The Effects of a Learner-controlled CAI Tutorial on High and Low Achieving Highschool Students

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ABSTRACT

The Effects of a Learner-controlled
CAI Tutorial on High and Low Achieving
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A learner-controlled tutorial program was produced as a supplementary educational resource to help highschool students enrolled in a Biology course to learn and review their knowledge on "The Digestive System". It was developed using the operating system Socrates which provides many learner-controlled options, including among others, control over random access and sequence of the material. A summative evaluation was conducted with 10th-grade students in Chomedy Polyvalente Highschool, in order to determine the program's overall effectiveness, as well as the ways and conditions under which it could be best implemented. Thirty students, classified as high and low achievers based upon their previous performance on this topic, were randomly assigned to one of three treatment conditions: system-control, learner-control, and no computer instruction. Subjects in the learner-control condition were given the tutorial with the choice to use these options. Subjects in the system-control condition followed a linear sequence with no provision for the use of options. Subjects in the no computer instruction condition received a traditional lecture review. A 38-item posttest was administered following their instructional treatments. Significant differences in performance were

obtained between subjects that received the tutorials and those who received the classroom review. The question whether the learner-controlled options in Socrates enhanced learning, depended on subjects' level of achievement. No differences in performance were found between high achievers in the system and learner-control conditions. However, low achievers in the learner-control condition outperformed low achievers in the system-control condition. Some differences were also found in the frequency and type of option selection between high and low achievers in the learner-control condition. In addition, an analysis of attitudinal data indicated that subjects liked the tutorials very much, regardless of the type of control strategy (learner vs. system) received.

To my parents,
Dr. Fernando Navas Uribe and
Ms. Alba Palacio de Navas

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Clara Inés Navas Palacio

TABLE OF CONTENTS

Chapter Page

LIST OF TABLES

LIST OF FIGURES

Figures | Page

LIST OF APPENDICES

Appendix | Page

CHAPTER 1

Rationale

During the past 60 years many technological media, devices and systems have been invented and developed, which have appeared to revolutionize and offer major contributions to education, namely to the effectiveness of the teaching/learning process. Among the most widely known are motion pictures, television, videotapes and discs, programmed learning, and individualized learning modules (R. Tyler, 1980). Now, with their rapidly expanding capabilities, appeal and affordable prices, microcomputers are at the forefront of this revolution (Roblyer, 1985). We have come to accept that microcomputers can be used in many different ways in both schools and homes to supplement or support classroom instruction. This approach called Computer-Assisted Instruction (CAI) has rapidly gained impetus in the last few years, and has been accompanied by an explosion in educational software production (drill and practice, tutorials, simulations, games, etc.). An estimated 6,500 educational software packages were produced in the United States alone in 1984.

Advantages of Computers and CAI

Overall, the computer serves as a tool to assist learning, for the student to obtain, review, apply, and even create knowledge by interacting with it in a hierarchy of modes of interaction (Manion, 1985). It has the potential of functioning as a surrogate tutor and allows a greater amount of individualized instruction to occur (Blum, 1983; Bork, 1982). Furthermore, as it has been claimed, "computers have untapped potential for enhancing student motivation as well as for stimulating effective learning" (Thorndyke & Summach, 1982, p. 5). In the tutorial role, the computer relieves the teacher of certain tasks which are otherwise time-consuming or seldom possible. A quick look at today's educational context will give some insight as to how and why CAI could be effective.

It is customary, regardless of their different learning styles and needs, for students to rely on the teacher and on his/her teaching method as their main source of instruction and learning. Given a teacher-pupil ratio of 1:25 or 1:30, there is virtually no time for a truly individualized approach to instruction. Students must all advance at the same speed and rate at which the teacher presents information in class. Such current approaches to teaching in highschool cause problems, stress, and anxiety for students, especially those who find some areas in a topic more difficult than others, and therefore require extra time, effort and help to understand them. The teacher may not always be available to help and tutor these students after class, so they are left to integrate the material on their own. It is important then, to provide facilities such that they can serve as substitute teachers or tutors, and therefore satisfy students' different needs. The computer has been portrayed as a device that can give an opportunity for some students to either view, learn, practice, and/or review what has been introduced and learned in class. Computer-based tutorials are easy to use and can be viewed again and again at the learner's convenience.

To summarize, some of the most widely accepted advantages and values of CAI are: (a) it involves the student in the learning process; b) it allows students flexibility in their rate of progress (they are able to proceed at their own pace, which is of great advantage for both slow and fast learners); c) it gives students opportunity to practice what they have learned; (d) it provides immediate, systematized, and individualized feedback and reinforcement of learning; (e) it can be used in remedial education; (f) it can store information, retrieve it at will and evaluate users' responses (in other words, it remembers learners' answers, scores their results, and can branch them to other parts of the program); (g) it can display color graphics, animation (motion) and speed, with the added feature of being able to interact with the user; and very important (h) it allows the learner to exert some kind of control over the material being learned (Thorndyke & Summach, 1982; Hord, 1984).

Context of the Problem

Despite of all these presumed advantages, CAI is still a relatively new practice, highly innovative and currently experimental in both nature and design (Manion, 1985). Because of the recency of the microcomputer revolution in education, problems and uncertainties in relation to the practice of CAI still exist, and its effectiveness "in terms of student performance continues to be a controversial matter" (Holmes, 1982, p. 25).

Analysis of the educational software programs that this 'revolution' has brought forth has revealed some fundamental flaws in their objectives and capabilities (Dreyfus & Dreyfus, 1984). The great majority lack quality (Hord, 1984; Beebe, 1983; Blum, 1983; Spielman, 1981; Elithorn, 1982) and cannot even pass a test of their educational value. These programs have been developed in a vacuum, with little effort spent on evaluating the relationship between CAI and the curriculum (J. Tyler, 1983). There are thousands of CAI programs on the market, some which even provide some type of learner control (e.g. menu-driven programs), but still good educational software is hard to find.

One of the reasons for this, is that most of the currently available software has been developed by people outside of Education, generally by programmers who have little or no background in instructional design or educational methodology; or by teachers who are experts in methodology, but lack programming skills. These software developers have not followed a systematic and planned approach, and have not incorporated results of learning research into CAI (Carter, 1984). Instead, they seem to use 'common sense' guidelines to design them, and they produce them in a 'commercially artistic' fashion (Roblyer, 1985).

Another very important reason for the poor quality of educational software is the lack of both formative and summative evaluation. The vast majority of educational software producers are turning out untested and untried software. Presently, "the effectiveness of materials is usually determined by a very subjective evaluation on the part of both publishers and purchasers" (Roblyer, 1985, p.43). A survey conducted in 1983 found that among the few publishers that field-test their programs, teacher evaluation rather than student achievement, was the chief indicator of their software's effectiveness (almost none use pre and posttests, or any data collection on student performance as indicators). It was also found that publishers and producers do not believe that preliminary field-testing or evaluation with the intended target population will enhance marketability of their software (Truett, 1984).

In addition to these problems, there is the fact that although there are many evaluation checklists (technical standards, pedagogical standards, etc.) on the market, the evaluation of educational software remains a very difficult task, because most of the criteria have not been widely agreed upon (Blum, 1983; Lewis, 1984). There has been a wide and varied range of opinions about what an ideal and effective educational software program should entail (Roblyer, 1981). Thus, the evaluation of educational software has no well established history of evaluation methodology (Truett, 1984).

At last, many of the operating systems and authoring or programming languages that have been used and are still used today are quite inadequate for developing a wide range of highly effective computer-assisted materials (Bork, 1982; Morris, 1984; Tallon, Ball & Tomley, 1982; Mudrick, 1984; Elithorn, 1982). The very nature of these languages imposes limitations on the design of programs and only allows for a certain type of control on the part of the learner to manipulate the material. Or, they require extensive knowledge in programming, thereby limiting their availability to only computer scientists.

Need for Higher Quality Software

It is important to remember that the value of the microcomputer greatly depends on the quality of the programs that are developed (O'Neill, 1984). At the same time, the quality of the programs depends to a large extent on the operating systems and authoring languages that are used for this purpose. As Tallon et al. (1982) suggested, "choice of language can dramatically affect the content of teaching, the teaching approaches adopted, and the type of learning which ensues" (p. 21).

In recognition of the need for better educational software, educators, instructional designers, and many others have become more involved and knowledgeable in this field. On the one hand, software and hardware developers have started to respond to the special needs of classroom teachers and students. Efforts have been made to invent new operating systems and authoring languages that allow for the production of higher quality educational software beyond the typical system-controlled and branching types (e.g. learner-controlled). On the other hand, efforts have also been made to develop better educational software programs, following as closely as possible the latest theories in instructional design, learning and CAI.

In an attempt to contribute to the betterment of highschool educational software in particular, this producer developed a tutorial program based on the needs of the learner and the curriculum. It is intended to provide information to help highschool students enrolled in a Biology course, to learn and review their knowledge on "The Digestive System". It is to be used as a supplementary educational resource and as support to regular classroom instruction, by those students who for one reason or another, have not achieved a satisfactory level of understanding of the material, as well as by those who want to review and therefore enhance their understanding of the material. Opportunities like this are seldom feasible in traditional programs. As Thorndyke & Summach (1982) suggested, students requiring further work or desiring to review a topic (e.g. to prepare for exams), should be provided with the necessary 'study' materials in the area, so that they can achieve the expected level of understanding at a rate conmesurate with their ability. The proposed learner-controlled tutorial program will provide such help, by giving an opportunity for some students to view and learn the material at their own pace and convenience, as well as for others to practice and review what has been introduced and learned in class. The program may be used in a school setting, (in which case no hard copy information on students' performance is available to the teacher, except for their scores on disk). It may also be used in an informal learning environment, such as a home.

The CAI program was developed using a new operating system called Socrates, in which the learner is able, if and when desired, to be in control of the program and therefore manage his/her own learning. It was produced by a company in Montreal, Canada, in congruence with suggestions from various educational technologists, instructional designers, and artificial intelligence experts.

Purpose of the Study

As Roblyer (1985) suggested, if the true potential of this field is to be developed, many more hypotheses with accompanying research needs to be done in order to determine what works, what doesn't, (with whom), and why; and thus promote more effective uses of the technology. More research has especifically been called for in the area of learner-control. Issues such as--how control should be granted, to whom, and under what conditions--must be addressed if instructional designers are to make good instructional programs (Carrier, Davidson, Higson, & Williams, 1984). Relative to all the above stated issues, a summative evaluation of the proposed learner-controlled CAI tutorial program was conducted in order to determine its overall effectiveness as a supplementary resource and support for classroom instruction. It was primarily an implementation study that aimed at determining the conditions (student and instructional) under which this program could best be implemented.

CHAPTER 2

The Learner-controlled Tutorial Program

Outline of Content and Form of Presentation

The program deals with the structure and function of the digestive system in human beings. It follows a pre-determined sequence based on the hierarchical relationship of concepts. It also follows a certain order to present particular information within each concept. However, the learner can interrupt and change this sequence at any given time and place, by using certain options/commands available in the operating system. At the same time, the program can be operated in a system-controlled fashion, that is, following the sequence outlined by this producer. (For a description of these options, see the Learner's Documentation Manual in Appendix A). The program covers a total of 12 concepts presented in the following order:

1) Introduction to digestion
2) Mouth
3) Teeth
4) Tongue
5) Salivary glands
6) Esophagus
7) Stomach
8) Ulcers
9) Liver and gallbladder
10) Pancreas

11) Small intestine

12) Large intestine

It presents particular information about each concept, such as a definition, examples, and the structure and function of organs. It then tests the students for comprehension and recall of the information and provides immediate feedback (knowledge of results). The program is about 1 hr 30 min long when taken sequentially without using any of the options available. It is one of a four part series designed for 10th-grade highschool students enrolled in a Biology course.

Objectives of the CAI Program

After studying the program, learners will be able to: (a) identify and describe the structure and function of all organs of the digestive system; (b) indicate the role of the liver, gallbladder and pancreas in the digestive system; (c) describe the absorption process and the various structures involved, as it occurs in the small intestine; and (d) list and describe the digestive processes which occur in the stomach.

Rationale for Production Design

All production decisions were based on empirical research on CAI, educational message design theories, and on a combination of instructional design models and principles. The tutorial program was produced following a team approach. The team was composed of subject-matter-experts (SME), an educational technologist, graphic artists, and programmers. Each member was responsible for different components of the plan, in accordance with their expertise. This is believed to be a better way of designing educational software than previous one-person approaches. Many authors and educators are now advocating that "creating good CAI... is a multifaceted task. Many people must contribute to its success" (J. Tyler, 1983, p. 26).

Development process. A systematic and planned process was followed for the initial development of the tutorial program. This process was divided into several stages (J. Tyler, 1983; Hord, 1984; Beebe, 1983; Smith & Boyce, 1984). Once the topic was selected from the highschool's curriculum, the first stage consisted of an analysis and identification of the instructional goal, objectives, pre-requisite skills, target audience, list of main concepts and subordinate concepts to be taught (see Appendix B), instructional sequence, and other preliminary issues. In the second stage, thorough research of the topic was carried out using as many as ten current highschool textbooks and the content was developed in the form of a script. In the third stage, the content was storyboarded depicting exactly what students would see on the screen. The storyboards denoted the logical order for presenting the screens, as well as detailed information regarding position of text, graphics, animation, sound and other information necessary for the artists and programmers to produce it.

Concept presentation. To aid students in developing a proper discrimation between the concepts involved (Smith & Boyce, 1984) particular information or components were included in each concept. A general introduction (advance organizer) was presented first, in order to stimulate learners to focus their attention upon the learning tasks to follow (implicitly stated objectives). Thereafter, introduction screens were used to explain why the concept was important, and/or how it related to others in the program. When applicable, they focused on ideas already familiar to the students in order to elicit pre-requisite knowledge (Smith & Boyce, 1984). Graphics and animation were used to attract students' attention. Following these, examples were provided to give the student a base on which to recognize or generate the concept (Jay, 1983). Non-examples (negative examples) of the concept were given in those few cases in which the concept could have been mistaken for another. Again, in those cases where examples were not sufficient to describe, demonstrate or define a concept, a definition was given. After these, three questions were asked about each concept to enable students to practice the material learned. According to Gagne (1977) this is a necessary condition to improve learning. The questions used were mainly multiple choice, fill-in-the-blank, and single-word answer. Feedback was given immediately after a response to inform the student whether the answer was correct or incorrect, and what the correct response was (Carter, 1984; Blum, 1983; Jay, 1983).

Provision was made to supply knowledge of results within the context of the question, and not simply by stating the correct letter or word. For a sample of concept presentation see Appendix C.

Feedback. A consistent form of feedback was used in which all answers were repeatedly acknowledged with a simple 'correct' or 'incorrect' in congruence with research that suggests that when a program chooses randomly among various phrases like 'great', 'terrific', 'right on', the student "may be led to believe that these phrases represent different levels of approval and consequently interpret a mere 'good' as half a failure" (Nievergelt, 1980, p. 14). As recommended in the literature, no exclamation mark or other type of 'threatening' tactics was used. In addition, feedback was designed so that it would not over-reinforce correct answers with elaborate praise, or reinforce wrong ones by providing a more rewarding graphic than that provided for a correct answer (Blum, 1983).

Screen design. Careful consideration was given to screen design, in accordance with the most widely accepted criteria, guidelines and research findings stated in CAI literature. Research indicates that the human mind understands information displayed on a page (screen) fastest if the layout is balanced, if the page is not crowded, and if related items are placed near to each other (Nievergelt, 1980). In light of this, double spaces were left between lines of text to encourage easy reading (Rivers, 1984). Also, to limit the amount of text that a learner periodically had to attend to on the same screen, portions of text were presented one at a time, allowing the learner to control the display by pressing return (manual override) between them (Smith & Boyce, 1984; Jay, 1983).

Screens were designed so as to be completely cleared before the presentation of each new display (Roblyer, 1985). Students were given manual override over page turning, in agreement with Nievergelt's (1980) and other authors' recommendations that a page should never suddenly disappear. Automatic and manual override were also given to the student after incorrect or correct graphic screens.

A colored question mark (?) was used consistently in the same area of the screen, as a symbol to indicate when a particular screen required student input. Various attention-focusing tactics, such as underlining, arrows, color-shading, filling-in, and sound (beeps) were used, to assist learners by directing their attention to pertinent portions of the display, and thus facilitate learning (Jay, 1983; Rivers, 1984). However, these devices were kept to a minimum, in order to not distract students from the instruction (Smith & Boyce, 1984).

Graphics. Overall, colored graphics were used to illustrate concepts, demonstrate relationships and therefore, support the intentions of the program. Research shows that graphics which are embedded in the instructional content or that are an integral part of the instruction, contribute to the learning process by presenting a visual model of the information to be learned (Blum, 1983). In other words, graphics can facilitate recall by inducing students to actively construct their own mental representation of the information (Bork, 1977). The motivational aspect of graphics was not overlooked either. Some were used to enhance the content or the feedback (Blum, 1983; Jay, 1983; Nievergelt, 1980). Short animated sequences were used to either add interest to the content or to simulate an action or function of a particular concept.

Formative evaluation. Formative evaluation was done by several experts from the various fields involved, but no time or money was allocated for evaluation with the intended target audience. First, the program was evaluated by software developers, evaluators and subject-matter experts in Prentice-Hall Inc., New Jersey. Then, in Montreal, a thorough in-house evaluation was done by: (a) a senior educational technologist (for overall instructional design); (b) a highschool biology teacher (for suitability of language and content to the target population); (c) a doctor, M.D. (for accuracy of content); (d) editors (for grammar and english style); (e) programmers (for compatibility of program's design to Socrates; and (f) this producer. Overall, the evaluation produced positive results. Minor changes and corrections were made to conform with the highschool's scope and depth of the topic.

Production constraints. Some production decisions were out of the control of the producer. In some cases these decisions related to constraints imposed by the operating system itself. For example, questions that required more than one sentence as answer were not possible, because the 'answer line' in Socrates has a 40 character/line limit.

Based on memory and time constraints, it was determined that only three questions per concept should be asked with no provision for a second trial. Other graphic feedback screens were not included and instead, the same graphic was used throughout the program to graphically inform students about the accuracy of their responses. Certain animation and joystick sequences were also removed. Also, the use of color was limited to four, since the tutorial programs run on various computers that have different color capabilities.

The Socrates Learning Environment

The operating system Socrates was used to develop the tutorial program as it appears to present some advantages over currently available programming (authoring) languages in the market. It provides learner-controlled options, including, among others, command over random access and sequence of the material presentation, and control over testing and record keeping functions. At the same time, Socrates allows the learner, if and when desired, to follow the fixed sequence developed by the producer. In this interactive system, instruction is comprised of various 'displays', which the learner can access by means of a regular keyboard. Each display contains only one kind of information (e.g. example, function of an organ, definition).

In many other authoring languages or operating systems, sequencing is controlled through the use of a 'menu' or 'map' or both. These are the so-called 'menu-driven' programs. They present a menu with the various topics from which the student can choose. The students can select where to begin. If they want, they may go back to the menu, access something else, request other information or activity, or exit the system at any time. Although this is an improvement over previous CAI programs, menu-driven software still seems to present some disadvantages to the instructional process. For example, before users can get to where they want, they have to go through the main menu. It is only from this or other menus in the program that students can select the particular topics or activities they wish to view. Once inside the option selected (e.g., test), students sometimes are required to finish it before they can return to the menu. They cannot choose what to see freely from anywhere else in the program.

The Time-shared, Interactive, Computer-controlled Information Television (TICCIT) system is like a menu-driven program, but it has an underlying interactive learner-control design which appears to be very similar to that of Socrates. It has 15 'special' learner-control keys or buttons that the student can use to indicate which instructional display or unit/segment of the material he/she would like to study next. There are 14 such options in Socrates. These features enable students to control their own presentation strategies. The TICCIT system is also based on the assumption that a given idea--concept, procedure, or principle--should be presented in each of the three modes: rule, example, and practice. They are called displays. Apart from these similarities, there appear to be three main differences between the two systems: (a) the availability of such keys as EASY, HARD and HELP, which can be used in combination with a rule, an example, and a practice display (e.g., EXAMPLE-HELP which presents the original example with additional information to help the student understand the rule); (b) the availability of an ADVICE key (i.e., students are given advice as to their status and their next move; and (c) the requirement for the student to select and sequence individual displays for him/herself, rather than the system selecting it for the student. In Socrates there is provision for both, system-selection and student selection of displays. Socrates also provides periodical advice to the student regarding the concepts that should be pre-viewed or re-viewed at a particular point during the instruction. But as opposed to the TICCIT system, advice cannot be solicited by the student.

The TICCIT system has often been critized as an extensive page turner (cited in Merrill, 1980). Merrill appears to agree with this assessment, but states that there is more involvement in the composition of pages than there is in an ordinary book. He states that "the computer does provide a structured authoring, data, and advising system that is considerably more complex than that which is possible in typical settings with a large number of students" (p. 88).

In other highly interactive systems like Plato, the sequence and selection of material is controlled by users' responses. These systems require feedback from the learner before advancing to a new program segment (Wallin, 1984). Other subtle types of control exist in which the program gives the user a choice, such as 'press E for excercises, NEXT to proceed to next topic'. Nonetheless, these are still somewhat limited types of control.

In Socrates, the learner does not have to wait for information to be processed by the computer before he/she can ask for particular information within a concept, or branch to other material. Even though the material is sequenced and presented in a pre-determined way based on a hierarchical relationship between concepts, the learner has complete freedom and control to interrupt it and alter it at any time from anywhere in the program, to ask for particular information (e.g. examples, definitions, structures, reviews, etc) within the concept being studied or of any other concept in the program. By having this type of control, the learner can explore and discover relationships between concepts simultaneously. After this learning acquisition phase, they can ask for their score, and depending on it, they can choose to review specific concepts that were not 'mastered', and then re-test themselves. In other words, they manage their own learning.

Other facilities in Socrates include allowing the student to choose the type of posttest they want to receive (i.e., with feedback, or without feedback -- their final score. Students can choose to re-start the program at any time, in which case their score is erased. They also may quit the program thereby saving their score on disk and allowing them to start in the same place the next time.

In accordance with established criteria and manuals of style in CAI design, the same type of information is presented consistently to the user in the same area of the screen, so that he/she knows immediately where to look for the information desired. The screen has three fixed divisions or places to present information: (a) the 'teaching window', where the material, graphic and text, is presented; (b) the 'answer line', where students either answer a question, or request particular information; and (c) the 'directions window', which presents information to the student regarding operation of the program, such as the page's purpose, where they are in the lesson, what to do there, how to proceed, and how to access the help screen (see Figure 1). Students can then refer to the information presented in this window (e.g. <u>function</u> of the <u>stomach</u>) to call for specific screens desired. This information stays there until the next page is presented.

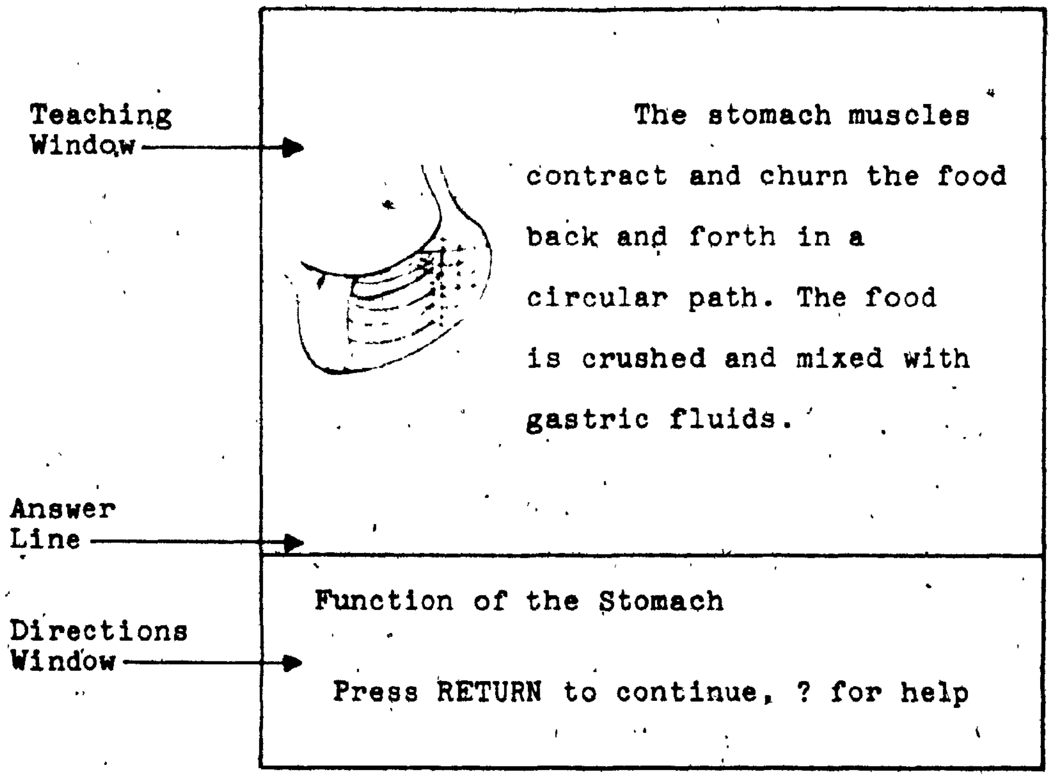

Figure 1. The Socrates screen.

CHAPTER 3

Review of Related Research

A manual library search using the Educational Resources Information Center (ERIC), as well as other journals, was performed in order to review related literature and thus collect pertinent information for the present study. Mainly, three general areas were investigated: evaluation of educational software, effectiveness of CAI, and learner-control studies. Unfortunately, very little evaluation of educational software has been done. Much of the literature available in relation to the use, design and evaluation of CAI programs, is mainly descriptive in nature and intent. Hundreds of Software Review Periodicals and directories abound, but they simply report and describe particular programs found in the market; they are not reports of research. The literature "does not address the problem of identifying and operationalizing new findings and results in educational research as they apply to the use of CAI in specific content areas" (Raschio & Lange, 1984, p. 24). It seems that the excitement felt over this new medium (the microcomputer) has taken the place of objective analysis of computer capabilities and limitations, and that these popular periodicals have become a conduit for promoting this uncritical approach (Roblyer, 1985). Even if evaluation studies conducted have produced valuable information, their message has not been clear. The studies have differed in experimental designs, settings, and in the types of computer applications they investigated. Furthermore, their results and findings have differed and even contradicted one another (Kulik, Bangert & Williams, 1983). It was therefore not surprising to find that almost every author in this field has recognized and acknowledged the need for critical evaluation of educational software.

The review which follows will focus particularly on studies that have looked into the effectiveness of CAI materials in general, and on research studies that have given different perspectives on the impact of learner-control.

Overall Effectiveness of CAI

The question of how effective is CAI has been the most commonly asked in the past decade. There has been a sufficient number of studies comparing CAI methods with traditional methods. These studies appear to suggest that the computer medium adds to the learning process. While these results indicate the usefulness of CAI, as Roblyer (1985) pointed out, they do not really address specific computer-related variables which may enhance or impede learning. However, other research studies focused on various variables within CAI. Of particular relevance to this study are the reviews which investigated the effectiveness of CAI on such variables as student achievement and attitudes.

Kulik et al. (1983) concluded, after conducting a meta-analysis at the secondary level, that computer-based teaching raised students' scores on final examinations by approximately .32 standard deviations or from the 50th to the 63rd percentile. Computer-based teaching had a smaller but positive effect on scores on follow-up exams months later. Kulik et al. also found that students developed very positive attitudes toward the computer and the course they were taking.

Thomas (1979) also reviewed the effectiveness of CAI with particular emphasis on results within secondary schools. He summarized findings from various studies (Edwards et al, 1975; Jamison et al, 1974) stating that students exposed to supplementary instruction through CAI performed at a higher level than those who were not. He mentioned a study by Broderick (1973, 1974) in which a teacher taught Biology with and without the use of CAI. Students were then compared on posttest scores. Significantly higher level of achievement was attained by the CAI students.

In another review, Atkinson (1984) included results from studies which examined conditions under which CAI was most effective. She cited Edwards et al. (1974) who found that how CAI was used (as supplementary material or as substitute) changed its effectiveness. When CAI was used as a classroom supplememt, achievement scores increased and learning was enhanced. Results were mixed for when it was used as a substitute. CAI has also been found to be particularly useful for lower ability and special education students. Also cited were studies by Chamber & Sprecher (1980) and Fuerzing et al. (1981) who stated that low ability students seem to gain more from CAI as a supplementary aid than higher abilitiy students. Kulik et al. (1983) also found stronger effects of CAI with low aptitude vs. talented students. All of these studies tend to indicate that CAI can be used succesfully to improve achievement scores of disadvantaged students at the secondary and college levels.

Fisher (1984) summarized findings from a range of studies conducted over the last 20 years. Essentially, he concluded, research shows that CAI is effective when certain conditions are met: a) when it is aimed at specific student body groups (and not given wholesally to the entire population); b) when it is fully integrated into the regular classroom curriculum (as a supplement to regular classroom instruction); c) when certain subject areas are selected (almost always effective in the areas of science); and, d) when the proper setting and scheduling is established (frequent short daily sessions are better for memorizing material than infrequent long ones). He also summarized results from studies that investigated students' attitudes toward CAI. Increased motivation, improved attendance and lengthened attention span were among some of the positive findings.

The tutorial used in the present study meets some of the above mentioned conditions or criteria. For example, its content was selected in accordance with the highschool biology curriculum. Also, as mentioned earlier, it was developed to be integrated into the regular classroom curriculum, as a supplementary aid and support (not substitution) for regular classroom instruction. Other conditions, such as that of aiming the package at specific student groups, is one of the proposed intentions of the current study.

Learner-Control

For the past several years, educators, instructional designers, learning theorists, programmers, and others, have been concerned with developing a truly individualized system in CAI. A widely held belief in many educational circles has been that learners should be encouraged to make choices for themselves and to exert personal control over their course of study (Carrier et al., 1984; Beard, Lorton, Searle & Atkinson, 1973). Hence, the term learner-control.

Learner-control is a very broad and vague term. Definitions have varied from that of allowing the student to make decisions on one aspect of the program to that of almost complete control of instruction (Steinberg, 1977). In other words, it assumes or implies that the learner is fully or at least partially responsible for the selection of learning strategies. Thus, when a program is said to allow for learner-control of instruction, it may allow for control over one or a combination of any of the following: (a) the number of examples shown, (b) the number of practice problems or questions received, (c) the choice to receive analytical feedback in addition to the feedback of the program, (d) the number of instances, (e) content sequence, and/or

(f) instructional sequence (Atkinson, 1972; Carrier et al., 1984).

The effectiveness of a learner-control strategy in CAI has not been clearly established (Steinberg, 1977; Fry, 1972). Research studies in this area have yielded conflicting conclusions and discrepancies exist among results.

On the one hand, negative results have been documented. In her review, Steinberg (1977) found that student control of instruction was sometimes, but not always, more motivating, and that attitudes were positively affected by learner-control; but that improvement or equivalent performance was not necessarily a correlate. Sometimes, performance under learner-control was the same as for the control groups, or even worse. As stated, "there was not verification of the rather subtle implicit assumption that learner control (sic.) per se will generate greater interest" (p. 88). Steinberg and Tennyson & Rothen (1977) said that one of the main problems affecting the success of learner-control is that students are not willing or cannot make instructional decisions of content-element selection and personal assessment. Moreover, they argued that learner-control strategies do not provide students with early meaningful information upon which to base learning strategy decisions. On the other hand, positive results have been obtained in favour of learner-control (Campanizzi, 1978; Di Vesta, 1975; Fleixbrod & O'Leary, 1974).

The studies which follow have looked into various areas and will therefore provide different perspectives on the effect of learner-control on performance and attitudes.

Learner-control and Individual Differences

The relationship of specific learners' characteristics or individual differences on learner-control has been the focus of many studies. Individual differences play an important role in the way in which a CAI program can be most effective. Snow (1980) for example, (cited in Carrier et al., 1984) argued that learners differ with respect to how well they: (a) like self-control over events within instruction, (b) will perform under such conditions, and (c) will use their skills in executing such controls. Many studies have provided support for his hypotheses. Among the individual differences reviewed which were found to be relevant in one way or another to the present study are: prior knowledge or achievement, internal vs. external locus of control, and field independence (FI) and field dependence (FD).

Prior knowledge or achievement. Carrier et al. cited a study by Rakow & Ross (1981) in which they found an ordinal interaction involving level of prior knowledge and the control variable. In their study, students who had low prior knowledge profited more from a computer-controlled sequence than from a learner-controlled one. No differences for control were found for students with high prior knowledge. Tobias (1976) have worked on the inverse relationship between prior achievement and amount of instructional support required. He first suggested and found that students low in prior achievement or who are less familiar with the content of the unit to be mastered, need instructional support and assistance in the form of clearly stated objectives, highlighting of important points, requirement for overt responding, and other guidance mechanisms. Whereas those high in prior achievement may be assigned to a lean instructional strategy (Tobias, 1982). He then revised these Achievement-Treatment interaction formulations and suggested that "only those forms of instructional support which improved students' macroprocessing or the frequency and intensity of cognitive processing of instructional input, would improve achievement" (p. 5).

Internal vs. external locus of control. Some researchers have felt that learner-control interacts with the aptitude variable known as locus of control, and that those who have a high degree of internally generated control over their own activities profit more from materials in which they can excercise such control (Roblyer, 1985). Using Rotter's locus of control questionnaire, Holloway (1978) identified learners as either being internally or externally controlled. He assigned them to a prescriptive assignment condition in which a tight structure was imposed in a self-instructional unit. Students in the other condition were allowed to vary the sequence used to study the content of the unit, and to choose the points at which they would receive self-tests. He found an ordinal interaction between locus of control scores and the treatment variable. High internality students performed better in the self-imposed structure condition than under the prescriptive one. Holloway concluded that internally oriented learners are adept and function optimally when asked to assume responsabilities for their own learning.

Cognitive style (FI and FD). Cognitive style has been suggested as an individual difference variable which may predict and affect learner's behaviour under learner-controlled conditions. Cognitive learning style has been defined by several authors as consistencies in the ways in which people perceive, encode, store and retrieve information. Of particular interest to the current study is cognitive style research conducted by Carrier et al. (1984). They explored how students with different cognitive styles responded to the opportunity to select options in a computer-based concept lesson. The goal of their study was to determine whether students with different cognitive restructuring capabilites would respond to instructional options in different ways. For this, they chose FI and FD students. It is characteristic of highly FI students not to accept a situation as given. They tend to restructure a stimulus field when it is beneficial to do so. They are more participative and typically require more practice in order to acquire new concepts. The question asked was if FI students would select more options than FD students. They used two treatment groups: one with options (options to see a paraphrased definition, four more examples, as many as two additional practice instances, and to see analytical feedback following the ordinary knowledge of results). The other one had no options (a straight forward sequenced presentation of definition, two examples, two practice instances, with simple knowledge of results). There were no differences due to treatment, but FI outperformed FD on the posttest. FI did not select more options than FD. It was found that the two groups (FI and FD) under the Options treatment, had similar patterns of option use "except in the case of the additional examples option, where FD students selected proportionately more" (p. 53). They did not encourage students to select options and they did not tell them that reviewing options would help them in the posttest. Frequency of option use decreased as students moved through each individual concept. Based on their results, they advanced the idea that the question in further research should not be whether to give options to the students, but more importantly, which options, and in what manner. Research should not examine frequency of options selected, but also the range of possible options, and "how option types relate to learner characteristics" (p. 53). The current study was designed to examine some of these issues. The cognitive variable chosen was prior achievement since the tutorial package is to be used as a supplementary resource to review what was learned in class. Similar treatment conditions were studied (one with options and one with no options). The options provided though were different from the ones Carrier et al. studied. Frequency of option use data were also collected. It was assumed that high achievers--

being more effective learners--would use more the options than low achievers, since they would know how and when to compare concepts. But more importantly, the aim was to determine if and which of the Socrates options were useful to the learners. For this, as opposed to the study of Carrier et al., subjects in the learner-control condition were encouraged to use these options, and were explained the reasons why they were useful.

Design of CAI (Learner-control Over Sequence and Amount of Content)

Another area of research in learner-control which has been investigated frequently is how to design CAI materials to enhance learning. For this, researchers have devised different methods or strategies of control, delegating some or all instructional decisions to students. Some have concentrated their efforts on the instructional sequence. As Johansen & Tennyson (1983) stated, "control of the amount and sequence of instructional information has been a recurring problem in the design of computer-based learning environments" (p. 226). In certain methods of CAI, learners may exert control by making decisions about the number and kind of events which occur during instruction (Carrier et al, 1984). Methods of control within computer programs have been varied: a) learner-control, in which the learner has a direct role in decision-making (i.e., Tennyson's and associates programs in which the learner is allowed to decide how many instances of the target concept they want to review before the final test); (b) adaptive control, in which the number of instances presented is controlled by the program, not the learner, and is determined by students' achievement level, on-task mastery criterion, and a loss ratio (i.e., Tennyson & Rothen's (1979),highly sophisticated program-controlled adaptive system that adjusts itself to meet on-task learning needs); and (c) learner advisement, in which there is learner-control but with advice regarding the number of items that the learner should review. Advocates of the learner-control method have widely criticized the adaptive strategy (see b, above). They claim that students become dependent on the system to tell them how and what to learn, and that society does not work this way. There exist other variations of these three types of control.

Park (1984) has also been concerned with the sequential organization and presentation of content elements. Traditional ways of organizing content sequence are based on the structural characteristics of the content (hierarchical relationships of tasks). But Park argued that the selection of specific content elements and the way in which they are presented during an instructional sequence should be determined, not according to the structural characteristics of the task, but rather, according to students' on-task learning needs. He stated that studies of Aptitude-Treatment Interaction (ATI), like those included in Cronbach and Snow (1977), seemed to imply that students' specific learning needs should not be determined by pre-measured aptitude variables, as suggested by Tobias (1976) and Rakow & Ross (1982), but by their on-task performance (response). On-task performance should be analyzed not only to identify student learning needs, but also the best instructional treatment, including the selection of content elements, presentation form, etc. Based on this, several adaptive (e.g., response-sensitive) sequencing strategies in computer-based instruction have been developed and improved.

Park & Tennyson (1980) investigated two variables of adaptive instructional strategies in concept learning. Highschool students were assigned to one of six treatment conditions. The first variable concerned information and tested the hypothesis that the selection of the number of examples according to on-task information would be more efficient than selection according to pretask information or pretask plus on-task information. Results confirmed the on-task information condition as being significantly better. Subjects needed less instructional time and fewer instructional examples. The second variable studied was presentation order. It was hypothesized that a response-sensitive procedure would be more effective than an insensitive one. Again results were significantly better for the response-sensitive group. The researchers concluded, in part, that "on-task information seems to provide the best data for adjusting instruction to individual needs, more so than pretask information (e.g., Aptitude x Treatment interaction variables)" (p. 369).

In another study of the effect of adaptive advisement on perception using a rule-learning task, Johansen & Tennyson (1984) investigated the proposition that learner control of instruction can be facilitated by directly affecting the student's perception of learning need. The researchers used three experimental groups: (a) advisement learner-control, b) partial learner-control, and (c) learner-control. Learner-control was used as the control group since previous research findings (Tennyson, 1981; Tennyson & Buttrey, 1980) had shown that program-control results in better posttest performance than learner-control. In the advisement group, students were continuously advised during instruction of their learning performance and needs (such as amount of and sequence of content) in relation to the desired acquisition of rules, and were allowed to make instructional decisions. In the partial leaner-control strategy, students had an introductory program-controlled section. Johansen & Tennyson expected this strategy to be more effective since students would be exposed to more instruction than those in the learner-control condition. Results indicated that subjects in the advisement group received, on the average, only 12% more examples than subjects in the partial learner-control group, but achieved a 17% increase in posttest performance. The other two groups terminated instruction fairly soon. Subjects in the learner-control condition had no means for assessing their prior knowledge in relation to necessary performance for correctly using the punctuation rules. Neither could they judge what amount or sequence of instruction was necesary to obtain required information to perform with mastery.

A study by Beard et al. (1973) compared computer selection vs. student selection of instructional materials, with the intention of examining the effect of student control on both performance and attitudes. Their three experimental conditions were also similar to the conditions in the current study. These were: (a) free-choice (students could alter the sequence and thus their position in the course at any time), (b) no-choice (they followed a straight path with no provision for altering the sequence), and (c) program-choice (they followed a modified path through the lesson, and were presented certain events when performance was below a set criterion). Results indicated no significant differences between these three conditions either on performance or attitudes. Apparently, the free-choice students did not make sufficient use of their choice option to alter the sequence dramatically. The authors stated that due to these results, they could not say that a curriculum offering extensive student control was either superior or inferior to a program-controlled sequence.

The effect of type of control (learner vs. program) of branching and provision of overviews in a CAI sequence was investigated by Campanizzi (1978). He wanted to determine the effect that these variables had on students' on-line achievement and response latency. For this, college students were randomly assigned to one of four treatment conditions:

learner-control with overviews, learner-control with no overviews, program-control with overviews, and program-control with no overviews. Overviews consisted of short statements that informed the learner of the principal concepts that would be presented in the instructional sets which followed. Subjects in the learner-control condition were advised and given the option of branching to a review if mastery of an instructional set had not been attained. Those in the program-control conditions were branched to them automatically. Results indicated significantly greater achievement gain under learner-control as opposed to program-control. Even though they could have received it the same number of times, the learner-control group received the reviews significantly fewer times than program-control. As Campanizzi stated, "given the opportunity to participate actively in decision-making, the individual may not always follow the advice, but will choose paths which will ultimately result in achievement" (p. 28). No significant differences were found for overviews. They seemed to have served as general organizational indicators of forthcoming material, but did not appear to contribute to significant achievement gain.

As is often the case in emerging areas of research, contradictory results make it very difficult to draw definite conclusions as to the effectiveness of learner-control strategies in CAI. As Steinberg (1977) suggested, these contradictions have occurred because the studies have failed to identify variables that either contribute or do not contribute to the effectiveness of learner-control. Consequently, much more research is needed to support the hypothesis that learner-controlled programs will have a greater impact on learning than system-controlled programs, and that the use of learner-controlled approaches will make more autonomous learners (Roblyer, 1985). Observational studies of the learner's behaviour in interaction with the program have been suggested, in order to gain better assessment of the effects that CAI has upon certain learning styles. As suggested, monitoring on-task behaviours, tracking down and observing the learners in interaction with a program may be a critical factor in understanding how succesfully or unsuccesfully students deal with learning new information (Lewis, 1984; Carrier et al., 1984). In accordance with some of the above, the present study was designed to investigate the relationship between quality lessons, learner-control (options in Socrates) and learning. Students were observed and monitored during their interactions with the program.

CHAPTER 4

Method

Sample

The subjects who participated in the study were thirty 10th-grade english speaking highschool students taken from a pool of 50 students currently enrolled in a Biology course in Chomedy Polyvalente Highschool in Laval, Quebec. This school was chosen because they had the equipment and facilities necessary to carry out the study. The school serves a community of first and second generation immigrants. The sample was composed mainly of Jewish and Greek ethnic background students. Subjects' age ranged between 15-17 years old. Neither familiarity with computers nor typing were prerequisite skills.

Design

The design of the evaluation was a posttest only, 2 x 3 factorial. There were two independent variables:
(a) Conditions of Instruction, which compared three instructional strategies (system-control, learner-control and no computer instruction but an in-class review); and
(b) Levels of Achievement, which had two levels (high achievement and low achievement). The design can be seen in Figure 2. Subjects in the system-control condition received a tutorial program with no provision for option use. They were to follow the linear sequence outlined by the system. Subjects in the learner-control condition received the same

		LEVELS OF ACHIEVEMENT	
		High	Low
CONDITIONS OF INSTRUCTION	System-Control	$n = 5$	$n = 5$
	Learner-Control	$n = 5$	$n = 5$
	No Computer Instruction (class review)	$n = 5$	$n = 5$

Figure 2. Experimental design.

tutorial program, but were given explanations and even encouragement to see all the options available to alter the sequence and access particular information whenever desired. Subjects in the no computer instruction condition, received a traditional and customary classroom review with the regular Biology teacher.

The dependent measures taken in this study were: (a) Posttest Scores, and (b) Attitudinal Scores. In addition, data were collected for the learner-control condition relative to the frequency of use of various options available in the system.

Objectives of the Study

There were five questions investigated in the evaluation study.

Question one. Is there any difference in posttest scores between subjects administered the CAI tutorials and subjects that received no package, but an in-class review?

Question two. Is there a difference between the two types of tutorials, the system-controlled and the learner-controlled?

Question three. Is there an interaction between the three instructional conditions and level of prior achievement (high and low)?

Question four. Is there a difference between high and low prior achievement in their frequency of use of options in the learner-control condition?

Question five. Is there a difference in learners' attitudes between the system-control and the learner-control conditions?

Materials

To carry out the study and obtain the necessary data, the following materials were used:

School's Biology scores. Teacher's scores were used to block students on the independent variable of achievement into the three instructional conditions. These scores were provided by the Biology teacher from an exam she administered at the end of the chapter on Digestion four months prior to the evaluation.

Computers. A fairly large Computer Science laboratory equipped with ten IBM Personal Computers and ten Electrohome RGB monitors was used in the study. Five computers were placed along one wall on one side of the laboratory, and five on the other side.

Tutorial package. Twenty copies of the CAI program "The Digestive System" were made and given to students in both the system-control and learner-control conditions.

Documentation Manual. In order to simulate the use of a software program in a real life situation, ten copies of part of the documentation manual or user's guide containing instructions and examples of how to use the commands were provided to students in the learner-control condition. Although the lists of commands was readily available in the program (HELP screen), it was considered appropriate to further provide them with a quick-reference guide (see Appendix A).

Checklist. A structured checklist was used to record frequency of use of options by students in the learner-control condition. The checklist outlined the specific information that was to be observed for every student, such as time and place started, number of session at the computer, time and place finished, and path taken by the student. Two formats for the checklist were designed (see Appendix D).

Posttest. A comprehensive posttest containing thirty-eight varied types of questions was administered to all subjects in the study. These questions were selected from science textbooks, from the teacher's end of chapter test, and from the teaching core of the CAI tutorial program. All of these were paraphrased in the posttest. Items such as multiple choice (14), and true or false (3) were used to assess students' knowledge and correct recognition of the material. Short-answer (4) and Fill-in-the-Blank (12) questions were included to assess students' recall of details of the material learned. And Brief Essay (5) questions were included to assess and evaluate students' ability to synthesize and comprehend the interrelationship of concepts learned (see Appendix E). The questions were graded as follows: multiple choice were worth 2.25; fill-in-the-blank, 2.5; true or false, 1.5; short-answer, 3.5; and essays, 4.0.

Attitudinal scale. An attitudinal semantic differential scale was constructed based on one developed by Williams, Coulombe, and Lievrouw (1983). It was administered to subjects in the system-control and learner-control conditions, to determine their overall opinion of the package. It was a 7-point Likert scale containing 22 items, the order of which were mixed up to avoid a mechanical type of response from the students. The purpose was to solicit students' attitudes, beliefs and feelings towards the program, in relation to, among others, its content, organization, presentation, motivation, and appropriateness of level of instruction. Most important, the intent was to investigate the relationship between learner-control (vs. system-control), motivation and learning. Their previous experience with computers was also determined (see Appendix F).

Procedures

Random assignment. In order to identify and divide the fifty students into high and low prior achievement, their Biology scores and their names were distributed on a vertical scale. Based on their scores, and therefore where they fell on the scale, they were identified and blocked into levels of high and low achievement, and a list was compiled for each level. Students who fell in the middle of the distribution were not used in the study. Once this was done, subjects were randomly assigned to either one of the three conditions of instruction. The names of students who fell under the high achievement level were written on an index card, with an H (for High) beside it. The cards were shuffled throroughly and cut several times. They were then dealt into three piles (one pile for system-control, one for learner-control and one for no computer instruction). The same process was repeated with students identified as prior low achievers. Three new lists of names, one for each condition, was completed.

Training of observers. Prior to undertaking the study in the school, five adults were trained to observe students in the learner-control condition. The training consisted of a running demonstration of the tutorial program. Observers were shown the instructional sequence followed and the concepts covered in the program, as well as the basic components or information given about each concept (e.g. introduction, examples, functions, definitions, etc.). A thorough explanation was given pertaining to the operating system Socrates, and to the access mode of the commands available. They were briefed on the overall purpose of the study, and most important, on the purpose and importance of their observation. A short practice then followed, during which time they were instructed as to the kind of data to look for, where to look for it, and how to record it on the checklist. They were then asked to choose either format of the checklist designed, or to suggest any changes to improve it. In this way, it was ensured that they all observed for occurrence and correct recording of the same events. Each observer was assigned the same two students--one for each period--throughout the study.

A sixth person was used as a helper, to be in charge of the system-control condition. The presence of this person balanced out the presence of observers in the learner-control condition. It was considered appropriate for students in this condition to know that a helper was available for anything they might want to ask regarding the operation of the computer or program. This helper was also informed about the general purpose of the study, and about her particular duties, one of which was the recording of time taken by each student.

Schedule of the study. The schedule was established based upon the length of the tutorial program and the time frame allowed by the Biology teacher (one week). Since the program is about 1 hr 30 min long when taken sequentially, that is, without using any of the options/commands, it would take one and a half school period (50-min each) for students in the system-control condition to study it. It was therefore thought appropriate to allot three periods, that is, double time, to students who would be using the commands in the learner-control condition.

Prior to initiating the study, the purpose of the study and the random sampling procedures were briefly explained to both Biology classes (6th and 7th period) participating in the study. They were told that only ten students were selected since they were only ten IBM personal computers available in the school.

Day one. On Monday April 29, students in the system-control and learner-control conditions selected from the 6th period (12:35 - 1:25 p.m.) list previously completed, were removed at the beginning of class, and brought into the computer science laboratory. The remaining students, especially the five from the no computer instruction condition were led to believe they had not been selected for the study. Once in the computer laboratory, they were divided into the two conditions (the system and learner-control) and an observer was in charge of each group.

The helper in charge of the five subjects in the system-control condition sat at a computer and explained to them about the 'Socrates screen' (e.g. the place where answers and where information about the particular screen appeared on the monitor screen). She informed them that they had up to three 50-min sessions at the computer to study the program, which was the normal duration of a school period. They were informed they could take as much time as they needed or wanted, but that once started, they were not allowed to go back and restart the program again. No mention was made of the availability of options in the program. It was also explained that they would complete a posttest when finished. They were instructed to type QUIT whenever they felt tired during a session, so that their score and place would be saved on disk for the next session. She then assigned them to a computer and gave them a copy of the disk program with their name on it. It was essential for each of these students to have their own disk, as they would all finish or quit in different places in accordance with their own pace. Students were asked to return their disk at the end of each session. The helper recorded starting and finishing time of each student on an attendance list. Throughout the sessions, she assisted those students who were not too familiar with the operation of the computer, or who had trouble spelling words.

Simultaneously, this researcher gave a personalized copy of the disk and of the documentation manual to the students in the learner-control condition. They gathered around a computer and were explained that the program followed a predetermined order to present the material, but that it was strongly advisable that they should, whenever they wanted or believed appropriate, alter and change that order by simply using certain commands shown in the HELP screen and on the documentation. They were told they were in complete control of their learning. Examples as to the kinds of things possible were shown (like looking at the overview and deciding where to start or where to go, why and how to go to different concepts/places, how to ask for examples, functions of organs, etc.). The purpose for using these commands was explained, which was to see the interrelationship of concepts (e.g how is the function of the stomach related to the function of the small intestine?). They were also given the same explanations as in the other group, in relation to time available, the posttest, and the Socrates screen. After this, they were assigned to a computer.

Each of the observers was given a folder containing: (a) the checklists for the two periods, (b) a copy of the list of concepts in the program, and (c) a list of the options or commands of Socrates as reference guides. They sat at a certain distance behind their assigned student, so as to avoid disturbing or intimidating them, and carried on-task monitoring using the structured checklist. The same data were collected for all students in this condition, regarding frequency use of options and path followed. Starting and finishing time and place were also recorded. Upon students' request, they explained and demonstrated if necessary, the correct usage of the commands.

The same procedures were followed on Day one with students in the 7th period (1:30 - 2:20 p.m.) class. At the end of each of the periods, students were reminded of their participation in the study thereafter.

Day two. On Tuesday, April 30, students in the learner-control condition from both the 6th and 7th period classes were reminded about the purpose of using the options/commands. Those who had never used computers before were told not to be afraid to explore the program and were shown what would result if the options were used improperly. Students in the third condition of instruction, the no computer instruction, completed a two-day traditional learning/reviewing session with their Biology teacher. The method used was lecturing, for which she followed the sequence outlined in their Biology textbook. No medium other than the blackboard was used to deliver the instruction.

Day three. On Wednesday May 1st, the posttest and attitudinal scale were given to nine students in the system-control condition who had finished. Two students in the learner-control condition, one who felt ready and another who could not assist after Wednesday, were also given both instruments. The posttest only was administered to all ten students in the no computer instruction condition, who had received the traditional in-class review.

Days four and five. Following their three-day treatment, on Friday May 3d, the remaining eight students in the learner-control condition and one in the system-control condition, were administered both the posttest and the attitudinal scale.

All questions previously unanswered regarding the purpose of the study, were discussed and explained to the students. Anecdotal data regarding students' attitudes toward the packages were collected.

CHAPTER 5

Results

Test of Random Assignment

A test of the random assignment of subjects to groups was conducted by way of a two-way analysis of variance on the achievement scores provided by the school teacher from a unit in Biology. A main effect for level of achievement was expected. No difference in treatment condition and its interaction with level of achievement would suggest that groups were similar in achievement prior to the evaluation. Results indicated that there was no significant interaction between the two independent variables, F (2, 24) = 1.864, p = .18. As expected, there was no significant main effect for the variable Conditions of Instruction, F(2, 24) = .352, p > .50, but there was a significant main effect for Levels of Achievement, F(1, 24) = 170.89, p = .001. Based upon this analysis, it was judged that treatment groups were equivalent in prior achievement.

Performance Data

An omnibus test of the design (MANOVA) was performed to analyze and answer the first three questions posed in this study. The questions were:

(a) Is there any difference in posttest scores between subjects administered the CAI tutorials and subjects that received no package, but an in-class review?

(b) Is there a difference between the two types of tutorials, the system-controlled and the learner-controlled?

(c) Is there an interaction between the three instructional conditions and level of prior achievement (high and low)?

In order to analyze performance data obtained, the posttest was divided into three main sections, each of these designed to measure different performance characteristics of the students. These three sections were: (a) the Recognition section, including all the 'Multiple Choice' and 'True or False' questions, which tested for straight identification and recognition ability of correct answers in the test; (b) the Recall section, included results from all the 'Fill-in-the-Blank' and 'Short-Answer' questions. As the title implies, these tested for students' correct recall of the material covered; and (c) the Synthesis section, included results from the five essay questions which tested for comprehension and for students' ability to synthesize the material learned. (For a copy of the Posttest, see Appendix E.) Three sets of scores were then derived for each student in the three treatment groups. Means and standard deviations were calculated for each of the three sections previously described and are presented separately in Tables 1, 2 and 3.

Table 1

Means and Standard Deviations of the Recognition Measure

Group	M	SD
	High Achievement	
System-Control	30.45	3.20
Learner-Control	28.65	4.60
No Computer (in-class review)	21.15	3.91
	Low Achievement	
System-Control	19.80	3.46
Learner-Control	23.85	3.11
No Computer (in-class review)	22.35	2.08

Note. Maximum score = 36. n = 5.

The grand mean was 24.38 and the standard deviation was 5.0

Table 2

Means and Standard Deviations of the Recall Measure

Group	M	SD
	High Achievement	
System-Control	36.46	3.81
Learner-Control	35.16	5.28
No Computer (in-class review)	10.73	4.58
	Low Achievement	
System-Control	7.76	3.84
Learner-Control	26.38	3.12
No Computer (in-class review)	7.71	4.67

Note. Maximum score = 44. n = 5.

The grand mean was 20.70 and the standard deviation was 13.21.

Table 3

Means and Standard Deviations of the Synthesis Measure

Group	M	SD
	High Achievement	
System-Control	17.17	4.22
Learner-Control	15.86	3.06
No Computer (in-class review)	3.03	1.37
	Low Achievement	
System-Control	.60	.82
Learner-Control	9.00	6.54
No Computer (in-class review)	2.36	1.51

Note. Maximum score = 20. n = 5.

The grand mean was 8.00 and the standard deviation was 7.40.

MANOVA. Due to the small mean obtained (.60) and to the low variability (.82) of low achievers in the system-control condition (see Table 3), only two of these dependent measures were submitted to a Multivariate Analysis of Variance (MANOVA). This multivariate test of significance was conducted to test for main effects and the interaction on the dependent variables, Recognition and Recall. Results of this analysis indicated that there was a significant two-way interaction between the treatment conditions and levels of achievement on these posttest scores, $F(4, 48) = 7.06$, $p < .001$. There was a significant main effect for treatment conditions, $F(4, 48) = 8.98$, $p < .001$, as well as a significant main effect for achievement level, $F(2, 23) = 36.04$, $p < .001$.

Results from the univariate test of significance on these two dependent variables (Recognition and Recall) also indicated significant main effects and an interaction between conditions of instruction and levels of achievement on each of these posttest scores. The results of the univariate tests of the main effects and interaction are presented in Tables 4 and 5. Figures 3 and 4 illustrate the two-way interaction found between instructional conditions and levels of achievement on the dependent measures Recognition and Recall, respectively. A visual inspection of these figures suggested that the relatively lower performance of low achievers in the system-control condition contributed substantially to the interaction. As a consequence, post hoc (Scheffé) tests were

Table 4

Results of the Univariate Tests of Significance on the Recognition Measure

Source	SS	df	MS	F	p
Treatment (T)	109.69	2	54.84	4.52	.022
Achievement (A)	169.22	1	169.22	13.95	.001
T x A	175.54	2	87.77	7.23	.003
Error	291.15	24	12.13		

Table 5

Results of the Univariate Tests of Significance on the Recall Measure

Source	SS	df	MS	F	p
Treatment (T)	2351.60	2	1115.80	64.24	.001
Achievement (A)	1365.79	1	1365.79	74.62	.001
T x A	907.77	2	453.88	24.80	.001
Error	439.25	24	18.30		

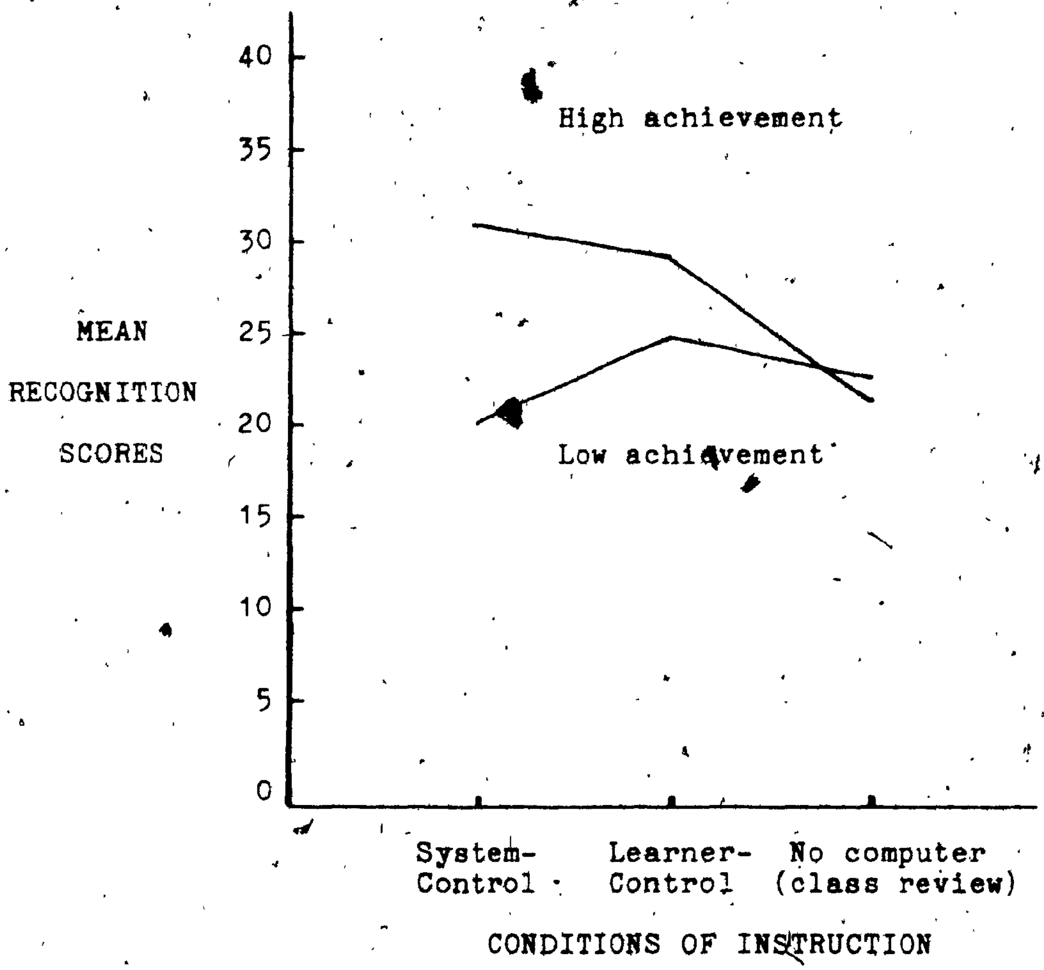

Figure 3. Achievement x Treatment interaction on the Recognition Measure.

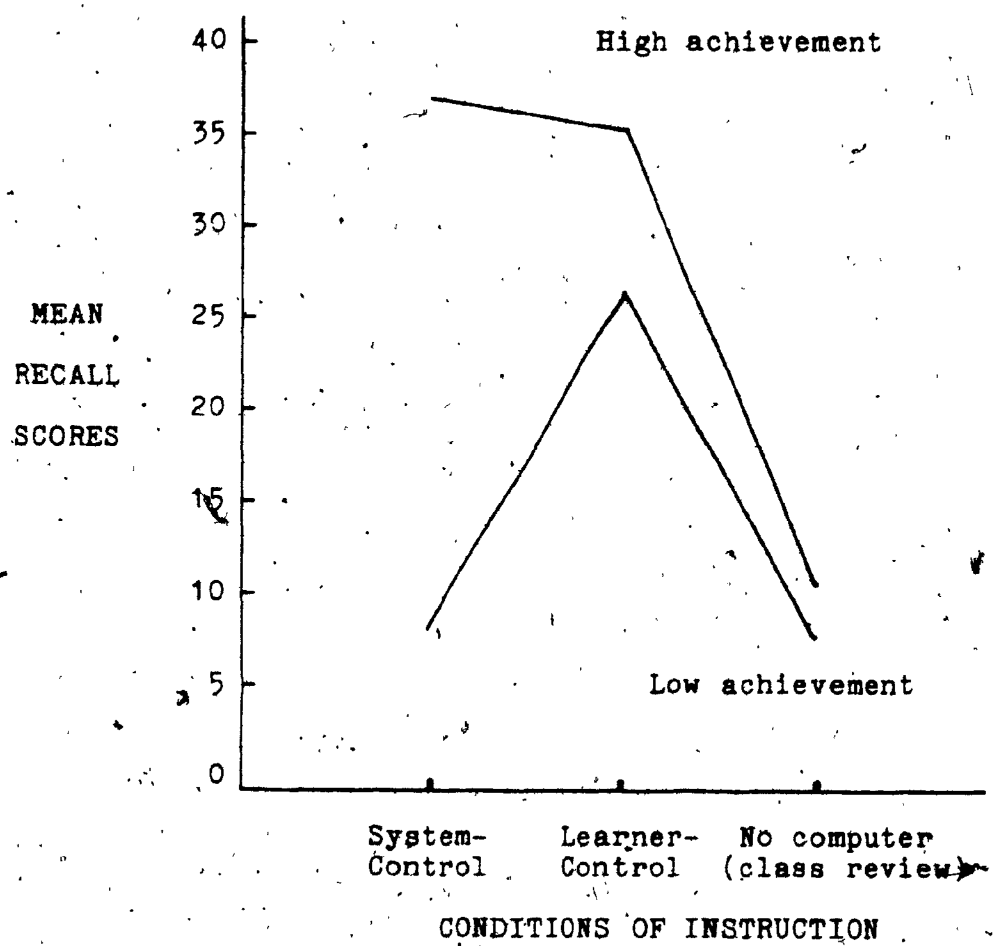

Figure 4. Achievement x Treatment interaction on the Recall Measure.

employed to isolate the locus of this effect.

Post hoc analysis (recognition). Several single comparisons were made from results obtained from this section of the posttest. First, high achievers were compared with low achievers in the learner-control condition. The calculated F was 4.68, which when compared to the F Scheffé obtained, 17.0, indicated that results were not significant. Second, high achievers were compared with low achievers in the system-control condition. The calculated F was 23.15. When compared to the F scheffé obtained, 17.0, results were found to be significant ($p < .05$). This shows that the significant interaction found earlier on this dependent measure is located in this part of the design; that is, between high and low achievers in the system-control condition.

Post hoc analysis (recall). The same single comparisons were made from results obtained from this section of the posttest. First, high achievers were contrasted with low achievers in the learner-control condition. The calculated F was 10.58 and the F Scheffé obtained was 17.0, which indicates that results were not significant. Then, high achievers were contrasted with low achievers in the system-control condition. The calculated F was 111.74 and the F Scheffé obtained, 17.0. Results were found to be significant ($p < .05$). The interaction on this dependent measure seems to be located again between the high and low achievers in the system and learner-control conditions.

Chi-square statistics (synthesis). A Chi-square was performed using the experimental data obtained from the Synthesis dependent measure. These data are shown in Table 6. As explained before, analysis of variance was not performed since the low achievers in the system control group had a small mean (.60) and a low variability (.82) as can be observed in Table 3.

In order to determine if the two independent variables were related on this section of the posttest, the null hypothesis of independence--that there would be no dependency or relationship between levels of achievement and instructional conditions--was tested and rejected. Results obtained were found to be significant, $\chi^2(2, N = 30) = 35.07$, $p < .05$, which suggests the same thing that was found for the other two dependent variables, Recognition and Recall. There is a dependency between performance on this measure and subjects' level of achievement.

Since it was not possible to compare cell means and check for an interaction as was done with Recognition and Recall, a second Chi-square statistic was conducted using the same experimental data shown on Table 6. This time, the null hypothesis of independence was tested by contrasting the system-control group with the learner-control group. Results were significant, $\chi^2 (2, N = 20) = 32.16$, $p < .05$, and the null hypothesis of independence was rejected. This seems to indicate that there was a relationship or dependency between achievement and performance under the system and learner-

Table 6

Data Used in Chi-square Statistics

Group	Σ
	High Achievement
System-Control	86
Learner-Control	79
No Computer (in-class review)	15
	Low Achievement
System-Control	3
Learner-Control	45
No Computer (in-class review)	11

Note. n = 5.

control conditions.

A third Chi-square statistic was conducted using the same data. The null hypothesis of independence was tested contrasting the learner-control group with the no computer instruction (traditional in-class review) group. Results obtained were not significant, χ^2 (2, N = 20) = .33, $p > .05$. The χ^2 associated with his comparison did not exceed the critical value of 5.99, therefore the null hypothesis of independence was confirmed. This indicates that there was no dependency between achievement and performance under these two treatment conditions.

On-task learning time. To examine the possibility that time spent on-task (at the computer) might have influenced posttest scores, two separate analyses were performed. First, the correlation coefficient between time and scores on each of the three main sections of the posttest were calculated and compared for subjects in the system and learner-control conditions. The Pearson r obtained for Recognition was .09; for Recall, .13; and for Synthesis, .16. These results indicate that there was no significant correlation between time spent studying the computer tutorials and scores on each of the three dependent variables.

Means and standard deviations of the time on-task spent by each subgroup in relation to their level of achievement and to their treatment condition are presented in Table 7.

Second, a two-way analysis of variance was conducted to test for main effects and for a two-way interaction between

Table 7

Means and Standard Deviations of Time On-Task

	Conditions of Instruction	
Achievement	System-Control	Learner-Control
High		
M	77.80	125.40
SD	29.86	24.71
Low		
M	76.60	111.80
SD	10.36	20.46

Note. Mean time spent by high and low achievers were 95.6 and 94.20, respectively. Mean time spent by subjects in the system and learner-control conditions were 71.20 and 118.6, respectively.

conditions of instruction and achievement in relation to time. Results indicated that there was no significant interaction between these two, $\underline{F}(1, 19) = .907$, $\underline{p} > .05$. There were no significant differences in time spent in relation to achievement level, $\underline{F}(1, 19) = .012$, $\underline{p} > .05$, but as was expected, a significant main effect was found in relation to treatment, $\underline{F}(1, 19) = 13.69$, $\underline{p} = .002$.

Frequency of Option Use Data

A checklist was used by observers to collect data and answer question four: Is there a difference between high and low prior achievement level in their frequency of use of options in the learner-control condition? (A copy of the checklist is presented in Appendix D.)

Table 8 presents the total frequency of use of each of the 14 options over the three day period, in relation to subjects' level of achievement.

Chi-square statistic. Based on these data gathered, a Chi-square was calculated for each of the 13 options (commands) available in the operating system Socrates. The 14th option, the QUIT command, was not considered since all subjects were instructed to use it at the end of each session in order to keep their place in disk memory. Results indicated that only one option, the GOTO command, was close to producing a significant difference in use between high and low achievers, χ^2 $(1, \underline{N} = 10) = 3.81$, $\underline{p} = .06$. Non of the other options produced significant differences. Note that the total frequency obtained for a level of achievement, in other

Table 8

Frequency of Option Use by Level of Achievement

Option	Achievement[a] High	Achievement[a] Low
DEFINE	7	6
EXAMPLE	12	11
FUNCTION	7	13
GOTO	37	22
HELP	3	1
OVERVIEW	20	18
REPEAT	4	5
RESTART	1	2
RESUME	2	0
REVIEW	7	14
REVIEW ALL	3	7
SCORE	17	25
TEST	35	39

Note. [a]n = 5 subjects per group.

words, the numbers depicted in Table 8 (e.g DEFINE 7,8), do not clearly indicate how many subjects in that level contributed to this frequency count or if it was only one. In order to see how high and low achievers did not differ in their frequency of use of options, Table 9 presents results from the tally record performed by observers on each of the subjects in this condition. Preferences for certain options in relation to their level of achievement can also be observed.

Results from the three day observations showed that frequency of option use increased as students became more familiar with them and with their purpose in relation to learning. Table 10 presents the frequency of use of these options by all subjects, in a chronological fashion. Options were used a total of 46 times the first day; 125 times the second; and 147 times the third. The 14 options were used a total of 318.

Attitudinal Data

It had been assumed that type of control strategy (system or learner) would have an influence on students' attitudes towards the packages. A 22-item scale was therefore administered to students in order to answer question five: Is there a difference in learners' attitudes between the system-control and the learner-control conditions? Copies of the attitudinal scale are included in Appendix F.

The coefficient Alpha Reliability was first of all estimated to evaluate the attitudinal scale used in the

Table 9

Frequency of Option Use of Each Student in the Learner-control Condition

Achievement	A	B	C	D	E	F	G	H	I	J	K	L	M	Total
HIGH														
Subject 1	1	2	1	9	-	-	-	1	-	1	1	4	4	24
2	2	2	1	6	-	6	-	-	-	-	1	1	17	36
3	1	1	1	4	-	3	-	-	-	-	1	1	-	12
4	2	1	1	13	-	10	3	-	1	2	-	9	13	55
5	1	6	3	5	3	1	1	-	1	3	-	3	1	28
LOW														
Subject 6	-	-	-	7	-	4	-	-	-	-	-	4	-	15
7	1	3	5	2	-	1	2	1	-	-	1	6	2	24
8	-	3	3	10	-	4	1	-	-	2	4	3	4	34
9	2	2	-	3	-	7	2	1	-	7	-	12	33	69
10	3	3	5	-	1	2	-	-	-	5	2	-	-	21

Note. A = Define; B = Example; C = Function; D = Goto; E = Help; F = Overview; G = Repeat; H = Restart; I = Resume; J = Review; K = Review All; L = Score; M = Test.

Table 10

Chronological Frequency of Option Use

	Days of the Experiment			
Option	Day 1	Day 2	Day 3	Total
DEFINE	5	4	4	13
EXAMPLE	14	7	2	23
FUNCTION	7	4	9	20
GOTO	10	32	17	59
HELP	3	--	1	4
OVERVIEW	2	20	16	38
REPEAT	1	6	2	9
RESTART	--	1	2	3
RESUME	2	--	--	2
REVIEW	1	9	11	21
REVIEW ALL	--	7	3	10
SCORE	--	16	26	42
TEST	1	19	54	74
QUIT	10	7	7	24

Note. n = 10.

study. The Cronbach alpha obtained was .82 which indicates that the instrument used was internally consistent. The items included in the scale were highly inter-correlated. They operated in a consistent and reliable manner across all the subjects, and measured about the same thing. There was a high similarity of responses among all the items across the sample.

Responses on the attitudinal scale were ranked and graded along a scale of 1 to 7. To make the interpretation of the results of this scale uniform, a score of 7 was always assigned to the best or more favourable response (5 for the last item), and a score of 1 to the poorest or least favourable response. Following is an example of the type of scale and scoring used:

INTERESTING ✓ ___ ___ ___ ___ ___ ___BORING (7)

Only the last item, no. 23, was graded along a 1 to 5 scale:

VERY FAMILIAR___ ✓ ___ ___ ___UNFAMILIAR (4)

A total score was given to each student in both the system and learner-control conditions. Mean response and standard deviations of each subgroup are given in Table 11.

ANOVA. Several methods were used to analyze the attitudinal data gathered. First, a two-way analysis of variance was performed to check for main effects and a two-way interaction between the two independent variables on

Table 11

Means and Standard Deviations of the Overall Attitudinal Score

	Achievement		
Conditions	High	Low	Marginal
System-Control			
M	123.00	123.00	123.00
SD	19.86	4.06	13.51
Learner-Control			
M	134.00	129.20	131.60
SD	6.67	14.30	10.52

Note. Maximum score = 159. *n* = 5. The grand mean was 127.30 and the standard deviation was 11.79.

the overall score on the attitudinal scale. No significant interaction was found, $F(1, 19) = .219$, $p > .05$. There were no significant differences between instructional conditions in responses to the items, $F(1, 19) = 2.82$, $p > .05$, nor between levels of achievement, $F(1, 19) = 2.19$, $p > .05$. Subjects performed differently because of the condition they were in or the level of achievement they possessed.

Likewise, a two-way analysis of variance was conducted for each of the 15 most discriminating items of the attitudinal scale. Results obtained were not significant in any of these items. Only one of these, Item 11 on the scale, allowing-controlling, produced a significant main effect in relation to conditions of instruction, $F(1, 16) = 10.881$, $p = .005$, but not to achievement, $F(1, 16) = 2.522$, $p > .05$. Moreover, no significant interaction was found between them, $F(1, 16) = 1.209$, $p > .05$.

t test. To compare means obtained and study whether there were differences between the system and learner-control conditions, a *t* test was performed separately for each of the 23 items of the scale. Again, only the same item mentioned before, allowing-controlling, was found to be significant, $t(18) = -3.15$, $p = .006$. Another item, interesting-boring, produced almost significant results, $t(18) = 1.96$, $p = .065$. For a complete report of the results obtained from the *t* test for each of the 23 items, see Table 12.

Other results obtained from the attitudinal scale related to students' previous experience with computers. Out of the twenty students that completed the attitudinal scale, 4 were very familiar with computers prior to undertaking this study; 12 were unfamiliar with them; and 4 were in between.

Table 12

Results of the t test on Items 1 - 6 of the Attitudinal Scale

Item	M	SD	t	p
GOOD				
Group 1	6.30	.823	.30	.764
Group 2	6.20	.632		
INTERESTING				
Group 1	6.60	.516	1.96	.065
Group 2	6.00	.816		
EASY				
Group 1	4.40	1.647	-1.42	.173
Group 2	5.40	1.506		
FRIENDLY				
Group 1	5.60	2.221	-1.83	.083
Group 2	6.90	.316		
FAST				
Group 1	4.90	1.853	-.14	.894
Group 2	5.00	1.414		
SPECIAL				
Group 1	5.40	1.075	.93	.362
Group 2	4.70	2.111		

Note. n = 10. Group 1 = System-control condition; Group 2 = Learner-control condition.

Table 12 (continued)

Results of the t test on Items 7 - 12 of the Attitudinal Scale

Item	M	SD	t	p
RELAXED				
Group 1	5.60	1.713	-1.25	.227
Group 2	6.40	1.075		
UNDERSTANDABLE				
Group 1	6.50	.527	-.74	.470
Group 2	6.70	.675		
SMALL				
Group 1	4.10	1.287	.47	.643
Group 2	3.80	1.549		
SIMPLE				
Group 1	5.50	1.269	-.56	.584
Group 2	5.80	1.135		
ALLOWING				
Group 1	2.80	1.549	-3.15	.006
Group 2	5.50	2.224		
USEFUL				
Group 1	6.70	.483	-1.10	.288
Group 2	6.90	.316		

Note. n = 10. Group 1 = System-control condition; Group 2 = Learner-control condition.

Table 12 (continued)

Results of the t test on Items 13 - 18 of the Attitudinal Scale

Item	M	SD	t	p
ORGANIZED				
Group 1	6.50	1.269	-.71	.487
Group 2	6.80	.422		
IMPORTANT				
Group 1	6.60	.966	0	1.000
Group 2	6.60	.516		
LIVELY				
Group 1	5.50	1.780	-.83	.416
Group 2	6.00	.667		
CREATIVE				
Group 1	6.40	.843	-.53	.602
Group 2	6.60	.843		
FUN				
Group 1	5.90	1.101	-1.21	.241
Group 2	6.40	.699		
SATISFYING				
Group 1	6.10	1.449	-1.03	.318
Group 2	6.60	.516		

Note. n = 10. Group 1 = System-control condition; Group 2 = Learner-control condition.

Table 12 (continued)

Results of the t test on Items 19 - 23 of the Attitudinal Scale

Item	M	SD	t	p
CLEAR			-1.20	.247
Group 1	6.30	1.252		
Group 2	6.80	.422		
FLEXIBLE			-.44	.662
Group 1	4.70	1.337		
Group 2	5.10	2.514		
MOTIVATING			.28	.785
Group 1	5.80	.919		
Group 2	5.70	.675		
DIFFICULT			-1.62	.122
Group 1	4.80	1.317		
Group 2	5.70	1.160		
FAMILIAR			.15	.883
Group 1	2.40	1.174		
Group 2	2.30	1.767		

Note. *n* = 10. Group 1 = System-control condition; Group 2 = Learner-control condition.

CHAPTER 6

Discussion

This study was undertaken to summatively evaluate a learner-controlled tutorial package developed with the operating system Socrates, with the purpose of making recommendations regarding the conditions under which it might be most succesfully implemented. It focused on the comparison of the effects of type of control (system vs. learner) on both performance and attitudes of high and low achieving students. In other words, it aimed to determine which type of students (high and/or low achievers) would benefit more from what type of control strategy (system and/or learner-control). For this, five questions were studied and results are discussed.

Question One

To support the need for supplementary curricular activities in the form of computer tutorials, the question--whether there was a difference in posttest scores between subjects administered the CAI tutorials and subjects that received no computer instruction, but an in-class review--was first of all posed and studied. Examination of the means obtained revealed that students using the computer tutorials performed significantly better than those receiving a traditional classroom review. These results seem to indicate that a support mechanism or supplementary resource aid of the sort used in this study produces significantly better results than the traditional lecture approach. These findings agree well with those from several studies which concluded that students exposed to classroom supplementary instruction through CAI, perform at higher levels than those who are not exposed (Jamison et al., 1974, Edwards et al., 1975, Broderick, 1973, 1974, cited in Thomas, 1979).

There are several factors that must be examined in an attempt to explain the results obtained. The first and most common is the novelty factor. Traditionally, students receive classroom instruction through the lecture method, having the teacher as the main source of information. Very few times do students have opportunities to receive supplementary instruction of the type used in this study. Educationally sound computer tutorials are either not available, not easily accesible to teachers, or simply not suited to a particular topic and audience. Thus, it was not surprising to find that this was the first time that most of the students who participated in this study had worked with a supplementary type of CAI package. Results obtained therefore may be attributed to the motivational power associated with the anticipated use of a novel device.

A second important factor may have been the individualized aspect characteristic of the tutorial packages. As opposed to a classroom situation, students using a CAI package are able to proceed at the pace which they, and not the teacher, consider appropriate to their individual learning styles. Needless to say, there are several more advantages of CAI that might have contributed to these findings, such as the opportunity for immediate practice and feedback, animation, and possibly, some control over their own learning.

A third factor that may have influenced results was the quality of the classroom review received by students in the no computer instruction condition. Even though the teacher's quality and intensity of the instruction delivered was not controlled for in this study, it is reasonably assumed that she performed as she would have normally done in any other classroom reviewing situation.

Finally, awareness of the existence of a posttest by subjects in the system and learner-control conditions may have had a differential effect on performance. Subjects in the no computer instruction group were led to believe they were not participating in the study.

Questions Two and Three

These questions studied whether there was a difference between the two types of tutorials, the system-controlled and the learner-controlled, and whether there was an interaction between instructional conditions and achievement. The means obtained showed that subjects in the learner-control condition attained significantly better performance, than subjects in the system-control condition. A difference between the two types of tutorials was therefore found. On first analysis, type of control strategy seemed to have had an effect on performance, learner-control being the one that offered or held the most benefits.

Further evidence from results of the various tests conducted indicated a significant interaction between subjects' level of achievement and performance under the system and learner-control conditions. In other words, performance under these two treatment conditions was closely related or dependent upon subjects' level of achievement. Now, instead of simply documenting the interaction found, which would not serve any purpose (Stinard & Dolphin, 1981), the aim was also to establish where and why did this interaction occur.

A closer analysis of these results revealed no significant differences between high and low achievers in the learner-control condition, but indeed, significant differences were found between high and low achievers in the system-control condition. Briefly stated, no significant differences in performace were found among high achievers in both conditions. These students seemed to have benefited from computer-assisted instruction whether they were in control of their own learning or not. Evidence suggests that the capacity to select the options in Socrates, did not result in a higher level of performance than the no option or system-control condition. These findings seem to be consistent with those of Tobias (1976) and Rakow & Ross (1982), in which high achievers or students with high prior knowledge did not differ in performance between a learner and a system-control condition.

However, the same cannot be claimed for the low achieving students. The analysis of means showed significant differences in performance between low achievers that received the system-controlled tutorial and low achievers that received the learner-controlled tutorial. The latter was found to be differentially beneficial for low achieving students. One possibility for this might have been that low achievers in the system-control condition simply did not make a serious effort to answer the posttest as best as they could.

In a first attempt to explain the differences in performance obtained between low achievers, time spent studying the tutorials was calculated and correlated with posttest scores. However, results from the Pearson r correlation statistic indicated that time was not a factor that had affected these scores in any systematic way. In addition, no significant interaction was found between achievement and treatment conditions on this variable. On the basis of these results, it was established that time did not have a differential effect on students' performance in either condition. Furthermore, low achievers in the learner-control condition did not necessarily perform better as a result of having spent more time on-task.

One was therefore led to examine more closely the relationship between students' level of achievement and program structure. Results of this examination would answer the question of why was learner-control more beneficial or effective for low achievers than system-control. The type of learner-control options available in Socrates allows learners, among others, opportunities to: (a) study the material in whatever order is preferred; (b) focus on particular details of a concept(s) as many times as desired; (c) redo work to achieve mastery; (d) use reviews; and (e) obtain immediate feedback. It seems that the significantly greater performance gain of low achievers under learner-control may have been the result of the opportunity to use these options. As opposed to low achievers in the system-control condition, they had the chance to test themselves repeatedly until a particular score was attained. They studied and compared the function of a particular concept(s) simultaneously. They also altered the sequence and chose specific concepts they wanted to study. They made use of the option REVIEW. The latter may have directed their cognitive processing in an optimal manner, since this command selects and presents the most important facts of all the concepts in the package at once. Also, low achievers might have profited from the fact that they could request the OVERVIEW screen whenever desired. Although Campanizzi (1978) found that the use of overviews did not appear to contribute to significant achievement gain, he pointed out that they "served as general organizational indicators of forthcoming material" (p. 28). The overview in Socrates might have given them a clearer map of the instructional sequence of the concepts, and might have therefore helped them to organize the material in a more coherent way. Subjects in the system-control condition were exposed to the overview screen only once at the beginning of the package, and did not have commands/options to use, apart from quitting the session whenever desired.

Although it was not possible to correlate frequency of option use with posttest scores, results very strongly suggest that their having used options (such as TEST, SCORE, FUNCTION, and REVIEW) was a prime cause of the observed differential benefit under learner-control. Simply stated, low achievers in this condition benefited significantly from having received more instruction. These findings agree well with those of Tobias (1976) and Stinard & Dolphin (1981). Fisher (1984) also stated that CAI had differential effects on students depending on their level of achievement. He reported results from a study in which the greatest pre/post test gains had been for low achieving students.

Question Four

This question tried to determine whether high and low achievers would respond to options in different ways. An on-task monitoring was carried out by five trained observers with the help of a checklist (see Appendix D). Mainly, frequency of option use data were collected. The aim of obtaining data regarding students' path through the program was not possible. This definitely has to be done by the operating system itself. Results from the tally record performed showed no significant differences between level of achievement and frequency of option use. High and low achievers did not really differ in their selection of options. Both used the options indiscriminantly as many times as they thought it was appropriate. These results seem to be in agreement with those from a study by Carrier et al. (1984) which explored frequency of option use of field independent and field dependent students in a computer-based lesson. They found that FI and FD students had similar patterns of option use.

Although results from the Chi-square statistic yielded no significant differences of option use between high and low achievers, on-task observations performed revealed some interesting results. The GOTO command, for instance, was close to producing significant results. This command allows students to completely alter the instructional sequence of the concepts. It is the only command that when executed does not bring the student back to where he/she was. It starts the course at the beginning of the newly requested concept. Based on the tally record, high achievers used the GOTO command more than low achievers. One can speculate that due to high achievers' confidence level, they felt more secure with altering the sequence, and thus losing momentarily the one imposed by the system. Thus, they could afford to be more adventurous and exploratory than low achieving students. The command FUNCTION on the other hand, was used more by low achievers. While it is an important 'instructional' command since it presents those screens that describe the function of a particular concept, it is a safe option to use because it brings students back to where they were. Low achievers also seem to have given more importance to the commands REVIEW and REVIEW ALL. As mentioned before, this may explain in part why low achievers in the learner-control condition performed significantly better than low achievers in the system-control condition who did not have these options. Another slight difference observed between levels of achievement was the use of the options TEST and SCORE. It appears that some low achievers were more concerned with their score, and thus felt the need to re-view and re-test themselves until mastery (on disk) was attained.

As was observed too, regardless of achievement level, TEST and consequently SCORE, were two widely used options. This does not agree with Steinberg's (1977) suggestions that students fail to practice enough when given the opportunity to monitor their own practice. Instead, these findings support the findings of a study by Stinard & Dolphin (1981). Although their experiment was not done in a CAI situation, their results have important implications and their suggestions can be applied elsewhere. Based on their results, they advanced the hypothesis that the term testing support was more appropriate than the term instructional support previously suggested by Tobias (1976). They found that poorly prepared students were compensated by frequent unit tests and opportunities to master unit content.

Contrary to other research findings, it was also interesting to note that as time passed and students became more familiar with the options in the operating system, frequency of option use increased, especially of those options such as REVIEW, TEST and SCORE. Other studies (Carrier et al., 1984) have found that frequency of option use decreased as students moved through each individual concept in the package. But examining frequency of option results more closely, one finds that there was a relatively low frequency of option use the first day. That is, students did not alter the sequency dramatically during the initial encounter. Similar findings were reported by Beard et al. (1973). As they concluded and suggested, the linear organization and sequence of a package does not really lend itself to a valuable excercise of student control of the package beyond reviewing or skipping. On the other hand, it may have been that students felt comfortable with the sequence as outlined by this producer, and felt no need to alter it at first, or to compare concepts. Only when they had finished the package once, or were practically finished, did they feel the need or curiosity to use other options more frequently. The use of such options as TEST and SCORE may have helped them to identify weaknesses and plan a strategy of study, as evidenced by the increase in use of options such as OVERVIEW, FUNCTION, REVIEW, and REVIEW All. This was also found to be the case in Stinard & Dolphin's (1981) study of self-paced mastery instruction. In their study, students expended more effort because the frequent and iterative testing of the PAS (Phase Achievement System) condition helped them to identify where they were weak.

Question Five

An attitudinal scale was administered to answer the question whether there were differences in attitudes between students in the system and learner-control conditions. The answer was no. Attitudinal results indicated that students liked the computer tutorials very much, irrespective of the type of control strategy or condition they were in. Both groups scored very similarly on the attitudinal scale. Mean responses did not demonstrate any strong negative feelings toward the package. These results seem to be consistent with what Steinberg (1977) has found in other studies; that learner-control per se will not necessarily generate greater interest. She pointed out that if a lesson is well designed, it may be motivating "even if the computer is the locus of control" (p. 89). Only one item, allowing-controlling, produced significant results. This item made a difference in relation to the condition of instruction they were in, but not to their level of achievement. One can speculate that this control factor may have contributed to the fact that the item, interesting-boring, produced almost significant results too.

A closer look at results reveals that subjects in the learner-control condition scored more in favour of the following items: easy, friendly, special, relaxed, lively, fun, satisfying, and clear. However, students in both conditions thought, in almost identical fashion, that the package was: important, motivating, good, understandable, useful, organized and creative. It seems reasonable to suggest, then, from the analysis of these data, that although no significant differences were found between these two conditions, subjects in the learner-control condition had slightly more positive attitudes toward the package.

Overall, students expressed very positive attitudes toward the program. Both groups said that animation, individual pacing of the material, clarity, and immediate feedback, among others, were the most attractive features of the tutorials. Students in the learner-control condition who were familiar with other tutorial packages, expressed surprise and satisfaction with the type of options available in Socrates. They said they had never encountered all these options before. When asked orally and informally what was more desirable, whether to review in class with the teacher and the book, or with a computer tutorial, many favoured the latter. Various reasons were given. One reason deserves mention as anecdotal evidence of students' appreciation of tutorials as effective supports of classroom instruction. In their own words, they explained that computer tutorials are more effective than books, since due to their limited space in memory, they can only present the most important facts about a topic. Books, on the other hand, present many more facts that are important, but not all necessary to be memorized or remembered. Some students expressed concern with the fact that computer tutorials were not readily available for them to use during the school year.

Summary and Conclusions

The present results and the literature reviewed emphasize the effectiveness of CAI materials as supplementary aids to classroom instruction. They seem to have a positive effect on motivation and achievement as well. Evidence showed that the tutorial programs offered better support of instruction than the traditional classroom lecture review.

The question whether the learner-controlled tutorial in particular was effective in providing supplementary instruction, largely depends on the specific target audience for which it is intended. In other words, the decision whether the type of learner-control offered in Socrates enhances performance and learning, has to be taken within the context of individual differences, in this case, achievement. Results from this particular study indicate that options like the ones available in Socrates do not necessarily enhance learning or performance in high achievers. Performance did not increase as a result of having had all those options in Socrates, as was evidenced by the similar gains of high achievers in the system-control condition. High achievers seem to have a sufficient amount of prior knowledge or to be equipped with certain learning mechanisms that do not deprive or enhance their performance under either control strategy. On the basis of the foregoing, it appears reasonably to conclude then, that the instructional sequence and overall design of the package was as effective for high achievers with or without the options. One may suggest then that what is needed with this type of learners, is a tutorial that offers supplementary information over and above what was taught in class, and/or maybe more instances of the same information. Otherwise, their prior knowledge level may not increase any further.

However, this learner-controlled package was shown to be very effective with low achievers. Results indicated that these type of students profit from the use of options available in Socrates. It seems that low achievers need to be able to manipulate the material in accordance with their individual learning styles, and that they benefit from more instruction. It can therefore be said that is was the operating system Socrates which offered special benefits for low achievers and presumably enhanced their performance.

The premise that high achievers would use more the options than low achievers, was not confirmed. Unexpectedly, frequency of option use was not dependent upon students' level of achievement. Instead, it was option type used, which was probably more related to achievement. Some low achievers were a little bit more concerned than high achievers with comparing functions and reviewing concepts. Overall, students did not make sufficient use of options the first day. Instead, they practically followed the linear sequence outlined by the system. Once they had seen the package once, they started to use these very frequently. If any pattern was observed in this study, was that the 'generic' options of the operating system such as REVIEW, REVIEW ALL, TEST, SCORE and GOTO, were used more frequently than the so-called 'instructional' options, except for FUNCTION. Generic options refer to the general commands that form the basic core of the operating system. Instructional options are those that are created based solely on the content of the package. This appears to give some insight into Steinberg's (1977) questions of "...which are the attributes of (learner) control that are motivating?...Does it provide the opportunity to practice until the student feels confident about his (her) knowledge?" (p. 89). Results indicated that this type of control options available in Socrates (TEST, SCORE, and REVIEW) which allowed students to practice until they felt that they had attained a satisfactory level of understanding, were used very frequently.

Based on the above, it can be concluded that the generic options of Socrates are more useful to the learner, if and only if, the instructional sequence and content of the package have been well designed in the first place. In other words, if sufficient, clear and good examples, explanations (structures), and definitions are included, there is no urgent need for the inclusion of instructional type of options, especially not for high achievers.

Students expressed very positive attitudes toward the tutorials, irrespective of the type of control strategy received. Although no significant differences were found in attitudes, it seems that learner-control generated slightly more favourable responses.

Recommendations

Overall, the evaluation performed made no indication of major flaws or deficiencies in the package. However, as on task observations showed, practice of the material learned was of upmost concern for students in the learner-control condition. Taking this into consideration, this study would recommend the inclusion of a larger and varied bank of criterion questions per concept. These should be presented at random upon students' request. Moreover, feedback to these questions should remediate and be more instructive, instead of simply providing knowledge of results. A similar recommendation was also stated by Stinard & Dolphin (1981). They suggested that what is needed in providing for individual differences "is a testing strategy that allows students to determine what they do and do not know and to focus their study effort on the latter through iterative testing" (p. 755).

Although the operating system Socrates presents some advantages than other ones in the market, it still has room for some improvements. As were originally designed but later removed, 'windows' are an effective way of presenting information concurrently on the screen. If the student is studying the function of a particular concept and needs to see a definition, for example, the latter can be presented simultaneously with what is currently being shown. Adding these to the operating system may give an extra dimension to the way information can be presented more effectively to the learner.

Finally, if the tutorial package is to be used in a school situation, a hard copy of students' progress and score should be made available for the teacher to keep. Furthermore, the system should be able to keep track of students' path through the lesson, so that teachers, evaluators and researchers interested in instructional design, can have opportunities to study individual differences and thus design better individualized instruction.

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APPENDIX A

learner's Documentation Manual

DEFINE

You can ask Socrates to DEFINE any concept on the disk you are using. Specify the concept you want defined.

Example: Define the stomach

Synonyms: **Def Definition What is (are) Explain**

EXAMPLE

You can ask Socrates to give you an EXAMPLE of any concept covered on the disk you are using. You can ask for other examples by typing EXAMPLE as many times as you wish.

Example: Give me an example of the pancreas

Synonyms: **Ex Show me**
Structure Shape Anatomy

FUNCTION

You can ask Socrates to give you the FUNCTION of any concept.

Example: Give me the function of the tongue

Synonyms: **Work Action**

GOTO

If you want to study another concept, you can ask Socrates to GOTO that concept. Socrates will forget where you left off and progress through the course from the newly-requested concept. In other words, the concept will change and you will not return to the previous one when you press RETURN.

Example: Goto the large intestine

Synonyms: **Go to Teach me**

HELP

When you ask for HELP you will be given a list of words that Socrates understands.

Example: Help

Synonym: ?

OVERVIEW

By typing OVERVIEW you can see a list of the concepts covered on the disk.

Example: Give me the overview.

Synonyms: **Ov Menu Directory**

QUIT

QUIT saves your score and allows you to start at the same place the next time.

Example: Let's quit

Synonyms: **Exit End**

REPEAT

When you ask Socrates to REPEAT what it has just shown you, the last few screens will be repeated. This gives you a chance to review a specific concept right away.

Example: Repeat

RESTART

When you ask Socrates to RESTART, your score will be erased and you will be brought to the beginning of the program.

Example: Restart

RESUME

If you have asked Socrates for information and decide that you don't want it, you can ask Socrates to RESUME. This command will take you back to the concept you were studying before you asked for the new information.

RESUME is useful when you have asked for information that involves many screens, and you don't want to progress through the entire series before you return to the concept you were studying. RESUME will not cancel GoTo or Restart.

Synonym: **Undo**

REVIEW

You can REVIEW any concept. You will be given the material again without receiving any tests.

Example: Review the small intestine

Synonym: **Rev**

REVIEW ALL

You can REVIEW ALL concepts. You will be shown everything on the disk without receiving any tests.

Example: Review All

SCORE

You can ask for a progress report by typing SCORE. Socrates will give you your score for all of the concepts on the disk.

Example: Give me my score

Synonyms: **Feedback** **How am I doing?**

TEST

You can take a TEST on a concept.

Example: Give me a test on the esophagus

Synonyms: **Test** **Question me** **Ask me** **Quiz**

APPENDIX B

list of Main and Subordinate Concepts

- INTRODUCTION TO DIGESTION
  - Mechanical
  - Chemical

- MOUTH
  - SALIVARY GLANDS
    - Parotid
    - Submaxillary
    - Sublingual
  - TEETH
    - Types
      - Incissors
      - Canine
      - Premolars
      - Molars
    - Structure
      - Crown
      - Neck
      - Root
    - Functions
  - TONGUE
    - Structure — muscles
    - Function — Taste buds

- ESOPHAGUS
  - Structure — mucus
  - Function — Peristalsis

- STOMACH
  - Structure
    - Walls
      - Gastric fluids
        - Hydrochloric acid
        - Pepsin
        - Mucin
      - Muscles
    - Pyloric valve
  - Functions
    - Food storage
    - Mechanical digestion
    - Chemical digestion
  - ULCERS

- PANCREAS
  - Structure
  - Function — Pancreatic fluids
    - Lipase
    - Amylase
    - Trypsin

- LIVER and GALLBLADDER
  - Structures — Ducts
  - Functions
    - Bile secretion
    - Bile storage

- SMALL INTESTINE
  - Structure
    - Sections
      - Duodenum
      - Jejunum
      - Ileum
    - Cecum
    - Walls — glands — Villi
  - Functions
    - Digestive fluids
      - Lactose
      - Amylase
      - Maltose
      - Bile
    - Absorption — Villi

- LARGE INTESTINE
  - Structures
    - Sections
      - Ascending colon
      - Transverse
      - Descending
    - Sigmoid colon
    - Rectum — Anus
  - Function — Absorption — Water and salts

APPENDIX C

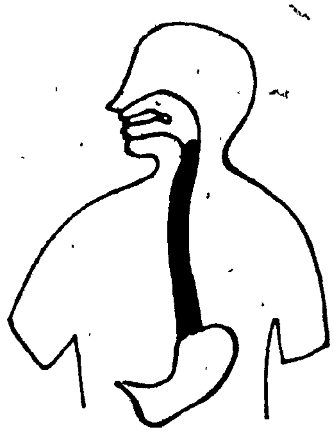
Sample of Concept Presentation: The Esophagus

Screen 1 - Title screen

THE ESOPHAGUS

Press RETURN to continue, ? for help

Screen 2a - Introduction

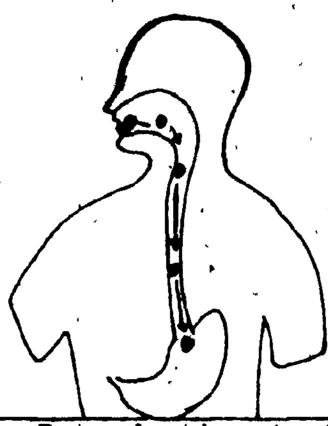


The esophagus plays a major role in the digestive system as a passage for food from the mouth to the stomach.

Introduction to the Esophagus

Press RETURN to continue, ? for help

Screen 2b - continued



The esophagus plays a major role in the digestive system as a passage for food from the mouth to the stomach.

Introduction to the Esophagus

Press RETURN to continue, ? for help

Note. Screen 2b is an animated sequence of food going down the esophagus into the stomach.

Screen 3a - Negative example

There is another tube in front of the esophagus.

It is the windpipe (Trachea).

(The student presses RETURN)

Introduction to the Esophagus

Press RETURN to continue, ? for help

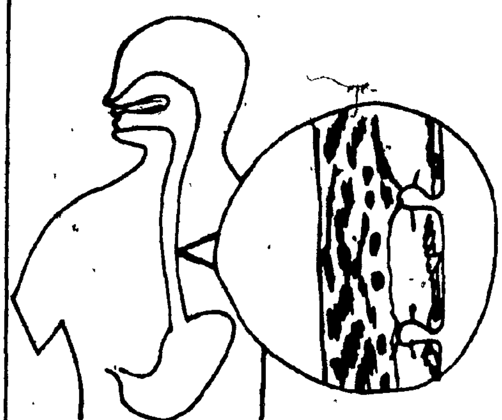
Screen 3b - continued

There is another tube in front of the esophagus.
It is the windpipe (trachea).

This tube is for the passage of air. When you swallow, the opening to the windpipe closes so that food enters only the esophagus.

Press RETURN to continue, ? for help

Screen 4 - Example



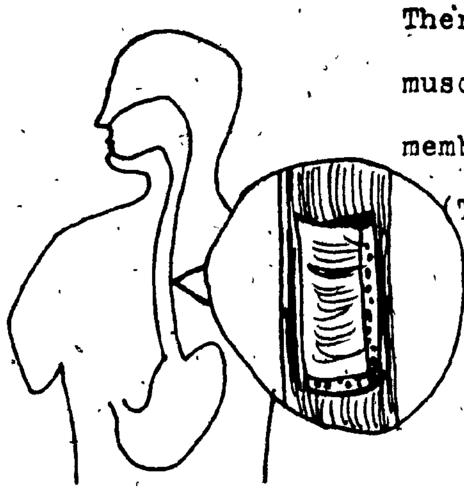
The esophagus is a tube between 25 and 30 cm in length.

Its wall is lined with a mucous membrane.

Example of the Esophagus

Press RETURN to continue, ? for help

Screen 5a - Example



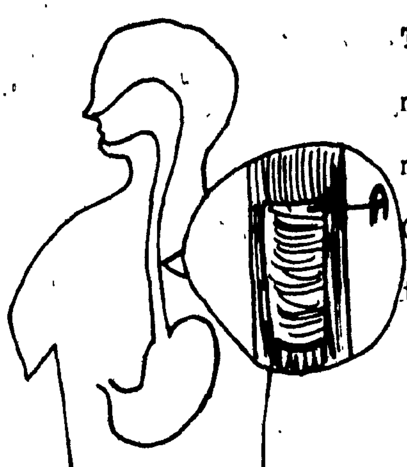
There are several layers of muscles beneath the mucous membranes.

(The student presses RETURN)

Example of the Esophagus

Press RETURN to continue, ? for help

Screen 5b - continued



There are several layers of muscles beneath the mucous membranes.

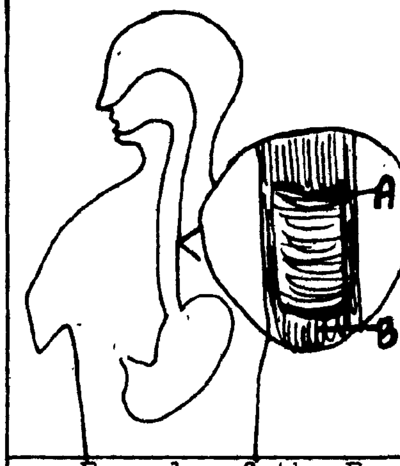
One layer (A) is arranged around the esophagus,

(The student pressess RETURN)

Example of the Esophagus

Press RETURN to continue, ? for help

Screen 5c - continued



There are several layers of muscles beneath the mucous membranes.

One layer (A) is arranged around the esophagus,

and the other layer (B) is arranged lengthwise (longitudinal)

Example of the Esophagus

Press RETURN to continue, ? for help

Screen 6a - Function

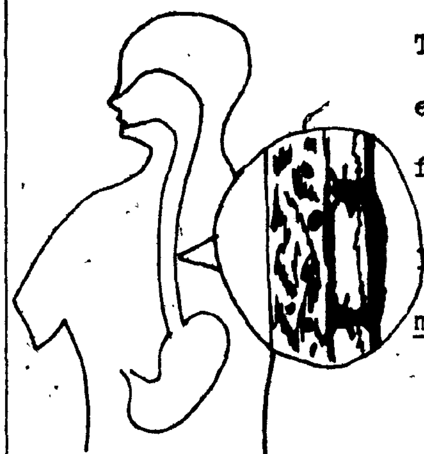
The main function of the esophagus is to conduct (move) food to the stomach.

(The student pressess RETURN)

Function of the Esophagus

Press RETURN to continue, ? for help

Screen 6b - continued



The main function of the esophagus is to conduct (move) food to the stomach.

Its mucous membrane secretes <u>mucus</u>.

Function of the Esophagus

Press RETURN to continue, ? for help

Screen 6c - continued

* This mucus lubricates the tube so that food passes easily to the stomach.

(The student PRESSES return)

Function of the Esophagus

Press RETURN to continue, ? for help

Screen 6d - continued

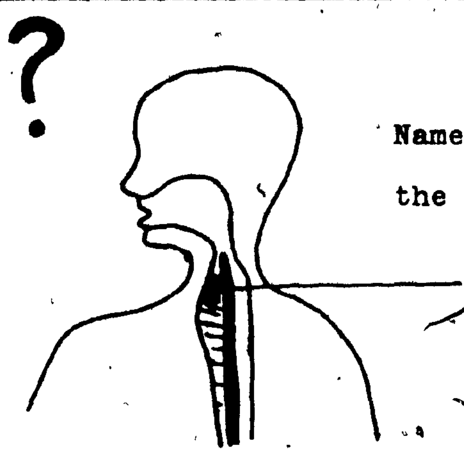
* This mucus lubricates the tube so that food passes easily to the stomach.

* The circular muscles contract in waves and push the food down. This process is called peristalsis (pl. peristalses).

Function of the Esophagus

Press RETURN to continue, ? for help

Screen 7a - Practice/test



Name the organ indicated by the arrow.

Test of the Esophagus

Type your answer and press RETURN

Screen 7b - Correct feedback/knowledge of results

CORRECT

Press RETURN to continue, ? for help

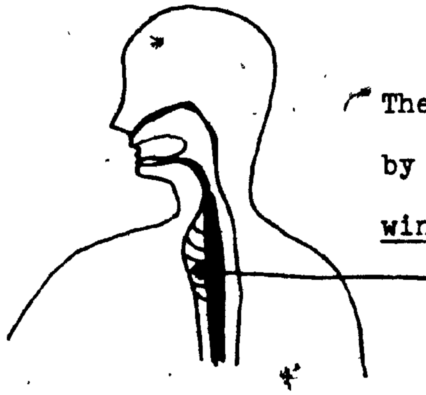
Note. The student is then presented with screen 8a.

Screen 7c - Incorrect feedback/knowledge of results

INCORRECT

Press RETURN to continue, ? for help

Screen 7d - continued



The name of the organ indicated by the arrow is the windpipe.

Review of the Esophagus

Press RETURN to continue, ? for help

Screen 8a - Test/practice

?

Wavelike muscle contractions that move food through the digestive system are called ________________.

Test of the Esophagus

Type your answer and press RETURN

Screen 8b - Correct feedback/knowledge of results

CORRECT

Press RETURN to continue, ? for help

<u>Note</u>. The student is presented with the next concept.

Screen 8c - Incorrect feedback/knowledge of result

INCORRECT

Press RETURN to continue, ? for help

Screen 8d - continued

Wavelike muscle contractions that
move food through the digestive system
are called <u>peristalses</u> .

Review of the Esophagus

Press RETURN to continue, ? for help

APPENDIX D

Observers' Checklists and List of Concepts

Checklist (Format A)

Student's name:________ Date:______ Session 1 2 3

Time started:________________

Place/concept started:____________________

DEFINE Within________Forward________Back________

EXAMPLE Within________Forward________Back________

FUNCTION Within________Forward________Back________

GOTO Forward________Back________

HELP ?____________________

OVERVIEW____________________

REPEAT Within________Forward________Back________

RESTART____________________

RESUME____________________

REVIEW Within________Forward________Back________

REVIEW ALL____________________

SCORE____________________

TEST Within________Forward________Back________

QUIT________________

Place/concept finished:________________

Time finished:______________

____
observer's signature

Checklist (Format B)

Student's name:__________ Date:_______ Session 1 2 3

Time started:____________________

Place/concept started:______________________

DEFINE	Within________	Forward________	Back__________
EXAMPLE	Within________	Forward________	Back__________
FUNCTION	Within________	Forward________	Back__________
GOTO		Forward________	Back__________
REPEAT	Within________	Forward________	Back__________
REVIEW	Within________	Forward________	Back__________
TEST	Within________	Forward________	Back__________

HELP ? ____________________________

OVERVIEW ____________________________

RESTART ____________________________

RESUME ____________________________

REVIEW ALL ____________________________

SCORE ____________________________

QUIT ________________

Place/concept finished:_________________________

Time finished:___________________________

____
observer's signature

List of Concepts in the Program

1) INTRODUCTION TO DIGESTION
2) MOUTH
3) TEETH
4) TONGUE
5) SALIVARY GLANDS
6) ESOPHAGUS
7) STOMACH
8) ULCERS
9) PANCREAS
10) LIVER AND GALLBLADDER
11) SMALL INTESTINE
12) LARGE INTESTINE

APPENDIX E

Posttest

Name of student:_______________________________

Part I - Circle the choice that best completes each of the following statements.

1) Which of the following is not a part of the digestive tract?
   a) mouth
   b) stomach
   c) large intestine
   d) liver.

2) The substance in saliva that breaks down starch is:
   a) mucin
   b) ptyalin
   c) water
   d) salt

3) Canine teeth are best fitted for:
   a) tearing
   b) cutting
   c) grinding
   d) chewing

4) A basic flavour to which the taste buds are NOT sensitive is:
   a) sweet
   b) sour
   c) salt
   d) pepper.

5) The enzyme pepsin digests:
   a) starch
   b) sugar
   c) fat
   d) protein

6) The stomach connects directly with the:
   a) jejunum
   b) ileum
   c) duodenum
   d) descending colon

7) The largest gland in the human body is the:
   a) pancreas
   b) liver
   c) gastric
   d) parotid

8) Of the following, the one that is NOT a muscle coat of the stomach is:
   a) transverse muscle
   b) circular muscle
   c) oblique muscle
   d) longitudinal muscle

9) Inside the small intestine, fats are digested by the enzyme:
   a) amylase
   b) trypsin
   c) lipase
   d) pepsin

10) Of the following, one that is NOT a component of saliva is:
   a) mucin
   b) pepsin
   c) ptyalin
   d) water.

11) The main function of the large intestine is to:
   a) secrete digestive enzymes
   b) digest foods
   c) absorb water and salts
   d) absorb nutrients

12) The last 15-20 cms. of the colon is called the:
   a) anus
   b) rectum
   c) sigmoid
   d) descending colon

13) Inside the small intestine, trypsin digests:
   a) proteins
   b) fats
   c) carbohydrates
   d) starch

14) The final result of digestion of protein is:
   a) amino acids
   b) fatty acids
   c) glucose
   d) maltose

Part II - Fill in the blank.

15) The knoblike structure which prevents food from entering the nasal cavity during swallowing is called the

____

16) A human adult mouth has ________ teeth.

17) The series of wavelike muscle contractions that move food through the digestive tract is called ________________.

18) Amylase, trypsin, and lipase are secreted by the

____________.

19) The sac-like apendage of the colon is called the

____________.

20) The longest part of the small intestine is the

_______________.

21) The largest pair of salivary glands are the

______________.

22) A/an _____ ________results when there is an oversecretion of hydrochloric acid or an undersecretion of mucin in the stomach.

23) The esophagus secretes ___________ to lubricate food as it passes to the stomach.

24) The liver secretes a greenish-brown fluid called

___________.

25) The _______________ prevents food from backing up into the stomach.

26) The principle absorptive structure in the small intestine is the __________.

Part III - Indicate if the following statements are True or False. Circle the correct answer.

27) Accesory digestive organs are those through which the food passes. true false

28) The breakdown of foods into simpler products is known as absorption. true false

29) Bile salts stimulate peristalsis of the small intestine. true false

Part IV - Short Answers

30) List the three pairs of salivary glands and indicate where they are located in the mouth.

31) List the three main sections of the large intestine.

32) What are the two ways of breaking down food during digestion?

33) List the three main parts of a tooth.

Part V - Brief essays. Write all your answers on the sheet provided. Please make sure you indicate the number of the question you are answering.

34) Name the three substances that make up gastric juice and briefly describe their functions.

35) a) Briefly describe the structure of the stomach. Take into consideration the nature of its walls and shape.
b) how does the stomach move and what are the results of this activity.

36) Briefly explain the absorption process and structures involved as it occurs in the small intestine.

37) a) Briefly describe the structure of the pancreas.
b) What is the special role of the pancreas in the digestive process? Take into consideration the function of the enzymes it secretes.

38) a) Briefly describe the function of the liver and the gall bladder.
b) how are the liver and gall bladder important to digestion.

APPENDIX F

Attitudinal Scale

Name: ____________________

Please place a mark in the space in each of the scales below that best describes how you feel about the <u>tutorial program</u> you have completed.

BAD___ ___ ___ ___ ___ ___ ___GOOD

INTERESTING___ ___ ___ ___ ___ ___ ___BORING

HARD___ ___ ___ ___ ___ ___ ___EASY

FRIENDLY___ ___ ___ ___ ___ ___ ___UNFRIENDLY

FAST___ ___ ___ ___ ___ ___ ___SLOW

ORDINARY___ ___ ___ ___ ___ ___ ___SPECIAL

RELAXED___ ___ ___ ___ ___ ___ ___TENSE

CONFUSING___ ___ ___ ___ ___ ___ ___UNDERSTANDABLE

BIG___ ___ ___ ___ ___ ___ ___SMALL

COMPLICATED___ ___ ___ ___ ___ ___ ___SIMPLE

ALLOWING___ ___ ___ ___ ___ ___ ___CONTROLLING

USEFUL___ ___ ___ ___ ___ ___ ___USELESS

DISORGANIZED___ ___ ___ ___ ___ ___ ___ORGANIZED

IMPORTANT___ ___ ___ ___ ___ ___ ___UNIMPORTANT

LIVELY___ ___ ___ ___ ___ ___ ___DULL

CREATIVE ___ ___ ___ ___ ___ ___ ___ UNIMAGINATIVE

UNINTERESTING ___ ___ ___ ___ ___ ___ ___ FUN

SATISFYING ___ ___ ___ ___ ___ ___ ___ UNSATISFYING

UNCLEAR ___ ___ ___ ___ ___ ___ ___ CLEAR

FLEXIBLE ___ ___ ___ ___ ___ ___ ___ RIGID

MOTIVATING ___ ___ ___ ___ ___ ___ ___ UNMOTIVATING

DIFFICULT ___ ___ ___ ___ ___ ___ ___ EASY

Please rate your familiarity with computers on the following five point scale.

VERY FAMILIAR ___ ___ ___ ___ ___ UNFAMILIAR

APPENDIX G

Raw Data

Subject	Condition	Achievement Level	Biology Score	Overall Posttest	Recognition	Recall	Synthesis	Time min.
1	System	High	47.0	94.75	33.75	41.50	19.50	75
2	System	High	46.0	85.49	31 50	34 99	19.00	130
3	System	High	42.5	74.18	25.50	39.00	9.68	65
4	System	High	49.0	85.50	37 25	35.07	18.18	60
5	System	High	46.0	80.50	29.25	31.75	19.50	59
6	System	Low	36.0	25.92	18.75	7 17	00.00	70
7	System	Low	27.0	16.75	14.25	2 50	00.00	85
8	System	Low	18.0	35.00	22.50	11 00	1 50	89
9	System	Low	26.5	36.00	22 50	12.00	1.50	75
10	System	Low	19 0	27.17	21.00	6.17	00 00	64
11	Learner	High	42.5	79.24	33 75	32.15	13 34	137
12	Learner	High	41.5	85.50	33.50	36.50	17.50	140
13	Learner	High	44.0	90.45	29.25	41 50	20.00	110
14	Learner	High	44.0	67 34	27.00	27.84	12.50	150
15	Learner	High	43 5	75 57	21.75	37 82	16.00	99
16	Learner	Low	34.0	66.12	25 50	25.12	15 50	137
17	Learner	Low	27.0	56.24	25 50	27.24	3.50	111
18	Learner	Low	28 0	65 24	21.75	27 49	16.00	124
19	Learner	Low	29 0	43.14	19.50	21.84	2.00	104
20	Learner	Low	24.5	65.25	27.00	30.25	8.00	83
21	No comp	High	42 0	32 86	21.00	9.84	2.01	
22	No comp.	High	43 0	40.91	21.00	16 41	1 50	
23	No comp	High	47.0	42 17	23.35	14.08	4.84	
24	No comp.	High	41 0	21.34	15.00	4.84	3.50	
25	No comp	High	47.0	35.34	25.50	8 50	1.34	
26	No comp.	Low	21.0	37.67	23.25	10.42	4.00	
27	No comp	Low	21.5	23.75	19.50	4.25	00.00	
28	No comp.	Low	26.5	42.01	24.75	14.09	3.17	
29	No comp	Low	25.0	27 75	23.25	2.50	2.00	
30	No comp	Low	29 0	31.00	21.00	7.33	2.67	

Subject	Attitudinal Score (Items 1-23) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	6	7	6	7	6	6	6	7	4	6	6	7	7	7	6	7	7	7	6	4	6	6	1
2	6	6	3	5	5	5	4	6	4	3	3	6	3	7	5	5	4	3	3	3	5	3	2
3	7	6	6	6	7	4	7	7	4	7	1	7	7	4	1	7	5	4	7	4	4	7	2
4	6	7	3	7	7	7	2	7	7	6	1	7	7	7	7	7	6	7	7	7	7	3	1
5	7	7	7	7	2	4	7	6	3	7	4	7	6	7	6	7	7	7	7	3	6	6	3
6	7	7	5	0	7	6	7	7	5	6	2	7	7	7	7	6	6	7	7	5	6	5	5
7	5	6	3	7	4	5	6	7	4	5	2	7	7	6	5	5	5	6	7	6	6	4	3
8	7	7	2	7	6	7	4	6	2	6	3	6	7	7	7	7	7	7	7	5	7	5	2
9	5	6	5	4	6	5	7	6	4	5	2	6	7	7	6	6	5	6	6	6	6	5	2
10	7	7	4	6	4	5	6	6	4	4	4	7	7	7	5	7	7	7	6	4	5	4	3
11	6	5	6	7	4	1	7	7	4	6	7	7	7	7	5	5	5	7	7	6	5	7	5
12	7	7	7	7	6	7	7	7	3	6	6	7	7	7	6	7	7	7	7	6	6	6	5
13	6	5	6	7	5	5	7	7	5	7	7	7	7	7	6	7	6	6	7	7	6	7	4
14	5	6	5	7	3	3	7	6	3	6	7	7	7	6	6	7	7	7	7	7	5	4	1
15	7	7	6	7	5	6	6	7	7	6	6	7	7	6	6	7	7	7	7	0	6	6	1
16	6	5	5	7	5	3	7	7	5	6	4	7	6	7	5	5	6	6	7	1	5	5	1
17	6	6	4	7	3	7	7	7	2	5	5	7	7	6	6	7	6	6	6	6	6	4	3
18	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	1
19	6	6	2	7	5	5	5	5	3	3	7	7	7	7	7	7	7	7	7	5	5	5	1
20	6	6	6	6	7	3	4	7	4	6	7	6	6	6	6	7	6	6	6	6	6	6	1

Note Maximum Biology score 50; Maximum Posttest score 100; Maximum Recognition score 36.00; Maximum Recall score 44.00; Maximum Synthesis score 20.00.