santa Clara. Students were matched for: 1) age, 2) sex, 3) student rank (i.e. freshman, etc.), and 4) previous computer programming experience; and divided into three groups of fifteen students each. In comparison of the mean final examination scores Tsai and Pohl noted that: 1) the lecture group and the CAI group were statistically equivalent; and 2) the group which had lecture supplemented with CAI had statistically higher scores than either the lecture or the CAI groups.

Lavin (1980) reported the effect of CAI in an introductory sociology course at Kent State University. The CAI programs in this project were self evaluation programs which consisted of a series of quizzes with corrective feedback. Users of CAI consistently scored higher in tests than nonusers, however, when the results were statistically analyzed it became apparent that "for the most part, students of high ability to begin with do not benefit from the use of CAI in terms of a better test performance than their nonuser counterparts" (p. 170). The major limitations of this study included: use of an "ex post facto" design which allowed the student to choose whether or not to use CAI (i.e. non-random assignment to treatment group); and use of identical questions in both the CAI program quizzes and the evaluation tests.

The last study (Deigman, et al, 1980) was actually a comprehensive report form the technical training division of the United States Air Force. This report compared the effectiveness of CAI, programmed instruction, and lecture in three medical training courses: medical laboratory, radiology, and dental assistant. The subjects were military trainees assigned to the Air Force School of Health Care Sciences at Sheppard Air Force Base, Texas. Students were assigned to either CAI or non-CAI exposure within the specific course (i.e. Medical Laboratory - CAI or lecture; Radiology - CAI or programmed instruction; Dental - CAI or lecture). The results of this study indicated that in relation to achievement CAI was generally found to be superior to both lecture and programmed instruction[4]. In addition it was noted that the use of CAI resulted in an overall time savings of approximately fifteen percent. The major limitations of this study included: absence of description of how subjects were assigned to treatment groups (i.e. by random selection or biased); use of grossly unequal sample sizes in the analysis; lack of adequate explanation of the drop out or incompletion rate in the study; and use of a post-test only design.

These six studies essentially presented six different pictures of CAI and achievement in post-secondary settings.

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[4] This will be further elaborated upon in the section "CAI and Personologic Variables".

A review of the unpublished research in this area yielded a similarly mixed picture of achievement with CAI. The results of both the published and unpublished works are summarized in Table 1. The results have ranged from slightly negative to extremely positive and may appear at first glance to be contradictory. However, if viewed in the light of instructional interactions the seeming discrepancies appear to vanish and the observed results may begin to make sense.

Most of these studies contained major methodological limitations and generally lacked information regarding specific demographic and psychological variables for their subjects. Thus, the possibility of making valid generalizations about CAI and achievement based upon these studies is extremely remote. However, these studies do clearly and affirmatively answer the question posed at the beginning of this section by exemplifying the mixed results obtained with various post-secondary applications of CAI in relation to achievement.

CAI and Retention

Comparatively few studies have been performed which dealt with CAI and retention of learned information. It seems that most of the individuals who have studied CAI and achievement have assumed that achievement and retention are directly correlated so that demonstration of equal achievement with various instructional modalities implies equal retention. This assumption, however, may be both

Table 1. Summary of "CAI and achievement" studies in post-secondary, non-basic medical science, courses

Author(s)	CAI Application	Result[1] -CAI vs Lecture
Proctor, 1968	Education	↔
Ibrahim, 1970	Mathematics	↑
Cartwright, et al, 1972	Education	↑
Ward & Ballew, 1972	Mathematics	↔
Castleberry, et al, 1973	Chemistry	↑
Lee, 1973	Geology	↔
Ozarowski, 1973	Statistics	↑
Goodson, 1975	Mathematics	↔
Hamm, 1975	Communication Skills	↔
Lee, 1975	Mathematics	↑
Bickerstaff, 1976	Mathematics	↔
Hughes, 1976	Business	↔
Chizmar, et al, 1977	Economics	↓[2]
Dixon & Judd, 1977	Statistics	↔
Johnson, 1977	Accounting	↓
Paden, et al, 1977	Economics	↔
Tsai & Pohl, 1978	Computer Programming	↔
Lavin, 1980	Sociology	↑[3]
Deigman, et al, 1980	Medical Laboratory	↑
Deigman, et al, 1980	Dental Assistant	↑
Deigman, et al, 1980	Radiology	↑[4]

[1] ↑ signifies "increased"
↓ signifies "decreased"
↔ signifies "no change"
[2] When user characteristics statistically controlled for
[3] ↔ for high ability users
[4] This study compared CAI and programmed instruction.

unwarranted and unwise. In real life situations, retained knowledge or information is infinitely more practical and useful than that which has been learned, but which is soon forgotten. Perhaps educators would find it more useful to measure retention and to imply achievement from measures of retention.

Only two published studies and four unpublished doctoral dissertations could be found which dealt with a comparison of retention between CAI and traditional teaching modalities (i.e. lecture, laboratory, programmed instruction). The results of these studies are summarized in Table 2.

Every one of these studies found retention from CAI to be statistically equivalent to that from the traditional teaching modalities. Thus, it appears that CAI is equivalent to the traditional modalities in retention as well as in achievement.

It should be noted, however, that research in relation to CAI and retention has another major problem in addition to the paucity of studies. The problem is that all the studies to date have focused upon short term retention. All of the tests for retention have been administered from one to seven weeks after the completion of instruction. This may yield important and interesting academic results, particularly in light of the exponential rate of decline in the time dimension of the learning curve. However, from a more practical and realistic perspective, what a student retains one week, or one month, after the completion of instruction is not as important as what s/he retains after six months, one year, or longer. Thus, there remains a need for more studies into short term retention of CAI taught material and an even greater need for studies to begin to examine long term retention.

Table 2. Summary of "CAI and retention" studies in post-secondary, non-basic medical science, courses

Author(s)	CAI Application	Result[1, 2] -CAI vs Lecture
Proctor, 1968	Education	↔ (2 weeks)
Ibrahim, 1970	Mathematics	↔
Ward & Ballew, 1972	Mathematics	↔ (4 weeks)
Karon, 1975	Medicine	↔
Jackson, 1976	Social Studies	↔ (1 weeks)[3]
Dixon & Judd, 1977	Statistics	↔ (7 weeks)

1 ↔ signifies "no change"
2 Time period in parenthesis refers to when after the completion of instruction that the retention test was administered.
3 This study compared CAI and programmed instruction.

CAI and Attitudes

Does CAI affect student attitudes toward CAI or subject matter? Are student attitudes toward CAI positive? The answers to these and several related questions are important in order to obtain a more complete understanding of the overall effects of CAI. However, before proceeding, a brief review of what attitudes are and why they may be of interest in an educational setting will be presented.

There are many, oftentimes seemingly diverse, definitions of attitude (Greenwald, 1968; Khan & Weiss, 1973; Lund, 1925). A definition, modified from Sarnoff (1960), which seems to be most useful, however, as it is both general and applicable to the educational environment is: "An attitude is an idea charged with emotion which predisposes a class of actions to a particular class of objects or situations".

As such, attitudes perform or facilitate many psychological functions for the individual. Attitudes:

1. help in understanding the world by organizing and simplifying complex environment input;
2. protect self-esteem by enabling the avoidance of unpleasant truths;
3. help adjust reactions in a complex world so as to maximize rewards from the environment; and
4. allow the expression of fundamental values.

It has been noted that: "What learners believe or think influences their behavior"; and "Students are more likely to learn and remember material for which they have a positive feeling" (Krathwohl, et al, 1964). It would appear then that attitudes may interact within the educational environment to influence directly learning outcome (Khan & Weiss, 1973; Malpass, 1969). However, the effect of attitudes on behavior is not that direct and simple because behavior is actually a multivariate function the outcome of which depends upon: 1) attitudes; 2) norms; 3) habits; 4) expectancies; and 5) reinforcements.

Only when all five of these factors are consistent is there consistency between attitudes and behavior. This was perhaps first noted, although not recognized per se, by La Piere (1934). La Piere had travelled extensively by car throughout the United States with a Chinese couple during the early 1930's. During this time, he noted that "in only one out of 251 instances in which we purchased goods or services necessitating intimate human relationships did the fact that my companions were Chinese adversely effect us" (p. 233). Six months following the conclusion of their trip, La Piere sent questionnaires asking, "Will you accept members of the Chinese race as guests in your establishment?" to each of the 251 establishments they had used, together with "an accompanying letter purporting to be a special and personal plea for response". Responses were obtained from 128 of the establishments. Of these, over ninety-percent responded negatively, only one establishment positively, and the remainder responded "uncertain". These results indicated to La Piere a complete absence of positive correlation between attitude, as measured by a questionnaire, and actual observed behavior. Modern researchers, realizing that behavior is multifactorially determined, would probably have reached a more moderate conclusion regarding the ability of questionnaires to accurately measure attitude.

From this brief review, and even before any of the studies dealing with CAI and attitude are reviewed, it should be expected that CAI may affect attitude and attitude in turn may affect achievement. However, the results may appear inconsistent and the relationships unclear, on direct, simple observation. Indeed, as was noted for CAI and achievement, CAI and attitudes may have to be viewed and analyzed in the more complete context of a model of instructional interactions in order to determine any clear underlying relationship between CAI and attitudes.

Much of the literature concerning the relationship between CAI and attitude consists of uncontrolled, subjective reports of student "feelings" towards CAI. These types of reports yield very little useful information and have been excluded from the present analysis.

The attitude studies which were examined fell into two categories: 1) those which dealt with CAI's effect on attitude toward the subject matter under study; and 2) those which dealt with CAI's effect on attitude towards CAI.

The results of these studies are summarized in Table 3. As can be seen for both types of attitude measurement, the overall effect, of CAI versus traditional teaching modalities, upon attitude toward CAI or subject matter is neutral. This is especially interesting considering that many of these studies merely compared the attitudes toward CAI or subject matter of those subjects exposed only to CAI and those subjects who were exposed only to traditional teaching modalities. Exposure itself may enhance attitude toward any measure (Zajonc, 1968), including CAI and subject matter, conversely, it must also be noted that attitude toward teaching modalities may decrease with time and use by students, i.e. "progressive disenchantment" (Neidt, 1964). Therefore, these studies must be interpreted with the proverbial grain of salt.

Table 3. Summary of "CAI and Attitude" Studies in Post-Secondary, Non-Basic Medical Science, Courses.

Author(s)	CAI Application	Result[1] [2] -CAI vs Lecture
A. CAI and Attitude Toward Subject Matter		
Goodson, 1975	Mathematics	↔ (Mathematics)
Pavlick, 1975	Statistics	↔ (Statistics)
Dixon & Judd, 1977	Statistics	↑ (Statistics)
B. CAI and Attitude Toward CAI		
Proctor, 1968	Education	↔ (CAI)
Ibrahim, 1970	Mathematics	↔ (CAI)
Mathis, et al, 1970	Psychology	↔[3] (CAI)
Lee, 1973	Geology	↔[4] (CAI)
Bickerstaff, 1976	Mathematics	↔ (CAI)
Hughes, 1976	Business	↔ (CAI)
Deigman, et al, 1980	Medical Laboratory	↑ (CAI)
Deigman, et al, 1980	Dental Assistant	↑ (CAI)
Deigman, et al, 1980	Radiology	↑[5] (CAI)

[1] ↑ signifies "increased"
↔ signifies "no change"
[2] Concept toward which attitude was measured is listed in parentheses.
[3] This study compared CAI and assigned readings.
[4] This study compared CAI and laboratory instruction.
[5] This study compared CAI and programmed instruction.

Thus, on the basis of these studies, it appears that effects upon attitude, toward both CAI and subject matter, must be considered equivalent for CAI and other more traditional teaching modalities. However, as noted earlier, these studies possessed several design flaws and for the most part lacked study and analysis via an interactive model. Use of an interactive model might possibly elucidate subtle characteristics of learners associated with a predisposition to favorable attitudes when using one instructional modality as compared with another. As noted by Neidt (1964), in his comparison of learner attitudes toward lecture, laboratory, programmed instruction and educational television: "extensive evidence was found to indicate that attitudes toward method, expectation and content are related to the personal characteristics of the learners" (p. 128).

CAI and Instructional Interactions

Several foresighted individuals in the early 1960's noted that optimal instructional use of CAI depended upon the application of information and techniques from the field of instructional interaction research. Rigney (1962), for example, noted that: "investigators trying to use this new tool [CAI] for instruction will have to develop their own specific methodology and their own fund of research experience within the broader context of traditional studies of individual differences in learning" (p. 169). In a review of "individual differences and CAI", from 1960 to 1968, Feldhusen and Szabo (1968) concluded that:

> What will be needed in CAI research will be systematic analysis of basic instructional variables and individual differences with Ss [subjects] who have transcended CAI's newness and with hardware and software which is fully debugged. (p. 271)

However, response to these and other requests for studying and analyzing CAI in the context of instructional interactions has been negligible. Indeed, as noted by Goodman (1978):

> Currently, among the factors least likely to be given due consideration, especially in computer assisted instruction, are the "learning styles", "cognitive maps", and "sensory modality" or "media preferences" of students. In particular, their propensity or otherwise, to make use of the newer integrated information systems and instructional media, especially the electronic media, is almost universally ignored and/or taken for granted. (p. 3)

Thus, despite the numerous published pleas, and the grievous need as demonstrated in the previous sections concerning: CAI and achievement; CAI and retention; and CAI and attitude; there remains an absolute deficiency of studies concerning CAI in the context of instructional interactions. Indeed, since the publication of the Feldhusen and Szabo review in 1968 only twelve published studies related to this issue could be found. This is approximately equivalent to only one published study per year.

The results of these studies, which examined variables for correlation or instructional interactions in relation to achievement with CAI, are summarized in Table 4. They will now be reviewed in alphabetical order by variable.

Table 4. Summary of "CAI and Instructional Interaction" Studies.

Variable	Measure	Observation[1]	Author(s)
Achievement Motivation	Achievement via Independence Scale of the CPI[2]	-	Reid, et al, 1973
	Armed Services tests[3]	+	Deigman, et al, 1980
Anxiety	Sarason[4] Scale	+	Sutter & Reid, 1969
	STAI[5] A- State Scale	+	Spielberger, et al, 1972
	STAI A- Trait Scale	+	Leherissey, et al, 1973
	STAI A- State Scale	-	Tobias, 1973
	Sarason Scale	-	Reid, et al, 1973
	STAI A- State Scale	+	Rappaport, 1975
	Test of Mathematics anxiety	+	Downing & Lowe, 1981
Aptitude	SAT - M[6]	+	Reid, et al, 1973
	Armed Services Tests[7]	+	Deigman, et al, 1980
Attitude	CAI - Math Attitude Survey	-	Reid, et al, 1973
Dogmatism	Rokeach[8] Dogmatism Scale	-	Rappaport, 1975
Dominance	Dominance Scale of the CPI[9]	-	Sutter & Reid, 1969
	Dominance Scale of the CPI	-	Reid, et al, 1973
Flexibility	Flexibility Scale of the CPI	-	Reid, et al, 1973
Mental Ability	Stanford Achievement Tests	+	Suppes & Morningstar, 1969

(Table 4 continued)

	______	+	Edwards, et al, 1975
	Grade on Lecture Test	+	Lavin, 1980
Sex	Male or Female	-	Fletcher & Atkinson, 1972
	Male or Female	-	Reid, et al, 1973
	Male or Female	+	Wooley, 1978
	Male or Female	+	Downing & Lowe, 1981
Sociability	Sociability Scale of the CPI	+	Sutter & Reid, 1969
	Sociability Scale of the CPI[10]	-	Reid, et al, 1973

1 "+" signifies a significant correlation or instructional interaction in relation to achievement.
"-"signifies lack of significant correlation or instructional interaction in relation to achievement.
2 Achievement via Independence (Ai) scale of the California Psychological Inventory.
3 These tests specifically measured "level of aspiration to achieve".
4 Sarason, I.G. Intellectual and personality correlates of test anxiety. Journal of Abnormal and Social Psychology, 1959, 59, 272-275.
5 State-trait anxiety inventory.
6 Mathematics section of the scholastic aptitude test.
7 These tests consisted of the "Armed Services Vocational Aptitude Battery" and the "Delta Training Aptitude Battery".
8 Rokeach, M. Political and religious dogmatism: an alternative to the authoritarian personality. Psychological Monographs, 1956, 70, 1-43.
9 Delta-training aptitude battery.
10 In this CAI study students were assigned to work in pairs.

Achievement motivation. Reid and his colleagues (1973) measured achievement motivation with the "Achievement via Independence" scale of the California Psychological Inventory and then correlated this measure with a CAI posttest performance measure. The results failed to determine any significant relationship between the two measures.

In another study on achievement motivation, Deigman, et al (1980), using an armed services test of achievement motivation (level of aspiration to achieve), found a significant correlation between CAI performance and achievement motivation. In addition, they noted an instructional interaction with subjects low in achievement motivation performing significantly better using CAI as opposed to programmed instruction; whereas, no significant differences in performance were noted for subjects high in achievement motivation.

From an observation of these two studies it is apparent that mixed results have been obtained to date for the variable "achievement motivation" in relation to performance with CAI. However, it has been noted by Domino (1971), that subjects who score highly on the Achievement via Independence scale of the California Psychological Inventory perform best in courses arranged to encourage independence. Thus, achievement motivation needs to be re-evaluated in the context of CAI studies designed to encourage independent learning.

Anxiety. Sutter and Reid (1969), using Sarason's Test Anxiety (TA) scale, found that: "A significant interaction was obtained between TA and achievement for the two groups. Students high in TA achieved better working alone, while those low in TA achieved better working with a partner" (p. 155).

Speilberger, O'Neil, and Hansen (1972) in their comprehensive review of the drive characteristics and the interfering response properties of anxiety, described in detail the results of four laboratory studies involving anxiety and CAI. These studies had been performed at the Florida State University CAI Center and utilized the State-Trait Anxiety Inventory (STAI) to measure anxiety. They determined a significant instructional interaction with the variable "anxiety" and CAI, as noted in their summary:

> Performance on CAI learning tasks was found to be an interactive function of level of A-State [anxiety state] and task difficulty. HA-State [high anxiety state] subjects consistently performed more poorly on difficult CAI materials than LA-State [low anxiety state] subjects. No consistent relationship was found between A-State and performance on easier CAI materials. (p. 145)

Using the same STAI measure, Rappaport (1975) obtained results of instructional interactions with CAI similar to those found by Spielberger, et al (1972):

> A-State and mathematical ability were related to performance in a manner which is consistent with predictions derived from Spence-Taylor drive theory. According to drive theory, in complex learning tasks where there are many competing response tendencies, high A-State (drive) will produce decrements in performance. When there are few competing response tendencies, high A-State will facilitate performance (Rappaport, 1975, p. 1063).

Another study (Downing & Lowe, 1981) using a different test to measure mathematics anxiety in relation to performance with CAI supported Rappaport's (1975) findings and further noted the following additional instructional interaction: "the performance effects during CAI were different for males and females at comparable levels of anxiety" (p. 5).

Leherissey, et al (1973), utilizing the STAI measure also found a significant instructional interaction, but this one involved the variable of anxiety-trait (i.e. a measure of predisposition to anxiety) as opposed to the previous studies which had measured anxiety-state (i.e. a measure of the present actual level of anxiety).

Not all studies involving anxiety and CAI, however, have yielded positive results. For example: Reid, et al (1973), using the Sarason scale of anxiety, and Tobias (1973) using the STAI measure, failed to detect any significant correlation or instructional interaction with

CAI performance.

That anxiety can interact to either facilitate or interfere in the instructional process has been known for some time (Mandler & Sarason, 1952) and has been well established in the research literature. The apparent inconsistency posed by the last two studies may have been due to confounding variables in the experimental design of the projects or to differential effects of anxiety caused by differing modes of CAI design and delivery.

Aptitude. Aptitude as a variable is closely related to mental ability and these two terms are often inappropriately used interchangeably. The major distinguishing characteristic is that aptitude, as used in this context, is a measure of current predisposition for more specific skills; whereas, mental ability is a measure of potential. This distinction can be compared to the distinction between anxiety-state and anxiety-trait respectively, as previously noted.

Only two published studies could be found which examined aptitude in relation to performance with CAI. In the first, Reid and colleagues (1973) measured intellectual aptitude by administering the mathematics section of the Scholastic Aptitude Test and found a significant correlation between the aptitude measure and the CAI posttest.

Similar positive results were found by Deignan, et al (1980). They determined the General Aptitude Index of their subjects from administration of the Armed Services

Vocational Aptitude Battery. Correlating this measure with performance they observed that "aptitude measures were shown to be related significantly to subsequent learner performance in all three courses" (p. 23) (medical laboratory, dental, radiology). They also noted the following instructional interactions in relation to the variable "aptitude" and achievement with CAI: 1) that low aptitude subjects had significantly greater percentage gains in achievement than high aptitude subjects when using CAI as compared to similar matched groups using traditional teaching modalities (i.e. lecture, programmed instruction); and 2) that middle aptitude groups appeared on average to perform better with lecture or programmed instruction, as opposed to CAI.

These studies strongly suggest the presence of an instructional interaction for the variable "aptitude" and CAI.

Attitude. A review of both the relationship between attitude and performance (behavior) as well as the effect of CAI upon attitude can be found in the "CAI and Attitude" section of this chapter.

The only published CAI study found which tried to relate subjects' attitude and achievement was the Reid, Palmer, Witlock, and Jones (1973) study. Prior attitude toward CAI, as determined by administration of an attitude survey, failed to correlate significantly with performance. This may have been due to the fact that the other factors, in addition to attitude, necessary to produce behavior were not correctly predisposed.

The significance of this study is not that it confirms or denies the presence of a relationship between the variable "attitude" and CAI performance - because it does neither. The significance of this study is that it highlights the glaring deficiency of proper controlled studies in this area.

Dogmatism. Rappaport (1975) utilized the Rokeach (1956) Dogmatism Scale to measure general authoritarianism and intolerance. He then had high and low dogmatic subjects proceed through CAI programs in the content area of mathematics. As might have been predicted, he noted that "the procedure of computer-assisted instruction per se did not produce significant differences between high and low dogmatic subjects" (p. 1065).

As previously noted, CAI is a relatively neutral technology, so that one would not have expected an interaction between dogmatism and CAI. However, had Rappaport used content different and perhaps more controversial than mathematics (i.e. social studies), an instructional interaction may have been produced, probably still not with CAI, but with the variable "dogmatism" and the subject matter used or its manner of presentation.

Dominance. Dominance was measured by Reid, et al (1973), with the Dominance Scale of the California Psychological Inventory. Correlation with CAI achievement measures failed to yield any significant results. This confirmed the results of an earlier study (Sutter & Reid, 1969) which had found no significant correlation between the variable "dominance" and CAI achievement. Thus, although more studies need to be done, it appears that the variable "dominance" is not related to CAI performance.

Flexibility. Reid and his colleagues (1973) also measured flexibility by means of the Flexibility Scale of the California Psychological Inventory. As was noted with the variable "dominance", correlation of CAI achievement measures with the variable "flexibility" failed to produce any significant results.

Mental ability. Suppes and Morningstar (1969) reported the effect of CAI programs which were used to teach mathematics drill and practice to elementary school students. Stanford achievement tests were used as the measures of mental ability. They found that CAI drill and practice in arithmetic was relatively more effective for low ability as opposed to average ability or high ability students.

Edwards, et al (1975), described the results of an unpublished CAI study by G. R. Martin. This study was also concerned with arithmetic drill and practice for elementary school students. Martin, like Suppes and Morningstar (1969), found that CAI drill and practice in arithmetic was more effective for low ability as opposed to higher ability students.

Lavin (1980) reported the results obtained from a CAI course in sociology for college students. The grade which the students received on a lecture test formed the basis for their mental ability classification. When CAI performance was analyzed in relation to achievement classification, it was noted that "CAI is of least value for high ability students" (p. 175).

Thus, all three studies seem to indicate that the variable "mental ability" significantly interacts with CAI. More specifically, these studies suggest that CAI, as a teaching modality, is preferentially effective for students with low mental ability. There are, however, several possible alternative explanations for the observed results. The first is that the high mental ability group may have been affected by a ceiling effect which would have made the attainment of significantly higher achievement results impossible. Another alternative explanation is that another contravening variable may be involved in the apparent interaction. For example, the variable "aptitude", which was previously discussed, could be involved. It may well be found upon further investigation that CAI works best for low ability students only if they possess high aptitude.

Sex. Several studies have examined the interaction of the variable "sex" with CAI. Fletcher and Atkinson (1972) studied the effect of CAI in reading with first grade students. They found that those students who used CAI had significantly greater posttest achievement in reading skills than those who did not. In comparing the relative percentage gain of CAI users and nonusers for boys and girls they concluded that "the data suggested that computer instruction benefits both girls and boys, but that it is relatively more effective for boys" (p. 597). An examination of Fletcher and Atkinson's data, however, indicates that while their conclusion regarding the relative superiority of CAI for boys is not completely untrue, it is definitely misleading and appears a bit far fetched. Suffice to say that Fletcher and Atkinson's "relative" superiority was not statistically significant.

The next study in this area also failed to detect a significant interaction. "The hypothesis that males would do better than females, both in terms of test scores and amount of time to complete the CAI task was not confirmed statistically" (Reid, et al, 1973, p. 70).

The next two studies, Wooley (1978) and Downing and Lowe (1981), were performed with college students. These studies yielded apparently significant instructional interactions of the variable "sex" with CAI. However, because of the presence of additional confounding variables, as noted below, the results are not completely clear and must therefore be interpreted carefully.

In the first of these studies, Wooley (1978) examined the effect of three different methods (orders) of presenting information in an astronomy CAI program. The different methods of presentation generally failed to produce significantly different results. However, when comparing male and female subjects, Wooley found that "females scored lower than males on all measures and significantly lower on the posttest of math ability and the CAI attitude instrument" (p. 177). The confounding variable in this study was attitude, which may have interacted with mathematics performance.

Downing and Lowe (1981) in a report examining mathematics anxiety and performance with CAI found that: "Overall math anxiety was not different for males and females, but the performance effects during CAI were different for males and females at comparable levels of anxiety" (p. 5).

It is not surprizing that several CAI studies have attempted to ascertain whether or not the variable "sex" interacts with CAI to produce differing academic performance. The issue of sex-related cognitive differences has received wide attention and has been hotly debated by educators and psychologists. However, although available evidence tends to support the existence of sex-related cognitive differences (Loucks, et al, 1979; Poole, 1971; Witkin, 1979), the issue has not been completely settled and one can still find highly polarized opinions on the subject (i.e. Restak, 1979; Sherman, 1978).

In relation to CAI the results as previously noted are mixed and must await further study before any conclusions may be drawn. However, if sex-related cognitive differences do exist, it is probably more likely that they interact with the content (i.e. reading, mathematics) taught by CAI rather than with the teaching modality itself. Researchers should be cognizant of this in order to make sense out of seemingly contradictory results in future studies.

<u>Sociability</u>. Sutter and Reid (1969) found a significant instructional interaction between the variable "sociability", as measured by the California Psychological Inventory, and CAI achievement. They had divided the CAI subjects into two groups: 1) those who worked their CAI alone; and 2) those who worked their CAI in assigned pairs. Accordingly, they found that: "The higher achiever in the paired group was characterized by high sociability, while the achiever in the alone group was characterized by low sociability" (Sutter & Reid, 1969, p. 155).

Reid and his colleagues (1973) found a significant positive correlation between the variable "sociability", as measured by the Sociability scale of the California Psychological Inventory, and a posttest measurement of achievement in a CAI mathematics program. At first this may seem to contradict the results found in some other studies which measured sociability in independent study situatons. For example, Bigelow and Egbert (1968), who found that subjects with the best attitude toward (satisfaction with) independent study had low scores on the Sociability and Socialization scales of the California Psychological Inventory.

Again, however, the answer to these seemingly contradictory results leads one back to a re-evaluation of the potential instructional interaction. A closer examination in this case suggests that, like the potential interaction for the variable "sex", the interaction of the variable "sociability" is not with CAI per se, but with the design of the CAI experience. Thus, in the case of Reid, et al (1973), students were assigned to work at their CAI experience in pairs and one would expect that in this CAI context higher sociability scores may correlate with achievement. However, working in pairs - although CAI and perhaps even individualized CAI - is not independent study. Therefore, if one were to repeat the experiment with students working alone at the terminals, it would be expected that lower sociability scores would correlate with achievement in this CAI context.

In summary of this section "CAI and Instructional Interactions", it should be noted that several studies have begun to analyze CAI in the context of instructional interactions. However, there remains a great dearth of information in this area. In addition, it seems quite probable that, as more and more educators and administrators become increasingly enchanted with CAI, the need for CAI studies in the context of instructional interactions will continue to become more and more important, while at the same time, becoming less and less noticeable. Increasingly, as computers and their applications, including CAI, become more integrated into our everyday lives, the danger grows that educators will complacently accept as fact the statement that "computers can teach all topics effectively for all students in all contexts".

CHAPTER IV

PROCEDURES AND METHODOLOGY

Subjects

The principal subjects were students enrolled in a required undergraduate pharmacology course at the University of Alberta during the 1979-1980 academic year. Ninety third-year pharmacy students enrolled in Pharmacology 431, "General Pharmacology", were informed about the project and asked to participate on the first day of class. Participation was voluntary and did not directly affect the student's course grade.

Some supplementary measurements were obtained from the principal subjects in the following year (1980-1981). In addition to the subjects involved in the major analyses, ninety-eight third year pharmacy students enrolled in Pharmacology 431 the following year (1980-1981) were asked to complete on a voluntary basis the California Psychological Inventory.

Pharmacy students were chosen as the subjects for this study for four separate but equally important reasons. First, both the students and their administration were willing to voluntarily participate in this project. The next reason was that, from the author's personal experience and an examination of a number of dental, medical, nursing and pharmacy calenders from various universities, it was obvious that pharmacy students received more didactic pharmacology lecture courses than any other single group of students.

Thus, the need for evaluation of CAI in pharmacology appeared to be greatest for pharmacy students. Again from the author's personal experience, it was noted that pharmacy students are extremely diverse in their achievement in the content area of pharmacology. Thus, the pharmacy students should provide subjects from all areas of the spectrum of high, medium and low achievers for analysis in this study. This reason for the choice of pharmacy students was confirmed by discussions with members of the department of pharmacology who confirmed that, in general, pharmacy students could usually be found among the top ten percent and bottom ten percent of pharmacology students. Finally, the last reason was that because of the author's position, in the Faculty of Pharmacy, follow up measurements and access to student records could more easily be obtained.

Steps taken to fulfill the obligations of ethical research and to adequately protect student rights included obtaining approval for this project from: the Dean of the Faculty of Pharmacy, the chairman of the Department of Pharmacology, and the course co-ordinator. In addition, every attempt was made, with the assistance of the course co-ordinator, to ensure that the "normal" teaching/learning situation was not disrupted.

Materials

Computer Aided Instructional Programs

The CAI programs, which were specifically designed and written for this project, were integrated as an adjunct to traditional teaching modalities in the pharmacology course, Pharmacology 431. A variety of CAI programs using various instructional strategies (self-evaluation, simulation, tutorial) were written in the University of British Columbia (UBC) "course-writer" computer language and placed in a program library[5]. This enabled delivery of the programs from the University of Alberta's cental AMDAHL computer via any terminal on campus. The programs were of 15 to 30 minutes duration and utilized an interactive format which required the user to actively participate in order to proceed within the program. The majority of programs followed a similar instructional paradigm and contained three major sections: 1) review questions with feedback; 2) a brief summary of the pharmacology of the drug group being studied; and 3) a list of key words and phrases.

Sections 2 and 3 were primarily didactic textual display reviews which were available to the students as aids in the programs. Section 1, the review questions with feedback, comprised the major portion (approximately 70 to 80 percent) of each program. This section was interactively programmed to have the user actively participate and used

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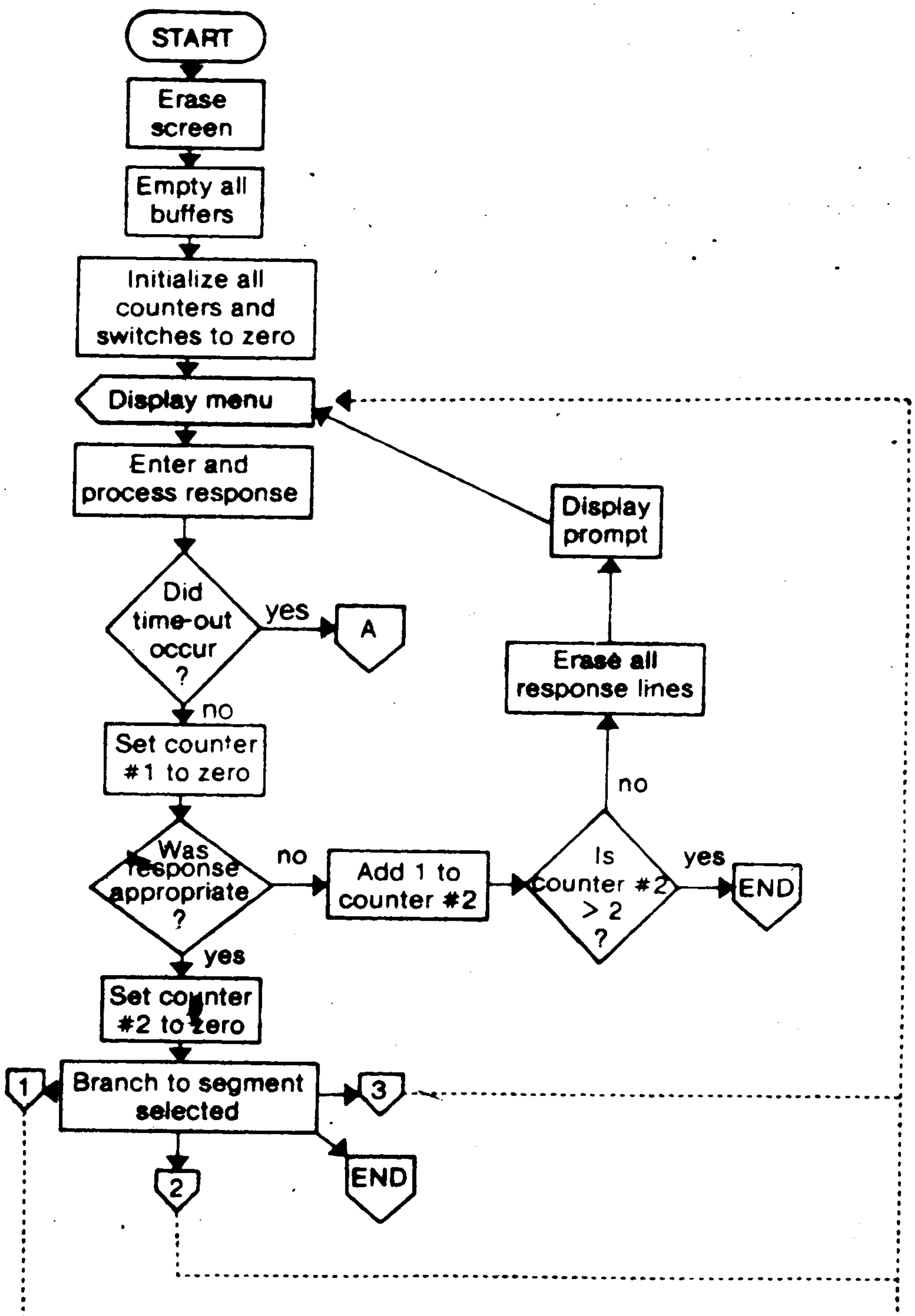
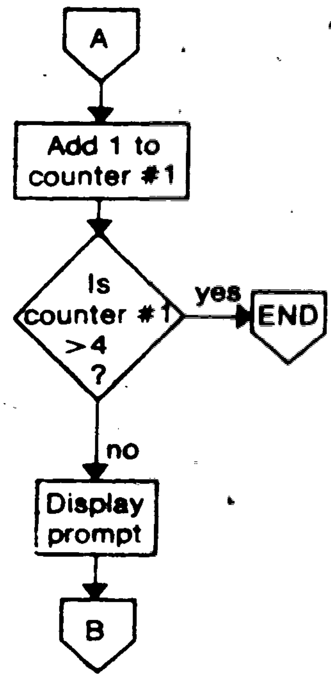
[5] See Appendix I for a complete listing of the CAI programs in pharmacology which were developed and/or modified for this project.

branching pathways to individually tailor feedback in response to user input. A flowchart of the logic and branches used in a prototype program is shown in Figure 1. From this figure it can be seen that the programs were designed to make good use of the limited CAI facilities available on the AMDAHL computer system. The CAI hardware available on the AMDAHL provided no graphics or audiovisual (i.e. cassette tape, film projector, videocassette, videodisc) support or interface. The software utilized allowed single character replies as well as word replies with key-letter answer judging to the the questions posed within the programs. In addition, the students were able to enter up to two lines of comments to the instructor anywhere within the programs, without interrupting course flow, by means of a "hey" command. Correct answer feedback consisted of positive reinforcement and/or positive reply with some additional discussion in about fifty-percent of the cases. Wrong answer feedback consisted of notification of wrong response as well as individual explanation tailored to the response and the same question was then presented again. If another wrong answer was subsequently given to the same question an individual explanation tailored to the response was again given and the student was automatically advanced to either additional discussion (this occurred in about eighty-percent of the cases) or to the next question. Students were entirely free to chose which CAI programs, as well as which parts of the selected CAI programs, they

Figure 1. Flowchart of the logic and branches used in a prototype CAI program



(Figure 1 continued)



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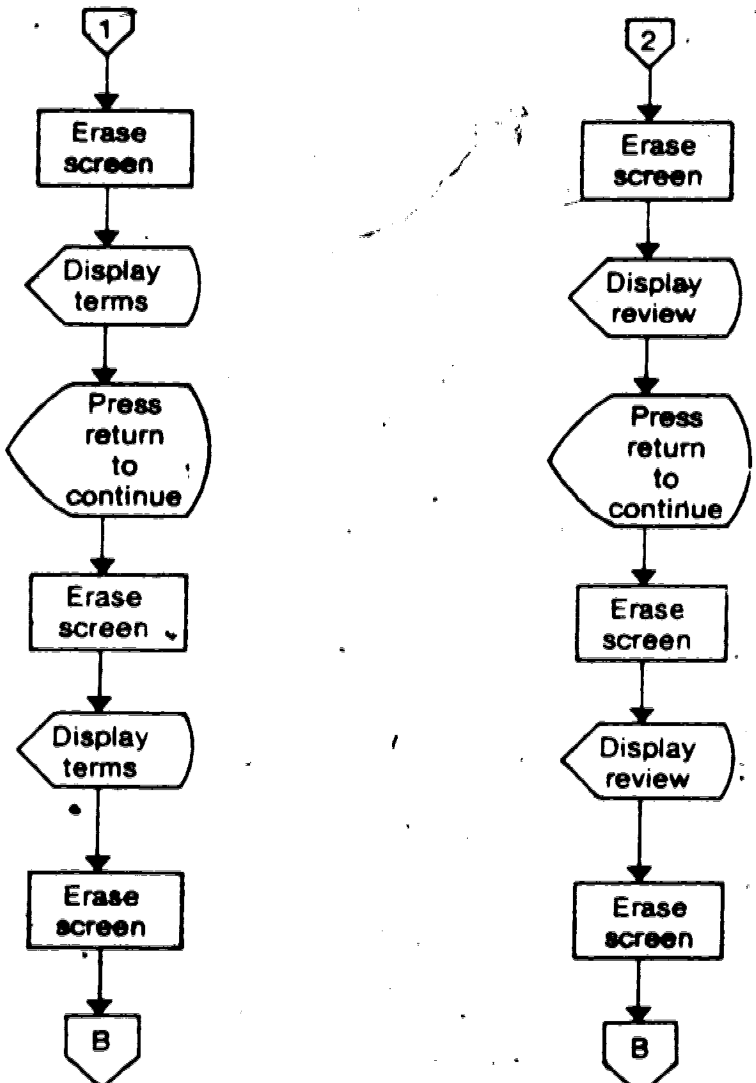

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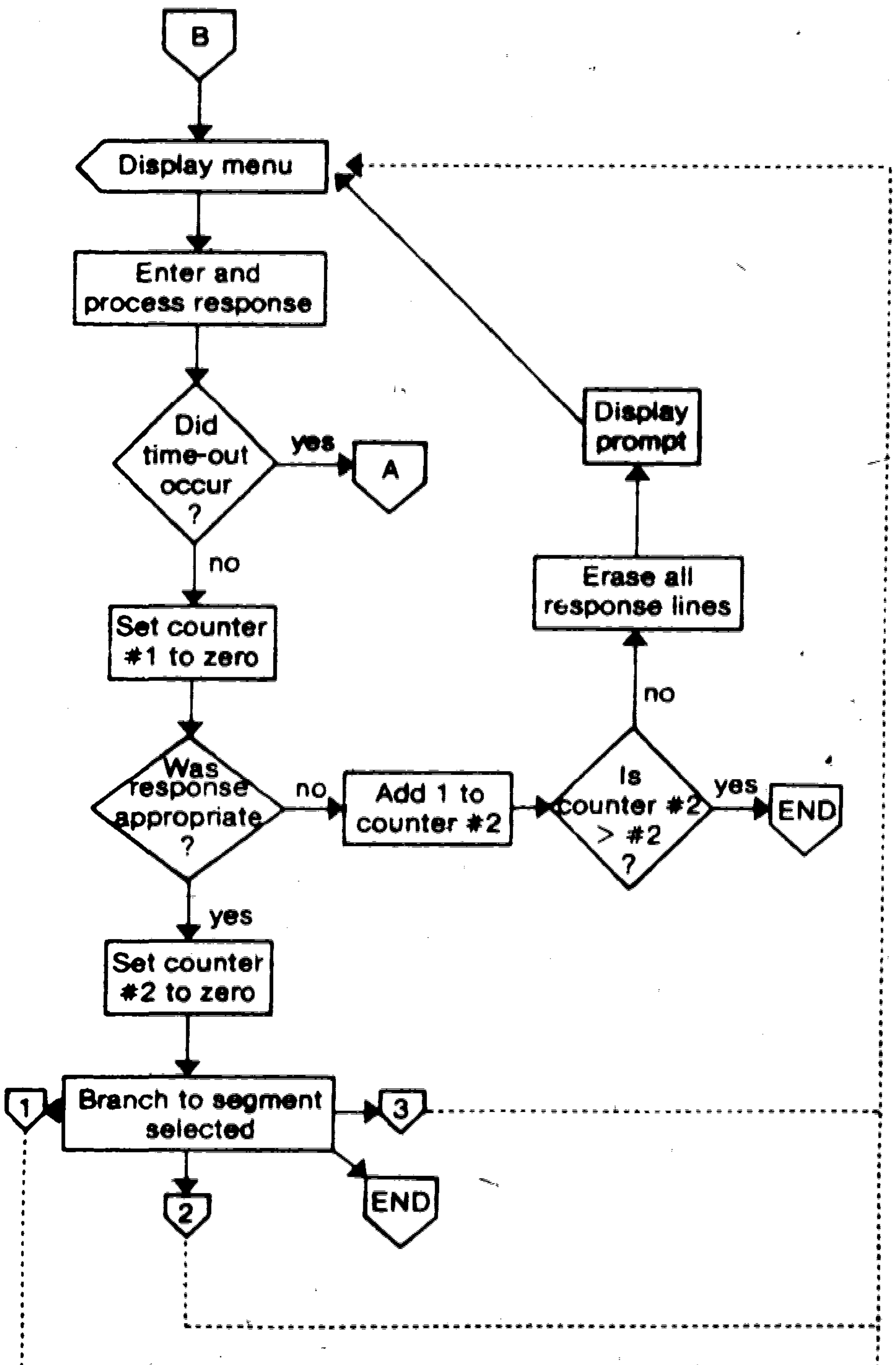

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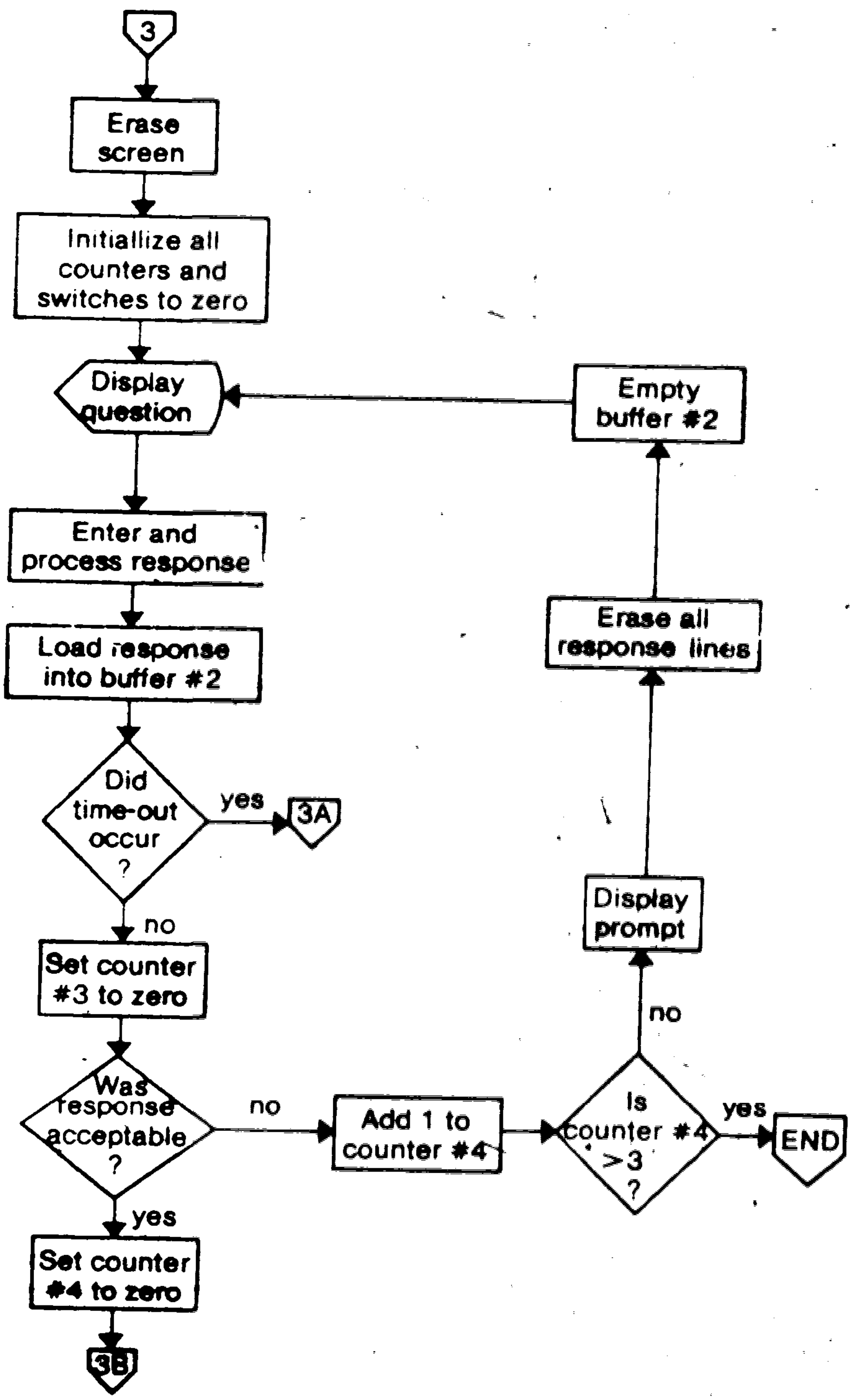

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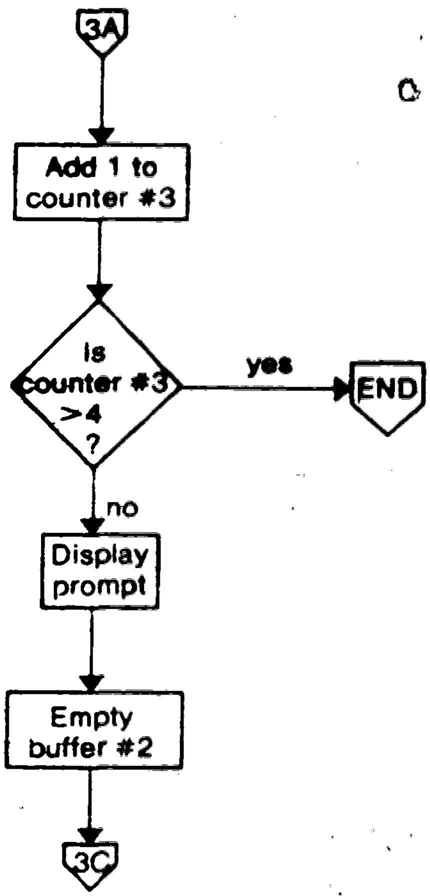

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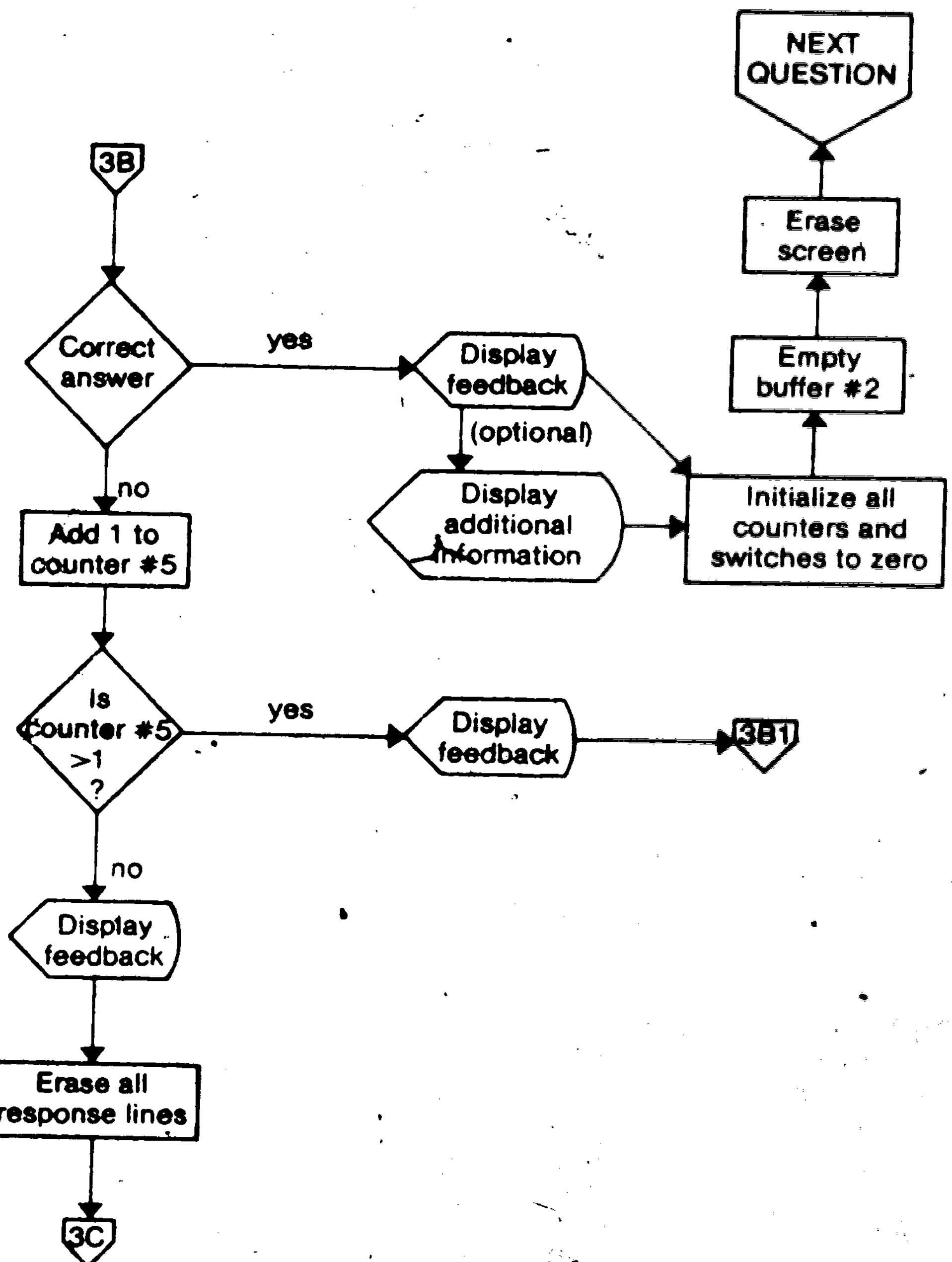

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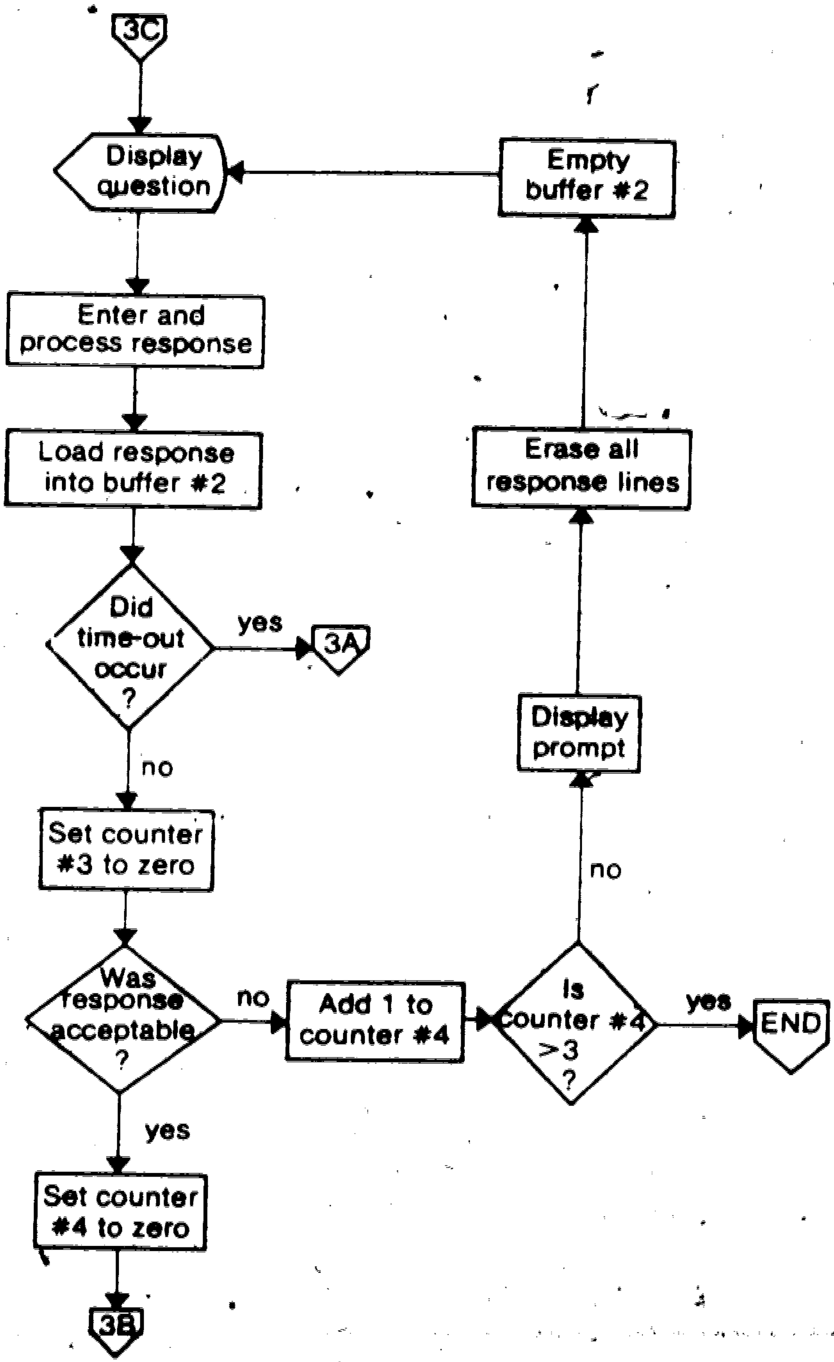

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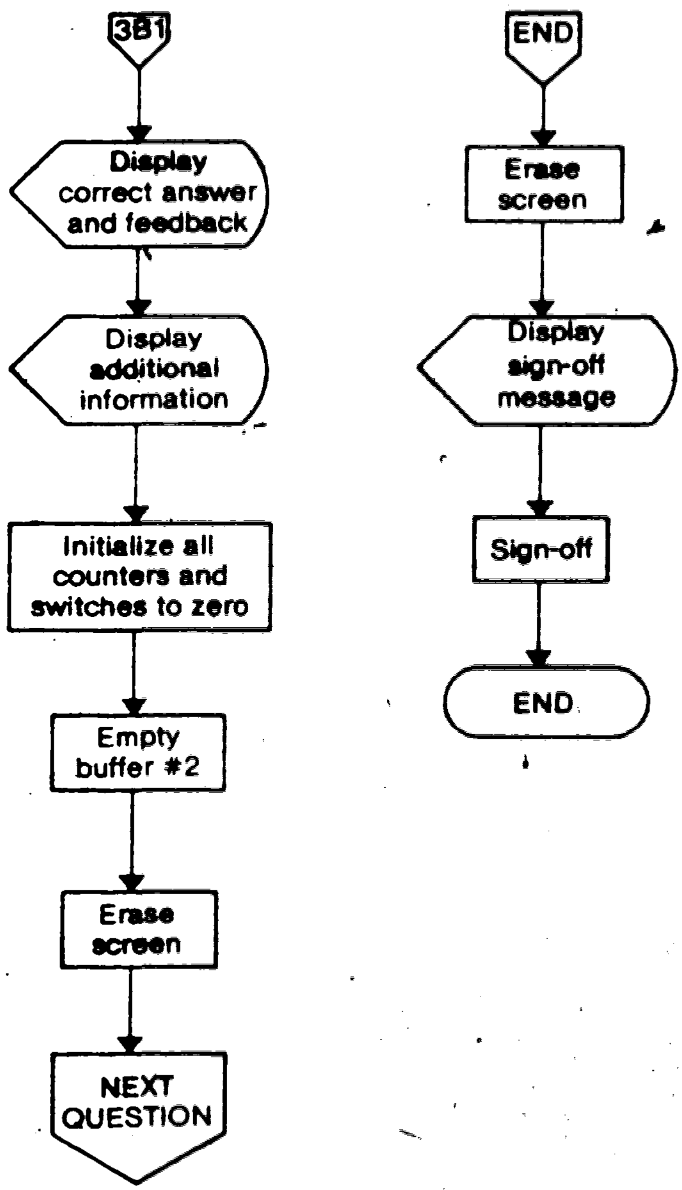
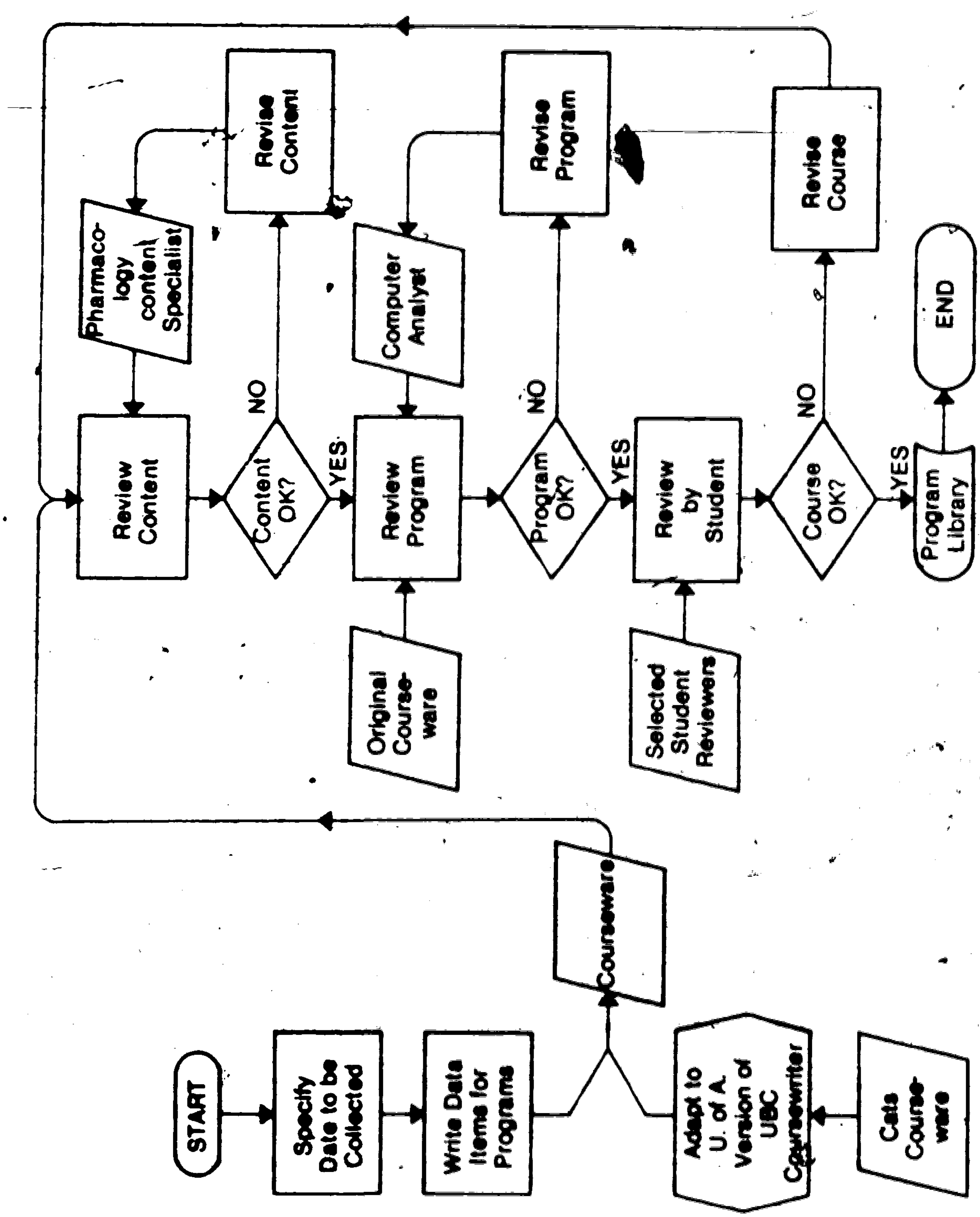


wished to see and complete.

Optimal (state of the art) use of CAI (i.e. entering and advancing students through various pathways by competency or mastery) was not attempted because: this is not the current state of the art for CAI in pharmacology; this would have negated any comparison between CAI and lecture unless a similar format was integrated into the lecture presentation; and it was decided to have the project be as realistic and practical as possible. In addition, it should be noted that the use of specific methods of CAI has not resulted in significantly greater influence on student performance (Hamm, 1975; Kulik, et al, 1980; Wooley, 1978). Thus, the particulars of the CAI presentation should not significantly affect the observed results provided that the material presented was educationally sound and relevant.

Each of the CAI programs underwent an extensive review and revision process before being placed in the program library and released for student use (Figure 2). This process of formative evaluation, which took place during the 1978-1979 academic year, provided a controlled period of CAI program development and testing by project personnel, pharmacology content specialists and selected student reviewers. This in turn allowed adequate time and attention for revisions to both subject matter and computer programming in order to ensure quality CAI program development prior to the start of the experimental portion of this study.

Figure 2. Flowchart of CAI program review and revision process



The students had access seven days a week to any public or teaching terminal on campus. In addition, an area adjacent to the pharmacy student study room in the Dentistry-Pharmacy Center equipped with three "Data Media" terminals, specifically for this project, was available Monday through Friday from 7 a. m. to 7 p. m. as an attempt to provide optimal accessibility for the students.

The subject matter of the CAI programs paralleled the lecture material in Pharmacology 431. The program name and the number of hours of use for each program were automatically recorded and updated for each student as s/he signed onto and off of the computer.

Attitude Questionnaires

Six major types of verbalized scales have been developed and used to measure attitudes. These are the: anticedents/consequents scale; behavioral differential scale; Likert scale; Q-Sort scale; semantic differential scale; and Thurston scale. The scale chosen for use in this project was the semantic differential. The semantic differential type of scale was developed by Osgood (1952) and provides a direct rating of attitudes with scales anchored on the extremes by bipolar adjectives. This scale uses face validity, that is the distinctions provided by the instrument correspond with those which would be made by most observers without the instrument. A seven point scale tends to provide optimal differentiation and approximately equal frequency of use among the seven alternatives (Nunnally, 1978; Osgood, 1958) and was thus used in the present study.

A specially designed questionnaire (Figure 3) was used to assess student attitude towards the concept of CAI. The questionnaire consisted of a list of twenty bipolar adjective pairs (scales) which the students rated on a seven point semantic differential scale. Three major factors (dimensions) were incorporated into this questionnaire: 1) evaluation (bipolar adjective pairs #1, 2, 4, 6, 9, 11, 15, 16, 18, 19); 2) anxiety (bipolar pairs # 3, 7, 10, 13, 17); and 3) familiarity (bipolar adjective pairs #5, 8, 12, 14, 20). The factors were based on those described in the literature.

The evaluation factor (Osgood, Suci & Tannebaum, 1957) was considered to be the most important factor as it relates closer than any other factor to the definition of attitude (Nunnally, 1973). Thus, ten of the twenty scales in this questionnaire were devoted to the factor of evaluation.

The anxiety factor was created by modifying the activity factor of Osgood, Suci and Tannebaum (1957). This was accomplished by careful selection of the bipolar adjective pairs for the five related scales in order to integrate a component of anxiety into the activity factor. This was done in order that it might be determined if anxiety affected student performance in the CAI programs in pharmacology and to observe if any changes occurred in these scales during the course of the project.

Figure 3. CAI Attitude Questionnaire

Computer Aided Instruction Attitude Questionnaire[1]

Student ID#__________ Date______________

(Please Circle your desired response)

Computer Aided Instruction is:

1. Boring	1	2	3	4	5	6	7	Interesting
2. Valuable	1	2	3	4	5	6	7	Worthless
3. Disturbing	1	2	3	4	5	6	7	Undisturbing
4. Appropriate for Teaching Pharmacology	1	2	3	4	5	6	7	Not Appropriate for Teaching Pharmacology
5. Simple	1	2	3	4	5	6	7	Complex
6. Bad	1	2	3	4	5	6	7	Good
7. Calm	1	2	3	4	5	6	7	Anxious
8. Mysterious	1	2	3	4	5	6	7	Understandable
9. Unpleasant	1	2	3	4	5	6	7	Pleasant
10. Tense	1	2	3	4	5	6	7	Relaxed
11. Fair	1	2	3	4	5	6	7	Unfair
12. Usual	1	2	3	4	5	6	7	Unusual
13. Restful	1	2	3	4	5	6	7	Nervous
14. Confusing	1	2	3	4	5	6	7	Clear
15. Useful	1	2	3	4	5	6	7	Useless
16. Negative	1	2	3	4	5	6	7	Positive
17. Apprehensive	1	2	3	4	5	6	7	Non-apprehensive
18. Ineffective	1	2	3	4	5	6	7	Effective
19. Quick	1	2	3	4	5	6	7	Slow
20. Unfamiliar	1	2	3	4	5	6	7	Familiar

[1] The numbering of the bipolar pairs of adjectives is for identification purposes of this thesis and did not appear on the forms which the students completed.

The final factor, familiarity, originally called understandability (Nunnally, 1961), was chosen to help measure the validity of the questionnaire. It was expected that as the subjects proceeded through the project they should become more familiar with CAI and that this should be reflected in the familiarity scales (Nunnally, 1978) of the attitude questionnaire if it was a valid and sensitive measure of attitudes.

It should be noted that some individuals question the ability of the semantic differential technique to measure "meaning" in a linguistic sense, as it was originally purported to do by Osgood, Suci and Tannebaum (1957). Carroll (1969), for example, noted that: "the semantic differential might better be termed an experiential differential". Thus, rating the noun "dog" in relation to bipolar adjective pairs (i.e. big/little, good/bad) might actually result in the rater interpreting that: the dog is big (not little); etc. and would thus reflect the particular individual's experience with "dogs" or a "particular dog". However, because this project is not directly interested in the measurement of "meaning", but is concerned with applying the semantic differential to measure attitude, it does not matter whether one interprets the semantic differential as measuring "meaning" or "experience" as it still remains a widely tested and highly satisfactory method of measuring attitudes and thus meets the requirements of this project.

The attitude questionnaire was administered at the first lecture session prior to the description of the project and again at the last session so that the effect of the CAI program in pharmacology on student attitude toward CAI could be determined. The questionnaire was also re-administered a third time during the 1980-1981 academic year in order to evaluate the stability of the measured attitudes.

In order to identify the questionnaires so that paired first, second, and third attitude questionnaire results could be analyzed, the students were asked to insert their unique computer identification number on the questionnaires. This same identification number was used throughout the project whenever data was collected from the students.

California Psychological Inventory

The California Psychological Inventory (CPI) is a specially designed tool used to assess various psychological variables. The test consists of 480 true-false questions measuring 18 scales [dominance (Do), capacity for status (Cs), sociability (Sy), social presence (Sp), self-acceptance (Sa), sense of well-being (Wb), responsibility (Re), socialization (So), self-control (Sc), tolerance (To), good impression (Gi), communality (Cm), achievement via conformity (Ac), achievement via independence (Ai), intellectual efficiency (Ie), psychological-mindedness (Py), flexibility (Fx), femininity

(Fe)] which have been widely researched and found to be adequate in terms of validity and reliability (Gough, 1975; Megargee, 1972).

The purpose of each scale is to predict what an individual will do in a specified context and/or to identify individuals who will be described in a certain manner. Gough's criteria for scale validity were that: 1) the scale must be able to identify individuals who behave in a specific manner; and 2) individuals with high scores on a particular scale must impress others as having the quality which the scale describes. Appendix II and Appendix III contain a list of adjectives which describe high and low scoring men and women respectively on the eighteen scales of the CPI. Underlying these scales are four broad categories which are listed in Table 5.

This inventory yielded specific psychological variables which were analyzed for correlation with CAI performance. A baseline for comparison of the psychological variables of the pharmacy students in this study with that which was reported in the literature for other pharmacy students was also provided by this inventory.

In addition, this inventory was used to determine the "psychological" representativeness of the pharmacy students participating in the study by comparing the mean scores obtained on the eighteen scales in two successive third year pharmacy classes at the University of Alberta.

Table 5. Categories and Scales of the California Psychological Inventory.

Category I. Measures of Poise, Ascendancy, Self-Assurance, and Interpersonal Adequacy

1. Do Dominance
2. Cs Capacity for status
3. Sy Sociability
4. Sp Social Presence
5. Sa Self-acceptance
6. Wb Sense of Well-being

Category II. Measures of Socialization, Responsibility, Intrapersonal Values, and Character

7. Re Responsibility
8. So Socialization
9. Sc Self-control
10. To Tolerance
11. Gi Good impression
12. Cm Communality

Category III. Measures of Achievement Potential and Intellectual Efficiency

13. Ac Achievement via Conformance
14. Ai Achievement via Independence
15. Ie Intellectual Efficiency

Category IV. Measures of Intellectual and Interest Modes

16. Py Psychological-mindedness
17. Fx Flexibility
18. Fe Femininity

The CPI was selected over other "psychological" tests because: 1) it is useful in normal individuals from many cultures (i.e. university students); 2) it has been extensively cross-validated and tested in high school and college students (i.e. appropriate age group for the subjects of this study); 3) it measures various traits which are of interest in this project (i.e. achievement via independence, responsibility, socialization); 4) the questions, although sometimes dated, are less objectionable to users than those found on some other forms (i.e. should thus increase compliance); 5) much comparative data is available (i.e. should thus facilitate interpretation); 6) ease of scoring (i.e. true or false); 7) reading level is quite easy (4th grade level); 8) it has been designed for group administration (i.e. booklets, answer sheets and scoring guides are available); and 9) there is no time limit (although most students finish within one hour). This last feature, completion within one hour, was especially important because if the inventory had taken significantly longer to complete (i.e. 4 hours) it would not have been practical to use it in this project.

Previous studies (Domino, 1968; Bigelow & Egbert, 1968) have shown that performance in independent study and programmed instruction correlated with the following CPI measures: high Ai, Re and Ie; and low So and Sy. It was therefore anticipated that similar correlations should be noted for those students who performed well with the CAI programs in pharmacology.

CAI Evaluation Form

Specific questions regarding the use of and attitude towards CAI in pharmacology were developed (Figure 4) and administered at the end of the 1979-1980 academic term. This allowed the collection of answers to open ended questions and comments regarding the student attitudes towards CAI which were used to elaborate upon and help validate the data collected via the closed ended attitude questionnaires.

It was, also anticipated that use of this form would facilitate comparison of the results obtained from other CAI studies which used similar course evaluation forms to measure student attitudes towards CAI.

Academic Performance Tests

In order to objectively measure academic achievement in relation to the instructional modality used (i.e. CAI alone, CAI concurrent with lecture, lecture alone) pretests and posttests on a selected pharmacology topic, "autonomic nervous system pharmacology", were constructed. Autonomic nervous system pharmacology was specifically chosen for analysis in this project because of its difficulty. It has been noted by the author and confirmed by discussions with various members of the department of pharmacology that most students find autonomic nervous system pharmacology to be relatively more difficult than other pharmacology topics. It

Figure 4. CAI evaluation form

Computer Aided Instruction (CAI) Evaluation

1. Overall how would you rate the computer programs in pharmacology that you used this term?

Poor			Average			Excellent
1	2	3	4	5	6	7

Comments: ______________________________________

2. Were the programs of use in organizing your study or finding areas where you needed more work?

Useless					Extremely Helpful	
1	2	3	4	5	6	7

Comments: ______________________________________

3. Given the "opportunity" to "repeat" this year (or take a similar course in the future) would you like to have more computer aided instructional programs like the ones used this term integrated into your pharmacology course?

YES NO

Comments: ______________________________________

(Figure 4 continued)

4. Should computer programs focus on ________?

Review of Material   Teaching New Material   Both

Comments: ________________________________

5. Which topics would you like to see taught (or not taught) by computer and why?

Comments: ________________________________

____

6. Please make any other comments you wish regarding the computer aided instructional programs used this term. (i.e., were any programs particularly good or bad? Did the programs complement the lectures? etc.).

____

____

____

____

____

____

was, therefore, anticipated that if CAI could be demonstrated to be effective in teaching this difficult pharmacology topic, then it probably would be as or more effective with easier pharmacology topics.

Each pretest and posttest consisted of fifteen multiple choice questions on this topic (Figure 5). These tests were randomly generated and printed for each student by the AMDAHL computer from a pooled data bank containing 150 questions for the topic and were administered in paper and pencil format. The data bank of questions was created and reviewed by the course coordinator, the principal investigator, and by a subject matter expert in the department of pharmacology for content accuracy and in order to ensure: that the material covered in the questions was presented in both the CAI and the lecture sessions; and that the questions were not presented verbatim in either the CAI or the lecture sessions.

The academic achievement tests were also used as a measure of long term retention of pharmacology knowledge.

Mega Interactive Model of Instruction

The Mega Interactive Model of Instruction (MIMI) has been proposed by Pagliaro (1979) as the basis for a conceptual framework with which to study and interpret instructional interaction research.

The model (Figure 6) considers instructional interactions as comprising a unit coterie (UC) of the

Figure 5. Example of randomly selected questions and format used to test academic performance in the topic autonomic pharmacology

For each of the following multiple choice questions, choose the most appropriate answer.

1. Each of the following is a characteristic of the indirectly acting sympathomimetic amines except:
   a. tachyphylaxis
   b. potentiation of actions by monamine oxidase inhibition
   c. absence of an alcoholic hydroxyl group
   d. prominent central nervous system effects
   e. potentiation of effects of cocaine

2. Adrenalin:
   a. is often combined with local anesthetics to prolong their action
   b. relaxes bronchial smooth muscle
   c. stimulates the gastrointestinal tract
   d. a and b above
   e. b and C above

3. Reduces noradrenaline in nerve terminals:
   a. morphine
   b. cocaine
   c. reserpine
   d. chlordiazepoxide
   e. chloral hydrate

4. Ganglionic blocking agents are known to potentiate the rise in blood pressure produced by a variety of pressor agents. This is due to:
   a. release of catecholamines by ganglionic blocking agents
   b. a cocaine-like action of ganglionic blocking agents
   c. blockade of compensatory cardiovascular reflexes which otherwise serve to attenuate the rise in blood pressure produced by the pressor agents
   d. their muscarinic effect
   e. a direct effect on the sympathetic blood pressure receptors

Figure 6. Mega Interactive Model of Instruction

instructional process. Four major variable[6] dimensions are involved in this model: 1). the instructor variable dimension; 2) the learner variable dimension; 3) the instruction/content/context variable dimension; and 4) the time variable dimension. In addition, the variables within each dimension are capable of interacting so that ultimately the unit coterie is comprised of interacting subsets of the four variable dimensions (i.e. Is, Ls, ICCs and Ts). Fundamentally and mechanistically this model can be considered as a variant of the basic four-way analysis of variance in which the four dimensions have been defined as above.

The individual and distinct natures of the unit coteries create an inherent amplitude of flexibility in the model. This allows for all possible permutations of combinations of the interacting subsets and for the notion that the weightings (importance) as well as the members of the interacting subsets can vary from unit coterie to unit coterie. As such, MIMI provides a much broader and more general focus than does ATI (or TTI) which focus primarily upon treatment. MIMI goes beyond treatment to describe and suggest analysis of the underlying variables which are responsible for or contribute to a particular observed II.

Instructional interactions in the context of this model are no longer considered in terms of a two dimensional

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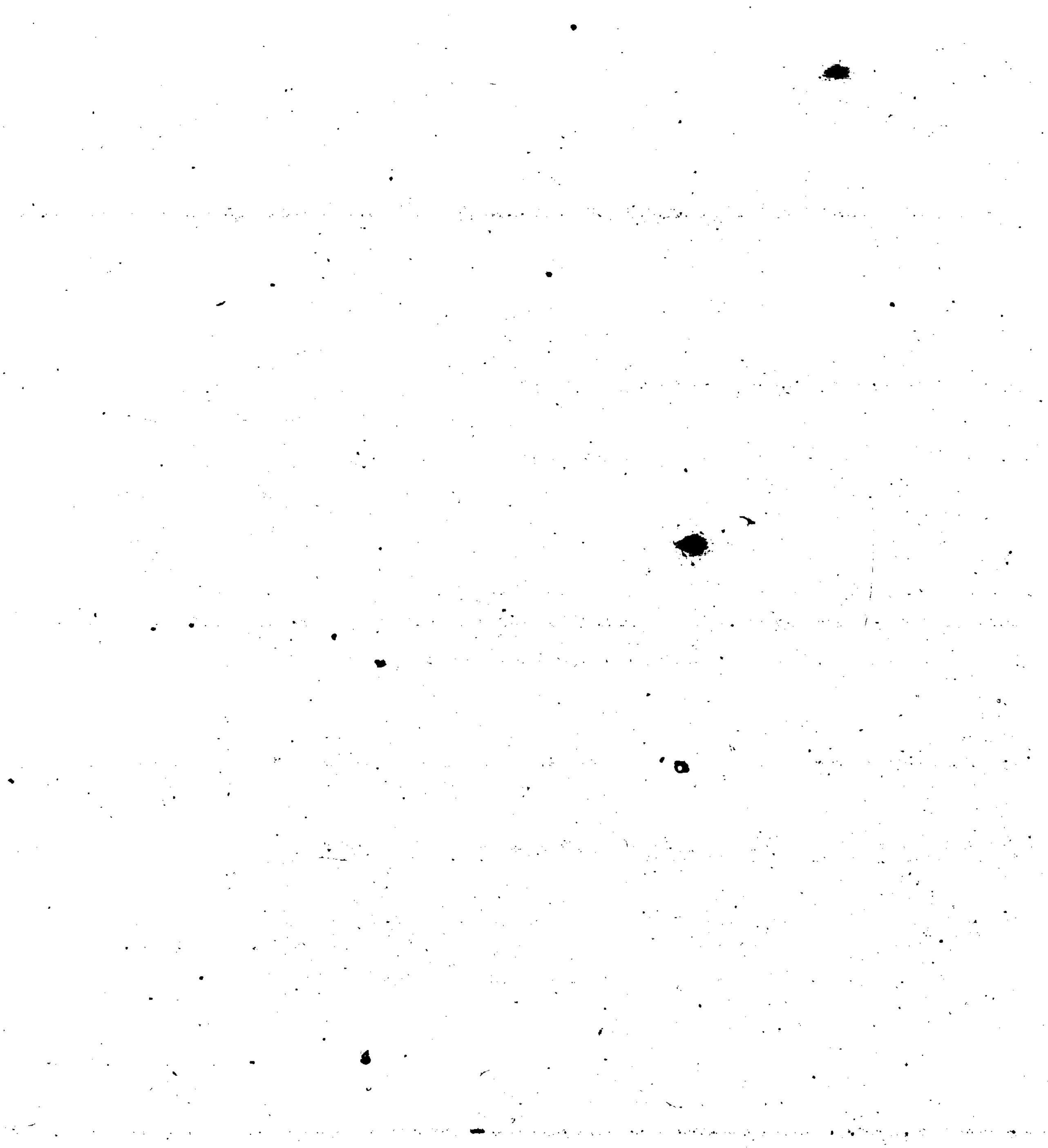
[6] The word variables is used here as a general inclusive term for what has been labeled at various times in the literature as: abilities, aptitudes, attributes or traits.

ordinal versus disordinal analysis as originally proposed by Cronbach (1957) and Lubin (1961), but are analyzed in relation to the unit coterie (Pagliaro, 1979). According to this model (Figure 7), the mean performance rating and the 95 percent confidence intervals for the mean are calculated for the subjects in the unit coteries under study. The 95 percent confidence interval lines are then extended from 0 to N unit coteries, and if any portion of the 95 percent confidence interval intersects another 95 percent confidence interval, these unit coteries are considered equivalent in relation to performance and no interaction is said to have occurred. If, however, the 95 percent confidence interval does not intersect a 95 percent confidence interval of another unit coterie, then an interaction is said to have occured.

MIMI also provides a useful framework for instructional designers. Instructional designers need not be limited to one dimension in which changes can be made in order to increase performance, but may use all four of the model's dimensions. Thus, for example, a change in method of instruction in order to achieve a certain increase in performance may be more "economically" obtained by an appropriate change (or changes) in the instructor, learner, and/or time dimensions. This provides instructional designers with a plethora of potentially viable options for each instructional problem limited only by their resourcefulness and ingenuity.

Figure 7. Instructional interactions in the Mega Interactive Model of Instruction



This model was developed with this project in mind in order to: illustrate the use of the descriptive, predictive and diagnositic aspects of MIMI; demonstrate how MIMI can be applied to real data from an instructional interaction study; and help explain the mixed results obtained from previous CAI studies in pharmacology.

Procedure

Description of the Design

This project was designed to obtain measurements of several types of variables including: achievement; retehtion; various demographic variables; and various psychological variables. A descriptive checklist of this study's experimental features is found in Table 6.

At the first lecture session of the 1979-1980 academic year, the students completed the attitude questionnaire pretest and were oriented to the use of CAI. At this time they were randomly assigned to one of three groups in order to assess the effect of CAI alone (T1), CAI concurrent with lecture (T2), and lecture alone (T3) (See Figure 8). A unique student computing services identification number and password were given to each student at this session. They were also given a timetable indicating at which times (according to group) they had access to the CAI programs.

In order to reduce noncompliance (i.e. a student letting another student use his/her identification number or not using the computer programs during the specified times)

Table 6. Descriptive list[1] of this study's experimental features

Variables measured

Achievement
Retention
Demographic variables
Personologic variables

Methodological features

Random assignment of comparison groups
- Yes

Control for instructor effect
- Same instructor

Control for historical effect
- Same semester

Control for scoring bias in criterion
- Objective test

Control for author bias in criterion
- Instructor developed test
- Commercial standardized test

Ecological conditions

Duration of treatment
- Whole semester

Course level
- Introductory

Content emphasis on "hard" discipline
- Hard (pharmacology)

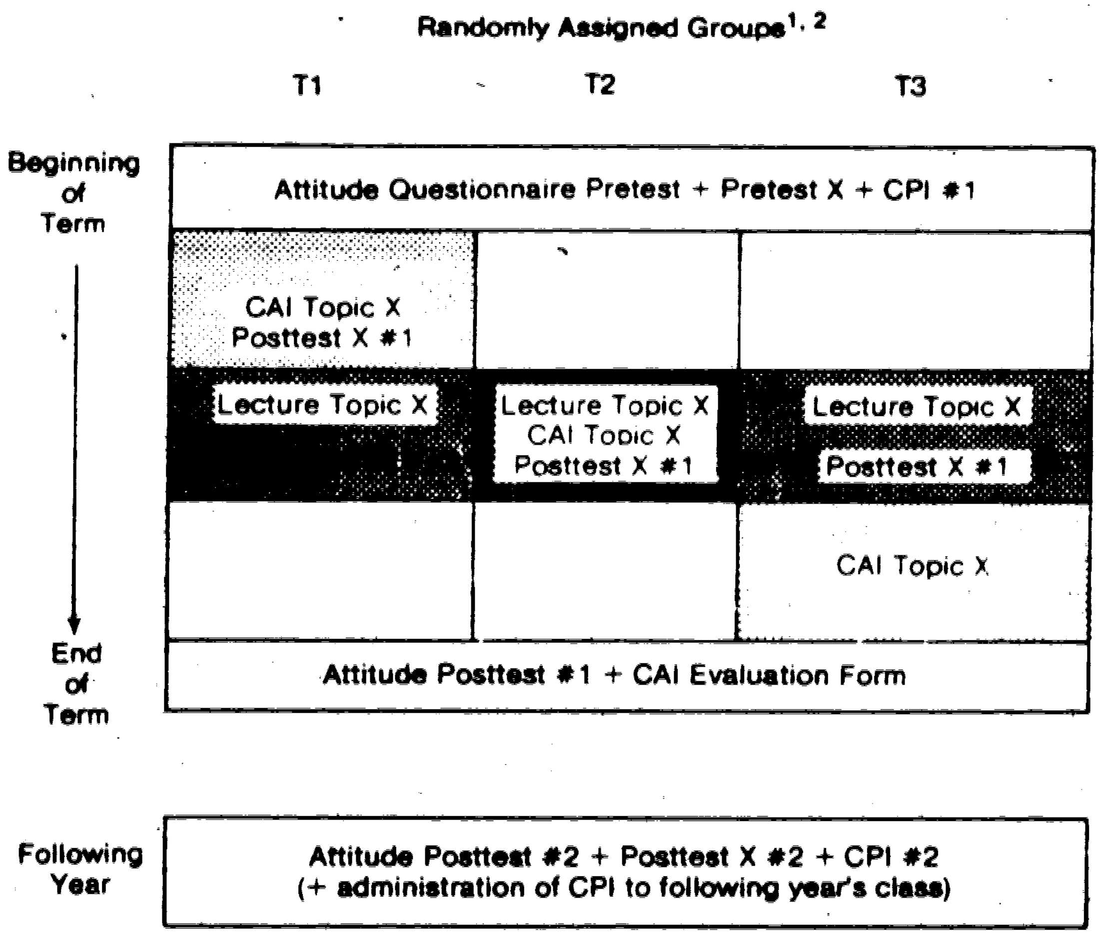
Content emphasis on "pure" knowledge
- Pure

University setting

Doctorate-granting institution

[1] Modified from Kulik, et al (1980)

Figure 8. Experimental design of this project



[1]T1 is CAI alone; T2 is CAI concurrent with lecture; and T3 is lecture alone.

[2]Except for the information denoted within parentheses, all of the information presented in this figure refers to the principal subjects of this study.

denotes CAI in Topic X

denotes Lecture in Topic X

the course coordinator informed the students during the first session of: the nature of the project; benefits for the students; and the contributions the students could make by their participation and compliance. It was also pointed out that although access to some programs would be delayed for some students, all students would have an opportunity for adequate exposure to all programs prior to their course examinations.

A pretest (pretest X)[7] to measure student academic performance in a selected pharmacology topic, "autonomic nervous system medications" (denoted by "Topic X" in the experimental design), was also administered to all students during the first lecture session. Posttests on this material were administered as the students, according to treatment group, completed the topic at the time listed in the experimental design (Figure 8). During this term, the subjects also completed a California Psychological Inventory (CPI #1). At the end of the first term, the students completed the attitude questionnaire posttest #1 and the CAI evaluation form.

During the following academic year (1980-1981), the principal subjects, now fourth year pharmacy students, were readministered the California Psychological Inventory (CPI #2) in order to measure the test-retest reliability of the CPI and to indicate whether it measured state or trait

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[7] The X refers to the topic "autonomic pharmacology" and is used throughout this thesis to help distinguish the academic performance tests from other measures.

variables. The attitude questionnaire posttest #2 was administered at this time in order to measure changes in attitude which may have occurred during the intervening year. At this time the subjects were also administered another academic achievement posttest (posttest X #2) in order to measure long term retention of knowledge in the selected pharmacology topic, "autonomic nervous system pharmacology". The second academic achievement posttest was generated and administered in the same manner as the previous posttest. At this time, the current third year pharmacy class was administered the CPI.

Analysis of the Results

Data was derived from six major sources: 1) academic performance tests; 2) California Psychological Inventory; 3) attitude questionnaires; 4) CAI evaluation forms; 5) student university records; and 6) automatic computer data collection records.

The primary source of data was the academic performance tests (i.e. pretest X, posttest X #1, posttest X #2). For the sake of clarity these tests are also referred to in the next chapter as "occasion 0, 1 and 2" respectively.

This data was analyzed using a 2-way analysis of variance (DERS computer programs ANCV25 and ANOV26)[a] and a

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[a] "DERS computer programs" refer to computerized statistical analysis packages prepared by and available from the Division of Education Research Services, University of Alberta.

3-way analysis of variance (DERS computer program ANOV30) Pearson correlations (DERS computer program DEST02) and multiple correlation and regression analysis (DERS computer programs MULR05 and MULR06) were also performed. This enabled the determination of the degree of correlation between specified predictor and criterion variables as well as the significance of contribution of each predictor variable to the multiple correlation equation.

The second major source of data, the California Psychological Inventory (CPI), yielded mean scores for 18 specific psychological variables which were analyzed for correlation with: academic achievement; retention; and attitude towards CAI (DERS computer programs DEST02 and MULR05).

The next major sources of data were the paired attitude questionnaires and the CAI evaluation forms. This data, analyzed using Pearson and multiple correlations (DERS computer programs DEST02 and MULR05), was further analyzed to determine which items drew together to form factors (DERS computer programs SEMD01 and FACT20). The SEMD01 program also yielded information regarding the potential bias or response set in the semantic differential attitude questionnaire. A two way analysis of variance (DERS computer program ANOV26) was performed with each scale of the attitude questionnaire in order to verify for this study the use of Snider and Osgood's (1969) criteria for the determination of significant changes when using a semantic differential questionnaire. This analysis also determined if the recorded attitude scores were significantly different from zero.

The final sources of data were: the student university records from which information regarding previous academic achievement (i.e. grade point average) and demographics (i.e. age, race, sex) was obtained; and the automatic computer data collection records which recorded both the name of the CAI pharmacology programs used and the amount of time spent on each program by each individual student. Pearson and multiple correlations were also performed with these sets of data (DERS programs DEST02 and MULR05).

For the purpose of analyzing, interpreting and reporting the data related to this project an arbitrary probability (p) level was chosen. The value used for this study to determine statistical significance was $p<0.05$, which is a value commonly used in the literature. As this level was chosen prior to the analysis of the data, and in order to present the obtained results in an organized, logical and consistent fashion, probabilities are always referred to in this report in relation to the 0.05 level. In other words, regardless of whether the probability generated by a particular test was 0.04 or 0.00004 it is referred to and identified in this thesis as $p<0.05$. Likewise, any probability generated which was greater than or equal to 0.05 ($p>0.05$), whether 0.05 or 0.95, was defined as denoting lack of statistical significance in the associated test.

CHAPTER V

RESULTS

Participation

Ninety third year pharmacy students enrolled in Pharmacology 431 (1979-1980) were asked to participate in the research project on the first day of class. Seventy-five of these students (83%) agreed to participate and were randomly assigned to one of three experimental groups. All the volunteers remained in the study for its duration, however, due to various reasons the data collected from fourteen of these volunteers was incomplete and these individuals were therefore not used in the major analyses. The results of the major analyses reported in this chapter, unless otherwise noted, were thus based upon data collected from the sixty-one volunteers for whom complete sets of data were available.

Ninety-eight pharmacy students from the following third year class (1980-1981) were asked to complete a California Psychological Inventory (CPI). Eighty-six of these students (88%) agreed to participate and completed the CPI.

Academic Performance Tests

The first group of analyses were performed to study academic achievement. Table 7 lists the obtained Pearson product-moment correlation coefficients for all the variables measured at the start of this project and posttest X #1 performance. Correlations are presented for the three

Table 7. Pearson product-moment correlation coefficients (r) for all variables measured at start of project with posttest X #1 performance (academic achievement)

Variable 1	Variable 2	Observed (r) Combined (n=61)	T1 (n=20)	T2 (n=21)	T3 (n=20)
Posttest X #1	sex	-.18	-.33	-.02	-.23
Posttest X #1	age	-.17	-.69*	.21	-.31
Posttest X #1	race	.01	-.03	-.02	.01
Posttest X #1	grade point average	.27*	.32	.24	.30
Posttest X #1	pretest X	.18	.32	.06	.15
Posttest X #1	hours of CAI use in topic X	.28*	.32	.39	.29
Posttest X #1	hours of CAI use total	.30*	.37	.48*	.22
Posttest X #1	midterm grade	.22	.23	.30	.24
Posttest X #1	CPI "dominance"	-.04	-.24	-.04	.11
Posttest X #1	CPI "capacity for status"	-.13	-.31	.05	-.17
Posttest X #1	CPI "sociability"	-.16	-.25	-.28	.00
Posttest X #1	CPI "social presence"	-.08	-.17	-.17	-.01
Posttest X #1	CPI "self-acceptance"	-.13	-.27	-.08	-.13
Posttest X #1	CPI "sense of well-being"	-.09	-.13	-.28	-.06
Posttest X #1	CPI "responsibility"	-.18	-.32	-.21	-.06
Posttest X #1	CPI "socialization"	.01	-.06	.00	.07
Posttest X #1	CPI "self-control"	-.05	.22	-.37	.07
Posttest X #1	CPI "tolerance"	-.13	-.13	-.46*	.25
Posttest X #1	CPI "good impression"	-.14	.07	-.56*	.12
Posttest X #1	CPI "communality"	.08	-.39	.23	.51*
Posttest X #1	CPI "achievement via conformity"	.00	.27	-.37	.08
Posttest X #1	CPI "achievement via independence"	.12	.11	.06	.22
Posttest X #1	CPI "intellectual efficiency"	-.06	-.20	-.08	.03

(Table 7 continued)

Posttest X #1 CPI "psychological mindedness"	.08	.08	.03	.10
Posttest X #1 CPI "flexibility"	.03	.33	.10	-.23
Posttest X #1 CPI "femininity"	.07	.04	.15	.11
Posttest X #1 SD "boring-interesting"	-.14	.18	-.47*	-.06
Posttest X #1 SD "valuable-worthless"	.04	-.24	.48*	-.07
Posttest X #1 SD "disturbing-undisturbing"	-.08	.22	-.35	-.11
Posttest X #1 SD "appropriate-not appropriate"	.10	.01	.40	-.11
Posttest X #1 SD "simple-complex"	.01	.11	-.03	-.07
Posttest X #1 SD "bad-good"	-.16	.24	-.56*	-.06
Posttest X #1 SD "calm-anxious"	-.06	-.15	.22	-.28
Posttest X #1 SD "mysterious-understandable"	-.13	-.01	-.68*	-.13
Posttest X #1 SD "unpleasant-pleasant"	-.09	.28	-.38	-.07
Posttest X #1 SD "tense-relaxed"	.13	.30	-.05	.12
Posttest X #1 SD "fair-unfair"	.07	.02	.18	.00
Posttest X #1 SD "usual-unusual"	.07	.32	.27	.21
Posttest X #1 SD "restful-nervous"	.09	.14	.27	-.16
Posttest X #1 SD "confusing-clear"	-.16	.04	-.42	.06
Posttest X #1 SD "useful-useless"	-.10	-.27	.45*	-.35
Posttest X #1 SD "negative-positive"	-.04	.38	.00	-.34
Posttest X #1 SD "apprehensive-non-apprehensive"	.15	.34	-.25	.34
Posttest X #1 SD "ineffective-effective"	-.03	.10	-.21	.09
Posttest X #1 SD "quick-slow"	.02	-.23	.16	.05
Posttest X #1 SD "unfamiliar-familiar"	.28*	.61*	-.23	.54*

T1 is CAI alone; T2 is CAI concurrent with lecture; and T3 is lecture alone.
CPI - California Psychological Inventory #1
SD - Semantic differential attitude questionnaire pretest
*Correlations which are significantly different from zero.

treatment groups both combined and separately. Significant individual correlations are noted. Four variables (grade point average, hours of CAI use in topic X, hours of CAI use total, - "unfamiliar-familiar" attitude scale) had a statistically significant correlation with posttest X #1 in the combined group. The largest single correlation (r=0.30) with posttest X #1, for all three treatment groups combined, was obtained with the variable, hours of CAI use total.

Table 8 lists the multiple correlation coefficient (R) for predicting posttest X #1 with the listed demographic predictor vari[illegible] of: treatment group; sex; age; race; grade point average; pretest X; and hours of CAI use in topic X. The only variable not used was the variable of "midterm grade", which would not be available for predictive purposes at the start of other experiments and was therefore not of interest for general predictive purposes. The R obtained for the full model was 0.41. This R was significantly different from zero ($p<0.05$).

The significance of contribution of each predictor variable listed in Table 8 to the multiple correlation coefficient in relation to the prediction of the criterion variable, posttest X #1, is presented in Table 9.

Table 9 was obtained by: adding a single predictor variable to the equation; computing a new multiple correlation coefficient; constructing an F Ratio from the ratio of the difference between the old and new multiple correlation coefficients; and then determining the

Table 8. Criterion and demographic predictor variables for multiple correlation in relation to posttest X #1

Type of Variable	Description
Criterion Variable	posttest X #1
Predictor Variables	treatment group sex age race grade point average pretest X hours of CAI use in topic X

R for full model = 0.41 ($p<0.05$)
n = 61

Table 9. Contribution of each predictor variable specified in Table 8 to the prediction of posttest X #1

Predictor Added	R	F	p
hours of CAI use in topic X	0.28	5.06	0.03*
pretest X	0.34	2.59	0.11
grade point average	0.38	1.77	0.19
sex	0.39	0.60	0.44
race	0.40	0.53	0.46
treatment group	0.41	0.20	0.65
age	0.41	0.08	0.77

n = 61
*significant at $p<0.05$

statistical significance of adding the single predictor variable to the full model (i.e. by means of a multiple stepwise regression). From this table it can be seen that the only predictor variable which by itself contributes significantly (p<0.05), in the context of the other predictors, to the multiple correlation coefficient of the full model is: "hours of CAI use in topic X".

Table 10 lists the results of an attempt to significantly increase the multiple correlation coefficient (R) for the criterion variable, posttest X #1, by adding psychological predictor variables to the demographic predictor variables listed in Table 8. These psychological predictor variables were obtained from variables which, when correlated with posttest X #1 performance, had a Pearson product-moment correlation coefficient greater than 0.1 (see Table 7).

The significance of contribution of selected predictor variables listed in Table 10 to the multiple correlation coefficient in relation to the criterion variable, posttest X #1, is presented in Table 11. Table 11 was obtained by means of a multiple stepwise regression. The variables were selected automatically by the computer program in order of contribution to the "optimal" multiple correlation and are listed in order of selection in Table 11. Only the first ten variables selected are presented in Table 11 because combined they account for ninety-six percent (i.e. 0.72) of the multiple correlation coefficient (i.e. 0.75) which was

Table 10. Criterion variable and predictor variables used to increase the multiple correlation in relation to posttest X #1

Type of Variable	Descritpion
Criterion Variable	posttest X #1
Predictor Variables	treatment group sex age race grade point average pretest X hours of CAI use in topic X CPI "capacity for status" CPI "sociability" CPI "self-acceptance" CPI "responsibility" CPI "tolerance" CPI "good impression" CPI "achievement via independence" SD "boring-interesting" SD "bad-good" SD "mysterious-understandable" SD "tense-relaxed" SD "confusing-clear" SD "apprehensive-non-apprehensive" SD "unfamiliar-familiar"

CPI - California Psychological Inventory
SD - Semantic Differential Questionnaire Pretest
n = 61

Table 11. Contribution of selected predictor variables from Table 10 to the prediction of posttest X #1

Predictor Added	R	F	p
SD "unfamiliar-familiar"	0.28	5.16	0.03*
SD "confusing-clear"	0.40	5.73	0.02*
grade point average	0.51	7.38	0.01*
SD "bad-good"	0.55	3.21	0.08
SD "tense-relaxed"	0.59	4.46	0.04*
SD "apprehensive-nonapprehensive"	0.62	2.54	0.12
hours of CAI use in topic X	0.64	2.80	0.10
CPI "responsibility"	0.67	3.40	0.07
CPI "achievement via independence"	0.69	2.80	0.10
CPI "tolerance"	0.72	3.93	0.05

CPI - California Psychological Inventory #1
SD - Semantic Differential Questionnaire Pretest
n = 61
*significant at p<0.05

obtained with all twenty-one predictors combined. From this table it can be seen that, in the context of the ten predictor variables selected, the predictor variables which individually contributed in a statistically significant manner ($p<0.05$) to the multiple correlation coefficient of the full model were: grade point average; and the "unfamiliar-familiar", "confusing-clear" and "tense-relaxed" scales from the CAI attitude questionnaire.

Similar analyses were performed to study academic retention (i.e. posttest X #2). Table 12 lists the obtained Pearson product-moment correlation coefficients for all the variables measured during this project and posttest X #2. Correlations are presented for the three treatment groups both combined and separately. Significant individual correlations are noted. Four variables (grade point average, "sense of well-being", "socialization", "communality") had a statistically significant correlation with posttest X #2 in the combined group.

Table 13 lists the multiple correlation coefficient (R) for predicting posttest X #2 with the demographic predictor variables: treatment group; sex; age; race; grade point average; posttest X #1; and hours of CAI use in topic X. The R obtained for the full model was 0.55. This R was significantly different from zero ($p<0.05$). The significance of contribution of each predictor variable listed in Table 13 to the multiple correlation coefficient in relation to the criterion variable, posttest X #2, is presented in Table

Table 12. Pearson product-moment correlation coefficients (r) for all variables measured at start of project with posttest X #2 performance (academic retention)

Variable 1	Variable 2	Combined (n=38)	Observed (r) T1 (n=13)	T2 (n=13)	T3 (n=12)
Posttest X #2	sex	-.07	-.67*	.23	.13
Posttest X #2	age	-.27	-.72*	.32	-.09
Posttest X #2	race	.00	-.29	.25	-.11
Posttest X #2	grade point average	.35*	.73*	.33	-.23
Posttest X #2	posttest X #1	.14	.62*	-.14	.08
Posttest X #2	hours of CAI use in topic X	-.11	.14	-.51	-.34
Posttest X #2	hours of CAI use total	-.08	.24	-.57*	-.23
Posttest X #2	midterm grade	.17	.41	.13	-.35
Posttest X #2	CPI "dominance"	-.02	-.09	-.03	.17
Posttest X #2	CPI "capacity for status"	.05	.08	.01	.25
Posttest X #2	CPI "sociability"	.00	-.13	.00	.33
Posttest X #2	CPI "social presence"	.16	.05	.19	.36
Posttest X #2	CPI "self-acceptance"	.11	-.07	.29	.39
Posttest X #2	CPI "sense of well-being"	-.34*	-.17	-.34	-.55
Posttest X #2	CPI "responsibility"	-.31	-.29	-.11	-.60*
Posttest X #2	CPI "socialization"	-.37*	-.50	-.25	-.40
Posttest X #2	CPI "self-control"	-.21	.14	-.55	-.43
Posttest X #2	CPI "tolerance"	-.21	.00	-.35	-.22
Posttest X #2	CPI "good impression"	.03	-.01	.05	.00
Posttest X #2	CPI "communality"	-.34*	-.52	-.26	-.15
Posttest X #2	CPI "achievement via conformity"	-.12	.00	.09	-.36
Posttest X #2	CPI "achievement via independence"	-.11	-.24	-.29	-.23
Posttest X #2	CPI "intellectual efficiency"	-.23	-.09	-.21	-.34
Posttest X #2	CPI "psychological mindedness"	.11	.07	.01	.22
Posttest X #2	CPI "flexibility"	.06	.23	-.34	.44

(Table 12 continued)

Posttest X #2 CPI "femininity"	-.03	-.26	-.07	.08
Posttest X #2 SD "boring-interesting"	.00	.10	-.06	-.33
Posttest X #2 SD "valuable-worthless"	-.18	-.38	.01	-.05
Posttest X #2 SD "disturbing-undisturbing"	.18	.53	.07	-.13
Posttest X #2 SD "appropriate-not appropriate"	-.07	.28	-.26	.00
Posttest X #2 SD "simple-complex"	-.06	.00	-.10	.32
Posttest X #2 SD "bad-good"	.25	.26	.47	-.12
Posttest X #2 SD "calm-anxious"	-.22	-.41	-.02	-.13
Posttest X #2 SD "mysterious-understandable"	.02	.34	-.23	-.46
Posttest X #2 SD "unpleasant-pleasant"	.01	.48	-.20	-.33
Posttest X #2 SD "tense-relaxed"	.07	.36	-.14	-.16
Posttest X #2 SD "fair-unfair"	.10	-.13	.45	.10
Posttest X #2 SD "usual-unusual"	-.16	-.36	-.01	-.22
Posttest X #2 SD "restful-nervous"	-.07	.02	.02	-.12
Posttest X #2 SD "confusing-clear	.14	.53	-.09	-.18
Posttest X #2 SD "useful-useless"	-.04	-.30	.00	.16
Posttest X #2 SD "negative-positive"	-.11	.23	-.66*	.29
Posttest X #2 SD "apprehensive-non-apprehensive"	.23	.42	.34	.26
Posttest X #2 SD "ineffective-effective"	.06	.33	-.28	.12
Posttest X #2 SD "quick-slow"	.19	-.58*	.84*	-.18
Posttest X #2 SD "unfamiliar-familiar"	.23	.67*	-.01	-.18

T1 is CAI alone; T2 is CAI concurrent with lecture; and T3 is lecture alone.
CPI - California Psychological Inventory #1
SD - Semantic differential attitude questionnaire pretest
*Correlations which are significantly different from zero.

Table 13. Criterion and demographic predictor variables for multiple correlation in relation to posttest X #2

Type of Variable	Description
Criterion Variable	posttest X #2
Predictor Variables	treatment group sex age race grade point average posttest X #1 hours of CAI use in topic X

R for full model = 0.55 ($p<0.05$)
n = 38

Table 14. Contribution of each predictor variable specified in Table 13 to the prediction of posttest X #2

Predictor Added	R	F	p
grade point average	0.35	4.97	0.03*
hours of CAI use in topic X	0.43	2.75	0.11
age	0.51	3.54	0.07
treatment group	0.54	1.36	0.25
sex	0.55	0.56	0.46
race	0.55	0.05	0.82
posttest X #1	0.55	0.00	0.95

n = 38
*significant at $p<0.05$

14. Table 14 was obtained by means of a stepwise multiple regression. The predictor variables in Table 14 are listed in order of their contribution to the full model. From this table it can be seen that the only predictor variable which contributed significantly ($p<0.05$), in the context of the other predictors, to the multiple correlation coefficient was "grade point average".

Table 15 lists the results of an attempt to significantly increase the multiple correlation coefficient (R) for the criterion variable, posttest X #2, by adding psychological predictor variables to the demographic predictor variables listed in Table 13. Personologic variables were selected for inclusion from Table 12 if their "combined" Pearson product-moment correlation coefficient was greater than 0.1.

The significance of contribution of selected predictor variables listed in Table 15 to the multiple correlation coefficient in relation to the criterion variable, posttest X #2, is presented in Table 16. Table 16 was obtained by means of a multiple stepwise regression. The predictor variables are listed in order of their contribution to the full model. From this table it can be seen that the only predictor variables which individually contributed in a statistically significant manner ($p<0.05$) to the multiple correlation coefficient of the full model in the context of the other variables were the "socialization" and the "self-acceptance" measures from the CPI, and the

Table 15. Criterion variable and predictor variables used to increase the multiple correlation in relation to posttest X #2

Type of Variable	Description
Criterion Variable	posttest X #2
Predictor Variables	treatment group
	sex
	age
	race
	grade point average
	posttest X #1
	hours of CAI use in topic X
	CPI "social presence"
	CPI "self-acceptance"
	CPI "sense of well-being"
	CPI "responsibility"
	CPI "socialization"
	CPI "self-control"
	CPI "tolerance"
	CPI "communality"
	CPI "achievement via conformity"
	CPI "achievement via independence"
	CPI "intellectual efficiency"
	CPI "psychological-mindedness"
	SD "valuable-worthless"
	SD "disturbing-undisturbing"
	SD "bad-good"
	SD "calm-anxious"
	SD "fair-unfair"
	SD "usual-unusual"
	SD "confusing-clear"
	SD "negative-positive"
	SD "apprehensive-nonapprehensive"
	SD "quick-slow"
	SD "unfamiliar-familiar"

CPI - California Psychological Inventory #1
SD - Semantic Differential Questionnaire Pretest
n = 38

Table 16. Contribution of selected predictor variables from Table 15 to the prediction of posttest X #2

Predictor Added	R	F	p
CPI "socialization"	0.37	5.78	0.02*
SD "quick-slow"	0.48	4.00	0.05
grade point average	0.54	2.94	0.09
CPI "communality"	0.60	3.73	0.06
CPI "self-acceptance"	0.68	6.24	0.02*
hours of CAI use in topic X	0.71	2.62	0.12
sex	0.75	3.45	0.07
age	0.78	3.18	0.09
SD "usual-unusual"	0.81	4.39	0.04*
SD "unfamiliar-familiar"	0.83	2.81	0.11

R for the listed predictor variables = 0.83 ($p<0.05$)
CPI - California Psychological Inventory #1
SD - Semantic Differential Questionnaire Pretest
n = 38
*significant at $p<0.05$

"usual-unusual" scale from the semantic differential attitude questionnaire.

Table 17 presents the mean scores and standard deviations obtained from the three academic achievement tests (pretest X, posttest X #1, posttest X #2) presented according to treatments. Two sets of mean scores are given for posttest X #1. The second set, based on n=38, is actually a subset of the first. This was done in order that correlational analyses could be performed with both the achievement and retention sets of data.

Table 18 is a summary two-way analysis of variance table for academic achievement with experimental treatments. The 'occasion (0,1)' main effects (i.e. pretest X to posttest X #1) were statistically significant ($p<0.05$). The 'treatment' main effects and the 'treatment X occasion (0,1)' interaction were not statistically significant.

Table 19 is a summary two-way analysis of variance table for academic retention with experimental treatments. The 'occasion (1,2)' main effects (i.e. posttest X #1 to posttest X #2) were statistically significant ($p<0.05$). However, the 'treatment' main effects and the 'treatment X occasion (1,2)' interaction were not statistically significant.

Mean scores and standard deviations obtained from the academic achievement tests presented according to level of achievement motivation by treatments are given in Table 20. Table 21 contains the summary analysis of variance for

Table 17. Mean scores and standard deviations obtained from the academic performance tests presented according to treatments

TREATMENTS	Pretest X (Occasion 0) (n=61)	Posttest X #1[1] (Occasion 1) (n=61)	Posttest X #1[1] (Occasion 1) (n=38)	Posttest X #2 (Occasion 2) (n=38)
T1[2]	3.95 ±1.77 (n=20)	5.85 ±1.68 (n=20)	5.92 ±1.89 (n=13)	8.54 ±2.37 (n=13)
T2	4.33 ±1.58 (n=21)	6.38 ±1.84 (n=21)	6.23 ±2.00 (n=13)	7.15 ±3.29 (n=13)
T3	3.75 ±1.89 (n=20)	5.60 ±2.54 (n=20)	5.50 ±2.51 (n=12)	7.33 ±2.26 (n=12)

Academic Performance Tests

[1] Two sets of mean scores are given for posttest X #1. The second set, based on n=38, is actually a subset of the first.

[2] T1 is CAI alone; T2 is CAI concurrent with lecture; and T3 is lecture alone.

Table 18. Summary two way analysis of variance table for academic achievement with experimental treatments

Summary Analysis of Variance Table

Source of Variation	DF	MS	F	p
Between Subjects				
Treatment main effects	2	2.27	0.55	0.58
Subjects within groups	58	4.14		
Within Subjects				
Occasion (0,1) main effects	1	109.96	37.24	0.00*
Treatment X Occasion (0,1) interaction	2	0.23	0.08	0.93
Occasion (0,1) X subjects within groups	58	2.95		

n = 61
*significant at $p<0.05$

Table 19. Summary two way analysis of variance table for academic retention with experimental treatments

Summary Analysis of Variance Table				
Source of Variation	DF	MS	F	p
Between Subjects	37			
Treatment main effects	2	4.34	0.66	0.52
Subjects within groups	35	6.57		
Within Subjects	38			
Occasion (1,2) main effects	1	60.83	12.25	0.00*
Treatment X Occasion (1,2) interaction	2	4.54	0.91	0.41
Occasion (1,2) X subjects within groups	35	4.97		

n = 38
*significant at p<0.05

Table 20. Mean scores[1] [2] and standard deviations obtained from the academic achievement tests presented according to level of achievement motivation by treatments

ACHIEVEMENT MOTIVATION	Pretest X T1	Pretest X T2	Pretest X T3		Posttest X #1 T1	Posttest X #1 T2	Posttest X #1 T3	
Low	3.71 ±1.38 (n=7)	4.43 ±1.27 (n=7)	3.67 ±1.21 (n=6)	[3.94]	5.43 ±1.27 (n=7)	6.57 ±1.99 (n=7)	5.00 ±2.83 (n=6)	[5.67]
Medium	5.00 ±2.53 (n=6)	4.29 ±1.60 (n=7)	4.30 ±2.21 (n=10)	[4.53]	6.00 ±2.61 (n=6)	6.00 ±1.53 (n=7)	6.30 ±2.31 (n=10)	[6.10]
High	3.29 ±1.25 (n=7)	4.29 ±2.14 (n=7)	4.50 ±2.52 (n=4)	[4.02]	6.14 ±1.35 (n=7)	6.57 ±2.30 (n=7)	6.25 ±0.50 (n=4)	[6.32]
	[4.00]	[4.33]	[4.16]		[5.86]	[6.38]	[5.85]	

[1] The values in brackets, which are underlined, are the mean scores for level of achievement motivation summed over treatments.

[2] The values in brackets, which are not underlined, are the mean scores for treatments summed over achievement motivation levels.

pretest X in relation to level of achievement motivation and treatment group. None of the effects noted in the analysis presented in Table 21 were statistically significant. Similar analysis, but in relation to posttest X #1, is presented in Table 22. None of the effects noted in the analysis presented in Table 22 were statistically significant.

Table 23 contains the mean scores obtained from the three way analysis of variance for aptitude (i.e. GPA), treatment group (i.e. T1, T2, T3), and academic achievement (i.e. Occasion 0,1). The summary analysis of variance is found in Table 24. Both the 'aptitude' and the 'occasion (0,1)' main effects were statistically significant ($p<0.05$). All other effects were not statistically significant. Post-hoc contrasts of the 'aptitude level' and 'treatment group' main effects are presented in Table 25. From Table 25 it is noted that a significant pretest X to posttest X #1 change occurred for each level of ability and for each level of treatment.

Mean scores and standard deviations obtained from the academic achievement tests presented according to pharmacology knowledge entry levels by treatments are given in Table 26. Table 27 contains the summary analysis of variance for pretest X in relation to pharmacology knowledge entry level and treatment group. This was done in order to verify the assignment of subjects to low, medium and high groups respectively on the basis of their pretest X scores.

Table 21. Summary two way analysis of variance table for academic achievement pretest X in relation to level of achievement motivation and treatment group

Summary Analysis of Variance Table

Source of Variation	DF	MS	F	p
Achievement motivation main effects	2	2.13	0.63	0.54
Treatment main effects	2	0.57	0.17	0.85
Achievement motivation X Treatment interaction	4	2.07	0.61	0.66
Error	52	3.38		

n = 61

Table 22. Summary two way analysis of variance table for academic achievement posttest X #1 in relation to level of achievement motivation and treatment group

Summary Analysis of Variance Table

Source of Variation	DF	MS	F	p
Achievement motivation main effects	2	2.08	0.51	0.61
Treatment main effects	2	1.87	0.46	0.64
Achievement motivation X Treatment interaction	4	1.63	0.40	0.81
Error	52	4.09		

n = 61

Table 23. Mean scores obtained from the three way analysis of variance for aptitude, treatment group, and academic achievement

Treatment

APTITUDE	T1	T2	T3
Low	4.75	4.67	5.08
Medium	4.25	5.33	4.33
High	5.92	5.83	5.92

Achievement Tests

APTITUDE	Pretest X	Posttest X #1
Low	4.00	5.67
Medium	3.61	5.67
High	4.89	6.89

Achievement Tests

TREATMENT	Pretest X	Posttest X #1
T1	3.89	6.06
T2	4.22	6.33
T3	4.39	5.83

Table 24. Summary three way analysis of variance table for aptitude, treatment group, and academic achievement

Summary Analysis of Variance Table

Source of Variation	DF	MS	F	p
Between Subjects	53			
Aptitude main effects	2	16.29	4.11	0.02*
Treatment main effects	2	0.84	0.21	0.81
Aptitude X Treatment interaction	4	2.06	0.52	0.72
Subjects within groups	45	3.96		
Within Subjects	**54**			
Occasion (0,1) main effects	1	98.23	34.07	0.00*
Aptitude X Occasion (0,1) interaction	2	0.40	0.14	0.87
Treatment X Occasion (0,1) interaction	2	1.45	0.50	0.61
Aptitude X Treatment X Occasion (0,1) interaction	4	1.70	0.59	0.67
Occasion (0,1) X subjects within groups	45	2.88		

n = 54
*significant at p<0.05

Table 25. Post-hoc contrasts for the three way analysis of variance (Table 24) among levels of academic achievement for given levels of aptitude and treatment group

	Pretest X[1]	Posttest X #1[1]	DF1	DF2	F	p
<u>Aptitude</u>						
Low GPA	4.00	5.67	1	45	5.78	0.02*
Medium GPA	3.61	5.67	1	45	8.79	0.01*
High GPA	4.89	6.89	1	45	8.32	0.01*
<u>Treatment</u>						
T1	3.89	6.01	1	45	9.77	0.00*
T2	4.22	6.33	1	45	9.27	0.00*
T3	4.39	5.83	1	45	4.34	0.04*

[1]Mean scores
n = 54
*significant at p<0.05

Table 26. Mean scores[1] [2] and standard deviations obtained from the academic achievement tests presented according to pharmacology knowledge entry levels by treatments

LEVEL[3]	Pretest X T1	Pretest X T2	Pretest X T3		Posttest X #1 T1	Posttest X #1 T2	Posttest X #1 T3	
Low	2.33 ±0.71 (n=9)	2.86 ±0.38 (n=7)	2.44 ±0.73 (n=9)	[2.54]	5.56 ±1.33 (n=9)	5.29 ±1.70 (n=7)	5.11 ±2.57 (n=9)	[5.32]
Medium	4.33 ±0.52 (n=6)	4.30 ±0.48 (n=10)	4.50 ±0.55 (n=6)	[4.38]	6.00 ±1.26 (n=6)	7.00 ±1.76 (n=10)	6.33 ±1.86 (n=6)	[6.44]
High	6.40 ±0.89 (n=5)	7.00 ±1.41 (n=4)	6.80 ±1.10 (n=5)	[6.73]	6.20 ±2.86 (n=5)	6.75 ±2.06 (n=4)	6.80 ±1.92 (n=5)	[6.58]
	[4.36]	[4.72]	[4.58]		[5.92]	[6.35]	[6.08]	

[1] The values in brackets, which are underlined, are the mean scores for ability groups summed over treatments.
[2] The values in brackets, which are not underlined, are the mean scores for treatments summed over pharmacology knowledge entry level groups.
[3] Level refers to pharmacology knowledge entry level as determined by pretest X scores.

Table 27. Summary two way analysis of variance table for academic achievement pretest X in relation to pharmacology knowledge entry level and treatment group

Summary Analysis of Variance Table

Source of Variation	DF	MS	F	p
Pharmacology knowledge main effects	2	78.49	145.68	0.00*
Treatment main effects	2	0.63	1.16	0.32
Pharmacology knowledge X Treatment interaction	4	0.29	0.54	0.71
Error	52	0.54		

n = 61
*Significant at p<0.05

The 'pharmacology knowledge' main effects were statistically significant ($p<0.05$). The 'treatment' main effects and the 'pharmacology knowledge X treatment' interaction were not statistically significant. Similar analysis, but in relation to posttest X #1, is presented in Table 28. None of the effects noted in the analysis presented in Table 28 were statistically significant.

Mean scores and standard deviations obtained from the academic achievement tests (pretest X and posttest X #1) presented according to treatments by sex are given in Table 29. Table 30 contains the summary analysis of variance for pretest X in relation to treatment group and sex. The 'sex' main effects were statistically significant ($p<0.05$) with females having significantly lower pretest X mean scores than males. The 'treatment' main effects and the 'treatment X sex' interaction were not statistically significant. Similar analysis, but in relation to posttest X #1, is presented in Table 31. None of the effects noted in the analysis presented in Table 31 were statistically significant (i.e. no sex differences were identified).

Mean scores and standard deviations obtained from the academic achievement tests presented according to level of sociability by treatments is given in Table 32. Table 33 contains the summary analysis of variance for pretest X in relation to level of sociability and treatment group. None of the effects noted in the analysis presented in Table 33 were statistically significant. Similar analysis, but in

Table 28. Summary two way analysis of variance table for academic achievement posttest X #1 in relation to pharmacology knowledge entry level and treatment group

Summary Analysis of Variance Table

Source of Variation	DF	MS	F	p
Pharmacology knowledge main effects	2	10.45	2.74	0.07
Treatment main effects	2	0.96	0.25	0.78
Pharmacology knowledge X Treatment interaction	4	1.05	0.28	0.89
Error	52	3.81		

n = 61

Table 29. Mean scores[1] [2] and standard deviations obtained from the academic achievement tests presented according to treatments by sex

	Pretest X			Posttest X #1		
TREATMENTS	Male	Female		Male	Female	
T1	4.60 ±2.41 (n=5)	3.73 ±1.62 (n=15)	[4.17]	6.80 ±2.49 (n=5)	5.53 ±1.36 (n=15)	[6.17]
T2	5.57 ±2.15 (n=7)	3.71 ±0.83 (n=14)	[4.64]	6.43 ±1.90 (n=7)	6.36 ±1.95 (n=14)	[6.39]
T3	4.33 ±2.18 (n=9)	4.00 ±1.84 (n=11)	[4.17]	6.44 ±2.60 (n=9)	5.46 ±1.92 (n=11)	[5.95]
	[4.83]	[3.82]		[6.58]	[5.78]	

1 The values in brackets, which are underlined, are the mean scores for treatment groups summed over sexes.

2 The values in brackets, which are not underlined, are the mean scores for sexes summed over treatments.

Table 30. Summary two way analysis of variance table for academic achievement pretest X in relation to treatment group and sex

Summary Analysis of Variance Table

Source of Variation	DF	MS	F	p
Treatment main effects	2	1.38	0.45	0.64
Sex main effects	1	13.68	4.46	0.04*
Treatment X Sex interaction	2	2.85	0.93	0.40
Error	55	3.07		

n = 61
*significant at p<0.05

Table 31. Summary two way analysis of variance table for academic achievement posttest X #1 in relation to treatment group and sex

Summary Analysis of Variance Table

Source of Variation	DF	MS	F	p
Treatment main effects	2	0.94	0.24	0.78
Sex main effects	1	7.94	2.05	0.16
Treatment X Sex interaction	2	1.72	0.44	0.64
Error	55	3.86		

n = 61

Table 32. Mean scores[1] [2] and standard deviations obtained from the academic achievement tests presented according to level of sociability (Sy) by treatments

SOCIABILITY	Pretest X T1[3]	Pretest X T2	Pretest X T3		Posttest X #1 T1	Posttest X #1 T2	Posttest X #1 T3	
Low	4.17 ±2.56 (n=6)	4.29 ±1.50 (n=7)	4.17 ±1.47 (n=6)	[4.21]	6.17 ±2.48 (n=6)	7.57 ±1.27 (n=7)	7.17 ±2.04 (n=6)	[6.97]
Medium	4.33 ±1.83 (n=6)	3.57 ±0.79 (n=7)	4.30 ±1.95 (n=10)	[4.07]	5.83 ±1.17 (n=6)	5.57 ±2.30 (n=7)	5.00 ±2.26 (n=10)	[5.47]
High	3.50 ±1.41 (n=8)	5.14 ±2.12 (n=7)	3.75 ±2.99 (n=4)	[4.13]	5.63 ±1.60 (n=8)	6.00 ±1.57 (n=7)	6.25 ±1.89 (n=4)	[5.96]
	[4.00]	[4.33]	[4.07]		[5.88]	[6.38]	[6.14]	

1. The values in brackets, which are underlined, are the mean scores for level of socialization summed over treatments.
2. The values in brackets, which are not underlined, are the mean scores for treatments summed over sociability levels.
3. T1 is CAI alone; T2 is CAI concurrent with lecture; and T3 is lecture alone.

Table 33. Summary two way analysis of variance table for academic achievement pretest X in relation to level of sociability and treatment group

Summary Analysis of Variance Table

Source of Variation	DF	MS	F	p
Sociability main effects	2	0.10	0.03	0.97
Treatment main effects	2	0.62	0.18	0.83
Sociability X Treatment interaction	4	3.03	0.90	0.47
Error	52	3.38		

n = 61

Table 34. Summary two way analysis of variance table for academic achievement posttest X #1 in relation to level of sociability and treatment group

Summary Analysis of Variance Table				
Source of Variation	DF	MS	F	p
Sociability main effects	2	11.68	3.22	0.04*
Treatment main effects	2	1.30	0.36	0.70
Sociability X Treatment interaction	4	1.97	0.54	0.71
Error	52	3.63		

n = 61
*significant at $p<0.05$

relation to posttest X #1, is presented in Table 34. The 'sociability' main effects were statistically significant ($p<0.05$). The 'treatment' main effects and the 'sociability X treatment' interaction were not statistically significant.

Attitude Questionnaires

Table 35 lists the results of the CAI attitude questionnaires. Means are given for pretest, posttest #1, and posttest #2 administrations. According to Osgood, Suci and Tannebaum (1957) and Snider and Osgood (1969) a change in the seven point semantic differential scale must be greater than or equal to 2.0 scale units to be significant at $p<0.05$ for individuals and greater than or equal to 0.5 scale units to be significant at $p<0.05$ for groups. Thus, for this project any change greater than or equal to 0.5 scale units was considered to be significant. A test of this guideline is presented in Table 36. The test consisted of analyzing the mean changes from pretest to posttest #1 by means of both Snider and Osgood's criteria and analysis of variance. The results, presented in the combined means column of Table 36, indicate that the two approaches gave identical results for 19 of the 20 attitude scales used in this project. The interpretation of only one scale, that of boring-interesting, presented differing results which depended upon the analysis used. Table 36 also gives a complete breakdown of pretest and posttest #1 mean scores for each scale of the attitude questionnaire according to

Table 35. CAI attitude questionnaire results[1]

Biopolar Adjective Pair	Opposing Adjective Anchor	Mean Pretest Marks (n=61)	Mean Posttest #1 Marks (n=61)	Mean Posttest #2 Marks (n=38)	Opposing Adjective Anchor
1.	Boring	6.1	5.7	5.6	Interesting
2.	Valuable	2.2	2.6	2.5	Worthless
3.	Disturbing	5.7	5.6	5.8	Undisturbing
4.	Appropriate for Teaching Pharmacology	2.8	2.4	2.9	Not Appropriate for Teaching Pharmacology
5.	Simple	3.7	3.2	3.2	Complex
6.	Bad	5.8	6.0	5.7	Good
7.	Calm	3.1	3.0	2.6	Anxious
8.	Mysterious	5.3	6.0	5.7	Understandable
9.	Unpleasant	5.7	5.8	5.6	Pleasant
10.	Tense	5.3	5.6	5.4	Relaxed
11.	Fair	2.0	2.6	2.3	Unfair
12.	Usual	4.6	3.8	3.5	Unusual
13.	Restful	3.0	2.6	2.8	Nervous
14.	Confusing	5.2	5.7	5.5	Clear
15.	Useful	2.0	2.1	2.0	Useless
16.	Negative	6.1	6.1	5.9	Positive
17.	Apprehensive	4.1	4.3	5.0	Nonapprehensive
18.	Ineffective	5.9	5.9	5.7	Effective
19.	Quick	2.7	3.2	3.7	Slow
20.	Unfamiliar	2.9	5.4	5.2	Familiar

[1]Marks are based on a 7 point semantic differential scale (see Figure 3).

Table 36. Presentation of attitude questionnaire pretest and posttest #1 mean results by treatment groups[1] with analysis of combined mean scores

Bipolar Adjective Pair	Pretest T1 (n=20)	Pretest T2 (n=21)	Pretest T3 (n=20)	Means (Combined) (n=61)	Means (Combined) (n=61)	Posttest #1 T1 (n=20)	Posttest #1 T2 (n=21)	Posttest #1 T3 (n=20)
1.	6.5	6.1	5.9	6.1	5.7[4]	5.6	5.7	5.9
2.	2.0	2.3	2.5	2.2	2.6	2.5	2.8	2.6
3.	6.0	5.7	5.5	5.7	5.6	6.2	5.5	5.0
4.	2.4	2.7	3.2	2.8	2.4	2.1	2.5	2.8
5.	3.2	3.7	4.2	3.7	3.2[5]	3.5	3.1	3.0
6.	6.0	5.9	5.7	5.8	6.0	6.0	6.0	6.2
7.	2.7	3.4	3.4	3.1	3.0	3.3	3.0	2.8
8.	5.8	5.2	4.8	5.3	6.0[5]	6.1	6.0	6.1
9.	6.0	5.7	5.4	5.7	5.8	6.0	5.6	5.7
10.	5.5	5.4	5.1	5.3	5.6	5.6	5.6	5.6
11.	1.5	2.1	2.6	2.0	2.6[5]	2.4	2.8	2.7
12.	4.8	4.6	4.3	4.6	3.8[5]	3.9	3.4	4.1
13.	2.7	3.3	3.1	3.0	2.6	2.4	2.7	2.9
14.	5.6	4.9	5.2	5.2	5.7[5]	5.7	5.9	5.6
15.	1.7	1.9	2.4	2.0	2.1	2.2	2.1	2.0
16.	6.5	6.1	5.9	6.1	6.1	6.3	6.0	6.0
17.	4.7	4.0	3.7	4.1[2]	4.3	4.5	4.1	4.5
18.	6.1	5.9	5.9	5.9	5.9	5.8	5.9	6.0
19.	2.6	2.8	2.7	2.7	3.2[5]	3.5	3.2	2.9
20.	3.2	2.6	2.9	2.9	5.4[5]	4.9	5.6	5.6

[1] T1 is CAI alone; T2 is CAI concurrent with lecture; and T3 is lecture alone.

[2] Pretest combined means which were <u>not</u> significantly difference from neutral, 4.0

[3] Significant pretest/posttest #1 change using Snider and Osgood's (1969) criteria of 0.5 or more scale units.

[4] Significant ($p<0.05$) pretest/posttest #1 change as determined by analysis of variance (DERS computer program ANOV26).

[5] Significant pretest/posttest #1 change according to both #3 and #4 above.

treatment group.

It is noted, when comparing the means of the pretest and posttest #1 marks presented in Table 36, that significant changes occurred in bipolar adjective pairs #1, 5, 8, 11, 12, 14, 19 and 20. Bipolar adjective pairs #5, 8, 12, 14 and 20 completely account for the factor of familiarity and as predicted all showed a positive increase from less to more familiar. Bipolar adjective pairs #1, 11 and 19 belonged to the factor of evaluation. These last three adjective pairs had observed significant changes in a negative direction, that is in the direction of poorer evaluation.

An analysis of the responses obtained from the semantic differential attitude questionnaire is presented in Table 37. This approach was developed by Maguire (1973) to check for bias or response set in a semantic differential attitude questionnaire. Maguire's approach expresses and analyzes scores in terms of the conventional analysis of variance model. Here, the score is expressed as (partitioned into) the population mean plus variance effects due to seven sources. The seven sources are: people effect; concept effect; scale effect; people by concepts interaction; people by scales interaction; concepts by scales interaction; and people by concepts by scales interaction.

The people (person) effect is the general disposition of a person to rate toward either the 1 or the 7 end of all scales. The concept effect is the tendency for a concept to

Table 37. Semantic differential questionnaire variance estimates

Estimates of Variance	
Source	Variance Estimate
People	0.01
Concepts	0.00
Scales	2.06
People X Concepts	0.00
People X Scales	0.38
Concepts X Scales	0.20
People X Concepts X Scales	1.38

n = 61

be rated systematically toward the 1 or 7 end of all scales. The scale effect is the tendency for people to rate all concepts toward the 1 or 7 end of a scale. The people (person) by concept interaction is the general disposition for a particular person to rate a particular concept toward the 1 or 7 end of all scales. The people (person) by scale interaction is the tendency for a person to use either the 1 or 7 end of a particular scale regardless of the concept being rated. The concept by scale interaction is the tendency for all people to place a concept toward the 1 or 7 end of a particular scale. The final source of variance is the people (person) by concepts by scales interaction. This interaction is actually a measure of the residual variance and represents the differential effect of particular persons, concepts and scales.

According to Maguire's (1973) model the variance due to people effect, concepts effect, and people by concept interaction should be small. The variance due to scales effect, people by scales interaction, and concepts by scales interaction should be larger and the variance due to people by concepts by scales interaction should be largest of all. From Table 37 the respectively observed variance estimates are: 0.01; 0.00; 2.06; 0.00; 0.38; 0.20; and 1.38.

CAI Evaluation Form

The results of the "CAI Evaluation Form" are presented in Figure 9. This questionnaire was meant to provide

Figure 9. CAI evaluation results

1. Overall how would you rate the computer programs in pharmacology that you used this term?

	Poor 1	2	3	Average 4	5	6	Excellent 7
(n)	0	0	1	5	23	30	2

	T1 (n=20)	T2 (n=21)	T3 (n=20)	Combined (n=61)
Mean	5.3	5.4	5.6	5.4

2. Were the programs of use in organizing your study or finding areas where you needed more work?

	Poor 1	2	3	4	5	Extremely Helpful 6	7
(n)	0	1	3	11	19	24	3

	T1 (n=20)	T2 (n=21)	T3 (n=20)	Combined (n=61)
Mean	5.2	5.2	5.1	5.2

3. Given the "opportunity" to "repeat" this year (or take a similar course in the future) would you like to have more computer aided instructional programs like the ones used this term integrated into your pharmacology course?

	YES	No
(n)	59	2

4. Should computer programs focus on ______________?

	Review of Material	Teaching New Material	Both
(n)	30	0	31

students with an opportunity to respond to open ended questions about CAI and to provide the project with an additional check on students attitude toward CAI in perhaps a more realistic or practical context than that provided by the "CAI Attitude Questionnaires".

All sixty-one volunteers filled out the CAI evaluation forms. The great majority only completed the first four questions and left the open ended questions blank. However, those who did complete the entire form responded with comments such as: "Excellent!; "Keep up the good work"; "Best part of the course"; and "More courses should use computer instruction". No negative comments were obtained.

The result of responses to the closed ended questions indicate that: 1) the students rated the computer programs in pharmacology highly (Mean 5.4 on a scale from one to seven); 2) the students found the pharmacology computer programs helpful in their studies (Mean 5.2 on a scale from one to seven); 3) the students overwhelmingly would like to use additional similar CAI programs (59 out of 61 affirmative responses, i.e. 97%); and 4) the students preferred to use CAI primarily to review old material and only secondarily to teach (learn) new material (30/61 review of material, 0/61 teaching new material, 31/61 both review of material and teaching new material).

The responses to the first two questions were analyzed using a one-way analysis of variance procedure with DERS computer program ANOV16. This was done in order to determine if there were any statistically significant differences in the evaluational responses among the treatment groups. Analysis of variance and Scheffe post-hoc pairwise contrasts indicated that the means obtained from the three different treatment groups (listed in Figure 9) were not statistically different.

California Psychological Inventory

The California Psychological Inventory was used in this project as a determinant of various psychological variables which might correlate significantly with academic performance in relation to CAI use. Several of its scales were also used in analyses of instructional interactions. The results of these correlation and instructional interaction analyses have been presented in the "Academic Performance Tests" section of this chapter.

Table 38 lists the comparison of mean CPI scores which were obtained from this project and from the literature. The first group (n=61) was comprised of the principal subjects for this project. The CPI was administered to them at the start of the project and the obtained results were used in the analyses discussed in the first section of this Chapter. The second group (n=48) was actually a subset of the first. This group was readministered the CPI one year following the conclusion of the major experimental portion of this project. The next group, the control group (n=86), was comprised of students from the following third year pharmacy

Table 38. Comparison of mean CPI scores

Scale	Test Group Pharmacy Students (first administration) (n=61)		Test Group Pharmacy Students (second administration) (n=48)	Control Group Pharmacy Students (n=86)	Literature Pharmacy Students (n=46)
Do	25.0	(r=0.83)	26.7	25.9	26.8
Cs	16.7	(r=0.68)	18.9	18.3	19.2
Sy	23.0	(r=0.73)	25.3	24.8	23.5
Sp	33.4	(r=0.77)	35.7	34.0	35.7
Sa	20.0	(r=0.72)	21.0	21.0	21.3
Wb	33.1	(r=0.59)	35.9	34.8	34.1
Re	27.7	(r=0.60)	30.4	29.2	28.8
So	37.7	(r=0.50)	38.5	38.0	38.1
Sc	26.8	(r=0.68)	31.0	29.3	29.5
To	19.8	(r=0.67)	22.0	20.5	21.8
Gi	15.8	(r=0.70)	17.5	16.8	16.5
Cm	24.7	(r=0.29)	25.7	25.3	25.3
Ac	25.2	(r=0.53)	28.1	26.5	26.8
Ai	18.0	(r=0.64)	20.1	19.5	20.0
Ie	36.0	(r=0.69)	39.2	37.3	37.0
Py	10.1	(r=0.58)	10.5	10.5	12.0
Fx	8.6	(r=0.49)	8.8	9.3	9.7
Fe	20.5	(r=0.76)	21.4	21.2	22.5

class. They were also administered the CPI one year following the conclusion of the major experimental portion of this project. The last group (n=46) was that which Gough (1975, p. 33) had reported in the CPI manual.

Table 38 also contains the correlations between the first and second administrations of the CPI. These were obtained from an analysis of the paired CPI responses from forty-eight students utilizing DERS computer program DEST02 and are presented for each scale of the CPI.

Student University Records

Table 39 lists the mean GPA's for the principal subjects according to treatment group. It also contains a breakdown of the principal subjects by age, race and sex.

Computer Data Collection Records

Table 40 contains the means and standard deviations of the CAI usage statistics. Usage is presented in hours for pharmacology topic X both alone and combined with other pharmacology topics according to treatments. The mean number of hours of CAI use in topic X for T1 (CAI alone) was 5.65 hours. The mean number of hours of use in topic X for all groups combined (n=61) was 4.36 hours. The overall mean usage for topic X together with the other pharmacology topics for all three treatment groups combined was 6.32 hours (n=61).

Table 39. GPA, age, race and sex of the principal subjects presented according to treatment group

	GPA[1]	Age[2]	Race[3]	Sex[4]
T1 (n=20)	6.38 ±1.06	20.80 ±1.75	16 C 4 O	15 F 5 M
T2 (n=21)	6.07 ±1.06	21.19 ±2.68	15 C 6 O	14 F 7 M
T3 (n=20)	6.27 ±1.15	21.05 ±1.50	16 C 4 O	11 F 9 M

[1] Means and standard deviations of treatment groups' GPA's based on a stanine rating of 1 to 9.
[2] Presented in years as of the beginning of the experimental phase of this project.
[3] C = caucasian, O = oriental
[4] F = females, M = males

Table 40. Means and standard deviations of the CAI usage statistics presented for pharmacology topic X both alone and combined with other pharmacology topics[1] [2]

	Topic X	All Topics Combined
T1[3] (n=20)	5.65 ±3.22	7.82 ±4.87
T2 (n=21)	3.76 ±2.21	5.72 ±3.27
T3 (n=20)	3.69 ±3.21	5.46 ±4.59

[1] Means and standard deviations for usage are presented in hours.
[2] The listed values are for the total number of hours of CAI use during the experimental phase of this project.
[3] T1 is CAI alone; T2 is CAI concurrent with lecture; and T3 is lecture alone.

The listed values were automatically collected from each student during the experimental phase of this project. It should be noted that treatment groups #2 and #3 did not have access to the CAI programs in topic X until the time specified in Figure 8.

For the sake of comparison it should be noted that ten hours of classroom lecture, devoted to covering the subject matter of "topic X", were presented to T2 (lecture alone) as well as to the other two treatment groups.

CHAPTER VI

DISCUSSION

Expected Outcome

The results of this study were expected to provide answers to the following four series of questions presented earlier in this thesis:

1. What effect does CAI have on student academic achievement in pharmacology? When CAI is used in addition to lectures, is student achievement increased in comparison to either lectures or CAI alone?

2. If CAI is used prior to lectures in pharmacology, is student retention of learned material, increased in comparison to CAI used either during or after lectures?

3. Does use of CAI affect student attitude toward CAI? If attitude toward CAI changes, is this change correlated with academic achievement in relation to the use of CAI in pharmacology?

4. Can a significant correlation or instructional interaction be found between specific student demographic or psychological variables and academic performance in relation to the use of CAI in pharmacology?

Since this is the first major objective study in this area, it is anticipated that the answers provided should have a significant impact on the future use of CAI in pharmacology.

Possible Complicating Factors

The conduction of experiments within the classroom setting always presents the possibility of "unforeseen" factors which can confound the experimental design, execution, or analysis of results. The "foreseen" potential confounding factors were identified as follows:

The first potential confounding factor was the possibility that the group of sixty-one volunteers used in the major analyses were not representative of the entire class of ninety pharmacy students. Since data on most of this project's measures were not obtained from the non-volunteers it is not possible to completely answer this question. However, examination of demographic data (GPA, race, and sex) which was available from the students' university records indicated that the subjects used in the major analyses were representative of the entire pharmacy class. For the total pharmacy class (n=90): mean GPA=6.10; percent Caucasian=0.78; percent Oriental=0.22; percent female=0.61; and percent male=0.39. Likewise, for the experimental group (n=61) the following comparative data was obtained: mean GPA=6.24; percent Caucasian=0.77; percent Oriental=0.23; percent female=0.66; and percent male=0.34.

A ceiling or floor effect reached on either the academic performance pretest or the first attitude questionnaire would have made it impossible to obtain significantly higher or lower, respectively, academic performance posttest or second attitude questionnaire results. If this had occurred, it would have happened on the first day of class so that there would have been time for the construction and the administration of another measurement tool. Fortunately, this did not occur.

Non-use of the CAI programs and/or non-completion of the posttests by the volunteer students would have negated the entire "raison d'etre" of the project. This was monitored throughout the duration of the study via the automatic computer usage records and students were reminded to participate by means of periodic announcements at class lectures and laboratories. Compliance of the student volunteers, although not one-hundred percent, did not pose a major problem in this study.

Another major potential complicating factor was that of "test fatigue". In order to minimize this it was determined prior to the start of the experimental portion of this study that the principal subjects would be subjected to a maximum of three hours of testing (i.e. the equivalent time-wise of one week of lectures) during the major experimental phase of the project and an additional one and one-half hours during the following year. As noted in Chapter IV one of the major reasons for selecting the CPI as the principal measure of psychological variables was the ability to complete the eighteen scales within one hour. Thus, although several additional psychological variables, for example cognitive styles (i.e. conceptual level, field independence), may have been of interest to this research, they were not measured because of the established test-time constraint. It is believed, however, that adherence to this test-time constraint contributed to both the observed compliance of the student volunteers and the general "good feeling" which the volunteers had toward the project (i.e. the project did not overtax or take advantage of the good nature of the volunteers).

Four laboratory periods in the course, Pharmacology 431, were allotted for demonstrating priciples of autonomic pharmacology via animal models. Due to unavoidable scheduling constraints the first two laboratory periods were scheduled prior to the completion of posttest X #1 and the remaining two laboratory periods were scheduled after the completion of posttest X #1. Since the laboratory sessions were open to students in all three treatment groups it was anticipated that the confounding caused by the laboratory sessions would affect the three treatments groups equallly. In fact T1 had only one laboratory session prior to posttest X #1 whereas T2 and T3 had two laboratory sessions prior to posttest X #1. Therefore, if the laboratory sessions had any effect T2 and T3 should have had an advantage over T1.

The final major foreseen potential confounding factor was that of "extracurricular activities" (i.e. any activity which the students performed on their own which could not be controlled for or measured, but which may have affected their academic performance in pharmacology topic X). A primary example would be students studying from their pharmacology textbook or from other sources available in the library. As this confounding factor could neither be controlled nor measured the only thing which could be done was to randomly assign the students to treatment groups with the expectation that the "extracurricular activities" would thus be evenly proportioned between groups and would thus contribute equally to modifying the academic performance means in the three treatment groups.

CAI and Achievement

WHAT EFFECT DOES CAI HAVE ON STUDENT ACADEMIC PERFORMANCE IN PHARMACOLOGY?

Academic performance in pharmacology was measured by means of tests [9] containing multiple choice questions in a specified pharmacology topic. The means for these tests, listed in Table 17, and the respective analysis of variance, presented in Table 18, indicate that the treatment group which used CAI alone had a significant increase in academic performance in pharmacology in relation to occasion (0,1) (i.e. pretest X to posttest X #1) mean differences (as did the other two treatment groups).

Thus, it appears that CAI is at least as effective as the other methods used in this project to teach pharmacology content.

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[9] A more complete description and further details of these tests can be found in the "Academic Achievement Test" section of Chapter IV.

WHEN CAI IS USED IN ADDITION TO LECTURES, IS STUDENT ACHIEVEMENT INCREASED IN COMPARISON TO EITHER LECTURES OR CAI ALONE?

The main effects listed in Table 18 indicate that there was a significant ($p<0.05$) occasion (0,1) (i.e. pretest X to posttest X #1) effect on academic achievement in relation to treatment modalities.

No significant difference between treatment groups (T1, T2, T3) in relation to occasion (0,1) academic achievement test results were noted. In addition, no instructional interaction between academic achievement occasion (0,1) results and treatment group association was noted.

Taken together, these results indicate that each treatment (CAI alone, CAI concurrent with lecture, lecture alone) was effective in creating a statistically significant increase in mean academic achievement posttest X #1 scores over the mean pretest X scores. The results further indicate that the three treatments were equally efficacious and that no single treatment was statistically superior to the others. Thus, the use of CAI in addition to lecture did not increase or decrease student achievement in comparison to either lectures or CAI alone.

However, it seems that for the first time, CAI has been objectively demonstrated to be both effective and equal to lecture in teaching pharmacology content. This important result should allay the fears of those pharmacology teachers and administrators who have been leary of adopting CAI as an adjunct or replacement for the traditional lecture mode of instruction.

Hopefully, a concomitant benefit of an increased use of CAI in pharmacology would be the development of an increased number of high quality CAI programs. In this regard, the paradigm outlined in Figure 1 might serve as a basis which could be further refined and modified to meet local needs and requirements.

In summary, although additional studies with different learners (i.e. dental students, medical students, nursing students) should be performed, the results of this study clearly indicate that CAI in pharmacology can significantly affect student achievement and that as a teaching modality CAI appears to be equally as efficacious as the lecture mode.

Time savings are secondary in importance in relation to academic performance. However, noting that academic achievement was observed to be equivalent for both the CAI and lecture modes of presentation, it is of some practical interest to measure and compare how much students' time the various modes required.

It has been often observed in past comparisons of CAI and lecture that CAI usage has resulted in time savings for the learner:

> Savings in learner time to complete a course of study were shown in the great majority of the studies, with as much as 50-percent savings in training and testing time (Computer Technology in Medical Education and Assessment, 1979, p. 24).

The present study also found a similar time savings. As noted in the "Computer Data Collection Records" section of the previous chapter, the mean number of hours of use in "topic X" for T1 (CAI alone) was 5.65 hours. It was also noted in that section, that 10 hours of formal classroom lecture were devoted to the presentation of "topic X". Thus, it is apparent that a savings of over forty-percent in students' time was demonstrated with CAI use in the content area of pharmacology. This finding confirms the results of an earlier CAI study (Bitzer & Bitzer, 1973) which also found significant time savings when CAI was used to teach pharmacology.

<u>CAI and Retention</u>

IF CAI IS USED PRIOR TO LECTURES IN PHARMACOLOGY, IS STUDENT RETENTION OF LEARNED MATERIAL INCREASED IN COMPARISON TO CAI USED EITHER DURING OR AFTER LECTURES?

Because CAI was integrated as an adjunct in a required pharmacology course it was agreed prior to the start of the project that each student would have exposure to both CAI and lecture coverage for all of the pharmacology topics by the end of the academic term (See Figure 8). Accordingly, it was not possible to compare retention in relation to CAI or lecture alone. However, it was possible to determine if the sequence of exposure to CAI in relation to lecture (i.e. prior to, concurrent with, after) had any significant effect upon retention. Retention in pharmacology was measured by a test which utilized the same pool of multiple choice questions which was used to measure academic achievement. Posttest X #2 was administered to the main study group during the 1980-1981 academic year, one year after the conclusion of the major experimental portion of the study. Thirty-eight of the original sixty-one study volunteers completed the retention measure.

The main effects listed in Table 19 indicate that there was a significant ($p<0.05$) occasion (1,2) (i.e. posttest X #1 to posttest X #2) effect on academic retention in relation to treatment modalities.

No significant difference between treatment groups in relation to occasion (1,2) academic retention test results was noted. In addition, no interaction between academic occasion (1,2) results and treatment group association was noted.

These results indicate that each treatment (CAI prior to lecture, CAI concurrent with lecture, CAI following lecture) was effective in creating a statistically significant increase in mean posttest X #2 (academic retention) scores over the mean posttest X #1 scores. The results further indicate that the three different sequences of presenting CAI and lecture are equally efficacious and that no single treatment sequence is statistically superior to the others.

As noted above, the retention measure (posttest X #2) was significantly higher than the previous measure of academic achievement (posttest X #1) (See Table 17). This increase occurred for all three treatment groups and is not readily explainable. The only study found which involved CAI and yielded a somewhat similar result in relation to retention was the McEwen and Robinson (1978) report.

McEwen and Robinson (1978) studied the effect of combined classroom instruction with CAI versus classroom instruction alone in relation to retention of French language instruction. Four months following the conclusion of their experiment they administered a retention test to the control and experimental groups of students. They found that oral and written retention had decreased significantly for the control group, while the written retention level did not change for the experimental group and the oral level of performance (retention) increased significantly for the experimental group.

In the present study, however, increased retention was found with all three treatment groups. During the intervening year (1980-1981), between the end of the experimental treatments and the administration of the retention measure, the students took additional one term courses in both pharmacology and therapeutics. These two courses did not specifically cover the pharmacology topic, "adrenergic pharmacology", which was measured, but may have indirectly contributed to the increased scores (i.e. perhaps by increasing the students' problem solving (test taking) ability in this content area). It should also be noted that the loss of subjects in the present analysis of retention (i.e. from 61 to 38) may have confounded the obtained results, although an examination of the means and standard deviations listed in the posttest X #1 columns of Table 17 seem to indicate that the smaller group (n=38) was quite representative of the larger parent group (n=61). It is obvious that the final answer to this question and others related to retention can only be found by the conduction of more studies in this area.

However, although more studies need to be performed in this area, the results of this study indicate that when CAI is used as an adjunct to traditional teaching modalities (i.e. lecture) the sequencing of CAI and lectures does not appear to affect student achievement, at least in relation to long term retention.

This finding, if supported by replication, could have a significant impact on CAI use in schools. If the sequence of student exposure to CAI does not affect student academic performance, then schools could use fewer CAI terminals to educate more students without decrements in academic performance.

CAI and Attitude

DOES USE OF CAI AFFECT STUDENT ATTITUDE TOWARD CAI?

The attitude questionnaire developed for this project was analyzed for response set, systematic orientation of scales, and general bias with Maguire's (1973) model.

According to Maguire's (1973) model for analyzing semantic differential questionnaire responses, the variance due to people effect (0.01), concepts effect (0.00), and people by concept interaction (0.00) should be small. The variance due to scales effect (2.06), people by scales interaction (0.38), and concepts by scales interaction (0.20) should be larger; and the variance due to people by concepts by scales interaction (1.38) should be largest of all (See Table 37).

The observed variance estimates, shown in parentheses above, agree very well with the expected variances according to Maguire except for the variance due to scales-effect which appears to be higher than expected. However, recalling that the scales-effect represents the tendency for people to rate all concepts toward either the 1 or the 7 end of scales, it becomes clear that the observed effect should be expected since in the current assessment the concepts (i.e. CAI) did not change, but were merely repeated as pretest and posttest.

If abnormally large people or people by concepts variances had been observed this would have indicated that some form of response set was affecting the data. Likewise, if a large concepts variance had been observed, this would have indicated a probable systematic orientation of scales. Since none of these variance deviations were observed it may be generally concluded that the semantic differential attitude questionnaire used in this project did not have a systematic orientation of scales and that the responses obtained from the subjects of this study did not contain response sets which may have affected the interpretation of the observed measures. These analyses support the reliability of the semantic differential attitude questionnaire which was developed and used for this project.

The analysis presented in Table 36 under the combined means column compared determinations of significant changes in the semantic differential questionnaire scales. Snider and Osgood's (1969) criteria of 0.5 scale unit changes in the mean for groups of individuals was compared with significant mean changes as determined by an analysis of variance with $p<0.05$. Agreement was obtained on nineteen of the twenty scales (95%) used in this project. This result seems to validate the use of Snider and Osgood's 0.5 scale unit change for the determination of statistical significance.

Results from the combined means column of Table 36 suggest that the subjects had definite attitudes toward CAI prior to the initiation of this project. This was indicated by the observation that only one of the twenty attitude scales, that of "apprehensive-nonapprehensive", was not significantly different from the neutral evaluation point of 4.0.

The changes noted in Table 36 from a comparison of the bipolar adjective pretest and posttest #1 pairs indicated a unanimous increase in all of the scales of the familiarity factor (bipolar adjective pairs #5, 8, 12, 14 and 20) from less to more positive. It was expected that as students used the computer programs they would naturally become and feel more familiar with them. Although this provides no unexpected information it does tend to validate the ability of the "CAI Attitude Questionnaire" to measure attitudes, at least in relation to the factor of familiarity.

The other changes noted in comparing results from the attitude pretest and posttest #1 indicated three changes in the evaluation factor (bipolar adjective pairs #1, 11 and 19) in a negative directive, that is poorer evaluation. However, considering that twelve other scales in these two factors did not show significant change it is probably safe to conclude that overall the factors of evaluation and activity did not change significantly from pretest to posttest #1.

Table 35 gives some indication of the stability of the attitude questionnaire responses. Attitude posttest #2 was administered one year after the conclusion of the major experimental phase of the project. Yet only three of the twenty attitude scales (#4, 17, 19) of posttest #2 changed significantly from the means observed in attitude posttest

#1.

The subjective student evaluations reported in Figure 9 confirm earlier work (Pagliaro & Burkhalter, 1979) which found that students rate highly CAI programs in the content area of pharmacology. It does not explain, however, the lack of change noted in the CAI attitude questionnaire factor of evaluation. The factor of evaluation according to Nunnally (1978) is practically synonomous with attitude and "should serve well as [a] measure of verbalized attitudes" (p. 609). One would, therefore, normally anticipate that both questionnaires should change (or not change) in like manners.

In conclusion, it would appear that although initial and subsequent student attitude toward CAI tended to be positive it was not significantly affected by student use of CAI.

IF ATTITUDE TOWARD CAI CHANGES, IS THIS CHANGE CORRELATED WITH ACADEMIC ACHIEVEMENT IN RELATION TO THE USE OF CAI IN PHARMACOLOGY?

Because no significant attitude changes occurred this question cannot be answered. Correlation of academic performance with the responses made on individual scales of the attitude instrument are however presented in the next section, "CAI and Instructional Interactions".

CAI and Instructional Interactions

CAN A SIGNIFICANT CORRELATION OR INSTRUCTIONAL INTERACTION BE FOUND BETWEEN SPECIFIC STUDENT DEMOGRAPHIC OR PERSONOLOGIC VARIABLES AND ACADEMIC PERFORMANCE IN RELATION TO THE USE OF CAI IN PHARMACOLOGY?

Correlational Analysis

The first part of this question involves the use of correlational analysis in order to determine variables which correlated significantly with academic performance. These variables could then be used to predict academic performance with CAI in other settings.

Table 8 lists the results of an attempt to form a multiple correlation between the criterion variable of academic achievement (posttest X #1) and a number of demographic predictor variables. A significant multiple correlation of 0.41 was obtained. When the contribution of each variable to the prediction was assessed (Table 9) the one variable which contributed significantly to the model was "hours of CAI use in topic X".

Table 10 lists the results of an attempt to increase the multiple correlation obtained in Table 8 by the use of some psychological predictor variables. The obtained multiple correlation of 0.72 (Table 11) was statistically greater than the previously obtained R of 0.41. In addition, it should be noted that the amount of variance accounted for (R^2) increased from 0.17 to 0.52. Thus, use of the psychological predictor variables increased the multiple correlation significantly and increased "the amount of variance accounted for" by over three-hundred percent in comparison to that obtained with the demographic predictor variables alone.

It should be noted, however, that although significant unique contributions are made by some psychological variables, the correlations of these variables with academic achievement is generally very low when compared with such demographic variables as grade point average and hours of CAI use (See Table 7). In addition, those psychological variables which were significantly correlated with posttest X #1 were not significantly correlated with posttest X #2.

From Table 11 it is apparent that the predictor variables which provide a unique contribution to the prediction of posttest X #1 in the context of the listed variables are: grade point average; and the "unfamiliar-familiar", "confusing-clear", and "tensed-relaxed" scales of the CAI attitude questionnaire.

Similar correlational analyses to those performed with posttest X #1 were also performed with posttest X #2, the retention measure. The multiple correlation for the full model obtained with the demographic predictor variables was 0.55 (Table 13). When the variables listed in Table 13 were analyzed by means of a multiple stepwise regression (Table 14), one variable, grade point average, was demonstrated to contribute significantly to the multiple correlation. However, when the number of variables were increased by the use of psychological predictor variables, a significantly higher multiple correlation coefficient (0.83) was obtained (Table 16), and the originally significant predictor variable no longer made an unique individual contribution to the prediction.

A comment must be made about the principal source of psychological variables (i.e. the CPI). According to Megargee (1972) the CPI was "designed to assess enduring personality characteristics as opposed to transient mood states [and] should [therefore] have high coefficients of stability" (p. 29). However, as noted in Table 38, the long term (i.e. one year) coefficients of stability for the eighteen CPI scales were observed to be moderate and not high. These test-retest coefficients, which ranged from 0.29 to 0.83, did occur in approximately the same range as those presented by Gough (1975, p. 19) for test-retest of high school students (i.e. 0.38 to 0.77). However, the observed correlations are not considered to be high enough, contrary to Gough's (1975) opinion, to confirm that the CPI scales measure trait as opposed to state variables. If the CPI measures changeable states then its usefulness and interpretation in correlational analysis will be limited.

Analysis of Variance

The second part of the question posed at the beginning of this section involved the use of analysis of variance techniques to determine if particular learner variables interacted significantly with CAI to differentially produce academic achievement increments or decrements. Each of these analyses examined performance on pretest X and posttest X #1 of students possessing particular demographic or psychological variables in relation to treatment group (i.e. T1-CAI alone, T2-CAI concurrent with lecture, T3-lecture alone). The variables selected were those found in the literature which had previously yielded a significant correlation or instructional interaction in relation to academic achievement (See Table 4). These variables included: achievement motivation, aptitude, sex, and sociability. The variables of anxiety and mental ability, although listed as possibly significant in Table 4, were not used for the following reasons. Measurement of anxiety had been integrated into five scales of the attitude questionnaire. However, when the attitude questionnaire was factor analyzed, the scales failed to load significantly upon any one factor. Thus, a valid measure of anxiety which could be used to divide subjects into low, medium, and high groups for analysis was not available. Normed tests, which could measure mental ability in relation to the subject matter of pharmacology, were also not readily available, therefore, this variable was not measured. However, a somewhat related variable "pharmacology knowledge entry level" was measured and analyzed for the presence of instructional interactions.

Achievement motivation. Achievement motivation was the first variable used to define a factor in a two-way analysis of variance. Achievement motivation was measured by the Achievement via Independence (Ai) scale of the CPI. Subjects were divided on the basis of their Ai scores on CPI #1 into three groups: low, Ai=12-16; medium, Ai=17-19; and high, Ai=20-25.

Table 21 lists a summary analysis of variance table for academic achievement pretest X in relation to level of achievement motivation and treatment. Neither the 'achievement motivation' nor 'treatment' main effects were significant. The 'achievement motivation X [by] treatment' interaction was also not significant. Similar analyses for posttest X #1 are presented in Table 22. None of these effects were statistically significant.

Thus, it appears that the results of this study fail to demonstrate an instructional interaction between academic achievement and achievement motivation, as measured by the

Ai scale of the CPI. This result is in agreement with that which was reported by Reid, et al (1973).

Aptitude. The summary three-way analysis of variance table for the next variable, aptitude, is found in Table 24. Aptitude was measured by grade point average (GPA) and divided into three groups: low, GPA=4.38-5.50; medium, GPA=5.61-6.84; and high, GPA=6.89-8.76. These GPA's were based on cummulative performance through the first two years in the pharmacy program at the University of Alberta. The GPA's are theoretically based on a stanine (marking on a 1-9) system, however, a minimum GPA of 4.0 is necessary to remain and progress within the pharmacy program. Thus, no GPA's less than 4.0 were found in this study's sample.

The 'aptitude' main effects and the 'occasion (0,1)' (i.e. pretest X to posttest X #1) main effects were statistically significant and post-hoc contrasts for these effects are presented in Table 25. The remaining analyses listed in Table 24 were not significant.

From Table 25 it is apparent that aptitude, as determined by GPA, does not significantly interact in a differential manner with academic achievement (i.e. all groups benefited equally). This finding is contrary to the two previously reported studies concerning aptitude and academic achievement (Deigman, et al, 1980; Reid, et al, 1973) which found an interaction when CAI was used. However, as noted above, a minimum GPA was required to stay in the pharmacy program. Thus, the distribution of GPA's used in this study were higher than the true population of GPA's and was skewed to the right. This feature may have affected the analyses and may account for the discrepancy in findings from the previously reported studies.

Pharmacology knowledge entry level. The next variable analyzed for instructional interactions was that of pharmacology knowledge entry level. The pretest X, which the students completed at the beginning of the experimetal phase of this project, served as an entry level measure of "pharmacologic" knowledge. Accordingly, the students were divided into three groups on the basis of their performance: low, number of correct responses on pretest X=1-3; medium, number of correct responses on pretest X=4-5; and high, number of correct responses on pretest X=6-8.

Table 27 contains the summary analysis of variance table for academic achievement pretest X in relation to pharmacology knowledge entry level and treatment group. The 'pharmacology knowledge' main effects were significant, but the 'treatment' main effects were not. The finding of significant 'pharmacology knowledge' effects would be expected because the analysis was deliberately set up to have different levels of pretest achievement. Thus, this analysis confirmed that the three groups, which had been divided according to the number of correct responses on pretest X, were statistically different. Table 28 presents the same analysis as Table 27 only in relation to performance on posttest X #1. No significant effects are noted in Table 28. However, in this case, one would have expected the 'pharmacology knowledge' main effects to have remained significant. Since they did not, this indicates a significant interaction has occurred between pharmacology knowledge entry level and academic achievement.

If one were to plot the mean pretest X and posttest X #1 scores presented in Table 26 and examine the resultant graphs, one would find that those students in the low and medium pretest X categories gained most from all three treatments, while those in the high category gained the least. In fact, those in the high category appeared to show almost no gain from pretest X to posttest X #1. This effect occurred across all three treatments. This was not a ceiling effect because the maximum possible score on the achievement tests was 15.

This finding is believed to be the first such reported effect in relation to CAI use in the content area of pharmacology. However, if pharmacology knowledge entry level is considered as a measure of mental ability in the content area of pharmacology then this finding would be in agreement with the three previously published reports (Edwards, et al, 1975; Lavin, 1980; Suppes & Morningstar, 1969) which all found evidence of instructional interactions of mental ability with academic achievement when using CAI. In this regard Tobias (1976) has noted that:

> Level of prior achievement can, of course, be easily defined by pretest scores . . . the higher the level of prior achievement, the lower the instructional support required to accomplish instructional objectives. Conversely, as the level of prior achievement decreases, the amount of instructional support required increases. (p. 67)

However, noting that the observed interaction persisted across treatments, it is probably a more likely conclusion that the interaction is with the design of both the CAI and lecture teaching strategies and not with CAI per se. In other words, the lectures and CAI programs were probably designed (consciously or subconsciously) in a norm referenced manner which attempted to bring all students to a certain desired minimal level of achievement.

Sex. The variable of sex was the next one analyzed for instructional interactions. Subjects were divided into two groups, male and female, for this analysis.

The summary two-way analysis of variance table for academic achievement pretest X in relation to treatment group and sex is presented in Table 30. The "treatment' main effects were not significant, however, the 'sex' main effects were significant. This indicates that females had significantly lower pretest X mean scores than did males. Table 31 presents a similar analysis only in relation to posttest X #1. Here we note that none of the effects were significant (i.e. mean scores for females and males were now statistically equal).

This implies that the females had significantly greater posttest X #1 performance increases in relation to their pretest X scores, which had been significantly lower than the males. Thus, it appears that this study suggests the presence of an instructional interaction with females achieving relatively greater academic achievement than males. It further appears that this finding is in conflict with the previous two studies (Downing & Lowe, 1981; Wooley, 1978) which also found an apparent instructional interaction with sex, but with males achieving preferentially higher than females.

As noted in Chapter III, an instructional interaction probably has occurred, not between sex and CAI, but between sex and the subject matter. In the previously reported studies, males did relatively better in the "mathematically" oriented subjects. In this study females did relatively better in the "verbally" oriented topic of pharmacology. This interpretation is borne out by the observation that the observed instructional interaction with sex occurred across all three experimental treatments (i.e. CAI alone, CAI concurrent with lecture, lecture alone).

<u>Sociability</u>. The last variable analyzed for instructional interactions was that of sociability. Sociability was measured by the Sociability (Sy) scale of the CPI. Subjects were divided into three groups on the basis of their Sy scores on CPI #1: low, Sy=15-20 (with one

observation at 8); medium, Sy=21-25; and high, Sy=26-34.

Table 33 lists the summary analysis of variance table for academic achievement pretest X in relation to level of sociability and treatment group. None of the effects noted in Table 33 were significant. Similar analyses for posttest X #1 are found in Table 34. Here we note that the 'treatment' and the 'sociability X treatment' effects were not significant, but that the 'sociability' main effects were significant. Table 32 indicates that the posttest X #1 scores for the low sociability group were higher than those obtained by either the medium or high sociability groups across all treatments. Post hoc contrasts further indicate that the low sociability group achieved significantly higher mean scores than the medium sociability group on the posttest X #1 performance.

Thus, this study has demonstrated an instructional interaction between level of sociability and academic achievement. All three experimental treatments noted the same effect and all three were primarily oriented toward independent study. This result was predicted in the section on sociability in Chapter III and further demonstrates that the results observed by Reid, et al (1973), were not with CAI, but with the design of the CAI experience. Thus, if students had been assigned to work at their CAI experience in pairs, instead of alone, the observed interaction would be expected to have been the opposite, as noted by Sutter and Reid (1969).

Conclusion. A number of instructional interactions have been demonstrated in this study. However, in each case, the interaction has persisted across treatments. Thus, it appears that instructional interactions which in the past had been tentatively associated with a specific treatment (i.e. CAI) may have actually been related to more basic variables such as the subject matter being taught or elements of the instructional process which in the present study were common to all three treatments.

CHAPTER VII

CONCLUSION AND RECOMMENDATIONS

CAI use in pharmacology has steadily increased since its inception in the early 1970's. However, this increased usage as reported in the literature has not been based upon, nor accompanied by, objective analysis of the relative effectiveness of this method of teaching pharmacology. As noted in Chapter II, most of the published literature concerning CAI in pharmacology consists of descriptions and reports of various CAI applications and systems. In over one decade of use only four publications could be found which contained quantitative data concerning the effectiveness of CAI in pharmacology and none of these studies satisfactorily answered the question of whether or not CAI in pharmacology significantly affects student learning and/or attitude.

Thus, the situation existed where an increasing number of students were being taught with a technique (CAI) which had yet to be carefully examined in an objective manner and determined to be effective in the content area of pharmacology.

This research project was designed to measure the effect of CAI in the content area of pharmacology upon student academic performance and to document the occurrence of significant correlations and instructional interactions in relation to CAI use and academic performance.

The subjects for this study were pharmacy students enrolled in an undergraduate pharmacology course at the

University of Alberta during the 1979-1981 academic years. The subjects were randomly divided into three different treatment groups (CAI alone, CAI concurrent with lecture, lecture alone) and proceeded through a series of CAI programs in a variety of topics in pharmacology.

Data was collected on a variety of demographic and psychological variables and on academic performance in a selected pharmacology topic. This data, analyzed by means of correlational and analysis of variance techniques, provided an objective analysis of the effect of CAI on academic performance in pharmacology and attitude toward CAI. In addition, specific demographic and psychological variables obtained from student records and the CPI were correlated with CAI usage and attitude toward CAI.

The results of this project indicate that "CAI alone" can be an effective modality for teaching pharmacology content and further that CAI was equivalent to the lecture mode of presentation. Thus, for the first time CAI has been formally and objectively demonstrated to be effective in the content area of pharmacology.

The results also corroborate the findings of an earlier study (Pagliaro & Burkhalter, 1979) which found that although students evaluated CAI highly, CAI did not affect student attitudes toward CAI per se. This finding should illustrate the folly of subjective reports which have in the past attempted to equate positive student and/or faculty evaluations of CAI with positive performance or attitude.

In addition to these basic findings this project went on to examine and attempt to confirm a number of instructional interactions involving CAI at a post-secondary level which had previously been reported in the literature.

In this regard the variables of achievement motivation, aptitude, pharmacology knowledge, sex, and sociability, were examined. The variables achievement motivation and aptitude failed to produce any significant instructional interaction in relation to CAI use and academic achievement. The remaining variables pharmacology knowledge, sex, and sociability were, however, involved in instructional interactions.

Students who at the start of the project had lower levels of pharmacology knowledge, were able to achieve significantly more on a percentage gain basis than those who started with higher levels of pharmacology knowledge. However, since this interaction was observed for all three treatment groups the interaction was probably not with CAI per se, but with a more basic variable. For example, perhaps the basic design of the entire pharmacology instruction may have been norm referenced and oriented to having all students achieve the same basic level of competence.

Similar effects were noted with the variable, sex. Females demonstrated significantly greater post-test academic achievement in relation to their pretest scores, which had been significantly lower than the males. However, here again the interaction persisted across treatments. This leads one to suspect that the interaction may again have been with a more basic variable. In this case the interacting variable may have been the subject matter itself, with females having a predilection for superior performance in the content area of basic pharmacology.

The last variable examined was that of sociability. Here an instructional interaction was observed with individuals possessing low sociability achieving significantly greater academic achievement scores than those possessing either medium or high measures of sociability. Again, however, the effect persisted across treatments and again leads one to conclude that the instructional interaction is again not with CAI, but with a more basic variable. In this case a likely candidate is the method of instructional presentation which was related to independent study and would thus tend to favor students with low sociability ratings.

Thus, although several instructional interactions were observed in the context of CAI, none of these appear to be unique to CAI per se. The description given in Chapter I of CAI as an essentially neutral technology, which has the potential to interact within the educational milieu in either a positive or negative manner, seems to have been supported by the findings of this study.

Several questions, issues and observations raised by this study should be considered in assessing the presented results and in planning other research in this area:

1. Is CAI such a broad term that its usefulness in research becomes meaningless unless its components are fully defined?

2. Is simple CAI necessarily of poor instructional quality? Perhaps software for more complex CAI strategies (i.e. patient simulations, diagnosis, remediation, review, consolidation) should follow more closely various learning and instructional principles.

3. Is the careful detailed monitoring of what occurs in the "traditional" teaching modality important for control and explanatory purposes in instructional interaction studies?

4. How much learning is acceptable on the part of the teaching staff (and possibly students) regardless of method of instruction? This issue is confounded with the problem of difficulty of content matter and test item difficulty. Perceived value and relevance also confound this issue.

5. To what extent should CAI or learner instructional strategies be constrained by the experimenter in order to provide a common basis of comparison?

6. From a practical point of view, must a value judgement be made as to whether "no statistically significant differences" are to be interpreted as equally effective or equally ineffective treatment procedures? This issue is confounded by the previous two points.

7. How complete should the monitoring of student "extracurricular activity" be?

In conclusion MIMI suggests many other factors (i.e. varying the amount of time spent in the particular instructional strategy, level of anxiety, cognitive style, use of less difficult pharmacology topics) to be considered in further research. It is recommended that further research be conducted to verify the instructional interactions noted in this study. In addition, research similar in nature to that presented in this study but with different groups of learners (i.e. dental, medical, and nursing students) still needs to be performed in order to verify for these different groups of learners the efficacy of CAI in the content area of pharmacology.

Appendix I

CAI program library listing by category

General Principles	Program I.D.
General Pharmacology I	G01
Pharmacokinetics I	G02
Pharmacokinetics II	G03
Fetal Pharmacology	G04
Review Questions	G05
Pediatric Pharmacology Quiz	G06

Autonomics and Cardiovascular	
Autonomic Pharmacology I	A01*
Synthesis & Biotransformation of Neurotransmitters	A02*
Cholinergic Mechanisms & Uses	A03*
Adrenergic Mechanisms & Uses	A04*
Autonomic Test Questions	A05*
Case History: Emergency Admission from Unexpected Drug Reaction	A06*
ANS Review Questions	A08*
Arterial Blood Pressure in the Anaesthetized Dog	A09*
Diuretics: Mechanisms of Action	A21
Diuretics Quiz	A22
Anti-Dysrhythmic Drugs	A23
Treatment of Cardiac Dysrhythmias	A30
Management of Hypertension	A31
Poisoning from "Heart Preparations" in the Home	A32
Cardiology Review Questions	A33
Digitalis Glycosides	A34
Treatment of Angia	A35
Accelerated Hypertension Test	A36
Propranolol in Cardiovascular Medicine	A37
Pharmacology of Reversible Obstructive Lung Diseases	A38
Asthma: Review and Case Study	A39
Introduction to Autonomic Pharmacology	AUTO*
Cholinergic Mechanisms	CHOL*
Catecholamine Biosynthesis	CATE*
Cholinesterase	CHOL*

Central Nervous System	Program I.D.
Neurophysiology Review Quiz	C01
20 Questions on CNS Pharmacology	C02
CNS Review Questions	C03
Local Anaesthetic Drugs	C12
Local Anaesthetic Review	C13
Sedatives and Hypnotics	C20
CNS Stimulants and Hallucinogens	C21
Tranquilizers	C22

*Programs from which questions for data bank were based (i.e. autonomic nervous system medication programs).

Appendix II

Adjectives characterizing high-scoring and low-scoring men on the eighteen CPI scales[a]

	High	Low
Do	Ambitious dominant forceful optimistic planful resourceful responsible self-confident stable stern	Apathetic indifferent interests narrow irresponsible pessimistic restless rigid reckless suggestible submissive
Cs	Discreet forgiving imaginative independent mature opportunistic pleasant praising progressive reasonable	Bitter gloomy greedy interests narrow nagging resentful restless tense touchy unkind
Sy	Clever confident interest wide logical mature outgoing resourceful reasonable self-confident sociable	Awkward bitter cold complaining confused hard-hearted interests narrow quitting shallow unkind
Sp	Adventurous interests wide pleasure-seeking relaxed self-confident sharp-witted unconventional uninhibited versatile witty	Appreciative cautious cooperative interests narrow kind mannerly patient prudish serious shy

Sa	Confident enterprising egotistical imaginative opportunistic outgoing polished self-confident self-seeking sophisticated	Bitter commonplace interests narrow quitting reckless submissive tense unintelligent withdrawn self-denying
Wb	Conservative dependable depentent good-natured inhibited logical pleasant poised praising relaxed sihcere	Anxious blustery distractible forgetful hurried impulsive mischieveous quitting shallow restless
Re	Capable conscientious dependable reasonable reliable responsible, serious stable steady thorough	Careless disorderly forgetful irresponsibility laxy mischievous pleasure-seeking reckless show-off spendthrift
So	Adaptable efficient honest inhibited logical kind organized reasonable sincere thorough wholesome	Deceitful defensive headstrong irresponsible mischievous outspoken quarrelsome rude sarcastic unconventional
Sc	Considerate dependable hard-headed independent painstaking precise reasonable reliable	Conceited fault-finding hasty headstrong impulsive individualistic self-seeking spunky

	self-controlled	tempermental
	self-denying	unrealistic
To	Forgiving	Affected
	generous	cold
	good-natured	egotistical
	informal	fussy,
	pleasant	hard-hearted
	reasonable	self-centered
	soft-hearted	shallow
	thoughtful	thankless
	unselfish	whiny
		fault-finding
Gi	Adaptable	Complaining
	changeable	dissatisfied
	considerate	fault-finding
	kind	irresponsible
	self-denying	headstrong
	soft-hearted	indifferent
	tactful	nagging
	unselfish	pessimistic
	warm	tempermental
	friendly	unkind
Cm	Cautious	Attractive
	conscientious	careless
	deliberate	courageous
	efficient	cool
	formal	distractible
	organized	forgetful
	practical	leisurely
	responsible	pleasure-seeking
	thorough	reckless
	thrifty	spendthrift
Ac	Ambitious	Apathetic
	capable	distrustful
	conscientious	hard-hearted
	considerate	hasty
	intelligient	pleasure-seeking
	logical	reckless
	mature	rude
	reasonable	shallow
	resourceful	shiftless
	responsible	show-off
Ai	Foresighted	Affected
	independent	bossy
	informal	cautious
	intelligent	daring
	lazy	egotistical
	pleasant	fearful

	rational	frivolous
	sarcastic	mannerly
	touchy	smug
	versatile	stern
Ie	Capable	Awkward
	confident	cold
	efficient	forgetful
	foresighted	hard-hearted
	independent	interests narrow
	intelligent	queer
	reasonable	restless
	self-controlled	sensitive
	sophisticated	shallow
	unaffected	suggestible
Py	Aloof	Active
	evasive	cheerful
	foresighted	energetic
	independent	flirtatious
	individualistic	humorous
	persevering	kind
	peroccupied	opportunistic
	reserved	outgoing
	unfriendly	sociable
	wary	talkative
Fx	Easy going	Determined
	fickle	efficient
	independent	hard-headed
	lazy	organized
	optimistic	planful
	pleasure-seeking	practical
	quick	stern
	sharp-witted	stubborn
	spendthrift	stolid
	spontaneous	thorough
Fe	Appreciative	Adventurous
	complaining	aggressive
	feminine	clear-thinking
	formal	daring
	meek	impulsive
	nervous	masculine
	self-denying	outgoing
	sensitive	pleasure-seeking
	weak	show off
	worrying	strong

[1]From Gough, 1975.

Appendix III

Adjectives characterizing high-scoring and low-scoring <u>women</u> on the eighteen CPI scales[1]

	High	Low
Do	Aggressive bossy conceited confident demanding dominant forceful quick strong talkative	Cautious gentle inhibited peaceable quiet reserved submissive trusting unassuming
Cs	Alert clear-thinking forceful individualistic ingenious insightful intelligent interests wide logical versatile	Absent-minded cautious meek mild retiring shy submissive timid weak
Sy	Aggressive confident dominant energetic flirtatious intelligent interest wide outgoing sociable talkative	Cautious inhibited meek modest quiet shy timid unassuming withdrawn
Sp	Adventurous daring flirtatious mischievous outgoing pleasure-seeking spontaneous versatile ingenious witty	Cautious conventional fearful gentle reserved sensitive submissive timid unassuming

Sa	Adventurous	Cautious
	argumentative	conventional
	bossy	gentle
	demanding	mild
	determined	modest
	dominant	peaceable
	outgoing	shy
	sarcastic	trusting
	talkative	
	witty	
Wb	Calm	Awkward
	capable	defensive
	clear-thinking	fault-finding
	fair-minded	hard-headed
	informal	opinionated
	mature	sarcastic
	obliging	self-pitying
	poised	tactless
	rational	unconventional
	wise	unstable
Re	Conscientious	Arrogant
	cooperative	awkward
	discreet	bitter
	firesighted	careless
	insightful	hard-headed
	planful	lazy
	reasonable	obnoxious
	reliable	rebellious
	tactful	restless
	responsible	sarcastic
So	Cautious	Defensive
	clear-thinking	careless
	conservative	fickle
	organized	foolish
	practical	impulsive
	reasonable	outspoken
	reliable	peculiar
	self-controlled	pleasure-seeking
	unassuming	reckless
	wise	uninhibited
Sc	Calm	Adventurous
	conservative	aggressive
	gentle	arrogant
	moderate	excitable
	modest	impulsive
	patient	rebellious
	peaceable	restless
	quiet	sarcastic
	reserved	temperamental

	self-controlled	uninhibited.
To	Calm	Arrogant
	efficient	autocratic
	insightful	bitter
	leisurely	defensive
	logical	distrustful
	mature	hard-headed
	responsible	infantile
	self-controlled	resentful
	tactful	restless
	understanding	sarcastic
Gi	Calm	Changeable
	conservative	cynical
	mild	frank
	moderate	moody
	modest	pessimistic
	patient	sarcastic
	peaceable	shrewd
	trusting	stubborn
	understanding	temperamental
		witty
Cm	Clear-thinking	Appreciative
	confident	artistic
	energetic	awkward
	humorous	feminine
	practical	forgetful
	rational	forgiving
	rigid	indifferent
	stern	irresponsible
	strong	unconventional
		undependable
Ac	Conservative	Adventurous
	efficient	careless
	idealistic	easy-going
	enterprising	lazy
	obliging	irresponsible
	planful	rebellious
	logical	sarcastic
	reliable	unconventional
	reserved	uninhibited
		zany
Ai	Calm	Awkward
	capable	excitable
	clear-thinking	foolish
	discreet	immature
	intelligent	infantile
	logical	rattlebrained
	mature	restless

	original	simple
	rational	unrealistic
		unstable
Ie	Capable	Absent-minded
	clear-thinking	awkward
	confident	interests narrow
	efficient	nervous
	informal	pessimistic
	intelligent	simple
	leisurely	slow
	logical	stubborn
	rational	tense
	relaxed	withdrawn
Py	Capable	Conventional
	cool	generous
	independent	honest
	ingenious	kind
	leisurely	praising
	logical	tense
	mischievous	trusting
	self-confident	unassuming
	sharp-witted	warm
	undependable	worrying
Fx	Careless	Cautious
	clever	conscientious
	daring	conservative
	imaginative	defensive
	individualistic	prudish
	ingenious	rigid
	mischievous	slow
	original	simple
	pleasure-seeking	sincere
	sociable	self-punishing
Fe	Conscientious	Coarse
	discreet	dissatisfied
	generous	lazy
	gentle	masculine
	helpful	pleasure-seeking
	mature	restless
	self-controlled	robust
	sympathetic	self-centered
	tactful	touchy
	warm	tough

[1]From Gough, 1975.

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