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ABSTRACT

The reported research was designed to investigate the impact of learner control on performance and anxiety in a computer-assisted instruction (CAI) task. The first phase entailed the development of a two-hour CAI program on the identification of edible plants. The second phase was experimentation to determine the effectiveness of learner control. Each of 162 undergraduate student subjects was placed in one of four groups: a control group who always used mnemonic devices, a control group who never used them, and two experimental groups who were given learner control over access to mnemonics, but differed in the extent of instruction on the use of that control. Responses to a state anxiety measure, learner control requests for mnemonics, and errors committed on segment and final tests were the dependent variables. Measures of individual differences were taken in the areas of task specific memory, locus of control, and achievement via independence. Providing mnemonic devices didn't have a facilitating effect, and thus, learner control, which depended on the devices, was not successful in reducing anxiety as predicted. (Author/WH)

AFHRL-TR-74-3

AIR FORCE

HUMAN RESOURCES

INDIVIDUAL DIFFERENCES AND LEARNER CONTROL I: PROGRAM DEVELOPMENT AND INVESTIGATION OF CONTROL OVER MNEMONICS IN COMPUTER-ASSISTED INSTRUCTION

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The reported research was designed to investigate the impact of learner control on performance and anxiety in a computer-assisted instruction task. The research was divided into three phases. Of these three phases, only Phases I and II are reported in this document. The first phase entailed the development of a two-hour computer-assisted instruction program on the identification of edible plants. The instruction was run on an IBM 1500 instructional system. The second phase was experimentation to determine the effectiveness of learner control. Four groups were used in the experimental design. The first group (Treatment Present) always received a presumably facilitating treatment (mnemonic devices relating plant names to their critical features) while the second group (Treatment Absent) never received this facilitating treatment. These two groups served as control groups. The third and fourth

Block 20. (continued)

groups were given learner control over access to the mnemonics but differed in the extensiveness of instructions received on the utilization of learner control. Responses to a state anxiety measure, learner control requests for mnemonics, and errors committed on segment and final tests were the dependent variables. Measures of individual differences were taken in the areas of task specific memory, Locus of Control, and Achievement via Independence. Subjects were 162 University of Texas at Austin undergraduate student volunteers who were paid for their participation. A comparison between the results of the TP and TA control groups showed that the presentation of mnemonic devices did not have the hypothesized general facilitating effect. Consequently, providing access to mnemonics via learner control did not have the hypothesized effect of reducing state anxiety or producing significant increase in performance above that of the TA group. The results of the observed relationships between the individual difference variables and learner control were complex; however, there was sufficient indication that these variables significantly interact with the use of learner control given a generally facilitating treatment being placed under learner control. Also, the intended development of well designed instructionally effective materials apparently reduced the impact of the individual difference variables.

SUMMARY

Problem. In response to changing training needs and the challenges of the "Zero Draft" and all volunteer services, the Air Force has placed increased emphasis on individualized training. As part of this emphasis, the Air Force has under development at Lowry AFB the Advanced Instructional System--a large computer-managed instructional system with a capability of supporting at least a 125 terminal, computer-assisted instructional (CAI) component. CAI offers the opportunity to adapt instruction on a moment-by-moment basis, to a student's needs or abilities. This adaptation is usually made by decision rules embedded within the CAI system but can also occur by allowing student (learner) control over sequence of instruction. The benefits of the latter should be increased student affect and simpler system programming. The reported research was designed to investigate the impact of learner control on performance and student affect in a computer-assisted instruction task as related to individual differences.

Approach. The research was divided into three phases. Of these three phases, only Phases I and II are reported in this document. The first phase entailed the development of a two-hour computer-assisted instruction of edible plants--a topic taken from the area of Air Force Survival Training. The instruction was run on an IBM 1500 instructional system. Phase Two was experimentation to determine the effectiveness of learner control (LC). An essential element of the experimental design was to prove that the learning variable placed under LC was generally facilitating. Two experimental groups were used to test this condition. A Treatment Present (TP) group always received a presumably facilitating treatment (mnemonic aids relating plant names to their critical features) while a second group (Treatment Absent) never received this facilitating treatment. Two additional experimental groups were also used. Both groups were given learner control over access to mnemonics but differed in the extensiveness of instructions received on the utilization of LC. It was hypothesized that the LC groups would have significantly better performance than the TA group. Measures of individual differences were taken in the areas of task specific memory, Locus of Control (IE), and Achievement via Independence (Ai). These latter two measures are essentially measures of perceived self-control and independence. It was hypothesized that students who are independent and feel that they have control over what happens (high Ai and IE) will utilize the learner control option more frequently and effectively than students who are more dependent on authority and perceive that external events strongly influence what happens to them (low Ai and IE). A further general

hypothesis was that external type people would make better utilization of the LC option given the condition of extended instructions (experimental group LCI) explaining the utility of the mnemonic aids. Lastly, and most important in terms of the general direction of the study was the hypothesis that LC would have a positive effect on student affect, in this case a reduction in student anxiety. A measure of state anxiety was used as the relevant dependent variable.

Results and Conclusions.

The first hypotheses that the experimental treatment to be placed under LC would be generally facilitating was not supported. There was no significant difference between the TP group and TA group. Instead an interaction occurred between these groups in terms of the task specific memory test. Consequently, the use of mnemonics was facilitating for only a small group of subjects who had good associative memory but were ineffectual or detrimental to most subjects. Because of these results, the remaining hypotheses were not expected to be confirmed and, in fact, this was the case. However, analysis did provide indicators that learner control is a viable concept. For instance, it was found that subjects reduced their use of mnemonics from the first segment of the experiment to the second segment and this reduction was greatest for the poor memory students. This reduction was differentiated in terms of subjects rated as internal or external by the Locus of Control measure. The pattern of LC requests for mnemonics between the first and second segment of instruction was more adaptive for internally than externally rated subjects. Whatthis shows is that though the type of instructions subjects received on the utility of LC did not have the hypothesized effect, the subjects' own experience with the usefulness of the mnemonics did.

Recommendations. Because the learning variable placed under learner control was not proven to be generally facilitating, the effectiveness of learner control in respect to individual differences and anxiety reduction could not be established. On the basis of the present results, it is postulated that the effect of the plant photographs were stronger mediational aids than anticipated, especially their role in a verbal stimulus-verbal response chain. Consequently, it was recommended that Phase III capitalize on and extend the findings of Phase II. Phase III of the research will basically follow the same research paradigm except that the plant photographs will be used as an instructional mediator placed under learner control.

The results of this study show the importance of instructional design. The two hour CAI segment was specifically written to be instructionally objective and effective. In such a situation the impact of individual differences on learning seems to be minimized.

It would appear then that decisions about adaptation to individual differences must, in part, be based on research which has included studies that have utilized a mainline set of instructional materials designed to maximize the achievement of the total student group.

PREFACE

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INTRODUCTION

In view of the zero draft, the training which the Air Force provides its members will be an important "drawing card" for both enlistments and re-enlistments. The training program is extremely important to how the Air Force is perceived because: (a) it is experienced by the enlistee right after entering active duty, at a time when he is highly impressionable and critical of his new environment; and (b) both the individual and the Air Force need to derive benefit from this training.

In many ways, the traditional forced-pace lecture style of teaching skills and concepts is incompatible with the interests of the types of people which the Air Force wishes to attract. It is consequently not surprising that the Armed Forces have recently placed increased emphasis on the importance of individualized instruction and in particular on computer-based instruction as exemplified by the Advanced Instructional System.

Historically, computer-assisted instruction (CAI) techniques have been based largely on the stimulus control principles of programmed instruction. The decision-making capability of the computer has been viewed as a means of implementing detailed adaptation to individual differences through moment-to-moment responsive control over the instruction presented to the student. Research and practice, however, have shown that traditional measures of the student's aptitudes and of his current behavior are often inadequate as a basis for efficient instructional decisions. In addition, rigid control over the student's progress and his inability to purposively alter the sequence of instruction presented often appear to have detrimental effects on the students affect toward the instructional situation and the subject matter. These and similar considerations have led to substantial interest in the potential of learner controlled or student controlled CAI.

Research on learner control within the context of computer-based instruction has occurred only relatively recently. In general, as will be documented in later sections, the learner control literature can be characterized as promising but confused. Several reasons for this confused state in the literature are apparent. First, there is no consensus on the definition of learner control. Research to date has included giving the learner control of the sequence of instruction, amount of pacing, whether to review material or not, etc. Second, there has been a failure of many researchers to take into account possible individual differences in response to learner control. Third, although one of the major hypothesized advantages of learner control is affective, seldom have reliable and valid measures of student affect been included in the research. Finally, in almost all of the learner control research to be reviewed, the independent variables placed under learner control were not themselves shown to have any appreciable effect on learning.

Thus, one focus of this research was to test the adequacy of a learner control paradigm in two studies. Our approach consists of first an information processing analysis of the behaviors to be learned concerning plant identification; then a variable is selected on the basis of a task analysis which is anticipated to facilitate learning. As an empirical check on this presumed instructional facilitation two control groups were used. One group always received the facilitating treatment and one never received the treatment. The learner control group was given a choice of whether or not to use the facilitative treatment. In the present research the dependent variables of interest were student affect (specifically state anxiety) and performance.

The research was designed to be conducted in three phases: The first phase documented a literature review and the design and development of the computer-based instructional materials. The second phase consisted of an experiment with the learning materials developed in Phase I and used the paradigm mentioned above. The results of this research will be documented in this report. In addition, the design of a second experiment for Phase III will be delineated. The results of the second experiment will be found in the final report.

PHASE I

LITERATURE REVIEW AND COMPUTER-ASSISTED INSTRUCTION COURSE DEVELOPMENT

PREVIOUS RESEARCH ON LEARNER CONTROL

Research on learner control (LC) in the context of computer-based instruction has occurred only relatively recently in the history of this area. The early studies (e.g., Mager, 1961; Mager & McCann, 1961; Newman, 1957) based learner control effects on a comparison of structured with unstructured learning situations, when students in the latter case were required to choose their own materials and method of study. This research was predicated on the assumption that: (a) the student has a sufficient comprehension of his own state of learning to determine, in most instances, what the sequence of instruction should be; and that (b) allowing the student control over his progress will make the learning situation more "attractive." These authors expected that LC would result in: (a) increased mastery of subject matter; (b) equivalent mastery in a shorter period of time, and/or (c) increased self-direction in the student's approach to learning. In addition, in those experiments using computer-based educational techniques, the experimenters anticipated that LC would result in an increased tendency for students to view the computer as a tool for learning, rather than as a dictatorial tutor. However, more recent research, which introduced greater control over the learning situation in general and over the LC option in particular, has failed to confirm these optimistic predictions.

Early Research--Positive Results

One of the earliest experiments indicating performance advantages for LC was reported by Newman (1957). Newman's subjects were 30 airmen who were randomly assigned to a "student group" or an "instructor group." The task was to learn the names of 20 electric symbols. The student group was given a list of the terms matched to the appropriate symbol and allowed to use their own technique for learning the list. The instructor group was instructed in techniques for learning the list and given a fixed sequence. Both groups were given the same amount of time. Although Newman had hypothesized that the instructor group would perform better as a result of the instructional designer's knowledge of learning techniques and sequencing, the opposite was found to be the case. The student, or "learner control," group performed significantly better than the instructor group on the posttest.

Systematic research on learner controlled instruction can be traced to two non-computer-based instructional studies by Mager (1961) and Mager and McCann (1961). Mager first explored the effect of allowing students complete control over the sequence of instruction in a course in electronics. The six students who served as subjects had no previous training in the area, but were shown through interview data to have considerable background information. They selected the materials to be studied and determined the amount of time allocated to any specific activity. Instructors were always available but functioned only as information sources. Mager found that students defined patterns of instructional organization which were quite different from those imposed by previous instructors and which placed more emphasis on functional relationships.

Mager and McCann (1961) then attempted to empirically determine the relative efficiency of learner-controlled and instructor-defined instructional sequencing in the context of a training program for newly hired engineers at Varian Associates. While the company's previous training program had consisted of six months of fairly formal training in the form of regular classroom instruction and specific departmental assignments, the "learner controlled" training program was very open. The six students were given a flowchart and a tour of the factory and were then left on their own to ask for information from anyone in the factory at any time. The trainees were judged ready for assignment after three months, one-half of the time required under the previous program, and were considered to be better prepared for their assignment than were previous graduates of the program. In the second phase of the study, six more trainees were provided with performance objectives and reference materials, and could arrange interviews with the experimenter at any time to demonstrate achievement of a block of knowledge. Thus, these trainees were given a more "guided" learner control situation. These students were judged ready for assignment after an average of 7-1/2 weeks.

While this study would appear to demonstrate at least a time advantage for LC, it contains a number of serious methodological problems. The previous instructional program had been judged unsatisfactory and boring by both the participants and the experimenter. The students' proficiency was evaluated subjectively by the experimenter, and the students, being new trainees, were in a highly motivating environment. Thus, while a dramatic reduction in learning time was demonstrated, these results must be viewed with caution.

An experiment by Campbell and Chapman (1967) reported results similar to those of Newman with a quite different subject group and task, fourth and fifth grade students in an eight month course in global geography. Each of nine units of study involved contained objectives, practice problems, and short programmed segments. Pairs of comparable classes from three schools were assigned to either program control or learner control methods. Classes working under the program control studied from linearly programmed texts, while LC classes utilized a resource collection, a file of all the materials on the topics available in the school. Program control subjects had no freedom to choose the sequence of study; the learner control group had total autonomy over which materials they used and in what order they were studied. The learner control group was found to perform significantly better on unit posttests and on a retention measure administered five months after completion of the course. In addition, the results of measuring student motivation revealed gains that were also in favor of the learner control group.

In contrast to these results, two earlier reports of studies by Campbell presented rather different results. An experiment reported by Campbell and Bivens (1963) yielded no final test performance differences between learner control and linear sequence groups although students preferred self-direction by a ratio of two to one. Campbell (1964) reported a series of seven small experiments contrasting learner control with a fixed instructional sequence in a variety of subject matter areas. In only one case, in the study of two mathematics units, was a significant performance advantage found for a learner control approach. In this instance, both the learner control and the linear sequence groups were each further divided into two groups, one of which received "coaching" on the type of study which they were to use, either self-direction or program direction. The performance of the coached learner control group was significantly superior to that of the other groups on a final test following the first unit and on a criterion test embedded in the second unit. On a final test following the second unit, this group's observed mean score exceeded that of the other groups but the difference was not found to be significant.

A study by Davis (1971) reported results similar to those of Campbell and Chapman (1967). Forty-one students from an educational psychology class were divided into two groups: a choice group (LC) and an assigned group. Students in the choice group were allowed to select their own study area from an instructor-determined menu. Those in the assigned group were given the same assignments at random. Results indicated increased achievement and a more positive attitude toward the subject matter in the choice group, although the differences between the two groups were not significant.

Grubb (1969) was the first to investigate the use of LC in computer-assisted instruction. The effects of varying amounts of learner control on performance were contrasted with performance following a linear sequence of instruction. Because Grubb's subjects were 50 IBM engineering trainees, it can be assumed that the subjects were mature and well motivated. The learning task consisted of two chapters in elementary statistics, each chapter programmed in two ways. The first was simply a linear sequence (L), while the second allowed the learner to control the sequence of instruction within the chapter (LC). Four groups of subjects were defined by assignment to the linear and learner controlled versions of each of the chapters with order counterbalanced (L-L, L-LC, LC-L, and LC-LC). A fifth group (LC) was also given control over the order of chapters.

An interesting feature of this study was that the learner control students were given a series of "maps" of the subject matter. Grubb hypothesized that the failure of some self-instruction courses was a result of fragmentation of the subject matter into small steps. The student learned the content but not the structure, or interrelationships, of the subject matter. The student, as Grubb put it, could "never see the course for the frames." Grubb's "maps" of the subject matter showed how one part related to another, thus aiding the student in choosing a sequence.

Grubb found that the LC-LC group, having control over sequencing within chapters but not between chapters, performed significantly better on the posttest than did the other four groups. In addition, the posttest performance of this group was less highly related to performance on the pretest, an alternate form version of the posttest, than was the performance of the other four groups. That is, LC-LC subjects produced uniformly high posttest performance across the entire range of pretest scores while for the other four conditions, posttest performance was heavily dependent on pretest performance. These findings would appear to suggest performance advantages for learner control for subjects over a range of aptitudes if appropriate keys or maps to the subject matter are provided.

In a second study conducted by IBM Corporation, Dean (1969) reported performance advantages for LC when students were allowed to control the amount of practice. Subjects were 120 fourth, fifth, and sixth graders who were instructed by a computerized arithmetic practice module. In this case, the linear group was required to complete five successful trials with a problem type before proceeding to the next unit. The learner control subjects could determine their own amount of practice. The learner control group achieved better performance on the posttest than the linear group and also decreased its variance from the pretest. However, these findings should be viewed with caution as the data were not analyzed statistically and were somewhat confused by interrelationships with grade level.

Another advantage for learner control was found by Newkirk (undated) who used a computer program to teach the structure and language of the hypothetical CLIP computer. Twenty-six subjects were randomly assigned to either a fixed, linear sequence program or a learner controlled program in which the subject was given control over the sequence within blocks of instruction and over his rate of progress. While Newkirk found no significant differences between the two groups in achievement as measured immediately after the program, a retention test given two weeks later indicated that the learner control group retained the subject matter better than did the linear group. While there were no significant differences in the immediate and delayed test scores for the learner control group, the linear group demonstrated a significant decrease in scores on the delayed test. In addition, the learner control group required less time to complete the program (a mean of 112 minutes as compared to a mean of 131 minutes) and rated their sequence of instruction as significantly more interesting than did the linear group. Thus, while this study does not substantiate immediate performance advantage of learner control, it does indicate, as did the Campbell and Chapman study, that retention may be improved by learner control.

Later Research--Conflicting Evidence

Barnes (1970) used 214 subjects from grades eight to thirteen to study the effect of LC on student performance in learning multiplication. Two variables were investigated: problem type and the nature of remedial feedback. Five problem types were created differing in the number of digits in the multiplier (1 or 2) and multiplicand (ranging from 1 to 4). Half of the subjects were assigned to a program control group which received problems randomly selected from the five available types. Subjects in the learner control group determined the problem type they wished to study by specifying the number of digits. The feedback provided for correct responses was constant for all students and consisted of a positive comment such as "good" or "correct." The remedial feedback provided for incorrect responses was either active or passive. One-third of the subjects were assigned to active remediation which required the subject to respond by correctly solving the problem under the tutorial direction of the program. A second third were assigned to passive remediation which merely presented the correct solution. The remaining subjects were allowed to determine the type of feedback received on each problem.

An analysis of gain scores indicated that neither the dimensions of problem type, type of remedial feedback, nor their interaction was significant. Barnes postulated that lack of readiness was an important confounding variable. Again, motivational factors were also considered to be important.

Olivier (1971) investigated the effects of learner control over sequence as compared to a fixed sequence of instruction determined by a Gagné-type analysis of the learning hierarchy. The subjects consisted of 176 educational psychology students. The task was a modified, shortened version of the artificial science of Xenograde Systems (Merrill, 1965). The learner control group showed significantly poorer performance than the fixed sequence group in terms of total percent correct on a posttest covering the hour-long instruction. In addition, there were no differences between groups in their expressed attitude toward the task. This is in direct contrast to previous researchers' findings of advantage for learner control over sequence (Campbell & Chapman, 1967; Davis, 1971;

Grubb, 1969). It should be noted that Olivier's study presented a more rigorous test of learner control in that the sequence assigned the program control group was based on an analysis of an assumed underlying hierarchy. It would not be surprising if any advantages of learner relative to program control were substantially diminished in the context of a truly hierarchical and difficult task.

Two studies conducted at The University of Texas CAI Laboratory have yielded complex results. Judd, Bunderson, and Bessent (1970) found that students given control over the sequence of instruction demonstrated equivalent or poorer posttest performance and did not differ in attitude toward the task from students assigned to an instructional sequence based on an analysis of the task--three topics in precalculus mathematics. Students given the results of a diagnostic pretest and control over whether or not they studied the corresponding instructional module did not differ in attitude and performed more poorly than did students directed into the modules under program control. A speculative conclusion was that when given control over the selection and sequence of materials, some subjects used their options to avoid rather than to pursue difficult materials.

In the second study (Judd, Collier, & Bunderson, in preparation), the sequence of presentation was fixed in the assumed optimal order for all treatments in a shortened version of the first task. Given the results of diagnostic tests, subjects selected fewer modules for study than were assigned to subjects in the program control group on the basis of the same tests. The two groups did not differ in posttest performance. Thus, subjects given control over this variable would appear to have been more efficient in their decisions than the corresponding algorithm.

Learner control over the amount of practice within modules was also contrasted with a program control condition in which amount of practice was determined by an algorithm which required that the student make two errorless passes through each problem before proceeding to the next problem. It was found that LC subjects worked more practice problems than were assigned to the program control subjects. This difference tended to increase as the subjects worked through the program until, in the latter half of the program, the LC subjects were working approximately twice as many problems as were the program control subjects, a difference which was significant. Again, however, the two groups did not differ in terms of posttest scores. With respect to this dimension, then, learner control students were quite inefficient in their use of the control options. No meaningful differences were found between any groups with respect to expressed attitudes toward the task.

Other investigators have suggested the importance of training or experience in learner control techniques in order to maximize the positive effect of learner control. Campbell, in the study previously discussed (1964), found that if subjects were given "coaching" or directed practice in the use of self-directed learning materials, their performance was then significantly superior to that of the linear controlled group. Fry (1971) also suggests in his study that the lack of experience with self-directed learning prevented the learner control group from making full use of the opportunities available to them. Grubb's (1969) study indicates that the use of some prompting, such as "maps" of the course material, is beneficial.

Brown, Hansen, Thomas, and King (1970), in a study investigating student selection of different media devices for the presentation of instruction, suggest that the amount of information presented to guide student decisions in sequencing may be a critical variable and should be investigated. Thus, it would appear that experience and/or training in self-directed techniques and guides, or prompts, to the specific subject matter may also be important variables.

In a study involving LC in a computer-managed instruction context, Gallagher, O'Neil, and Dick (1971) investigated the relationship of variations in evaluation technique and sequence of instruction on state anxiety levels in a computer-managed, individualized instruction course for graduate students. Following their completion of a module of instruction, students were evaluated by either their instructor or by interacting with a computer terminal. Subsets of these students were also either assigned a sequence of study or allowed to determine their own sequence for studying the modules--the learner control option. While all four groups achieved the required 80% mastery on the final examination, students evaluated at the computer terminal demonstrated lower levels of state anxiety than students evaluated by their instructors. More important to the purpose of this review, the data indicated that students under the computer-managed instructional condition experienced lower levels of state anxiety if they were allowed to choose their own instructional sequence as opposed to having the sequence imposed.

Another recent experiment, by McCann, Lahey, and Hurlock (1972), investigated the effect of allowing learner control over instructional sequence within modules of an 11-module CAI course on basic electronics. Subjects were U.S. Navy trainees in a basic electricity/electronics school. The LC option was introduced in the third module, with program control based on pretest performance in effect for the first two modules. In contrast, program control was in effect for all 11 modules in the comparison, program control condition. The results showed no performance differences on combined module test scores, on either of two main posttest scores, or on lesson training time. A six-item posttest evaluation questionnaire showed that the LC students rated CAI significantly better than did the program control students. The authors concluded that LC over instruction may promote a more positive attitude toward training, but not have any significant effect on performance.

Individual Differences--An Important Variable

Individual difference variables would appear to be an important consideration for the effectiveness of learner control. Several of the experiments which have found positive advantages for learner control (Grubb, 1969; Mager & McCann, 1961; Newman, 1957) have involved highly motivated and/or intelligent subjects who might well be expected to do better under less structured conditions. Analogously, failure to find advantages for learner control have often been attributed to lack of readiness (Barnes, 1970), lack of motivation, or lack of experience with the subject matter (Judd, Bunderson, & Bessent, 1970; Olivier, 1971). A few recent studies have begun to investigate the effects of individual difference variables on students' use of learner control. These studies appear to offer promise in alleviating some of the confusion and suggesting a more profitable line of research.

Fry (1971) investigated the effect of two variables, aptitude and inquisitiveness, with respect to learner control, linear control, random sequence, and a no-instruction control group. All students determined their own pace, while students in the learner control group were also allowed to determine their own sequence and to ask questions, which were recorded and used for the other groups. While the data indicated that the learner control students, in general, demonstrated poorer performance on the posttest than did students in the linear or randomly sequenced groups, interesting interactions were found when the data were analyzed in relation to the two individual difference variables. Those subjects who scored high on the aptitude and inquiry scales learned significantly more under the LC condition than did other types of students under that condition. Those with high aptitude but low inquiry learned significantly more under the condition of a fixed linear sequence. The results for low aptitude subjects were inconclusive.

Conclusions

In summary, the implications for the utility of learner control in computer-assisted instruction are rather mixed. One reason for the confused state of the literature is that there is no consensus on the definition of "learner control." Research to date has included learner control over a variety of variables in the learning situation: content area, sequencing of context units, pacing, redundancy/review of material, detail of material, and even media for presentation of the material. Thus, it is virtually impossible to find agreement on the factors over which learners are given control.

However, the existing literature does suggest some conditions under which learner control is effective in producing performance and/or affective differences. The early experiments (Mager, 1961; Mager & McCann, 1961; Newman, 1957) used highly trained adult subjects (airmen, engineers), who can be assumed to have a considerable amount of sophistication about study techniques in general and about the material they were to learn in particular. In addition, these studies permitted learner control over a variety of resource materials as well as over the rate at which the students progressed through the material (and Mager's work even permitted control over the total time spent on the material). Later studies (e.g., Barnes, 1970; Judd et al., 1970; Olivier, 1971) appear to have used subjects who were less sophisticated, at least about the type of material they were studying, and these studies generally failed to show any kind of learner control facilitation. In addition, the later studies began to restrict the range of material and freedom of pacing over which subjects had control, thereby quite possibly eliminating a factor from learner control which was important to facilitated learning.

Another factor apparently related to the effectiveness of learner control is the sophistication of subjects concerning self-directed (learner-controlled) study itself. That is, learner control is more effective in studies where students have already had some experience with it (e.g., Fry, 1971) or where specific "coaching" in use of learner control was provided (Brown et al., 1970; Campbell, 1964; Grubb, 1969).

Another important problem concerns the comparisons made in many of the experiments reported. In most of the cases in which learner control was shown to be advantageous, the comparison group was administered a linear or random sequence of instruction which made no attempt to adapt to individual differences (i.e., Campbell & Chapman, 1967; Davis, 1971; Dean, 1969; Grubb, 1969; and Newkirk, undated). Experiments which contrasted learner control with instructional decisions made by an adaptive algorithm (Judd, Bunderson, & Bessent, 1970; Judd, Collier, & Bunderson, in preparation) might be faulted on the basis of the fact that the comparison was made with only a single decision rule, in the absence of any evidence that the parameters used by the decision rule were appropriate.

In introducing experiments on learner control, various researchers have almost invariably referred to its assumed affective and/or motivational advantages. Empirically, however, these affective advantages have proven to be quite elusive. If learner control does indeed have affective advantages, the conditions under which these advantages may be expected have yet to be defined. As will be suggested in a later section of this report, part of the problem may revolve around the lack of sensitive and operationally defined measures of student affect.

With the exception of Fry's (1971) experiment, none of the studies reviewed have examined differences in student reactions to learner control as a function of noncognitive individual difference variables.

Those experiments which have examined cognitive variables in the form of pretest scores (Grubb, 1969; Judd, Bunderson, & Bessent, 1970; Judd, Collier, & Bunderson, in preparation) have obtained conflicting results. As Fry (1971, p. 16) suggests, the unacknowledged presence of such individual difference variables, cognitive as well as noncognitive, may well account for much of the confused state of the literature. The further investigation of noncognitive individual differences thus appears to be well justified.

RATIONALE FOR INVESTIGATING PERSONALITY VARIABLES IN THE CONTEXT OF LEARNER CONTROLLED CAI

As was discussed, one of the primary criticisms of the past research on learner control has been the failure of many of the researchers to take into account possible individual differences in response to learner control. Since learning psychologists have for some time been aware of individual differences in learning strategies, it appears quite likely that different individuals would respond differently to learner control. If the personality variable or variables which may account for these differences could be identified, it is quite likely that many of the conflicting results in previous learner control studies could be explained. Thus, one might find that certain types of individuals benefit greatly from certain types of learner control, while others need more specific guidelines or cues in order to improve their performance through learner control.

One general personality trait which appeared to be related to the efficient use of learner control is the independence of the student. Early proponents of learner control argued that the individual student is more aware of his own weaknesses and strengths than is the instructor, and is thus better able to guide or direct his own learning if given the opportunity. While the studies of various learner control options have been inconclusive concerning this hypothesis, this may be the result of failure to control for personality variable differences. Thus, this hypothesis may be true for the independent student who is aware of his learning needs and acts to operationalize this knowledge. The more dependent student who normally depends on an instructor to guide him may, however, require more specific guidelines in order to become cognizant of his own needs.

Locus of Control

Two different scales were chosen to measure this general personality variable. The first measure concerns the personality construct locus of control or internality-externality. The internal-external control construct is viewed as a generalized expectancy operating across a wide variety of situations. When an individual perceives that an event or behavior is contingent upon his own behavior or characteristics, this belief is termed internal control. If, on the other hand, the individual interprets a reinforcing event as not being entirely contingent upon his own actions, but being attributable to chance, fate, luck, or under the control of others, or as unpredictable, this belief is called external control (Rotter, 1966).

The growing interest in the internal-external control construct is evidenced by the increased amount of research in this area since Rotter's (1954) social learning theory was published (MacDonald, 1970). Research has dealt with a number of problems including social class differences (Battle & Rotter, 1963; Gore & Rotter, 1963); children's tests of internal-external control (Bialer, 1961); attempts to control the environment (James, Woodruff, & Werner, 1965); internal-external control and resistance to subtle suggestion (Gore & Rotter, 1963; Seeman, 1963); and more recently studies of internal-external control differences in attention, and limitations of cue explication in various learning tasks. These latter studies have demonstrated differences in the learning styles of externals and internals which appear to be related to the type of skills one utilizes with learner control.

A major finding resulting from these studies has been that internals generally appear to perceive greater ego involvement in a learning situation than do externals. Reasoning that ego involvement would probably be high in skill dependent tasks, Rotter and Mulvy (1965) hypothesized that given skill instructions for a difficult discrimination task, internals would demonstrate longer decision times than would externals. These instructions stated that although the discrimination was difficult, previous research had shown that some people were more skilled than others in making such discriminations and that results depended on the subject's ability. The hypothesis was confirmed. A second hypothesis, that given chance instructions (the discrimination was so difficult as to be a matter of luck) externals would demonstrate longer decision times than internals, was not supported. The differences were nonsignificant. Similar results have been reported by Julian and Katz (1968).

A later study by Lefcourt (1967) concentrated on the performance of internals and externals under chance and skill conditions. It was found that internals performed significantly better than externals when given chance instructions; however, as the instructions became more highly skill oriented, the performance of the externals rose until under high skill instructions it was equivalent to that of the internals. This would indicate that not only is the decision time faster for an external subject under skill instruction, but his performance is improved relative to his performance under chance instruction. Lefcourt suggests that these results indicate the less distinct tendency of external subjects, as opposed to internal subjects, to accept or reject the task structuring. This tendency may reflect their lesser acuity in perceiving opportunities for control as compared with internal subjects. That is, increasingly well defined task instructions appear to provide a missing cognitive link for externals.

Lefcourt, Lewis, and Silverman (1968) acted to confirm some of these findings. They found that internals were less easily influenced by chance oriented directions and more readily accepted skill directions.

In fact, they tended to perceive almost every task as a skill task, thus invoking greater ego involvement, regardless of the directions given. Incongruent directions were simply disregarded. Externals were found to be much more accepting of the directions given, thus more easily influenced by them. Again, Lefcourt suggests this is a result of their lesser ability to perceive opportunities for control.

Thus, it appeared that the external subject could be analogous to the student who has depended on the instructor or some other external agent to guide his learning and has not perceived his opportunities for control. He, therefore, requires more specific guidelines than the internal subject in order to perceive his own needs and take the opportunity for control. In the studies reported, it appears that the increasingly well-defined task instructions provide a missing cognitive link for externals which helps them to improve their performance. It was postulated that a similar type of instruction could well improve externals' performance under learner control conditions.

Other research has demonstrated additional traits of internals which would appear to contribute to a superior performance with learner control. Davis and Phares (1967) found that, in addition to the differences between internals and externals under chance and skill instructions, in information-seeking tasks, internals requested significantly more information than externals. This is again probably a result of their greater ego involvement in learning tasks. This finding further supported the hypothesis that internals would make greater use of learner control options than would externals.

Achievement via Independence

According to the California Psychological Inventory (CPI) (Gough, 1957), the Ai scale measures those factors of interest and motivation which facilitate achievement in any setting where autonomy and independence are positive behaviors. High scorers are characterized as being mature, independent, self-reliant and having superior intellectual ability and judgment, whereas low scorers are seen to be cautious, dependent, and reliant on others. For the proposed research, it was postulated that the higher scorers would take advantage of and benefit more from learner control options. The personality characteristics of the high scorer appear to be congruent with those which have been found to be characteristic of subjects who benefit most from learner control: maturity (Grubb, 1969) and inquisitiveness (Fry, 1971).

Extensive research has been done using the Ai scale. Its ability to differentiate between high and low achievement has been demonstrated repeatedly (Barnett, 1961; Gough, 1957; Gough, 1964;

Keimowetz & Ansbacher, 1960; Pierce, 1961). A recent study by Stroup and Eft (1969) concerning the relationship between freshman grade point average (GPA) and scores on different scales of the CPI found that the responsibility scale and the Ai scale were most highly correlated with freshman GPA. While nine scales were found to be significantly related to GPA for females and eleven for males, these two had the highest significance values for both groups.

Evans (1969) compared the Ai scale to the achievement and intellectual efficiency scales of the CPI with regard to ability to predict GPA, verbal ability and quantitative ability. In each case the Ai scale was found to be a better predictor than the other two scales. These two studies and the others cited would appear to indicate that this scale does succeed in measuring at least some variables of achievement.

More important to the purposes of the proposed research, it has been demonstrated that the Ai scale can differentiate between independent and dependent students (Gough, 1957; Heist & Yonge, 1965; Johnson & Frandson, 1962; Parloff & Datta, 1968). The research reported by Parloff and Datta (1968) is a good example of this ability. Their subjects were 938 high school students who had been selected by the Science Talent Search as the "Scientists of Tomorrow" on the basis of their being in the top 20% of a nationally administered science aptitude test. These students submitted science projects which were judged for the combination of novelty and effectiveness by a panel of scientists. The students were also administered the CPI as well as a number of cognitive measures. Those students whose projects were judged to be the most novel and effective were found to have significantly higher scores on the Ai scale than those whose projects were judged to be less novel and effective. The various cognitive measures failed to distinguish between the two groups. This was due, no doubt, partly to the fact that the group as a whole was cognitively homogeneous, having been selected on the basis of aptitude scores. The study does, however, indicate the ability of the Ai scale to predict success in a setting which rewards independent work.

A somewhat similar study reported by Davids (1966) showed that one major difference between over- and under-achievers among "potential scientists," as judged by high science aptitude scores, was that over-achievers scored significantly higher on the Ai scale than did under-achievers.

Domino (1969) examined the performance of 348 college juniors in courses which were divided into two operationally defined categories: those rewarding independent behavior of students, and those rewarding conforming behavior. The GPA of each student under each of these types of courses and each student's score on the Ai scale of the CPI were obtained. The results of the analysis of these scores and grades showed that: (a) students with high Ai scores achieved a significantly higher mean GPA than did students with low Ai scores in those classes that rewarded independent behavior, but that (b) students with high Ai scores did not achieve a significantly higher mean GPA than students with low Ai scores in those classes that rewarded conforming behavior. Although the mean GPA for both types of courses was approximately the same, (c) students with high Ai scores achieved a higher mean GPA in classes rewarding independent behavior than in classes rewarding conforming behavior, while (d) students with low Ai scores achieved a higher mean GPA in classes rewarding conforming behavior. The last two results, although not statistically significant ($.05 \leq p \leq .10$ for both statements), do provide an indication of an interaction of the Ai scores with the two types of courses.

These studies and the operational definition of Achievement via Independence suggested that this measure would be a valid predictor of individual success with learner control in that it is a specific measure of independence in a learning environment. The Ai scale appeared to be the best test in this area in terms of reliability and validity. The reliability coefficient, as reported in the CPI manual, is .82 for adults. This was found using a test-retest method with a one-year interval between tests. The validity of the test is evidenced by the many studies which show its usefulness in predicting academic achievement in cases that require individual work (Davids, 1966; Domino, 1969; Johnson & Frandson, 1962). In addition, its construct validity is demonstrated by its correlation with other measures of independence. For example, it has shown correlations of .46 and .51 with the autonomy scale of the Omnibus Personality Inventory (Heist & Yonge, 1965). While these measures of reliability and validity are not extremely high for tests in general, they are relatively high for personality tests.

Student independence as a general personality concept would seem to be an important variable affecting the use of learner control. Students who are aware of their own learning needs and perceive the opportunities for control should make greater and more effective use of learner control options. It was anticipated that these two measures, the locus of control construct and the measure of Achievement via Independence, would be valid measures of the type of independence which characterizes students who are effective in using learner control.

RATIONALE FOR INVESTIGATING THE IMPACT OF LEARNER CONTROL ON ANXIETY

While the variables of mastery and time to completion are sufficiently specific, the presumed affective advantages of learner control, perhaps its most promising aspect, have been ill-defined. The use of attitude scales has resulted in few clear-cut findings. The research reported operationalized the dependent variable of affect as scores on state anxiety scales (Spielberger, Gorsuch, & Lushene, 1970) administered on-line during the learning task.

Anxiety would appear to be an important affective variable related to learner control. It was hypothesized that a student's anxiety would be raised if he feels that he has no control whatsoever over the learning situation, while, conversely, as the student's perceived control is increased, allowing him to manipulate the learning material according to his individual strengths and weaknesses, his anxiety would be greatly reduced.

Results of a pilot experiment conducted at this Laboratory provided support for these hypotheses (Collier, Poynor, O'Neil, & Judd, 1973). When students in a learner control group were given control over the availability of memory support in a concept learning task, the learner control group demonstrated consistently lower levels of anxiety than either of two control groups, one having no memory support and one having forced memory support.

As a result of these preliminary findings and the need to further investigate the affective advantages of learner control, the variable of anxiety was investigated in this study with the hypothesis that the learner control group would demonstrate less anxiety than the control groups.

The measure of anxiety employed was a subset of the State-Trait Anxiety Inventory (Spielberger, Gorsuch, & Lushene, 1970) which was developed to measure both anxiety as a relatively permanent trait (trait anxiety) and anxiety as a transitory state resulting from a particular situation (state anxiety). As this study is concerned with state anxiety in a learning situation, a short form of the A-State scale was used.

This short form of the scale consists of five items chosen on the basis of their high item-remainder correlations with the total scale. These items were: (a) "I am tense," (b) "I feel at ease," (c) "I am relaxed," (d) "I feel calm," and (e) "I am jittery." The subject responded to each item by rating himself on the following four-point scale: (a) "Not at all," (b) "Somewhat," (c) "Moderately so," (d) "Very much so." The items were presented on a cathode ray tube terminal of the IBM 1500 instructional system.

Leherissey, O'Neil, and Hansen (1971) reported alpha reliability coefficients for five state anxiety scales in a computer-assisted learning task of .87, .83, .87, .86, and .93. O'Neil (1972) reported alpha reliabilities for the three five-item A-State scales given during a CAI learning task of .86, .88, and .89. Leherissey, O'Neil, Heinrich, and Hansen (1973) report alpha reliabilities of .87, .89, and .92 for the three short-form scales given during a CAI learning task. Hedl (1971) reported alpha reliabilities of .91 and .92 before and after a computer-based intelligence test. Further research by Hedl (personal communication) using computer-based intelligence tests found alpha reliabilities of .83, .87, .89, and .93. In summary, reported alpha reliabilities have ranged from .83 to .93 in 17 comparisons. These values indicate that the five-item state anxiety scale has high internal consistency.

Evidence of construct validity for this scale has been provided by four studies (Leherissey, O'Neil, & Hansen, 1971; Leherissey, O'Neil, Heinrich, & Hansen, 1973; O'Neil, Spielberger, & Hansen, 1969; Spielberger, O'Neil, & Hansen, 1972). In all of these studies, state anxiety varied as a function of task difficulty, i.e., higher state anxiety during more difficult materials. In addition, high levels of state anxiety were debilitating to performance. Further evidence for the reliability and validity of the A-State scale can be found in the manual for the State-Trait Anxiety Inventory (Spielberger, Gorsuch, & Lushene, 1970). Thus, the scale appears to have sufficient reliability and validity data to serve as a useful measure of state anxiety for this study.

Furthermore, there is clear and extensive evidence that anxiety can interfere with the learning process and performance on tests (Sarason, 1960; Spielberger, 1966). Emery and Krumboltz (1967) and Suinn (1969) describe the effects of test anxiety as including an inability to recall and organize material, difficulty comprehending simple sentences and instructions on exams, feelings of tension, disruption of eating and sleeping patterns prior to exams, and sometimes nausea. Anxiety often leads to failure in the university environment (Alpert & Haber, 1960; Paul & Eriksen, 1964; Suinn, 1969). There is evidence that highly test-anxious students receive lower grades and have a higher attrition rate than do less anxious students of equivalent intellectual ability (Paul, 1968; Spielberger, 1966; Spielberger & Katzenmeyer, 1959).

RATIONALE FOR THE RESEARCH DESIGN

In almost all of the learner control research previously reviewed, the independent variables placed under learner control were not themselves shown to have any appreciable effect on learning. For example, in those studies concerning learner control over the sequence of instruction, no evidence was presented that different sequences could be expected to result in different instructional outcomes. It need not be surprising, therefore, that indecisive results are obtained when these variables are placed under learner control. The research strategy was designed to include a determination of the instructional efficacy of the variable to be placed under learner control.

The approach began with an information processing analysis of the class of skills or behaviors to be learned. The behaviors, and hence the subskills required for the performance of a task, were determined by analyzing how an expert would perform the task. The cognitive operations required were determined by asking the expert to think out loud while performing the task. This resulted in a concrete, logical representation of the expert's problem solving process. This representation provided three types of information which was used for the design of instruction: (a) a detailed description of the behavior defined by the terminal objective; (b) a definition of the prerequisite behaviors; and (c) an indication of the cognitive skills which were likely to impact the instructional process. The first and third factors were of greatest interest for the present research.

The independent variable to be placed under learner control was selected on the basis of the task analysis and on the variable's anticipated facilitating effect on learning. As a check on this presumed facilitation, the experiment contained two control groups, one of which always received the facilitating treatment and one of which never received the treatment. Subjects in two additional experimental groups were given control over the variable. Any conclusions concerning the effect of learner control on performance would have to be considered ambiguous if the performance difference between the two control groups was not significant. With regard to performance, the independent variable under consideration was considered as a viable learner control option only if the learner control group's performance measures exceeded those of the treatment-absent group and at least approached those of the treatment-present group.

This research design assumes, of course, that the instructional variable under investigation is presumed to have a generally facilitating effect on performance for all students. The question then arises as to why individualization, via learner control or otherwise, is necessary at all. Why not administer the treatment to all students? In most situations, the answer will involve cost; real costs in instructional resources or costs to the student in terms of time. For example, it is known that overlearning increases retention, but it is not generally assumed that all students should receive extensive doses of overlearning drill. In view of the striking paucity of positive results and the confused state of the learner control literature, research using the above design appeared to be appropriate at this time.

In the present research, the dependent variables of major interest were affect (specifically anxiety) and performance. If placing a particular variable under learner control does have a positive influence with respect to affect, the experimental learner control group would be expected to exceed both control groups on this measure. The decision as to whether or not learner control is appropriate for a given instructional situation will be a function of both performance and affective advantages, if any. The relative importance assigned to these two considerations will vary from one instructional situation to another. The research design outlined can provide the data for making such a decision.

PRODUCT DEVELOPMENT

Formulation

During this first phase of the development process, a content area was selected jointly by the CAI Laboratory personnel and the Air Force technical monitor. The selection of a specific topic was constrained by the requirement that the material selected be similar to some subset of the information included in the Air Force manuals 64-3 (Survival: Training Edition) and 64-5 (Search and Rescue: Survival). A basic concern was that the topic selected attract a sufficient number of motivated subjects from the undergraduate population at The University of Texas. Thus, the initial product development effort involved the determination of student interest in the various subtopics comprising survival training.

A topic preference questionnaire was designed and administered to over 100 students selected from two sections of an introductory psychology course, two sections of an introductory statistics course, and the members of a cave exploring club at The University. The results of this poll indicated that of the eight topics, students were most interested in edible plants, first aid and food preparation. Of these three, edible plants was selected as the topic which was most suited to the experimental task requirements.

Following the selection of the specific instructional topic, the instructional development process was outlined on the basis of a systems approach model (Dick & Gallagher, 1972). A schematic representation of this model is presented in Figure 1.

Design

The systems approach model, while presented as a linear process incorporating feedback loops, actually represents a heuristic more than an algorithm. It will seldom be the case that each step in the process will be completed prior to the next step and the particular requirements of each specific development task will determine the exact procedures utilized. The present effort began with a very general goal statement: some aspect(s) of the identification and use of edible plants was to be taught and to be taught in such a way as to be consistent with the requirements of the experimental design. The design required that a generally facilitating treatment be placed under learner control. The exact nature of the treatment was to be determined on the basis of a task analysis and the treatment was to provide support for a cognitive process on which the task was heavily dependent. Thus, in order for the facilitating treatment to have a substantial effect on subjects'

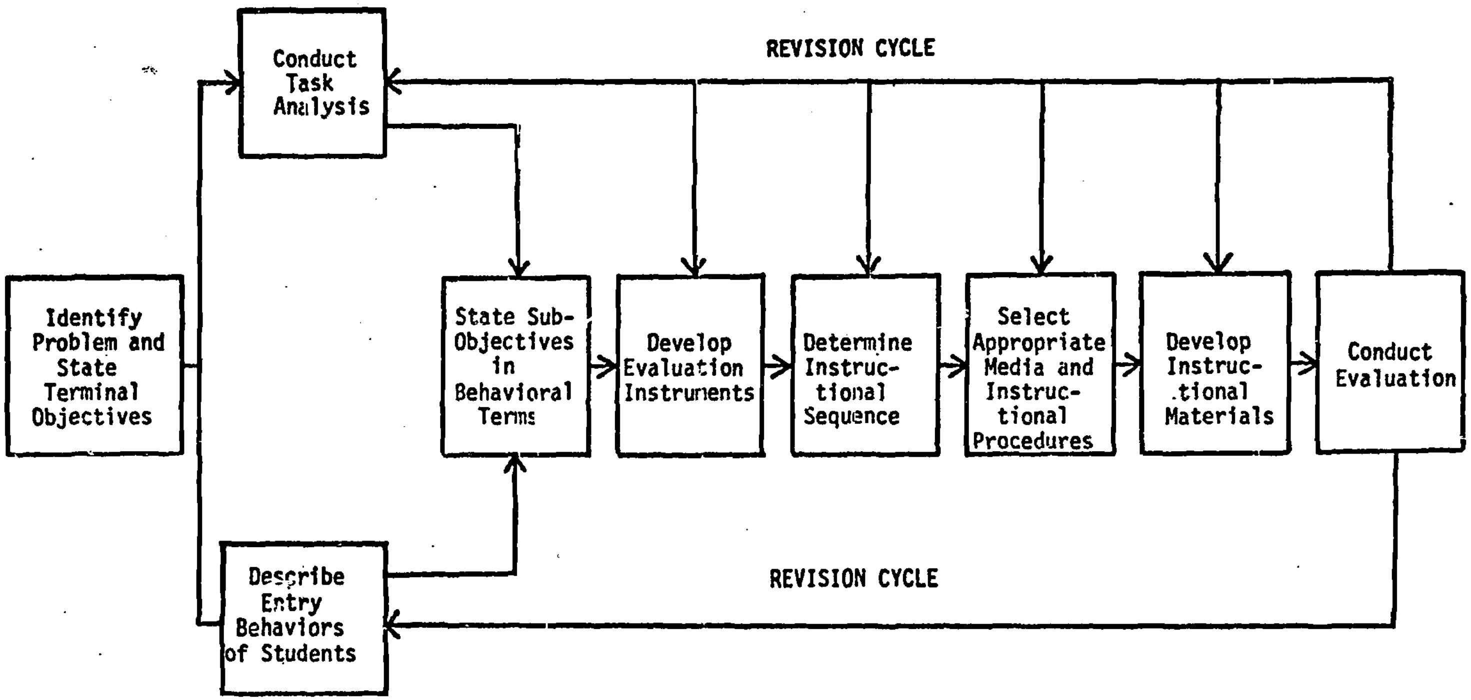

Fig. 1.--Systems approach model for the development of instructional materials (Dick & Gallagher, 1972).

performance, it was desirable that the task be structured in such a way as to place strong emphasis on a single, specific cognitive process. This consideration dictated that relatively little of the instruction be concerned with training on hierarchically related prerequisite skills and that the bulk of the subjects' efforts in the instructional task involve a limited number of cognitive skills. An additional constraint was that the program was to require approximately two hours of the subjects' time.

The instructional design process began with the definition of tentative objectives, appropriate for both the instructional topic and the requirements of the experiment. These initial objectives involved teaching subjects to discriminate between a set of edible plants and very similar, inedible plants (mimics). In order to determine the feasibility of the tentative objectives, a botany instructor on the product development team collected descriptive information on a set of edible plants and their mimics for possible inclusion in the program. The nature of the information collected and an example for one plant is illustrated in Figure 2.

Given the proposed terminal objectives, a detailed information processing analysis of the task was conducted (Bunderson, Olivier, & Merrill, 1971; Merrill, 1970; and Resnick, Wang, & Kaplan, 1970). An information processing analysis, as opposed to a hierarchical analysis, is appropriate when a substantial number of operations in the task require information which is dependent on the results of prior operations. A hierarchical analysis (Gagne, 1968), on the other hand, is more appropriate when there is concern that some or all of the students will not possess certain intellectual skills or capabilities which are considered to be prerequisite to successful completion of the task. The knowledge and skills required for the performance of this task were determined by analyzing how an expert would perform the task. The result of this analysis is presented in Figure 3. The statements above the line in each box represent the givens--the stimulus conditions. The statements below the line represent the actions to be taken. This flowchart is a concrete, logical representation of an expert's problem solving process. The process was validated by discussion with the botany instructor.

The results of this analysis led to a redefinition of the goal in terms of specific objectives related to the knowledge and skills required by a subject in order to positively identify an edible plant. The overall goal of the edible plant training program was translated into the following terminal objectives:

1. Given a picture of an edible plant (at a distance which permits identification of the critical features), the student will supply the common name of the plant.

Edible Plants

Common Name *Wafer Ash* Latin Name *Ptelea trifoliata*

Habitat *Rocky-gravelly areas throughout area*

Edible Portion(s) *Fruits*

Immediately edible? Yes ___ No *X*

If not, what is the method of preparation? *ground seeds added to bread dough makes exceptionally light bread. Also may substitute for hops in brewing beer.*

Seasons when edible: *Summer*

Verbal description of plant during that season: *aromatic shrub with pallid or white epidermis and bark; leaves alternate with 3 leaflets; flowers in terminal panicles, greenish, white; fruit a samara*

Rarity of plant's occurrence: Very Rare ___ ___ *X* ___ ___ Very Common

Nr. of slides currently available ___

Mimic Nr. 1

Common Name *Poison Ivy* Latin Name *Rhus toxicodendron*

Verbal description of how mimic differs from target plant *Fruit is a whitish berry; leaves are broader; poison ivy is usually a low herb or vine*

Mimic Nr. 2 (if any)

Common Name ___ Latin Name ___

Verbal description of how mimic differs from target plant ___

Mimic Nr. 3 (if any)

Common Name ___ Latin Name ___

Verbal description of how mimic differs from target plant ___

Fig. 2.--Description of edible plant and its mimics

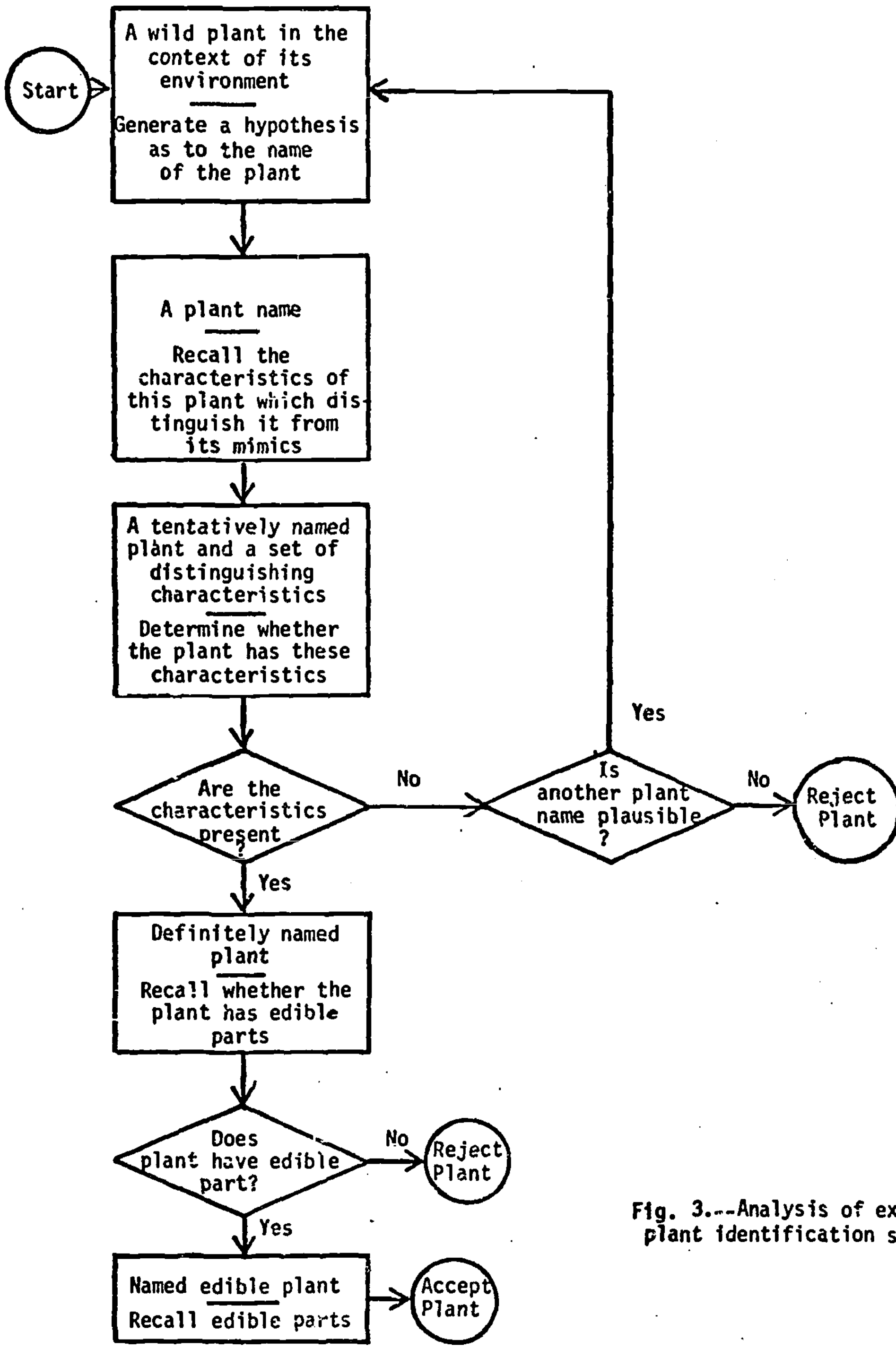

Fig. 3.--Analysis of expert's plant identification strategy

2. Given the common name of an edible plant, the student will supply the critical features necessary to identify the plant.

3. Given either the picture or the common name of an edible plant, the student will supply the name(s) of the edible portion(s) of the plant.

The specific plant identification strategy to be taught in the program was also defined by the results of the information processing analysis. A flowchart of this plant identification strategy is presented in Figure 4. Its similarity to the process represented in Figure 3 is obvious.

Careful study of the information processing analysis results revealed certain underlying psychological processes and constructs associated with the various subtasks in the edible plant identification strategy. These are listed in Table 1. The subtask numbers correspond to the numbered steps in Figure 4. For example, Subtask 1, generating a hypothesis as to the plant name, was assumed to involve discriminated recall of a verbal response to a visual stimulus. This process was further assumed to rely on the constructs of visual discrimination, visual memory, verbal memory, and associative memory.

Examination of the constructs listed in Table 1 shows that the learning task, as it was structured, was heavily dependent on visual/verbal memory. This strongly suggested that learning would be improved if the subjects were induced to increase their mediational activities in linking the various visual and verbal stimuli to the required verbal responses. Thus, it was concluded that an appropriate experimental variable would be a treatment which provided facilitation of the subjects' mediational activities. It was further assumed that the most difficult of the subtasks would be the second, recall of the characteristics of the plant which distinguished it from its mimics. It was therefore decided to develop visual/verbal mediators which would link the plant name (as a stimulus) to those characteristics of the plant (henceforth referred to as the plant's critical features) which were critical to its discrimination from similar but inedible plants. These memory aids or mnemonics would be verbal presentations of the plant name and the critical features in a form that encouraged the formation of individual visual images for each plant. Each mnemonic would be in the form of a very short story or descriptive statements. The objects and events depicted would refer to concrete stimuli which could readily be imagined. The instructions given the subjects as to the use of these mnemonics can be found in the Experimental Procedures section of this document. The following example was the mnemonic used for the plant Greenthread: "Imagine using <u>green thread</u>

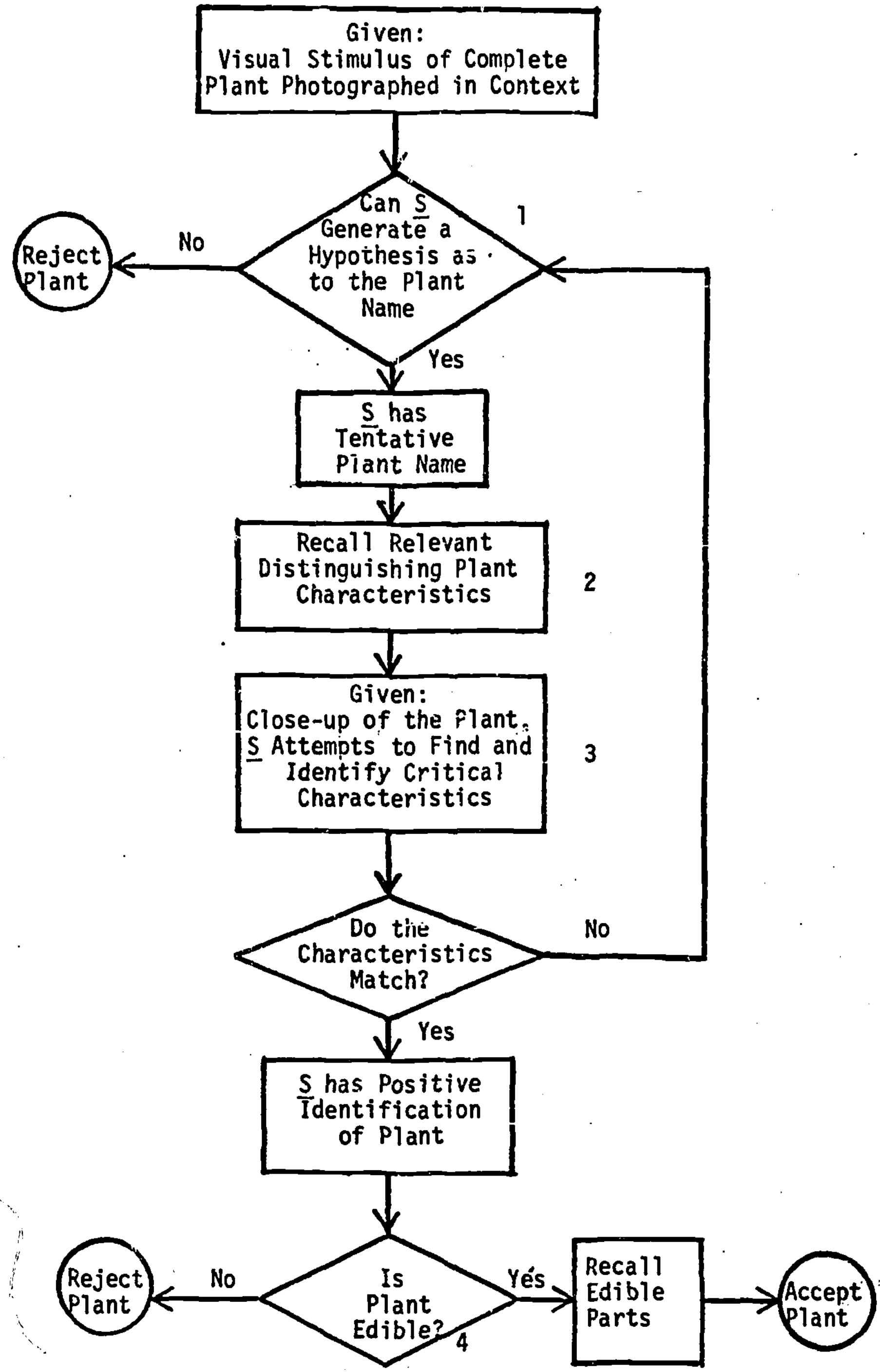

Fig. 4.--Plant identification strategy to be taught.

Table 1

Processes and Constructs Associated with the Edible Plant Identification Strategy

Subtask Number	Process Assumed to be Involved	Associated Psychological Constructs
1	Discriminated recall of a verbal response to a visual stimulus	visual discrimination visual memory verbal memory associative memory
2	Discriminated recall of a verbal response to a verbal stimulus	verbal memory associative memory
3	Pattern recognition and matching	visual discrimination visual memory
4	Discriminated recall of verbal responses to a verbal stimulus	verbal memory
5	Discriminated recall of verbal responses to verbal or visual stimuli	verbal or visual memory associative memory

to sew on the eight yellow arms of a sweater for your pet octopus." The subject would then see a summary where the critical aspects of the mnemonic were related to the plant. For example, "eight yellow arms" corresponded to the critical feature of the flower having eight yellow petals.

Once associative memory was determined to be a critical component for successful completion of the learning task, it was reasoned that a test of associative memory administered to subjects prior to instruction should be predictive of performance on the task in the absence of the facilitating treatment. It was assumed that the presence of the facilitating treatment would reduce the predictive ability of the test. After examining available tests of associative memory, it was concluded that a more appropriate approach would be to develop a test which was specific to the task. That is, the characteristics of the test would match the relevant characteristics of the task so as to tap the same cluster of abilities. The test itself will be described more fully under Product Preparation.

It was initially intended that black and white drawings of the plants be used to supplement the verbal descriptions of the plants. Examination of available texts, reference books, and training manuals concerning plant identification suggested that color was an extremely important discriminative cue. The preparation of colored drawings was found to be prohibitively expensive. Consequently, it was decided that colored photographs of actual plants would be used in the program. Inquiries placed with two state university botany departments and a number of state agencies revealed that no complete sets of photographs of appropriate plants were available. Therefore, an experienced outdoor photographer was retained on a consulting basis.

Given the results of the information processing analysis and the decision to make use of colored photographs, it was possible to define the details of the instructional strategy. The next factor to be considered was whether student responding was to be handled in a constructed response or multiple choice mode. Since the identification strategy to be taught called for the recall rather than recognition of the plant name, critical features, etc., it would have been preferable to use a constructed response mode throughout the program. Limits on the time and resources available, however, ruled out the extensive answer processing work which this approach would have necessitated. Thus, only the recall of the plant name was programmed as a constructed response. All other subject responses were limited to a multiple choice format.

At this time, the knowledge and skills the instruction was designed to teach, the conditions under which the knowledge and skills were to be demonstrated by the subject, and the evaluative criteria were specified. It was then necessary to determine a format for the segment and final tests. The decision was made to pattern these tests after the active responding sections of the instruction. The test for each plant was in three sections. The first was the identification of a picture of the plant; the second was the description of the critical features; and the third was the identification of the edible part. The flowcharts for both types of testing are discussed in the Product Description section of this document. Once the format was determined, the tests were prepared in a manner parallel to the instruction preparation.

Once the instructional strategy was defined, the number and types of photographs required were determined. In addition to those photographs indicated on the final version of the instructional strategy flowchart, it was originally planned for there to be one photograph for each plant with numbered superimposed arrows pointing to critical features in the photograph. This photograph would have been used to allow the subject to indicate the critical features on the plant. Because of the technical difficulties involved in the preparation of this type of slide, it was decided to delete this photograph for each plant along with the supporting instructional material.

When the overall outline of the course and the specific instructional strategy for teaching individual plants had been defined, rough instructional scripts were written for two plants and for a module to teach the instructional strategy itself. These scripts could be considered to be the first draft of the program eventually presented to subjects. The process of development from these rough scripts to the finished instructional program is detailed in the following Product Preparation section.

Product Preparation

Program production procedures developed by The University of Texas Computer-Assisted Instruction Laboratory were utilized to translate the rough instructional script into a computer-assisted instruction format. It was during this process that details of the instructional strategy and tests were defined. The format established was repeated for each plant.

Since color had been determined to be an important discriminative cue and the decision had been made to incorporate color photographs into the program, the availability of appropriate plants or their photographs determined which plants could be included in the program. A major problem developed when it was found that only very few of the mimics of the edible plants were available for photography. This necessitated a change in the overall plan of the program. Rather than using these mimics as distractors, it was concluded that it would be necessary to rely on the similarity of the various edible plants themselves to create a sufficiently difficult task to suit the purposes of the experiment. In view of the number of plants involved, the amount of detail to be remembered, and the subjects' unfamiliarity with the materials, this was not considered to be a major problem.

Following definition of the instructional strategy, the number and type of photographs (35mm slides) required for instruction and testing was determined. For each plant, this included three context or distance shots, three close-ups, one to three detailed close-ups of the critical features, and one close-up of the edible part. Although the overall quality of the photography was excellent, it was necessary to eliminate a number of slides due to commercial products appearing in the slide, insufficient lighting for projection by the computer terminal image projector, or strong contextual cues in the field. None of the slides used in the final test appeared earlier in the program but some of the instructional slides had to be used during the segment tests.

In addition to the plant photographs, two diagrams were constructed and photographed to clarify terminology employed in the program, i.e., diagrams illustrating two different types of lobed leaves.

During the majority of the program preparation phase, the development team worked with the 35mm slides themselves. This allowed minor program changes to be made with relative ease. Later, the photographs were arranged into the desired sequence, cropped as necessary, and rephotographed onto 16mm film. Where it was necessary to use a particular photograph more than once, it was simply rephotographed at the appropriate point. The negative of this film was then paired with a second film strip which was precoded for use by the IBM 1512 image projector. The answer print resulting from this process was then viewed on the image projector. After determining that minor changes in lighting and tinting were necessary, a set of 10 production film strips were produced.

The instructional material to be displayed on the cathode ray tube (CRT), anticipated student responses and details of the branching logic were all documented on display planning guides. Visual displays to be presented via an image projector were referenced by these same planning guides. The complete set of this documentation, referred to as an author's draft, constituted a paper mock-up of the program. These guides, which represent the IBM 1510 CRT display, facilitated off-line authoring. Each sheet represents a single frame or portion of a frame. The branches to be taken contingent on a correct response, anticipated incorrect responses, or unanticipated responses are indicated, as is the number of the slide to be shown in parallel with the CRT display. Working with these paper mock-ups of the displays allows the instructional author to see an accurate representation of the program while facilitating additions and alterations to the instructional sequence. Cards punched directly from the formatted display serve as input to a preprocessor program which produces Coursewriter II code. This display code is then integrated with the branching logic prepared by a programmer. Finally, the display guides provide a form of detailed program documentation which is relatively language free.

An example of one such planning guide is reproduced in Figure 5. The display number is in the upper right hand corner of the guide. Following the conventions established for this course, the first two characters of the number represented the plant--WA for wafer ash, FD for false dandelion, etc. The third character was a zero for instruction, a one for a segment test, or a two for a final test. The hundreds digits divided the instructional or testing sequence into its major components. For example, 400 components always involved the student typing in the name of the plant, the 800 series involved identifying the plant's edible parts, etc. This convention held across both instruction and tests. The tens digits divided the major components into their subdivisions and the ones digits were merely sequential. In a repetitive program such as this one, consistency between program components has been found to be of great help for both programming and debugging.

The slide number in the upper left corner of the guide represented the number of the image projector frame to be shown with that particular display.

The format of the display guide itself represented the layout of the IBM 1510 CRT display. Characters plotted in columns 0 or 39 are not usually easily readable so the messages were restricted to the center 38 columns. A line of text requires two rows. Since most frames within the program did not contain a large amount of text, one or more rows were skipped between successive lines of text. In many cases, the messages or major portions of the messages were repetitive from one plant to another, so many guide pages were duplicated with blanks and details were filled in later.

The square box shown represented the initial position of the cursor. The S or K in the lower right hand corner of the display was displayed on the screen and was a cue to the student that he was to press the space bar or to type in his response via the keyboard.

Branching instructions were written on the bottom of the page. The simplest command was NF, or next frame, no branching involved. CA and CB represented correct answer and the actual correct answer followed it in parentheses. Similarly, WA and WB represented anticipated wrong answers. The number 1 or 2 following the UN referred to whether this

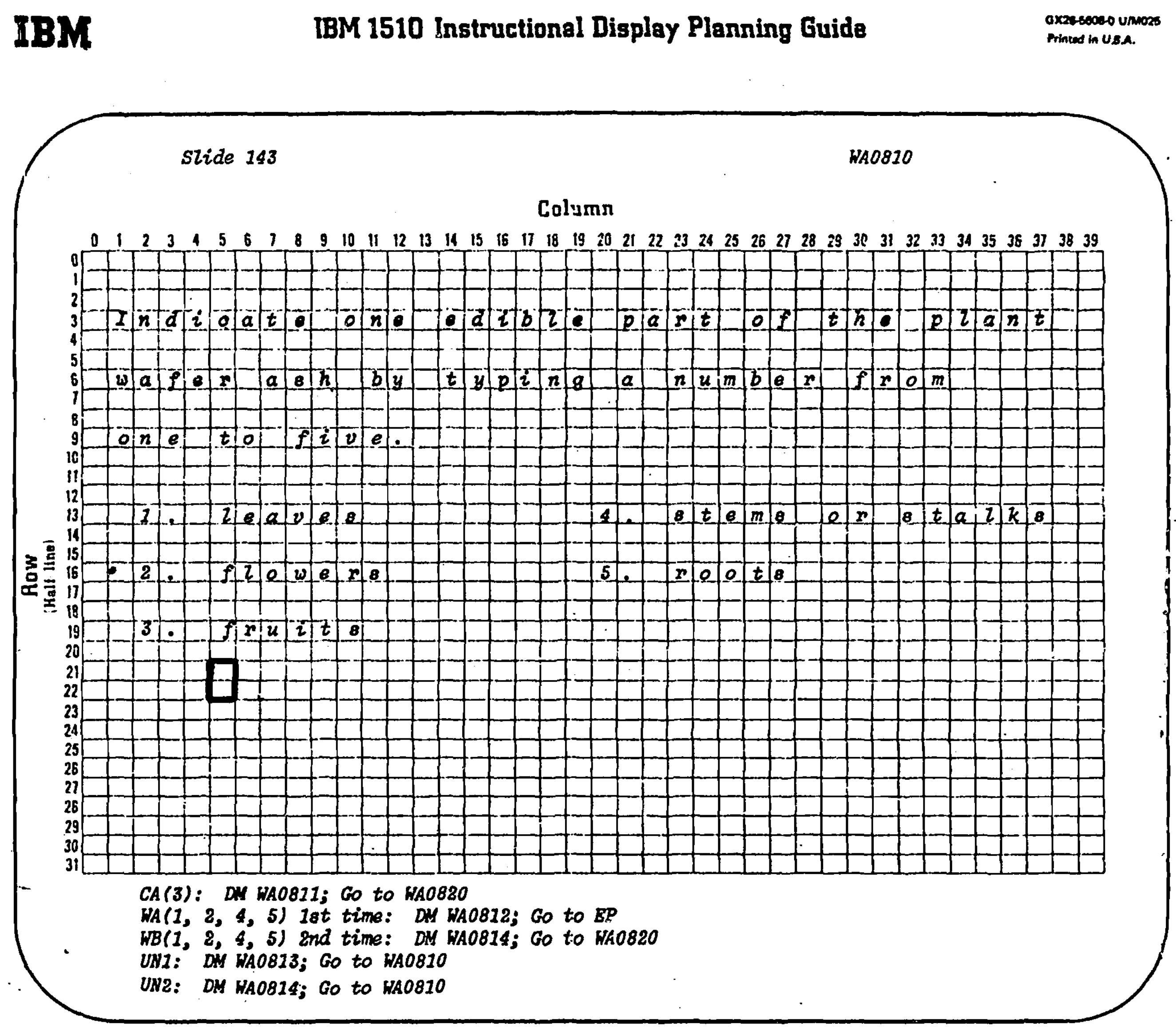

Fig. 5.--Display planning guide.

particular response was the student's first or second unanticipated response to this display. This is a standard Coursewriter command. Unfortunately, there is not an analogous counting function for the WA and WB commands and so, where necessary, a counter was used to record this.

DM represented display message. The response required by the message displayed was always a space bar. There was no opportunity for branching and the sequence following the message displayed was fixed. Hence, the CM command was followed by a GO TO statement. The GO TO EP command returned the program to the current display, usually with a message added onto the bottom of the display.

The instructional content of the display planning guides was keypunched directly from the guides and submitted to the Coursewriter II Preprocessor (Mitchell & Conner, 1971). The preprocessor is a program written in Fortran IV and run on the University's CDC 6600 computer which outputs Coursewriter II statements on cards for input into the IBM 1500 System Coursewriter II card assembler. The branching logic was coded in Coursewriter II directly from the planning guides and collated with the display cards prior to submission to the preprocessor. The scheme of relying heavily on these planning guides has not eliminated programming problems but it has been found to be quite useful. Displays which are similar to each other can be almost mass produced. Components of the program can be rearranged in different orders without loss of information. Finally, it is considered that this would be an excellent means of transferring instructional programs between different types of systems. The one problem which this approach shares with other documentation schemes is the difficulty of keeping the display guides updated with later programming changes.

In addition to the instruction and tests on the specific plants and the identification strategy itself, it was necessary to provide a means of teaching the subjects to use the instructional computer terminal. A short module had previously been developed for this purpose and was simply incorporated into the program. Similarly, the state anxiety scale had been previously programmed for other research and copies of the scale were inserted in the program at appropriate points. Finally, displays to provide an introduction to the content of the program, specific instructions for the different experimental treatments, displays to provide transition from one plant to another or from instruction to testing, and a closing statement regarding the hazards of eating wild plants were prepared.

As was previously discussed, an attempt was made to find an existing associative memory test with characteristics similar to the experimental task. Guilford (1967) describes a number of associative memory tests which have desirable features, but none were considered adequately specific to the experimental task. The decision was therefore made to develop a paper-and-pencil memory test which would have characteristics similar to the memory demand characteristics of the task itself.

The heaviest memory load in the experimental task involved associating a set of critical features with the name of a plant. It was decided that the task specific memory test should have this same type of format, that is associating a number of features with a name. The content area chosen for the memory test was clothing types. It was assumed that all subjects would be at least somewhat familiar with this content area.

The test consisted of giving the subject descriptions of two or three articles of clothing worn by each of 12 men. An example would be, "Mr. Smith is wearing a blue circle-patterned <u>tie</u>, brown corduroy <u>slacks</u>, and a tan trench <u>coat</u>." The 12 descriptions were presented in three groups of four men each. Following each group, the subject was tested on his recognition of the correct articles of clothing to be associated with each name. The experimental task which the test was designed to mimic involved a two-stage memory problem. First the subject had to select the plant parts containing critical features and then he had to indicate the correct description of each of the correct plant parts chosen. The memory test was constructed in a similar fashion. Given a man's name, the subject first indicated the types of clothing the man had been described as wearing. On the next two or three pages, he was given the types of clothing and required to recognize the correct description of each type.

Following pilot testing with a small group of subjects, a number of changes were made in the test. The error rate was low and within a very limited range. Since the measure was to be used for predictive purposes, a higher, more variable error rate was desirable. The test could not be lengthened since it was already too time consuming. The number of descriptions was reduced to ten, divided equally between two groups, thus increasing the number of descriptions per group. The paper used for the test forms was thin enough that subjects could see through some pages and pick up cues from the following pages. In order to control for this possibility, the back of each sheet was marked with crosshatching which prevented the following pages from being readable. Instructions were also included reminding each student not to look back at previous pages. These efforts increased the error rate to a level which, while it was still low, was considered workable.

Product Tryout and Revision

The final step in the systems approach model concerns the evaluation of the instructional effectiveness of the materials developed. This evaluation was actually conducted in several steps throughout the development process.

As soon as the instruction sequence and test for the first group of four plants was completed, a small number of pilot subjects was run through the available material for purposes of determining task difficulty, validating the memory test, and obtaining more accurate estimates of the time required to complete the task. Using slides and the instructional, segment test, and final test planning guides as a mock-up of the program, several members of the project staff and 12 volunteers were run on various components. As a result of these tests, the instructional component dealing with the plant identification strategy was revised. In addition, it was concluded that the program would require approximately three hours' subject time while a program of two hours' duration was considered desirable. Consequently, three of the 15 original plants were immediately dropped from all ongoing work.

When a substantial portion of the program had been implemented on the computer system and debugged, a second set of pilot subjects was run to detect instructional flaws. This procedure was continued as successive parts of the program were completed. As the program neared completion, the emphasis shifted from the conventional behavior debugging of an instructional program to the determination of whether the program would meet the particular requirements of the proposed experiment.

It will be recalled that the experimental paradigm required a high degree of task difficulty under the treatment absent condition. The initial findings indicated that the instructional strategy employed was too effective; that is, subjects made too few errors on the segment tests. A number of successive revisions were undertaken to correct this problem, i.e., to make the program less effective. Each revision was evaluated in terms of error count and interview data obtained from groups of six to 10 pilot subjects.

First a review of the critical features was deleted from the instruction for each plant. This review had reduced the descriptions of the critical features to a number of short statements very similar to the statements used in testing, thus facilitating recognition of the correct responses.

The distractors employed in the segment tests and final test were rewritten in an attempt to increase intralist confusion. Incorrect alternatives which had been correct alternatives on previous questions were removed. Thus, once an alternative had served as the correct response to a question, it was not subsequently used as a distractor. The alternatives removed were replaced by distractors composed of a recombination of components of other alternatives.

The portion of the instruction for each plant pertaining to critical features which required active responding on the part of the subject was deleted, since practice in making a response increases learning of that response.

The amount of information given in feedback to the subjects following their responses in the two segment tests was reduced to decrease the instructional value of these tests. The number of incorrect responses to a specific question allowed before correction was given was increased to increase the possible variation in scores. All of these modifications were found to be somewhat effective in increasing error rate but no one of them resulted in any dramatic increase. Consequently, all of the modifications were retained. Should it later be desirable to employ the program for strictly instructional, as opposed to experimental, purposes, selected program components could be reinstated.

Two of the 12 plants were found to be particularly easy for the subjects to learn and consistently contributed very few errors to the total error count. Since the program still required somewhat more than the desired two hours of program time and since it was anticipated that having a larger number of plants to be learned in each group might increase error rate, the program structure was revised from three groups of four plants each to two groups of five plants each. The two additional, low error rate plants were placed at the end of the program, following the final test and the final administration of the anxiety scale. No subjects were required to study these plants. Rather they were offered as an option for any subjects who wished to study the two additional plants.

On the basis of observation and interview data obtained from the pilot subjects following their experience with the program, it was concluded that a major factor contributing to the surprisingly high degree of learning was the efficacy of the plant photographs as a memory aid. Not only were subjects able to recognize a previously displayed plant and to recall its name but the photographs also appeared to facilitate their recognition of the critical identification features associated with that plant name. As the program tests were structured, that portion of the test dealing with an individual plant always began with a photograph of the plant and the requirement that the subject type in the name of the plant. The next portion of the test then required that the subject select the critical features of the named plant from a list. While no photograph was displayed during this portion of the test, it was concluded that the temporal proximity of the plant photograph was providing valuable assistance to the subjects' recall of the plant's critical features. Consequently, the tests were rewritten to separate the identification portion of the test (which required the presence of a photograph) from the critical features portion of the test. That is, in one portion of the test, the subject was shown photographs of all of the plants on the test and required to recall their names while on another portion of the test the plant names were presented (in a different order) and the subject was required to select the critical features of the named plant from a list. This final program modification increased the number of errors to a level which, while still lower than had been anticipated, was considered to be adequate for the purposes of the experiment.

Attention then shifted to the assumed facilitating effect of the mnemonic devices as memory aids. The initial group of pilot subjects run under the treatment present condition, which provided the mnemonic devices, revealed a number of minor problems. The instructions to the subject regarding the use of the mnemonics were rewritten and a number of the mnemonics themselves were revised or rephrased to eliminate confusing terms and to increase the logical consistency of the set of mnemonics as a whole. A second group of eight pilot subjects were run under the treatment present condition and it was found that their number of errors was approximately one-half of the number of errors of the last pilot subjects run under the treatment absent condition. It was therefore concluded that the availability of the mnemonic devices was indeed facilitating relative to the treatment absent condition.

Finally, a small group of subjects was run under the two learner control conditions to assure that the learner control options were operable and that the instructions as to their use were understandable. In all, a total of 56 pilot subjects were run for purposes of behavioral debugging and/or evaluating program modifications.

Product Description

A flowchart of the overall program structure is presented in Figure 6. This same overall flowchart and detailed flowcharts of the various program components are also contained in Appendix A.

The program began with a single display giving the title of the course, "Edible Plants of Central Texas," and a one-sentence description of its content. The subject was told that he would first be taught to operate the instructional computer terminal and instructed to press the space bar to proceed.

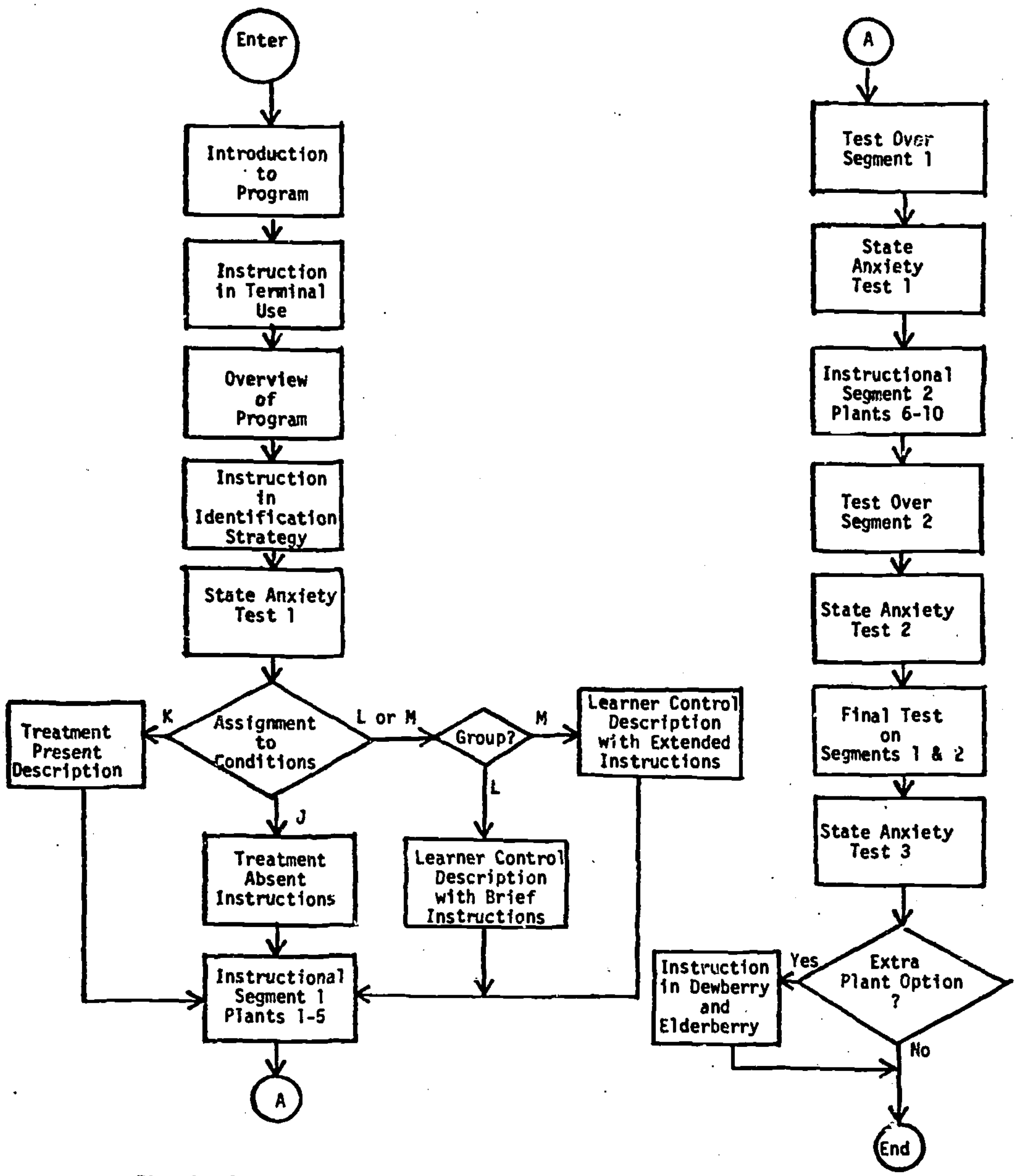

Fig. 6.--Overall program structure.

The module concerning instruction in the use of the terminal has been employed in a number of programs developed at The University of Texas CAI Laboratory. It instructs the student in the use of relevant control keys, the meaning of the display code S (press the space bar) and K (type and enter a response), how to enter a response, and how to correct a response. The subject is given practice in correcting and entering responses. Additional instruction normally contained in the module, concerning signing off and on the terminal and the use of the light pen, was deleted for purposes of this program.

In the overview section of the program, the subject was told what it was he was going to learn. He was told that he would first be taught a general strategy for identifying edible plants and would then be given specific instruction on two groups of five plants each. Each of these two instructional segments would be followed by a test over that group of plants and the second segment test would be followed by a final test over all 10 plants. He was also told that at several points in the program he would be asked to indicate how he felt at that point in the program. This last reference was, of course, to the four state anxiety scales.

The plant identification strategy module is outlined in Flowchart 1.0 in Appendix A. Following a statement as to the importance and utility of the strategy, the subject was shown a summary of a six-step identification strategy corresponding to the strategy outlined in Figure 4. Each step in the strategy was then expanded upon using the tomato plant as an example. The strategy was then reviewed again in summary. The subject was then taken through a second example, the plant purslane, in which he was required to select the sequence of steps to be taken. Each response elicited confirmation or corrective feedback and additional information about the plant. Finally, a summary of the strategy was presented a third time.

Immediately following this learning experience, the subject was administered the state anxiety questionnaire for the first time. Following an explanation of how he was to respond to the scale, the subject was shown a series of five statements, e.g., "I feel calm," and requested to type in a number from one to four indicating the degree to which that statement reflected his feelings, e.g., "1" equals "Very much so," and "4" equals "Not at all."

At this point, subjects were routed into the four different experimental treatments. Assignment to treatments was on the basis of the first letter of the subject's four character identification number: subject J101 would be assigned to the treatment absent condition; subject K102 to the treatment present condition; subject L103 to the learner control condition with limited instructions; and subject M104 to the learner control condition with extended instructions. The specific instructions given to each treatment group are provided in the Methods section of this report.

Regardless of his experimental treatment, the subject then began the first instructional segment. The outline of the instructional segments is presented in Flowchart 2.0 in Appendix A. The instruction for each of the five plants in a segment was essentially the same and began with a context picture of the plant, its name, and the area in which it was found. The plant's two or three critical features were then described in succession on the CRT while close-up photographs of the critical features being described were shown on the image projector. Treatment present subjects were then presented with the mnemonic relating the plant's name to its critical features. If the subject wished, the mnemonic and the explanation of its relation to the critical features could be repeated any number of times. Subjects in the two learner control conditions were first asked whether or not they wished to see the mnemonic. Subjects in the treatment absent condition skipped past this portion of the program.

All subjects were then given a description of the plant's edible part(s) while an appropriate photograph was shown on the image projector. The subject was then shown a context photograph of the plant and asked to type in its name. The first incorrect response elicited only a "No, try again," type of feedback. The second and successive incorrect responses elicited corrective feedback. The mnemonic aids were then again presented to subjects in the treatment present condition and made available to subjects in the two learner control conditions. The specific procedures were identical to those described previously.

The subject was then shown a series of three plant photographs, one or two of the plant being studied and the other(s) of another, similar plant, and asked to type "Yes" or "No" in response to the question of whether this was a picture of the plant being studied. Again, corrective feedback was supplied only following an incorrect response. Finally, the subject was required to select an edible part from a list of five plant parts and to type in its number. Corrective feedback was given following a second incorrect response. Following the correct response or a second incorrect response, the subject was requested to select another edible part or to indicate that there were no more. Once a plant part had been selected, whether it was correct or incorrect, its number was marked with an asterisk. If a subject selected the same part a second time, he was told that he had already made that selection and his attention was directed to the asterisk.

The same instructional sequence was repeated for all five plants in the segment. The last display for the last plant indicated that the subject would next be tested on the plants in that segment.

The sequence of steps in the segment tests are shown in Flowchart 3.0 in Appendix A. The test was divided into two components. The first component tested the subject's recognition of the descriptions of the critical features and edible parts. The first step, concerning critical features, entailed the most complex testing strategy. A plant name and a numbered list of five plant parts was displayed. The subject was required to type the number of a plant part containing a critical feature. If he was wrong, he was simply told that his answer was not correct and that he was to try again. His selections were not marked with an asterisk. If his response was correct, four different descriptions of the selected part were displayed and the subject was requested to select the correct description. Again, incorrect responses elicited a "No, try again" type of feedback with no indication on the display of the number of his selection. A correct response was confirmed and the initial list of five plant parts was again displayed with the addition of a sixth category, "No more critical features." Since each plant contained at least two critical features, the subject was required to repeat the process outlined above at least once more. A premature decision that the plant had no more critical features elicited a message stating that the subject had not indicated all of the critical features. Once the two or three correct critical features had been selected, the only correct response was the sixth category. This response elicited confirmation and the subject continued to the component of the test concerning the edible part of this plant.

This portion of the test was essentially similar to the responsive portion of the instruction on edible parts with the exceptions that only minimal corrective feedback was given, and previous selections were not indicated on the display by asterisks.

This sequence was repeated for all five plants in the segment. The subject then entered the second component of the test in which he was required to type in the name of each of the five plants when presented with its picture. As was the case in the instructional portion of the program, a variety of incorrect spellings of the correct answer were programmed as alternative correct responses. Only unrecognizable responses were counted as incorrect. The first incorrect response elicited noncorrective feedback. The second and last allowable incorrect response elicited corrective feedback. Again, the identification portion of the test was repeated for all five plants in the segment.

The subject was then administered the state anxiety scale for a second time. With the exception that the instructions requested that he indicate his feelings while taking the immediately preceding test, it was exactly the same as the first administration of the scale.

The procedures for the second instructional segment, the segment test and the third administration of the anxiety scale were identical to those outlined above.

The final test, which covered all plants from both the first and second instructional segments, was similar to the segment tests but the order of the two components was reversed and no corrective feedback was provided. The outline of the final test is presented in Flowchart 4.0 in Appendix A. The test began with the picture identification sequence over all ten plants. In each case, the subject was allowed up to two incorrect responses and no corrective feedback was provided. The second component of the test concerned recognition of the critical features and edible parts of all ten plants. Both types of tests were modifications of the segment tests designed to minimize the amount of informative feedback. Following completion of this component of the test, the subject was administered the state anxiety scale for the fourth and final time. Again, the instructions were phrased so as to indicate that the subject should report his feelings on the immediately preceding test.

All subjects were then informed that two additional plants were available for study if they wished to continue. They were also told that they would not be tested over these two plants. Those who chose this extra plant option received instruction on two plants which was identical in format to that in the instructional segments previously described.

The final few frames in the program thanked the subject for his participation and warned him that he should consider the program to be only an introduction to the topic of edible plants. He was warned of the danger of incorrectly identifying a plant as edible, readvised of the importance of distinguishing a plant from its inedible mimics by means of its critical features, and advised to obtain and make use of a good field guide.

PHASE II

DETERMINATION OF PERSONALITY VARIABLES WHICH AFFECT THE USE OF LEARNER CONTROL AND THE MEDIATED EFFECTIVENESS OF INSTRUCTION ON THE USE OF LEARNER CONTROL

STATEMENT OF THE PROBLEM

Given the preceding description of the instructional product, it is possible to define the experimental design in greater detail. A basic assumption of the design was that the mnemonic memory aids relating the plants' names to their critical features would be an effective, generally facilitating treatment. That is, subjects in the treatment present condition for whom the memory aids were always provided would make fewer errors on the critical features components of the two segment tests and the final test than would subjects run under the treatment absent condition--those who never saw the mnemonics. A significant performance difference between these two groups would be taken as evidence that the variable over which the learner control subjects were given control was indeed an effective instructional variable. Since identification of critical features was considered to be prerequisite to or at least strongly related to identification of the plants, it was further postulated that subjects run under the treatment present condition would make fewer errors on the plant identification components of the tests than would subjects who did not have access to the mnemonics. Recognition of the plants' edible parts was not directly related to the skill of correctly recognizing the plants' critical features but it was reasoned that the reduced memory load resulting from the use of the critical features mnemonics might be reflected in a reduced error rate on the edible parts components of the tests.

For learner control to be a viable alternative to program control, it is essential that students make effective use of the options available to them. For this particular program, this assumption implied that subjects given learner control over access to the mnemonics would elect to use the mnemonics with sufficient frequency to substantially improve their performance relative to the performance of subjects who were denied access to the mnemonics.

The dependent variable of major interest concerned affect rather than performance. If learner control per se does indeed have positive affective characteristics, then having control over an instructional treatment which has been demonstrated to be facilitating should serve to reduce subjects' task related anxiety. The specific dependent measure employed was the state anxiety scale of the State-Trait Anxiety Inventory (Spielberger, Gorsuch, & Lushene, 1970). The scale was administered immediately following each of the two segment tests and the final test.

Since it was reasoned that different subjects might react quite differently to a novel computer-assisted instruction situation regardless of their particular experimental treatment, it was desirable to obtain a baseline measure of state anxiety. This measure was obtained by administering the state anxiety scale immediately following the first instructional module, concerning the plant identification strategy, but prior to any experimental manipulations. This pre-experimental measure was then used as a covariable in comparing the state anxiety levels of the two groups of learner control subjects run under the treatment absent and treatment present conditions. It was postulated that subjects in the two learner control groups would indicate lower state anxiety levels than would subjects in either the treatment absent or treatment present groups.

On the assumption that subjects may be induced to make more use of available learner control options, it was postulated that subjects given more explicit instructions regarding the utility of mnemonic memory aids would make more use of these aids than would subjects who were not given such instructions. Thus, two separate sets of instructions regarding the use of learner control were written. The first, briefer set of instructions merely described the availability of the mnemonic memory aids and suggested how they were to be used. The second, extended set of instructions emphasized the importance of the mnemonics for this type of learning task. Two learner control conditions were thus defined, differing only with respect to the type of instructions given at the beginning of the experimental portion of the instructional program. It was postulated that subjects given the more extensive set of instructions would make more frequent requests for the mnemonics and would consequently make fewer errors on the critical features and identification portions of the tests. Due to the relatively indirect effect of the mnemonics on performance on the edible parts components of the tests, no particular performance differences were expected between the two groups on these components.

On the basis of the previously discussed research, it was anticipated that subjects who were rated as being relatively externally controlled on the Locus of Control scale would make less frequent use of the learner control options than would more internally rated subjects. On the basis of the research reported concerning the impact of instructions on the behavior of externally controlled subjects, it was further anticipated that the frequency with which external subjects requested the mnemonic memory aids would be particularly sensitive to the nature of the pre-experimental instructions. Thus, it was postulated that, given only the briefer set of learner control instructions, internally controlled subjects would make more frequent requests for mnemonics than would externally controlled subjects. To test the second assumption, it was postulated that externally controlled subjects who received the extended set of instructions would make more requests for mnemonics than would similar subjects who received only the briefer set of instructions. Since it was assumed that the mnemonic memory aids would be generally facilitating, it was further postulated that both internally controlled subjects given the briefer set of instructions and externally rated subjects given the extended set of instructions would make fewer errors on the critical features portions of the test than would externally controlled subjects receiving only the brief instruction set.

A parallel line of reasoning led to the expectation that those subjects who were rated low on the Achievement via Independence scale of the California Psychological Inventory and who were given only the brief set of learner control instructions would use learner control less and would make more errors than would either high scoring subjects given the brief set of instructions or low scoring subjects given the extended instruction set.

It will be recalled that the facilitating treatment of mnemonic memory aids was designed on the basis of an analysis of the learning task which indicated that successful performance of the task was heavily dependent on visual/verbal associative memory. A task specific memory test was developed to measure this particular cluster of cognitive skills. It was anticipated that, in the absence of the mnemonic devices, subjects' performance on the task embedded tests would be positively correlated with their performance on the memory test. The presence of the mnemonics was expected to be a generally facilitating treatment but it was also to be expected that the mnemonics would effect a greater change in the performance of poor memory subjects than of good memory subjects. That is, while it might be expected that good memory subjects would still register a somewhat higher performance level than would poor memory subjects, the relationship between performance on the task and on the memory test would not be as strong as was the case for the subjects run under the treatment absent condition. In effect, the pattern of results expected was that of an ordinal interaction between treatment and memory ability.

If it was indeed the case that the mnemonic devices had a greater facilitative effect for poor as opposed to good memory subjects and since it did require some time for the learner control subjects to access and study each memory aid, it might be expected that poor memory subjects run under the learner control conditions would request access to the mnemonics more frequently than would good memory subjects. If such a result were found and if the general level of performance of the learner control subjects substantially exceeded that of subjects denied access to the mnemonics, considerable support would be obtained for the contention that students can make intelligent, effective use of learner control.

No specific hypotheses were formulated concerning these speculations but it was decided that subjects' scores on the task specific memory test would be used as a covariable in all analyses concerning dependent variables of performance and number of memory aid requests. The statistical method employed for all of the major analyses was that of multiple linear regression (Kelly, Beggs, & McNeil, 1969; Ward & Jennings, 1973).

Briefly, this technique, as it was employed in this study, consists of determining, for each of two experimental groups, a line of best fit for the regression of the dependent or criterion variable on the covariable or predictor variable. This full or unrestricted model accounts for some proportion of the total variance of the dependent variable. The remaining variance, that which is accounted for by the model, may be expressed in terms of the error sum of squares. A second model is then determined which incorporates the restriction that both regression lines be parallel. Due to this restriction, the second model will account for a smaller proportion of the total variance than was accounted for by the first model. The difference between the error sums of squares of the two models is equivalent to the between-groups sum of squares of conventional analysis of variance. Division by the appropriate degrees of freedom yields the analog of the between-groups mean square. The equivalent of the within-groups mean square is determined by dividing the error sum of squares of the unrestricted model by the appropriate degrees of freedom. Given these values, an F ratio can be computed to determine whether or not the restricted model accounts for a significantly smaller proportion of the variance than does the unrestricted model. If the test is significant, it is concluded that the regression lines of the dependent variable of the covariable are not parallel. That is, there is an interaction between the experimental treatments and the covariable.

If the regression lines do not deviate significantly from being parallel, one of the assumptions necessary for analysis of covariance has been met. A third model is then determined which incorporates the additional restriction that the parallel regression lines have a common Y intercept; that is, that the regression lines are superimposed on each other. Normally, this model will account for a still smaller proportion of the variance. A second F test determines whether the difference between the error sum of squares of the second and third models is greater than would be expected by chance. If the difference is significant, it may be concluded that the two experimental treatments had differing effects across all values of the covariable. If the difference is not significant, predictive accuracy was not increased by knowledge of the differing experimental treatments and it must be concluded that no effect was demonstrated.

This two-step process was followed in testing all of the experimental hypotheses. If the first F test was found to be significant, the hypothesis was evaluated in terms of an interaction. If the first test was not significant, the hypothesis was evaluated in terms of mean differences. In all but one case, the covariable employed was that of number of errors on the task specific memory test. The single exception concerned the hypothesis that subjects run under learner control conditions would express lower state anxiety than would subjects run under either the treatment absent or treatment present conditions. In this case, expressed level of state anxiety on the first, pre-experimental anxiety scale was used as the covariable.

The specific hypotheses tested are summarized as follows:

1A. Subjects who are always provided with mnemonics for the critical features will make fewer errors on the critical features component of the two segment tests and the final test than will subjects who have no access to the mnemonic memory aids.

1B. Subjects for whom the mnemonics are provided will make fewer errors on the plant identification components of the test than will subjects who have no access to the mnemonics.

1C. Subjects for whom the mnemonics are provided will make fewer errors on the edible parts components of the tests than will subjects who have no access to the mnemonics.

2. Subjects given learner control over access to the mnemonics will make fewer errors on all three components of the two segment tests and the final test than will subjects who had no access to the mnemonics.

3. Subjects given learner control over access to mnemonics will express less state anxiety following each of the segment tests and the final test than will either subjects who are always presented with mnemonics or subjects who never have access to the mnemonics.

4. In general, subjects given learner control over access to mnemonics but only limited instructions as to their utility will request the mnemonics less frequently than will subjects who are given more extensive instruction as to the value of mnemonics.

5. In general, subjects given learner control over access to mnemonics but only limited instructions as to their utility will commit more errors on the critical features and identification portions of both segment tests and the final test than will subjects who are given more extensive instruction as to the value of mnemonics.

6. Given learner control over access to mnemonics but only limited instructions as to their utility, subjects rated as more "internally controlled" on Rotter's (1966) internal-external locus of control (IE) scale, will access the mnemonics more frequently than will subjects rated as being more externally controlled.

7. These same (internally controlled) subjects will make correspondingly fewer errors on the critical features components of the two segment tests and the final test than will subjects rated as being more externally controlled.

8. Subjects who are rated as being more externally controlled on the IE scale and who are given learner control over access to mnemonics and extensive instructions as to the value of the mnemonics will request the mnemonics more frequently than will similar subjects who are given only limited instruction concerning the value of mnemonics.

9. These same (externally controlled) subjects will make correspondingly fewer errors on the critical features and identification portions of two segment tests and the final test than will similar subjects given only the limited instructions.

10. Given learner control over mnemonics but only limited instruction as to their utility, subjects with higher scores on the Achievement via Independence (Ai) scale of the California Psychological Inventory (CPI) (Gough, 1957) will request the mnemonics more frequently than will subjects who score lower on the scale.

11. These same (high Ai score) subjects will make fewer errors on the critical features and identification portions of the two segment tests and the final test than will subjects with lower Ai scores.

12. Subjects with low scores on the Ai scale who are given learner control over mnemonics and extensive instructions as to the value of mnemonics will request the mnemonics more frequently than will similar subjects who are given only limited instruction as to the value of mnemonics.

13. The same (low Ai score) subjects will make fewer errors on the critical features and identification components of the two segment tests and the final test than will similar subjects given only the limited instructions.

METHOD

Subjects

The subjects were 189 male and female undergraduate students between the ages of 18 and 25 drawn from the undergraduate student population at The University of Texas at Austin. To recruit subjects, advertisements were placed in the student newspaper and various dormitory and apartment complexes. Each participant received a five dollar remittance. Subjects were scheduled in groups of not more than eight and, within each group, were randomly assigned to one of the four experimental conditions. Twenty-seven subjects were rejected from consideration due to systems errors resulting in incomplete data, invalid test anxiety scores, or language problems (foreign students). The final group of 162 subjects consisted of 73 males and 89 females.

Apparatus

All instructional materials and instruments were presented on the computer system of the Computer-Assisted Instruction Laboratory at The University of Texas at Austin. The CAI Laboratory instructional computer facility consists of an IBM 1800/1500 system supported by five 1810 disk drives, two 2402 tape drives, a 1442 card read/punch, and a 1443 printer. There are nine 1510 cathode ray tube (CRT) terminals with 1512 image projectors and light pens and and three 1518 typewriter terminals. Eight of the CRT terminals with associated image projectors and two of the typewriter terminals are located in a special terminal room in Sutton Hall at The University of Texas. The CRT terminals are placed in individual, acoustically treated carrels, while the typewriter terminals are located in a separate section of the room, available for general access. The 1500 system itself and the remaining terminals are located in a specially-constructed machine room and an adjacent programming area. The system is available for use daily (50 to 80 hours per week) with a proctor on duty in the terminal room. In this particular study, all subjects were run on the CRT terminals with image projectors in the carrels.

Individual Difference Measures

(a) Task Specific Memory Measure. The memory test developed for this study is described in this document under the heading Product Development--Product Preparation. This is a paper-and-pencil measure. Subjects' answers were indicated by check marks in the test booklet.

(b) Locus of Control Measure. This personality variable was measured by the internal-external locus of control scale developed by Rotter (1966). Subjects' answers were indicated on an Optical Scanning Form, Standard Answer Sheet A.

(c) Achievement via Independence Measure. This personality variable was measured by the Achievement via Independence (Ai) scale of the California Psychological Inventory (CPI) (Gough, 1957). Answers were indicated on an Optical Scanning Form, Standard Answer Sheet A.

(d) Anxiety Measure. State anxiety was measured via a short, five-item form of the State Anxiety Scale (Leherissey, O'Neil, & Hansen, 1971) of the State-Trait Anxiety Inventory (Spielberger, Gorsuch, & Lushene, 1970). The scale was administered and answers were entered on-line at the terminal at four points in the instructional program.

Learning Materials

The learning materials designed for the experiment are described in this document under the heading Product Development--Product Description.

Experimental Procedure

Subject identification numbers were randomly assigned to four experimental groups in the ratio of 6 : 3 : 4 : 4. Each of the four groups was assigned a specific alphabetic character for the first of the four characters in the student identification number. The first group (J, treatment absent) was not given access to mnemonic memory aids. The second group (K, treatment present) was always shown the mnemonic memory aids. The third group (L, learner control) was given learner control over access to the mnemonics and given a brief set of instructions as to their use. The final group (M, learner control with extended instructions) was given learner control over access to the mnemonics and extensive instructions as to their utility.

Upon entering the student terminal room, all subjects were seated at a large table and asked to complete a student identification sheet. In addition to providing a basis for their remuneration, this sheet served as a record form for the subjects' scores on the paper-and-pencil measures and the post-experimental interview data. At this time, the experimenter reassured each subject that the experiment involved no forms of shock or deception and that his performance on the program and his scores on the paper-and-pencil measure would be held in strict confidence.

Subjects were then administered the three paper-and-pencil measures in the following order: task specific memory test; locus of control scale; and achievement via independence questionnaire. None of these measures was timed.

As the subjects completed the paper-and-pencil measures, they were signed onto the computer terminals one at a time by the experimenter. Each student was signed on with a unique identification number and, as was discussed above, the first character of this number determined the specific experimental treatment which the subject received. The subject was told that the program would be self-explanatory and any questions regarding content of the program were deferred until the completion of the program.

The instructional program itself has been described in detail under the heading of Product Development--Product Description and will be recapitulated only briefly here. Initially, all subjects received instruction in the use of the computer terminal. They were then given an overview of the structure of the program, being warned that two segment tests and a final test would be administered over the details of the 10 plants and that they would be asked to record their feelings at a number of points in the program. Next, all subjects received instructions on the components of the plant identification strategy. This was followed by the first administration of the state anxiety questionnaire. At this point, subjects in all four experimental conditions had received exactly the same treatment. The purpose of this first administration of the scale was to provide a baseline measure of state anxiety as a control for individual differences.

The next step in the program involved the first differential treatment of subjects in the four experimental groups--instructions regarding the use of the mnemonic devices. Subjects run under the treatment absent (J) condition never had access to the menmonics and, consequently, were given no information about them. The set of "placebo" instructions which these subjects received is as follows:

> Before you begin the course, we would like to remind you that you will be asked to learn the name, the critical features, and the edible parts of many different plants during this short course.
>
> This is a complex task as there are often many similarities among the plants you are to learn. As you are presented the instruction on each plant, study carefully all the critical features so you will be able to associate them with that plant. In this way you can make the best use of the learning material.

Subjects assigned to the treatment present (K) condition were always shown the mnemonics at two points in the instructional sequence for each plant. The instructions which these subjects received are as follows:

In addition to the standard instructions for each plant, you will read a short story concerning the name and critical features of each plant. It has been discovered that students who use the memory aids find them to be a great help in remembering the critical features of the different plants.

In addition, they perform better on the individual tests and are able to finish the course in a shorter time than students who do not make use of the memory aids. Therefore, it will be to your advantage to make use of the short stories. Since there are so many critical features for you to learn during the course of the instruction, we believe you will find it to your benefit to pay attention to these memory aids.

Subjects assigned to the first learner control (L) condition were given learner control over the access to the mnemonics but the instructions which they received did not emphasize the value of the mnemonics for the learning task. The set of instructions administered to subjects run under this condition is given as follows:

In addition to the learning material itself, you will be given the opportunity to receive memory aids to help you remember the features of each plant. These memory aids are provided in the form of a very short story involving the name and critical features of each plant.

During the instruction on each plant, you will be asked whether you wish to see the memory aid for that plant. You may then take advantage of this opportunity if you desire to do so. You will have the opportunity to make this choice twice for each plant.

Subjects assigned to the second learner control (M) condition were also given learner control over access to the mnemonics and the instructions which they received emphasized the utility of the menmonics for learning the materials. The set of instructions administered to these students is given as follows:

In addition to the learning material itself, you will be given the opportunity to receive memory aids to help you remember the features of each plant. These memory aids are provided in the form of a very short story involving the name and critical features of the plant.

It has been discovered that students who use the memory aids find them to be a great help in remembering the critical features of the different plants. In addition, they perform better on the individual tests and are able to finish the course in a shorter time than students who do not make use of the memory aids.

Therefore, it will be to your advantage to make use of the short stories. During the instruction on each plant you will be asked whether you wish to see the memory aid for that plant. You may then take advantage of this opportunity if you desire to do so. You will have this choice twice for each plant.

Since there are so many critical features for you to learn during the course of the instruction, we believe you will find it to your benefit to make use of this option.

In addition to the preceding instructions, subjects in the treatment present (K) and two learner control (L and M) conditions were also given instruction as to how the mnemonic aids would be presented and how the subjects were to make use of these mnemonics. This common set of instructions, which immediately followed the differential sets of instructions given above, is listed as follows:

You will first read the story on the screen. Certain words which relate to the name and critical features of that plant will be underlined. The next screen will explain the exact relation between these words and the plant itself. You may then back up to the story and read it again with this in mind. Remembering the story <u>will</u> help you to recall the name and critical features of each plant when you take the group and final tests.

The plant name will appear near the beginning of the story. The characteristics of the <u>green</u> objects in the story correspond to the critical features of the leaves on that plant. These clues will become obvious when you see the stories.

When you're reading the story try hard to get a clear mental picture of the objects and events contained in the story. Take a few moments to really <u>concentrate</u> on your mental picture so you can <u>recall it</u> later as a memory aid when you take the group and final tests.

During the tests try to recall your mental picture of the story. The name of the plant should help you to recall the story. Think of the story for a few moments and try to recall the critical features mentioned in it. In this way you can make the best use of these stories as memory aids.

Immediately following the administration of these instructions, all subjects began work on the first instructional segment concerning five of the 10 plants. The only effect of experimental treatments concerned the availability or non-availability of the mnemonic memory aids at two points in the instructional sequence for each plant. Subjects in the treatment absent (J) condition were never shown the mnemonics nor was there any indication that any component of the program was missing. Subjects in the treatment present (K) condition were first shown the mnemonic story immediately following the description of the plant's critical features. The story, which was contained on one CRT display, was followed by a display which related the relevant terms in the story to the plant's name and critical features. If he so desired, the subject could repeat the two display sequences as many times as he wished by typing the character "m." Alternatively, he could press the space bar to continue with the instructional sequence. This control information was always given at the bottom of the second display in the sequence. Subjects in the two learner control conditions (L and M) received the same treatment. Rather than simply being shown the mnemonic sequence, they were asked whether they wanted to see the mnemonic story for that particular plant. If they did, they could access the same mnemonic sequence as was described for the treatment K subjects by typing the character "m." Alternatively, if they pressed the space bar, they continued with the instructional sequence in the same manner as subjects under the J treatment condition.

All subjects then continued through the instructional sequence for that plant in exactly the same manner. The edible part(s) of the plant were described and shown on the image projector. A context photograph of the plant was displayed and the subject was required to type in the name of the plant.

The memory aid treatment was then repeated. For treatment J subjects, there was no break in the instructional sequence. Treatment K subjects were again shown the same mnemonic story and the subsequent display relating the story to the plant's critical features. Treatment

L and M subjects were again asked whether they wished to see the mnemonic aid and the sequence was presented if it was requested.

All subjects then completed the instructional sequence for the plant in the same manner. Repetition of this sequence for five plants constituted the first instructional segment. All subjects were then administered the same test over the plants in that segment. The number of errors which students committed on the critical features, plant identification, and edible part(s) components of the two segment tests and the final test provided the basis for performance comparisons between the four experimental treatments. The test was followed by the second administration of the state anxiety scale.

The second instructional segment also contained five plants and was programmed in exactly the same format as the first segment. This was followed in turn by the second segment test and the third administration of the anxiety scale. The final test, covering all 10 plants, was then administered. All subjects received the same test, regardless of experimental treatment. In format, the test was similar to the two segment tests with the exceptions that the two major components of the test were administered in a reversed order, corrective feedback following incorrect responses was minimized, and the number of errors allowed per test question was increased. The final test was followed by the fourth and final administration of the state anxiety scale. All subjects were then given the option of studying two additional plants. No test was administered over these two plants and the only data collected concerned whether or not the subject did elect to study the optional plants. The program then terminated with a warning as to the necessity of caution in attempting to identify edible plants in their native habitat.

Upon completing the program, the subject notified the experimenter who administered a standardized post-instructional interview. The purpose of this interview was to provide a general evaluation of the instructional aspects of the program rather than to obtain additional data relating to the experimental manipulations. The proctor then thanked the subject for his participation, answered questions concerning his performance, reassured him that he should be receiving his payment check in approximately two weeks, and cautioned him not to discuss the content of the experiment with his acquaintances.

RESULTS AND DISCUSSION

Data pertaining to subjects' performance on the two segment tests and the final test, their responses to the four state anxiety questionnaires, and their learner control requests for the mnemonics were recorded on magnetic tape and disk during the experiment itself. At the conclusion of the experiment, these data were automatically punched. Data from the task specific memory test, the IE and the Ai scales were punched by hand from the test booklets and answer sheets.

As a first step in the data analysis, the data were submitted to a program (DISTAT) run on the University's CDC 6600 system, which computed statistics for all variables for each of the four experimental groups (Veldman, 1967).

Examination of these distribution statistics indicated that all of the performance measures (error counts from the three tests) were severely skewed in a positive direction. That is, there was a preponderance of subjects who made very few errors, while relatively few subjects made fairly large numbers of errors. As was discussed under Statement of the Problem, the data were to be analyzed by means of linear regression analysis. One of the few assumptions underlying the application of this statistical technique is that the criterion or dependent variable be normally distributed (Kelly, Beggs, & McNeil, 1969). This assumption could not be justified given the distributions of raw scores. Therefore, all of the test error count data were transformed to the $\log_e$ of the original error scores. The data were then re-examined via program DISTAT and, while a few of the distributions were still somewhat skewed, none of the transformed score distributions differed significantly from normality.

A similar situation was found to exist with respect to the distribution of error scores from the task specific memory test. Again, there was strong positive skewness. While the linear regression approach does not require that the covariable be normally distributed, experience with a number of statistical comparisons using raw memory test error scores indicated that the conclusions which would be drawn from these comparisons were not accurate representations of the interactions between the experimental conditions and the memory test covariable. The relatively few subjects with high memory test error scores had an undue influence on the patterns of regression lines. Consequently, the decision was made to submit the memory test data to the same $\log_e$ transformation. Again, the transformed scores approximated a normal distribution.

Data derived from the task embedded state anxiety scales, the IE and Ai scales, and the number of learner control requests were all approximately normal in distribution. Therefore, raw data were used in the analyses concerning these variables.

The decision to employ transformed scores as the covariable in all but one set of the analyses to be reported creates a problem for the reader in that $\log_e$ data are not easily interpreted and are, in fact, relatively meaningless to the average reader who is attempting to understand just how subjects performed under the various experimental conditions. As an attempt to alleviate this problem, data have been reported in two forms. For each analysis of interest, the cell means have been reported in terms of raw data. In the case of significant differences ($p < .05$) or differences which were of interest because they approached significance ($p < .10$), the F test values reported refer to tests which were conducted via program COVARY (Veldman, 1971) on transformed data. In the case of interactions between the experimental conditions and the covariable, the interactions have been graphed. The covariable and, in most cases, the criterion or dependent variable shown in these graphs are in terms of $\log_e$ scores. It was decided that it would be misleading to present graphs of raw data while the actual tests of the interactions being represented were made with $\log_e$ data. In these graphs, the right ends of the regression lines terminate two standard deviations above the mean of the covariable distribution. The left ends of the regression lines are terminated at zero. Since the distribution of $\log_e$ memory test scores was still somewhat positively skewed, a continuation of the left end of the regression line to $-2\ \sigma$ would have implied nonexistent memory test raw scores of less than zero.

Validation of Experimental Paradigm Requirements

It will be recalled that a requirement of the experimental paradigm employed was that the treatment to be placed under learner control be independently shown to have a generally facilitating effect on performance in the task. Thus, it was hypothesized that subjects run under the treatment present (TP) condition (presentation of mnemonic memory aids for each plant) would make fewer errors on the critical features and identification portions of the two group tests and the final than would subjects in the treatment absent (TA) condition (Hypothesis 1).

Since the mnemonic memory aids directly concerned the association of the plant names with their critical features, performance on the critical features components of the tests was the most direct measure of the effect of the mnemonics and will be discussed first.

The mean error scores of the treatment absent and present conditions are presented in the left half of Table 2. As may be seen from examining the data for Critical Features and Identification, the presentation of mnemonic devices did not have the generally facilitating effect desired. In general, the effect of the treatment appears to be somewhat debilitating. Examination of the data via the comparison of linear models revealed the relationships to be somewhat more complex.

Table 2

Errors on Each of Three Components of the Three Tests

	Treatment Absent (TA)		Treatment Present (TP)		Learner Control Brief Instructions (LC)		Learner Control Extended Instructions (LCI)	
	$\bar{X}$	σ	$\bar{X}$	σ	$\bar{X}$	σ	$\bar{X}$	σ
Critical Features								
Test 1	5.05	4.94	6.26	6.15	4.33	4.20	4.67	3.14
Test 2	4.59	4.65	5.22	4.76	3.47	4.51	4.23	3.74
Final	6.07	5.85	8.04	8.84	4.97	4.11	5.45	3.90
Identification								
Test 1	3.41	2.16	2.89	2.41	2.95	1.83	2.73	1.57
Test 2	0.61	1.21	0.59	0.95	0.27	0.71	0.53	1.14
Final	2.87	3.49	3.26	3.85	2.03	2.47	1.73	1.90
Edible Parts								
Test 1	0.82	1.51	0.93	1.25	1.20	1.52	1.10	1.51
Test 2	0.49	0.80	0.74	1.04	0.47	0.74	0.40	0.62
Final	2.59	1.74	5.00	5.81	2.60	1.79	2.97	1.90
Number of Subjects	56		27		40		39	

Consider first the performance on the critical features component of the final test. This was considered to be the most important comparison of the set. A significant interaction was found between the memory covariable (as measured by the task specific memory test) and experimental condition ($F = 5.21$, $df = 1/79$, $p = .024$). This interaction is illustrated in Figure 7. Contrary to expectation, there was no appreciable relationship between memory test errors and errors on the critical features portion of the final for the TA group. Hence, the relatively flat regression line shown for this group. On the other hand, there was a substantial positive relationship between errors on the memory test and on the critical features portion of the final for the TP group, resulting in the sharply sloping regression line shown for this group. These results may be interepreted as indicating that, relative to the TA group, the mnemonics were instructionally facilitating for subjects with particularly good memories (as measured by the task specific test) but were debilitating for other subjects.

This same pattern of interactions was present in the critical features error scores on the first and second segment tests but in neither case was the interaction significant. Thus, in each case, the regression lines could be considered to be parallel--meeting the assumption for analysis of covariance. Analysis of covariance did not indicate significant differences between the two groups for either of the two tests. In summary, the pattern of interaction was maintained for critical features test performance throughout the task but was significant on only the final.

Since the association of critical features with the plant name was considered to be prerequisite to or at least strongly related to the task of identifying the plant from its photograph, it would not be surprising if this same pattern of interaction were repeated for the identification error data. The pattern of interaction was present on the first segment test and the final test, but in both cases the interaction only approached significance ($F = 3.04$, $df = 1/79$, $p = .081$ for the first segment test and $F = 3.20$, $df = 1/79$, $p = .074$ for the final test). There was no indication of interaction between memory test score and experimental condition for the data resulting from the second segment test. Analysis of covariance indicated no differences between the mean scores of the two groups on any of the three tests.

There was no reason to expect the experimental manipulations to have any direct effect on subjects' performance on the edible parts components of the tests but it was anticipated that the assumed reduction in memory load resulting from subjects' use of the mnemonics might have a positive effect on their performance on these test components. Thus, these data were subjected to the same set of analyses as the critical features and identification data. In no instance did the interaction with memory test score approach significance. Analysis of covariance indicated no significant difference between group means on

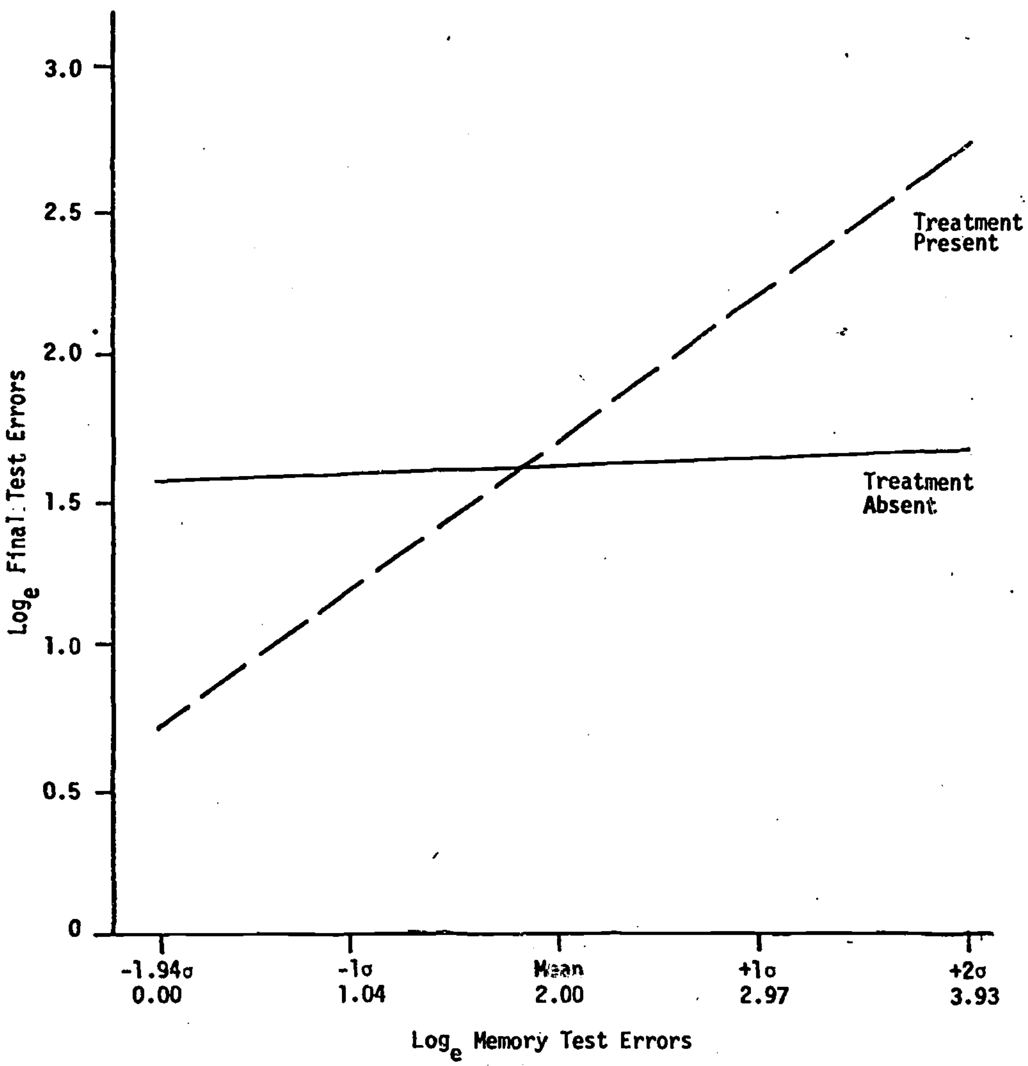

Fig. 7.--Final test critical features' errors for treatment absent and treatment present as a function of memory test errors.

the first or second segment tests. On the final test, TP subjects made significantly more errors on the edible parts component of the test than did TA subjects ($F = 7.21$, $df = 1/79$, $p = .009$). It must be concluded that the availability of mnemonic devices for critical features and the subjects' presumed attempts to make use of them resulted in interference with their recall of the edible parts.

In summary, the presentation of mnemonic devices associating a plant's name with its critical features did not have the desired general facilitating effect. On the most direct measure, performance on the critical features component of the tests, the mnemonics were facilitating for a small proportion of subjects, those with particularly good associative memories as measured by the task specific test, but were ineffectual or debilitating for most subjects. Although not as pronounced, there was a tendency for this pattern of interaction to be repeated on the identification components of the tests. On the edible parts components of the tests, where performance was only indirectly influenced by the experimental manipulations, the presentation of mnemonics resulted in distinctly poorer performance on the final test.

Effect of Learner Control on Performance and Affect

On the assumption that the great majority of subjects given learner control over a variable presumed to be generally facilitating would make extensive use of it, it was hypothesized that these subjects would make fewer errors on the two segment tests and on the final test than would subjects who did not have access to the mnemonic (Hypothesis 2). Again, subjects' scores on the task specific memory test were used as a covariable. The original intention was to test this hypothesis using the combined scores of all subjects in the two learner control groups. As will be discussed in a subsequent section of this report, however, the behavior of the subjects in the two groups differed somewhat with respect to both their use of the learner control options and their performance on the tests. Therefore, the two learner control groups were separately contrasted with the TA group. The mean numbers of errors committed by subjects in each of the two learner control groups are shown in the right half of Table 2. The comparison of interest is with the data presented in the first column of Table 2--that of the TA condition.

Consider first the comparison of the learner control, brief instruction (LC) group with the TA group. In general, the observed group means were lower for LC than for TA, thus tending to support the hypothesis but in no instance were the mean differences between the $\log_e$ error scores of these two groups significant. For two of the comparisons, there was a significant interaction between experimental conditions and the covariable of error score on the memory test. The first of these occurred on the critical features component of the final test ($F = 6.11$, $df = 1/92$, $p = .015$). The nature of this interaction is illustrated in Figure 8. As was also shown in Figure 7, there was no appreciable relationship between memory test score and performance on the final test for TA subjects. There was a substantial positive relationship, however, for LC subjects. The same pattern of interaction was repeated for the identification component of the final test ($F = 5.15$, $df = 1/92$, $p = .024$). In addition, interactions in the same pattern approached significance for data from the critical features component of segment test 2 ($F = 2.91$, $df = 1/92$, $p = .077$) and the edible parts component of the final test ($F = 2.93$, $df = 1/92$, $p = .087$).

Comparison of the performance of subjects in the learner control group given the extended instructions (group LCI) with that of the TA subjects yielded different results. In this case, none of the interactions between experimental conditions and memory test score approached significance. The regression line shown for the LCI subjects in Figure 8 is typical in its relationship to that of TA subjects. Thus, the assumptions necessary for analysis of covariance were met for all nine comparisons made. None of the mean differences approached significance.

It must be concluded that the performance of the two groups of subjects given learner control over access to mnemonics was not significantly better than the performance of subjects denied access to the mnemonics. The selectively facilitating (and debilitating) effects of the mnemonics are reflected in the slightly sloping regression lines of the two learner control groups as contrasted with the TA group. In this respect, performance of the LC subjects more closely resembled that of TP subjects than that of TA subjects. Why this should be the case for LC, as opposed to LCI, subjects is not at all evident. As will be discussed in a subsequent section of this report, LCI subjects made slightly greater use of the mnemonics than did LC subjects.

With regard to the possible affective advantage of learner control, it was hypothesized that subjects given learner control over access to mnemonics (groups LC and LCI) would express less state anxiety following each of the two segment tests and the final than would either subjects who were always shown the mnemonics (group TP) or those who never had access to the mnemonics (group TA) (Hypothesis 3).

The first step in evaluating this hypothesis was to determine whether the two learner control groups differed from each other in terms of their anxiety. Expressed state anxiety on the pre-experimental measure was employed as a covariable. Since all of the anxiety score distributions approximated normality, raw, rather than transformed, scores were used for both the covariable and the criterion variables. No significant interactions were found between the two (LC and LCI)

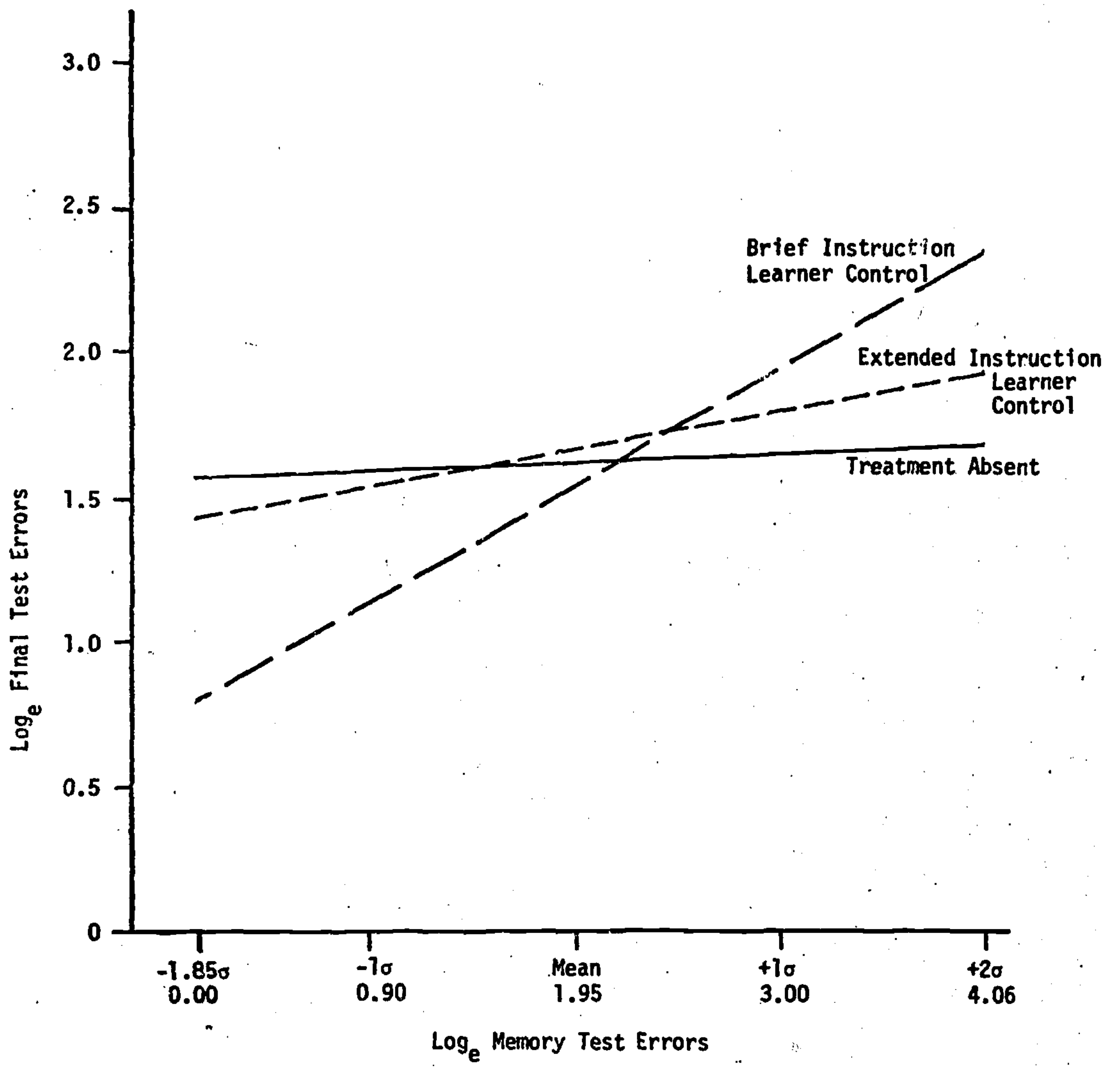

Fig.8.--Final test critical features' errors for treatment absent, brief and extended instruction learner control subjects as a function of memory test errors.

experimental conditions and pre-experimental memory test score on any of the three anxiety scales embedded in the task. Analysis of covariance found no significant differences between the LC and LCI means on any of the three anxiety scales. Thus, subjects in the two learner control groups were combined for purposes of the analysis of major interest.

The mean state anxiety scores of the TA, TP, and combined learner control groups are presented in Table 3. There were no interactions between experimental conditions and the memory test score covariate. Thus, analysis of covariance was employed to determine possible mean differences between groups on each of the three anxiety scale administrations. No significant differences were found among groups for any of the three scale administrations.

It must be concluded that, under the conditions of the present experiment, giving subjects learner control over the instructional variable of access to mnemonic memory aids did not have the hypothesized effect of reducing state anxiety. It should also be noted, however, that this should not be considered a valid test of the hypothesis since the hypothesis assumed that the variable over which subjects were given control would be generally facilitating. As was previously discussed, this was not found to be the case. The question of whether or not learner control over an instructional treatment which is generally facilitating reduces anxiety still remains unanswered.

Use of Learner Control as a Function of Instructions

It was hypothesized (Hypothesis 4) that, in general, subjects given learner control over access to the mnemonic aids but only limited instruction as to their utility (group LC) would request the mnemonics less frequently than would subjects who were given more extensive instructions as to the value of their use (group LCI).

The mean number of memory aid requests made by subjects run under each of the two conditions during each of the two instructional segments is shown in the upper portion of Table 4. In neither case was there a significant interaction between experimental conditions and memory test score. Thus, a covariance analysis was conducted for each of the two instructional segments. As may be seen from a comparison of the means in Table 4, there was a tendency for LCI subjects to make more requests for mnemonics in both of the instructional segments than did LC subjects. This tendency only approached significance for the data from the first instructional segment ($F = 2.72$, $df = 1/76$, $p \approx .099$) and was not significant for the second instructional segment. These differences might have been more pronounced and, hence, significant, if, as intended, the mnemonics had been generally facilitating.

Table 3

State Anxiety Scores on Three Task Embedded Scales

	Treatment Absent (TA)		Treatment Present (TP)		Learner Control	
	$\bar{X}$	σ	$\bar{X}$	σ	$\bar{X}$	σ
Scale 1--Following Segment Test 1	9.84	3.80	9.00	3.51	9.08	3.37
Scale 2--Following Segment Test 2	8.89	4.13	8.26	3.03	8.48	2.58
Scale 3--Following Final Test	9.09	3.86	8.04	3.18	8.86	3.69
Number of Subjects	56		27		79	

Table 4

Number of Requests for Mnemonics and Test Errors as a Function of Learner Control Instructions

	Brief Instructions (LC)		Extended Instructions (LCI)	
	$\bar{X}$	σ	$\bar{X}$	σ
Mnemonic Requests				
Segment 1	4.93	2.43	5.87	2.77
Segment 2	3.07	2.60	3.85	3.45
Critical Features Errors				
Test 1	4.33	4.20	4.67	3.14
Test 2	3.47	4.51	4.23	3.74
Final	4.97	4.11	5.54	3.90
Identification Errors				
Test 1	2.95	1.83	2.72	1.57
Test 2	0.27	0.71	0.53	1.14
Final	2.03	2.47	1.73	1.90
Number of Subjects	40		39	

It is of interest to note the degree to which the number of requests was reduced for both groups from the first to the second instructional segment. Regardless of type of instructions received, the subjects' experience with the limited utility of the mnemonics resulted in substantially diminishing the number of their requests. The effect of subjects' experience with the mnemonics on their learner control request behavior was even more pronounced when number of requests were examined in the light of the memory test covariable. For all learner control subjects, the combination of groups receiving both types of instructions, there was a positive correlation ($r = .073$) between number of memory test errors and number of mnemonics requests during the first instructional segment. That is, there was a tendency for subjects with poorer memories to request memory aids more frequently. This pattern of behavior would have been quite appropriate if, as the instructions had stated, the mnemonics had indeed been generally facilitating. During the second instructional segment, this trend was reversed, resulting in a negative correlation between memory test errors and mnemonics requests ($r = -.120$). Poor memory subjects made fewer requests than did good memory subjects. This suggests that after experiencing the limited utility of the mnemonics during the first segment test, those subjects with relatively poor memories reacted appropriately by reducing the number of their requests. The difference between the two correlation coefficients approached significance ($z' = 1.82$, $p = .069$).

On the assumption that the use of the mnemonics would be generally facilitating and that subjects given the extended instructions would make more use of mnemonics than would subjects given only the abbreviated instructions, it was further hypothesized (Hypothesis 5) that the LCI subjects would make fewer errors on the critical features and identification components of the two segment tests and the final test than would LC subjects. The error data for these groups are shown in the lower portions of Table 4.

Consider first the critical features error data. Given that the LCI subjects tended (although not significantly) to request more mnemonics and that the use of mnemonics was debilitating for at least as many subjects as for whom it was facilitating, it is not surprising that the mean number of errors committed by the LCI subjects exceeded that of the LC subjects. There was no interaction with the memory test covariable on the first or second segment tests. As determined by analyses of covariance, the observed group means were not significantly different on the first segment test but approached significance on the second ($F = 3.16$, $df = 1/77$, $p = .076$). On the final test, the interaction between the experimental condition and memory test score did approach significance ($F = 3.77$, $df = 1/76$, $p = .053$). The nature of the interaction was that there was a much stronger positive relationship between number of errors on the memory test and number of errors on the critical features component of the final test for the LC subjects than for the LCI subjects given the extended instructions. If one assumed that the two regression lines were parallel, thus meeting the assumptions of analysis of covariance, there was not a significant difference between the means of the two groups.

Turning now to the identification error data, one finds a similar but somewhat weaker pattern of results. There was no interaction with the memory test covariable on the first or second segment tests nor were the observed mean differences significant on either test. On the final test, the interaction with the memory test score covariable again approached significance ($F = 2.93$, $df = 1/76$, $p = .087$) and, again, the nature of the interaction was that there was a stronger positive relationship between number of errors on the memory test and number of errors on the identification component of the final test for the LC subjects. If it is assumed that the two regression lines are parallel, there was no significant difference between the means of the two groups.

To summarize, the effect of the extended learner control instructions was to cause a slight (marginally significant) increase in the number of mnemonics requests made by the subjects receiving these instructions during the first instructional segment. This effect washed out, presumably due to the subjects' experience with the limited utility of the mnemonics, by the second instructional segment. All subjects, regardless of experimental treatment, reduced their use of mnemonics during the second segment and students with poor memory, as measured by the task specific test, switched from using the most mnemonics to the least. The number of errors committed by subjects receiving the extended instructions was at least as great as that of the subjects receiving the briefer instructions. On both the critical features and identification components of the final test, there was a tendency for the extended instructions to diminish the relationship between the memory test score and performance on the test. Although this result would be expected if the use of mnemonics had been generally facilitating, it is not at all obvious why it occurred given the particular conditions of this experiment.

Use of Learner Control as a Function of Locus of Control Score and Instructions

It was hypothesized that, given learner control over access to mnemonics and only limited instructions as to their utility (condition LC), subjects who were rated as being more "internally controlled" on Rotter's (1966) Internal-External Locus of Control (IE) scale would make more requests for access to the mnemonics than would subjects who were rated as being more "externally controlled" (Hypothesis 6). It was further hypothesized, on the assumption that the mnemonics would be generally facilitating, that these same subjects would make fewer errors on the critical features components of the two segment tests and the final test (Hypothesis 7).

All 162 subjects run in the experiment were rank ordered on the basis of their scores on the IE scale. The median score was found to be 10.11 ($\bar{x}$ = 10.74, σ = 4.24). The 79 subjects run under the two learner control conditions were divided into two groups on the basis of this median: those whose scores indicated that they tended to be internally controlled (IE $\leq$ 10, N = 40); and those whose scores indicated that they tended to be externally controlled (IE $\geq$ 11, N = 39). The group means contrasting the learner control request behavior of these two types of subjects under the condition of limited learner control instructions are shown in the upper portion of Table 5.

The differences between the groups were in the hypothesized direction in that the observed mean numbers of requests were slightly higher in both the first and second instructional segments for subjects rated as being more internally controlled but as is discussed below, neither of the observed differences was significant.

For both the first and second instructional segments, the data were analyzed using $\log_e$ score on the memory test as a covariable. In neither case was the interaction between IE score and the covariable significant. Although nonsignificant, the pattern of interaction in the first instructional segment is of some interest. Those subjects who were classified as internals tended to increase the number of their requests as a positive function of their error score on the memory test. That is, internally classed subjects with poor memories made more requests for mnemonics than did good memory, internally controlled subjects. In contrast, the number of requests made by subjects who were classed as being externally controlled was relatively independent of score on the memory test. If the mnemonics had indeed been generally facilitating, the behavior of the subjects classified as being internally controlled would have been appropriate. As will be discussed below, however, in this particular situation their behavior was actually detrimental to their performance. In the second instructional segment, both groups of subjects tended to reduce the number of their requests as a function of increasing error score on the task specific memory test.

Since there was no significant interaction between the two classes of subjects and the covariable, analyses of covariance were conducted for each of the two instructional segments. In neither case did the observed mean differences approach significance.

Contrary to what had been hypothesized, the observed mean numbers of critical features errors for subjects in the brief learner control instructions group were higher for subjects classified as being internally controlled than for subjects classified as being externally controlled. These error scores are also shown in the upper portion of Table 5.

Table 5

Mnemonics Requests and Test Errors as a Function of

Locus of Control (IE) Scores and Instructions

		Internals IE ≤ 10		Externals IE ≤ 11	
Brief Learner Control Instructions	Number of Subjects	23		17	
		$\bar{x}$	σ	$\bar{x}$	σ
	Locus of Control Score	7.13	2.18	14.24	2.77
	Mnemonics Requests				
	Segment 1	5.30	2.42	4.41	2.43
	Segment 2	3.35	2.72	2.71	2.44
	Critical Features Errors				
	Test 1	4.57	4.61	4.00	3.84
	Test 2	3.61	3.42	3.29	5.89
	Final Test	5.52	4.43	4.24	3.78
Extended Learner Control Instructions	Number of Subjects	17		22	
		$\bar{x}$	σ	$\bar{x}$	σ
	Locus of Control Score	6.76	2.28	13.91	2.16
	Mnemonics Requests				
	Segment 1	6.00	2.67	5.77	2.91
	Segment 2	4.29	3.14	3.50	3.71
	Critical Features Errors				
	Test 1	4.88	3.04	4.68	3.33
	Test 2	3.88	3.31	4.68	4.13
	Final Test	4.94	4.12	6.00	3.88

On the first test, a significant interaction was found between internal-external classification and error score on the task specific memory test ($F = 6.50$, $df = 1/36$, $p = .015$). The nature of this interaction is illustrated in Figure 9. While there was essentially no relationship between critical features errors and score on the task specific memory test for externally classed subjects, there was a substantial positive relationship between the number of errors on the two tests for subjects classed as being internally controlled.

As contrary to expectation as these results are, they may be explained by reference to the finding that the mnemonics were not generally facilitating and to the two groups' differing trends in learner control behavior discussed above. It will be recalled that during the first instructional segment, for subjects classified as being internally controlled, subjects with poorer memories, as measured by the task specific test, tended to make more requests for mnemonics than did similar subjects with relatively good memories. Since the mnemonics were actually found to be debilitating for poor memory subjects, it would be expected that this pattern of learner control behavior would result in a strong positive relationship between error scores on the two tests. On the other hand, externally controlled subjects, in general, made fewer requests (although not significantly fewer) than did internally controlled subjects and for these subjects the frequency of their requests was independent of their score on the memory test. Thus, the performance of externally controlled subjects with poorer memories was not depressed by extensive use of mnemonics.

There were no significant interactions between internal-external classification and the covariable of task specific memory test score on either the second segment test nor the final test. In each case, the number of critical features errors tended to increase as a positive function of task specific memory test errors for both groups. Since the pairs of regression lines were essentially parallel in each case, analyses of covariance were conducted. For neither test were the observed mean differences significant.

It was hypothesized that subjects classed as being relatively externally controlled who were given the extended learner control instructions would make more requests for mnemonics than would similar subjects who were given only the briefer learner control instructions (Hypothesis 8). It was further hypothesized that externally controlled subjects given the extended learner control instructions would make correspondingly fewer errors on the critical features portions of the test than would similar subjects given only the briefer learner control instructions (Hypothesis 9). The observed group means of number of requests and number of errors are shown in the right hand portion of Table 5.

With respect to the number of mnemonics requests, no significant interactions were found between experimental conditions and the

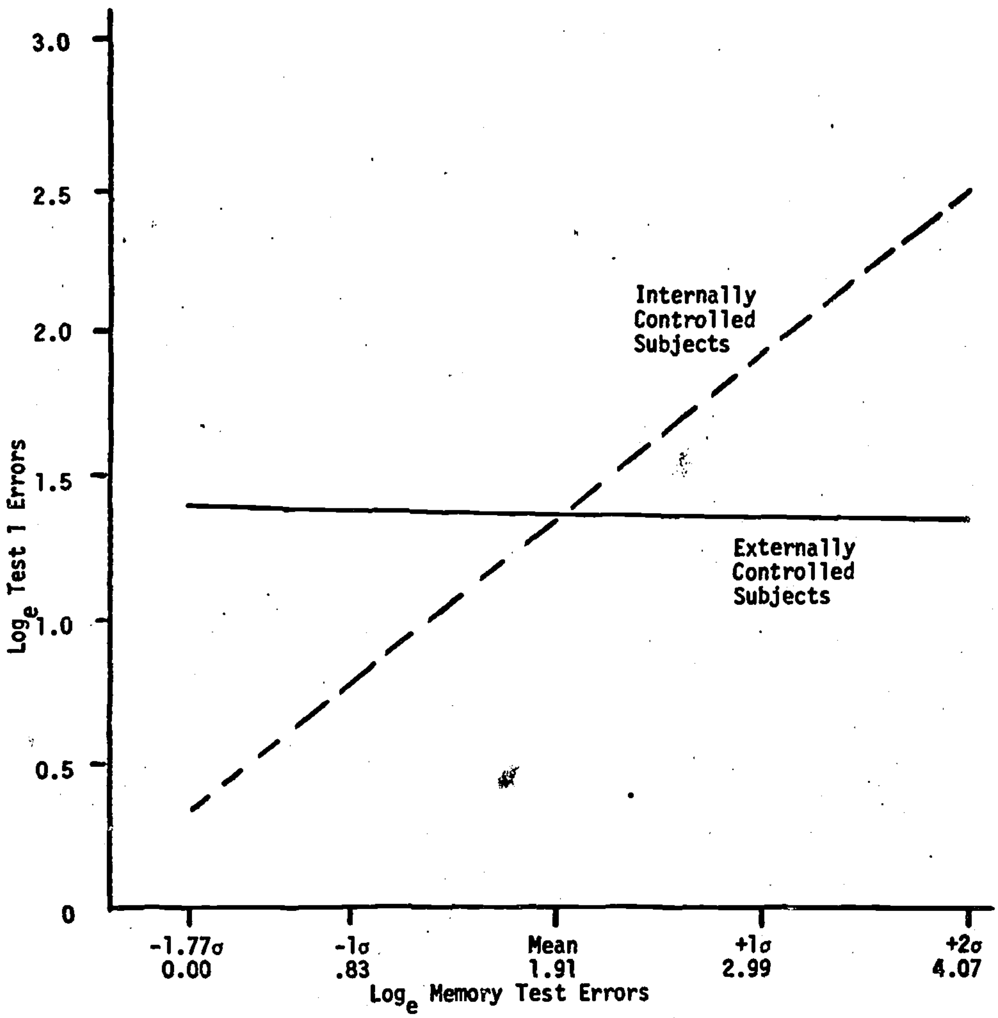

Fig. 9.--Segment test 1 critical features errors for internally and externally controlled subjects given brief learner control instructions as a function of memory test errors.

memory test covariable for either instructional segment. Although the observed group means indicate differences in the hypothesized direction--that is, higher request rates for externally controlled subjects run under the LCI condition--analyses of covariance found no significant differences between groups. With regard to the number of critical features errors committed on the three tests, no significant interactions were found between the experimental conditions and the memory test covariable.

Contrary to expectation, the observed mean number of critical features errors were higher on each of the three tests for LCI subjects than for subjects run under the LC condition. Analyses of variance indicated, however, that these differences were not significant on either of the segment tests nor on the final test.

In summary, under the conditions of the brief learner control instructions, there was a tendency for subjects classified as being internally controlled to increase the number of their mnemonics requests during the first instructional segment as a positive function of their number of errors on the task specific memory test while the request rate of externally classed subjects was unrelated to memory test score. During the second instructional segment, subjects with poorer memories reduced their number of requests regardless of Locus of Control classification.

In the light of the generally adverse effect of mnemonics, any generalizations regarding differences in the learner control behavior of internally and externally controlled subjects must be very tentative. It would appear, however, that, in general, the behavior of subjects classed as being internally controlled was more adaptive. At the beginning of the first instructional segment, the only information available as to the utility of the mnemonics was that which had been supplied in the instructions. On the basis of this information alone, the learner control behavior of the internally controlled subjects was appropriate and would have resulted in improved performance if the mnemonics devices had indeed been facilitating. During the second segment, following more experience with the limited utility of the mnemonics, internally controlled subjects with poorer memories substantially reduced their number of requests. In contrast, while there was a reduction in requests from the first to second instructional segment, the pattern of requests from externally controlled subjects appeared to be less sensitive to initial instructions and subsequent experience.

The hypothesis that externally controlled subjects would commit more critical features errors was not supported. Both the failure of this hypothesis and the significant interaction between memory test score and locus of control classification during the first segment test may be attributed to the generally debilitating effect of the mnemonics. As was discussed in the preceding paragraph, it is suggested that this hypothesis might well have been supported if the mnemonic devices had indeed been generally facilitating memory aids.

Following the line of reasoning adopted above, it might have been expected that the more extensive learner control instructions would have raised the number of requests made by externals during at least the first instructional segment. Although the observed number of requests was higher for those externally controlled subjects receiving the more extensive instructions, the difference failed to obtain significance. Again, any generalization must be tempered by the failure of the mnemonic devices to fulfill their supportive role but it would appear that the behavior of the externally controlled subjects was only slightly influenced (if at all) by the nature of the instructions. Due to the generally adverse effect of the mnemonics, differences in error rate were again counter to what had been anticipated.

Use of Learner Control as a Function of Achievement via Independence Score and Instructions

It was hypothesized that, given learner control over access to mnemonics but only limited instruction as to their utility (condition LC), subjects who scored relatively high on the Achievement via Independence (Ai) scale (Gough, 1957) would make more requests for access to the mnemonics than would subjects who scored relatively low on the scale (Hypothesis 10). On the assumption that the mnemonics would be generally facilitating, it was further hypothesized that these same subjects would make fewer errors on the critical features components of the two segment tests and the final test (Hypothesis 11).

All 162 subjects run in the experiment were rank ordered on the basis of their scores on the Ai scale. The median score was found to be 19.23 ($\bar{x}$ = 19.31, σ = 3.51). The 79 subjects run under the two learner control conditions were divided into two groups on the basis of this median: those with relatively low Ai scores (Ai $\leq$ 19, N = 36); and those with relatively high Ai scores (Ai $\geq$ 20, N = 43). The group means contrasting the learner control request behavior of these two types of subjects under the condition of the briefer learner control instructions are shown in the upper portion of Table 6. Contrary to what had been hypothesized, the observed mean numbers of requests were higher for subjects classed as being relatively low in Achievement via Independence than for high Ai subjects.

A more complex situation was revealed when the data were examined in the light of the task specific memory test score covariable. During both the first and second instructional segments, significant interactions were found between the covariable and the classifications of high or low Ai (F = 5.38, df = 1/36, p = .025 for the first segment and F = 4.22, df = 1/36, p = .045 for the second). The nature of the

Table 6

Mnemonics Requests and Test Errors as a Function of Achievement via Independence (Ai) Score and Instructions

		Low Scorers Ai ≤ 19		High Scorers Ai ≥ 20	
Brief Learner Control Instructions	Number of Subjects	19		21	
		$\bar{X}$	σ	$\bar{X}$	σ
	Achievement via Independence Score	16.95	2.07	21.67	1.62
	Mnemonics Requests				
	Segment 1	5.11	2.26	4.76	2.65
	Segment 2	3.42	2.36	2.76	2.81
	Critical Features Errors				
	Test 1	5.42	4.91	3.33	3.40
	Test 2	4.10	5.07	2.90	4.11
	Final Test	6.26	4.88	3.81	3.06
Extended Learner Control Instructions	Number of Subjects	17		22	
		$\bar{X}$	σ	$\bar{X}$	σ
	Achievement via Independence Score	16.53	2.24	22.09	1.77
	Mnemonics Requests				
	Segment 1	5.18	2.51	6.41	2.91
	Segment 2	3.53	3.08	4.09	3.76
	Critical Features Errors				
	Test 1	4.94	2.51	4.64	3.65
	Test 2	4.71	3.85	4.05	3.77
	Final Test	5.94	3.90	5.23	4.08

interaction during the first instructional segment is shown in Figure 10. For high Ai subjects, the number of mnemonics requests was positively related to their number of errors on the task specific memory test, while a negative relationship was demonstrated for low Ai subjects. While the number of requests was reduced for both groups during the second instructional segment, the pattern of interactions was the same. As was the case for those subjects who were classed as being internally controlled, the behavior of the high Ai subjects would have been appropriate if, as the subjects had been told, the mnemonics were actually facilitating. In this particular situation, however, the learner control behavior of the low Ai subjects was actually more adaptive.

These differences between groups in terms of mnemonics requests were not reflected in subjects' performance on the critical features portions of the two segment tests nor on the final test. In no case was there an interaction between the covariable and classification of high or low Ai. Although the differences between the observed mean error rates were in the predicted direction, subsequent analyses of covariance found no significant differences between groups on any of the three measures. Given the pattern of learner control requests, it would appear reasonable to suggest that the hypothesis might well have been supported if the mnemonics had indeed been generally facilitating.

It was hypothesized that subjects who registered low scores on the Ai scale and who were given the extended learner control instructions would make more requests for mnemonics than would similar subjects who were given only the briefer learner control instructions (Hypothesis 12). It was further hypothesized that the low Ai score subjects receiving the extended instructions would make correspondingly fewer errors on the critical features portions of the tests than would similar subjects given only the briefer learner control instructions (Hypothesis 13). The observed group means of number of requests and number of errors are shown in the left hand portion of Table 6.

With respect to the number of mnemonics requests, there was no interaction between the experimental conditions and the memory score covariable in either instructional segment. The observed mean numbers of requests were only slightly higher under the condition of the extended learner control instructions and analyses of covariance found no significant differences between groups during either instructional segment. Similarly, no interactions with the covariable or group differences were found for any of the three error measures.

In general, the learner control behavior exhibited by the high and low Ai subjects was somewhat analogous to that of subjects classified as being internally and externally controlled. Like the internally controlled subjects, subjects who registered higher Ai scores increased the number of their learner control requests as a

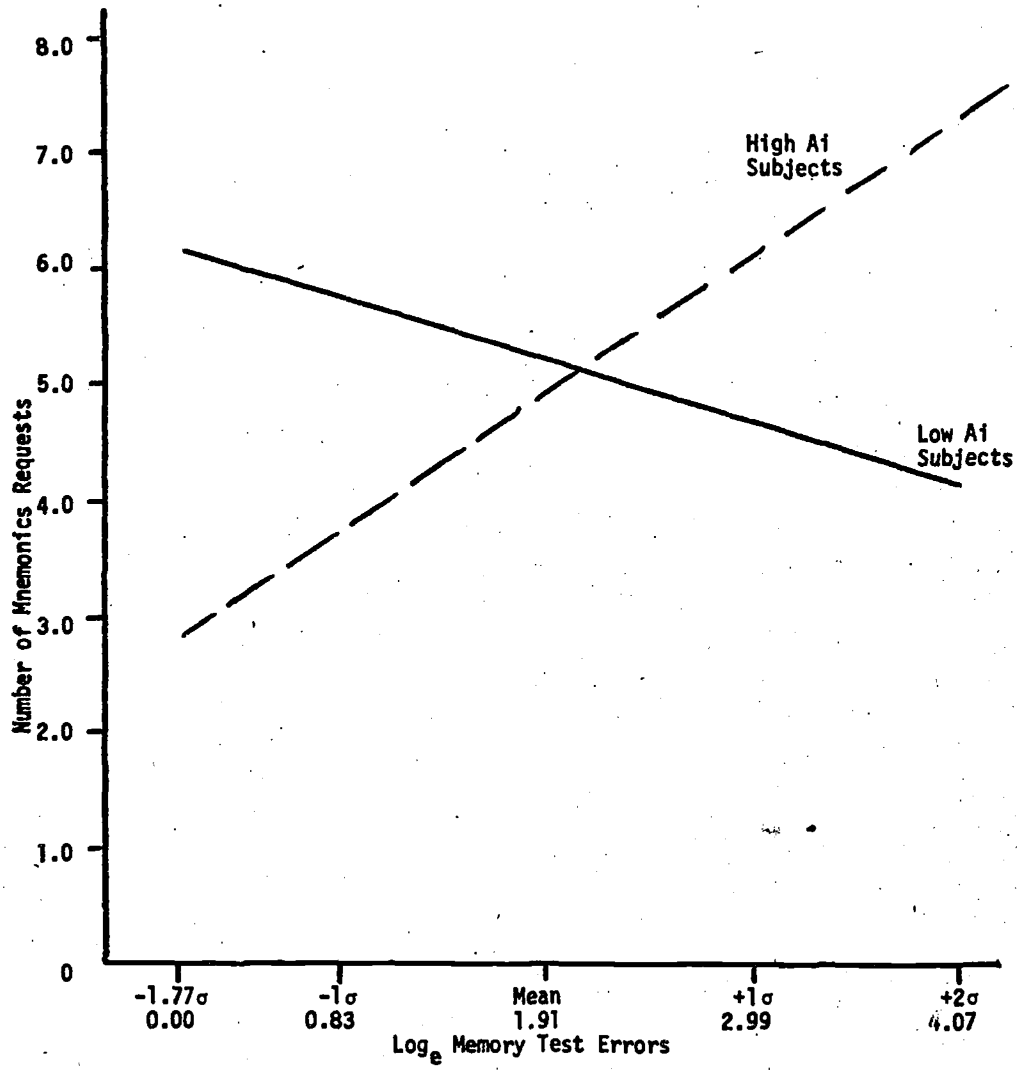

Fig. 10.--Segment 1 mnemonics requests for low and high Ai score subjects given brief learner control instructions as a function of memory test errors.

positive function of their errors on the memory test. On just the basis of the instructions concerning the mnemonics, this would have been appropriate. Unlike the internally controlled subjects, however, high Ai subjects continued this pattern of behavior into the second instructional segment. For subjects with low Ai scores, those with relatively poor memories, as measured by the task specific test, made substantially fewer requests during both segments than did those with relatively good memories. In general, it would appear that the high Ai subjects were more prone to accept and follow the instructions regarding the use of learner control than were low Ai subjects. This line of conjecture is supported by the data resulting from a comparison of the brief and extended learner control instructions. Contrary to what had been hypothesized, the extended instructions had only a negligible effect on the number of requests made by low Ai subjects. The observed differences between the two types of instructions were actually more substantial for high Ai subjects.

None of the anticipated differences in number of critical features errors were found. It is suggested, however, that the higher error rate hypothesized for low Ai subjects given the brief learner control instructions would have been found if the mnemonics had indeed been generally facilitating.

SUMMARY AND CONCLUSIONS

The research reported was conducted in the context of a two-hour computer-assisted instructional program concerning the identification of edible plants. The experimental design consisted of four groups: one always received a presumably facilitating treatment (mnemonic devices relating plant names to their critical features); a second never received the facilitating treatment; and two groups were given learner control over access to the mnemonics which differed with respect to the extent of the instructions which they received concerning the utility of the mnemonics.

The dependent variables of interest were number of errors committed on two segment tests and a final test, number of learner control requests for mnemonics, and responses to a state anxiety measure (Leherissey, O'Neil, & Hansen, 1971). Individual difference measures consisted of a task specific memory measure developed for this contract; a locus of control measure (Rotter, 1966); and a measure of achievement via independence (Gough, 1957).

Subjects were 162 University of Texas at Austin undergraduate student volunteers who were paid for their participation.

The presentation of mnemonic devices did not have the desired general facilitating effect. Although mnemonics did facilitate the performance of a few subjects--those with particularly good associative memories as measured by the task specific memory test--they were ineffectual or debilitating for the majority of the subjects. Thus, it was not surprising that providing subjects access to the mnemonics via learner control did not have the hypothesized effect of reducing state anxiety.

The failure of the mnemonics to effect a substantial improvement in performance may be attributed to a number of factors. First, as was indicated by the strong positive relationship between the performance of subjects in the treatment present condition and their error scores on the memory test, a subject's ability to employ the mnemonics effectively was apparently dependent on his memory ability. It is postulated that, because of their length and complexity, the mnemonics were an effective memory aid only for those subjects who possessed sufficient memory ability to make use of the organizational strategy which the mnemonics supplied.

Secondly, it is postulated that the effect of the photographs of the plants, their critical features and edible parts provided much stronger mediational aids than had been anticipated. While it was recognized that such photographs would be easily recognized, their role as mediators in a verbal stimulus-verbal response chain was underestimated.

It is considered to be very likely that the strength of the photographs as mediators was sufficient to wash out much of whatever facilitating effect the mediators might have had in their absence. As will be discussed in the final section of this report, these considerations led to a redesign of the experiment in which emphasis was placed on the use of photographs rather than on mnemonics as mediators to create an experimentally-manipulable facilitating treatment.

Finally, it is suggested that the results of this experiment highlight the importance of instructional design. The instructional program was written with dual objectives. The primary objective was to provide a vehicle for the research but a secondary concern was that the program itself be instructionally objective. It was assumed that the context in which the research could be applied would involve programs developed, according to sound principles of instructional design. It is suggested that the impact of individual difference variables on learning is substantially reduced by well designed instruction. Thus, the mnemonics employed in this study might well have had their presumed facilitating effect if total task had been structured as a simple list learning exercise. This is not to suggest that individual differences need not be a concern to the instructional designer or that research concerning individual differences should be conducted only in the context of artificial, laboratory type tasks. Rather, it should be recognized that if instruction is to be adapted to individual differences, it will be necessary that at least some of the research on which this adaptation must be based must be conducted in the context of decently designed instruction and that this constraint will require extremely close attention to all aspects of the instructional situation if significant differences between treatments are to be revealed.

Although the observed relationships of the other individual difference variables (locus of control and achievement via independence) to subjects' use of learner control are complex, the results appear to make sense, especially given the lack of instructional effectiveness of the mnemonics. Both of these variables would appear to be worthy of further investigation in a less complex situation in which the treatment placed under learner control was indeed facilitating for all subjects. It is anticipated that the results of such an experiment would substantially assist in the interpretation of the results of the current study in which the treatment had differential effects for different subjects.

The hypothesized effect of the extended instructions with regard to increasing the use of learner control by subjects classed as being externally controlled or having low achievement via independence scores was not supported. Although there was a slight effect in the hypothesized direction for externally controlled subjects, it did not approach significance. The extended instructions had only the most negligible effect on low Ai subjects. The subjects' own experience with the mnemonics appeared to be at least as potent a variable as the instructions which they received.

Given these results and the re-analysis of the task discussed above, a second study was designed to capitalize on and extend the findings of the first. Thus, in this second study (Phase III), the facilitating treatment will be the presence of the plant pictures. The instructional program will be rewritten so that subjects in the treatment absent condition will see no pictures and learner control subjects will be given learner control over the pictures. The second, extended instruction learner control group will be dropped and emphasis will be placed on the degree to which subjects make effective use of learner control during the second instructional segment given knowledge of their performance on the first segment. Details of the experimental method to be employed are reported in the final section of this report.

PHASE III

PROPOSED DESIGN FOR LEARNER CONTROL STUDY II

STUDY II METHOD

Subjects

The subjects for this experiment will be selected from a similar population as in the first study. There will be 120 male and female University of Texas at Austin undergraduates, enrolled for the fall 1973 semester. They will be between the ages of 18 and 25, inclusive, be able to produce a valid University identification card, and will be screened for prior training in plant identification. The later screening is necessary because there is at least one botany course taught at the University which includes field work in identifying native Texas wild plants. Obviously, students from that course cannot be considered as naive subjects. In addition, since so many subjects were lost in the first experiment because English was not their native language, volunteers for the second experiment for which this is true will be screened out.

Materials and Procedures

Pretesting procedure. Two changes will be made in the pretesting materials used in the original experiment. The format of the task specific memory test, devised in this laboratory, will be changed so that each man's name and description will be presented on a separate page for initial study. Students will be allowed six minutes to study the 10 pages, and they may do so only in a linear fashion--they will not be permitted to go back and look at pages they have previously studied. These changes will make the memory test more like the computerized tests the subjects will take on the critical features of the plants.

The second change in the pretest procedure will be the inclusion of the MA-3, a standardized, timed, short-term associative memory test published by the Educational Testing Service. This test was adapted from the First Names Test by L. L. Thurstone, and will serve as a validation measure for the task specific memory test.

Computerized instruction. Because the results of the first experiment showed that the mnemonic memory aids were not instructionally effective, the decision has been made to use the pictures themselves as a memory aid, to ensure a facilitating treatment. Learner control subjects will be given control over pictures. To effect this, the computer program from the original experiment will be rewritten, so that the subjects in the treatment absent (TA) condition will see no pictures during any part of instruction on any of the plants. The only pictures these subjects will see will be those presented when they are asked to identify (enter the name of) the plant during the testing phases of the program.

This change will permit the inclusion of two options for subjects in the learner control (LC) condition. At the very beginning of the instruction for each plant, when the name and habitat of the plant are presented on the CRT, the subject will be asked if he wishes to see pictures illustrating the various characteristics of that plant. If he answers yes, he will then receive the same set of pictures as was presented in the first experiment, including the context photograph and close-up photos of the various critical features and edible parts, as they are described on the CRT. The second LC option will come immediately following the point at which the student has been asked to enter the name of the plant he is currently studying. At this point the student will be asked if he would like to review the pictures of just the critical features of that plant. If the subject selects this option, he will be presented with the same set of photographs of the plant's critical features, and the appropriate descriptions.

Subjects in the treatment present (TP) condition will automatically receive both the complete set of pictures and the review pictures of critical features. Thus, the TP condition of this experiment will be essentially the same as the TA condition of the first experiment, with the addition of the critical features review pictures.

In addition to the changes described above, the overall organization of the instructional program will be revised in an attempt to increase the error rate in the TA condition. The two plants which were used to provide subjects with optional additional instruction after the final test in the first experiment will be used in this experiment as part of an initial group of four plants. A segment test over these four plants will follow the instruction, to provide some implicit feedback on performance to students in the LC condition, who will presumably be able to adjust their use of the LC options accordingly. The remaining eight plants will be divided into two groups of four for instruction, the two groups being separated by one of the four presentations of the state anxiety scale. There will be no segment test for these eight plants.

The module instructing the subjects on a strategy for identifying an edible plant in the field will be moved from its original position (prior to instruction in the first experiment) to a position between instruction on the last plant and the beginning of the final test. Thus, this module will serve as an interpolated task between instruction and testing. This move, made possible by the fact that this strategy is built into the instruction and therefore not required by the subjects to perform well on the task, should serve to increase the overall error rate. Thus, the revised instructional program will contain only two tests, the segment test on the first four plants and the final test over all 12 plants, with the latter separated from the instruction by a three- or four-minute interpolated task. State anxiety measures will be taken prior to instruction, after the first segment test, embedded in the middle of the instruction on the second group of eight plants, and following the final test.

Experimental Procedure

When subjects arrive at the laboratory for their appointments, usually in groups of three to six at a time, they will be seated and administered the test battery according to a standard set of instructions which the experimenter will read to them. They will take the timed MA-3 test first, followed by the timed task specific memory test, and then the IE and Ai scales, which are untimed. The experimenter will be dressed formally, introduced by title and last name, and will generally conduct himself in a formal manner. The anticipated effect of this procedure will be to elevate the state anxiety measures, which were surprisingly low in the first experiment. During the debriefing interview, the experimenter will be warm and friendly, both to alleviate the subjects' tension and to elicit as much information as possible from the subjects about their reactions to the CAI program.

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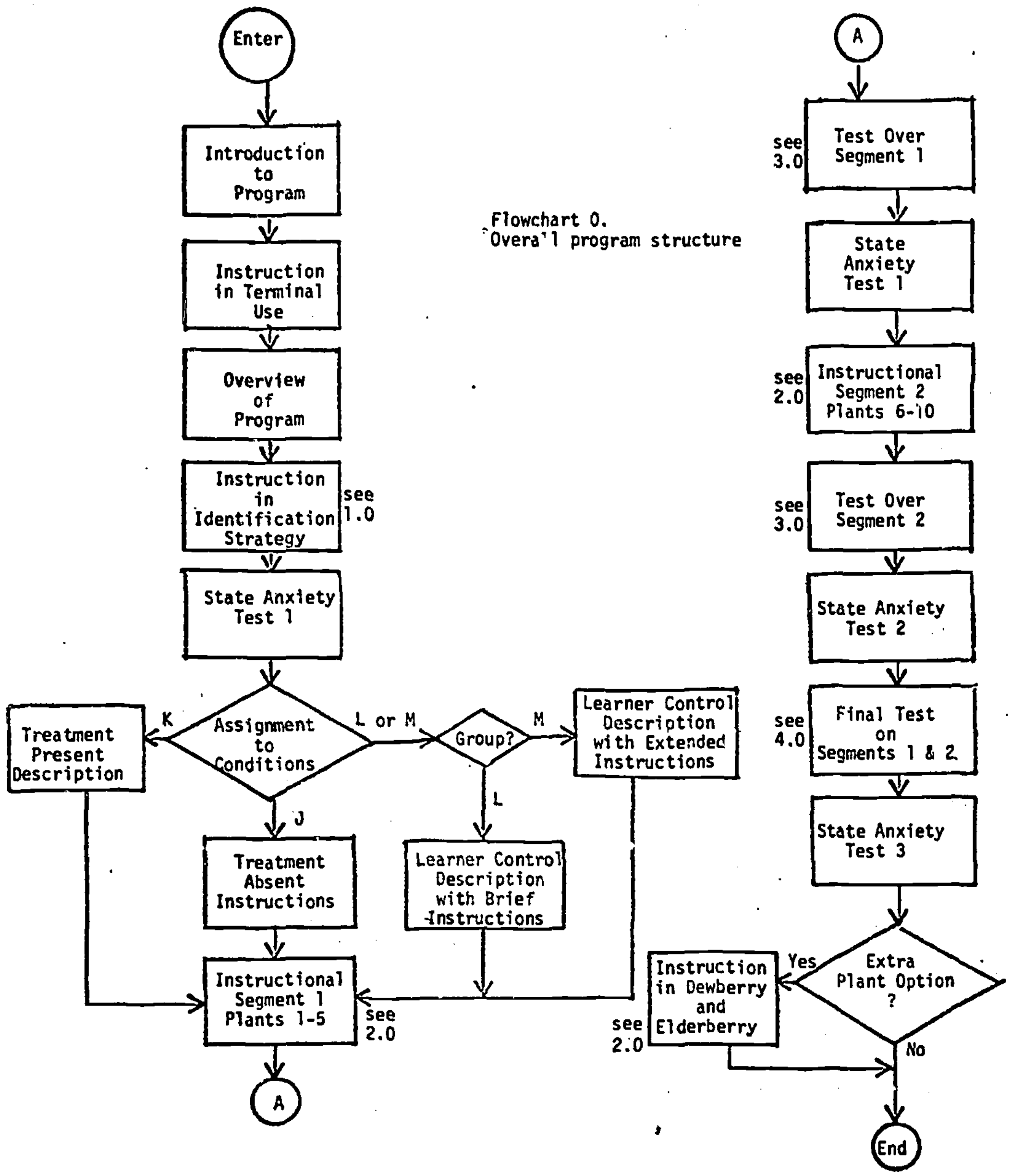
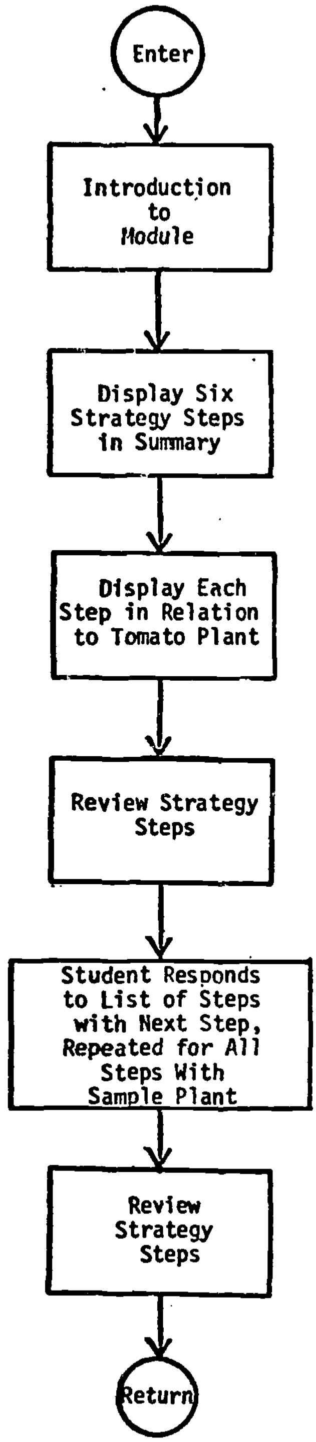
APPENDIX A

INSTRUCTIONAL PROGRAM FLOWCHARTS

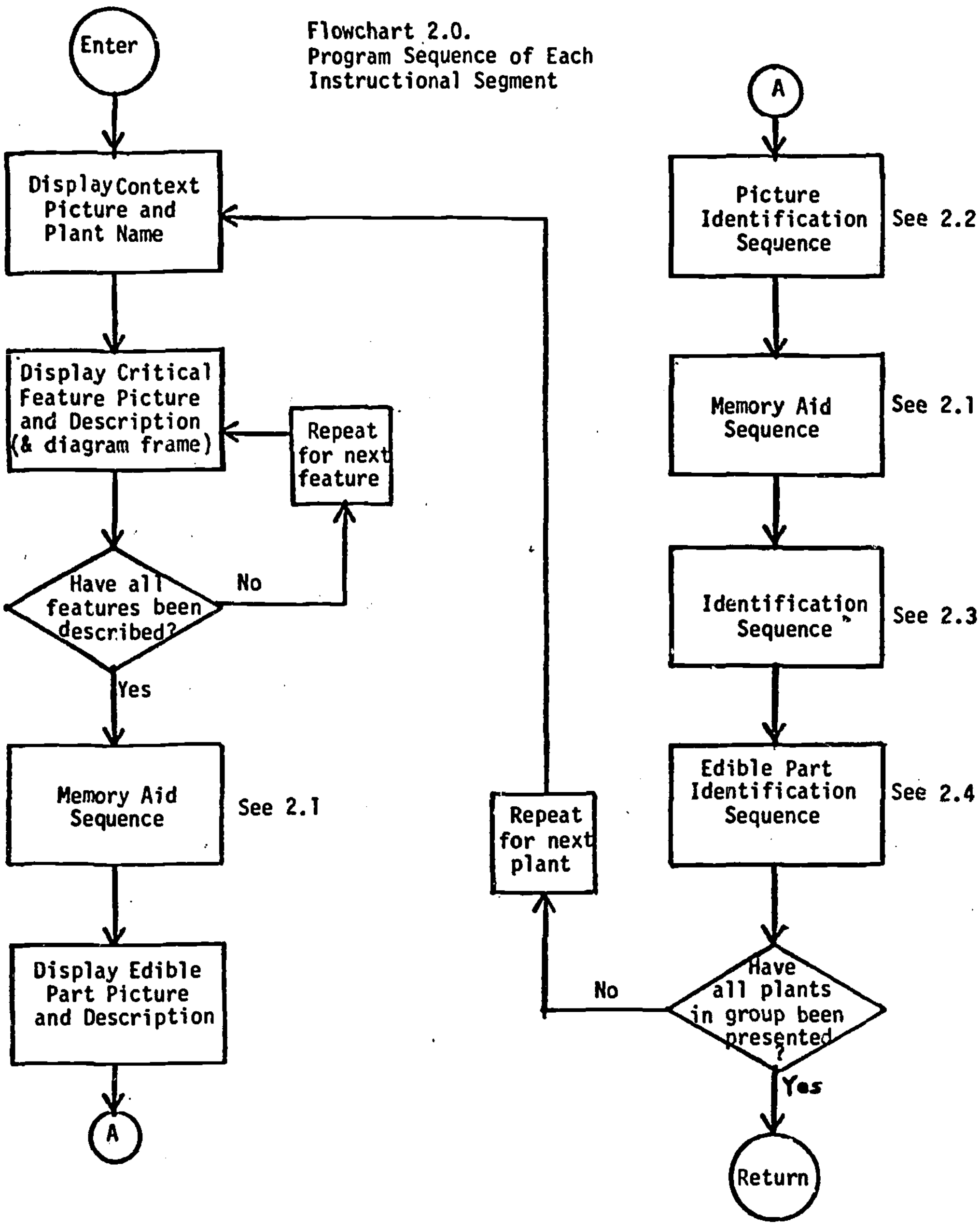


Flowchart 0.
Overall program structure

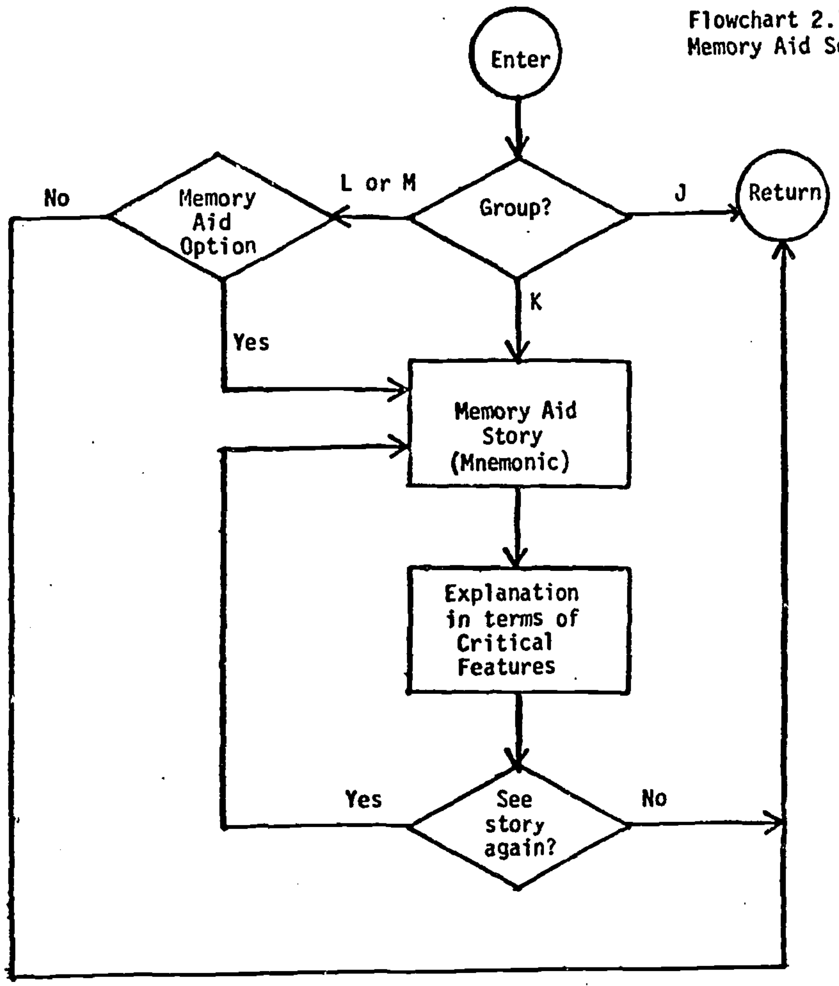


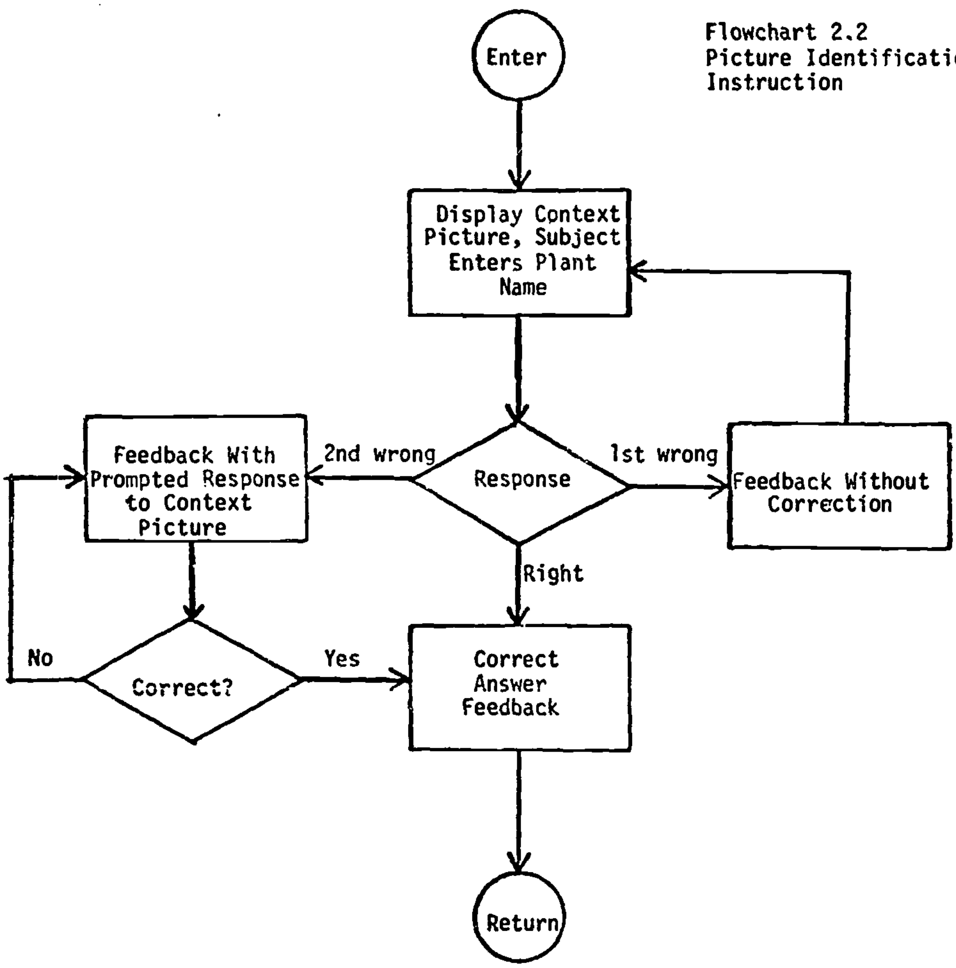
Flowchart 1.0.
Plant Identification
Strategy Module

Flowchart 2.0.
Program Sequence of Each
Instructional Segment

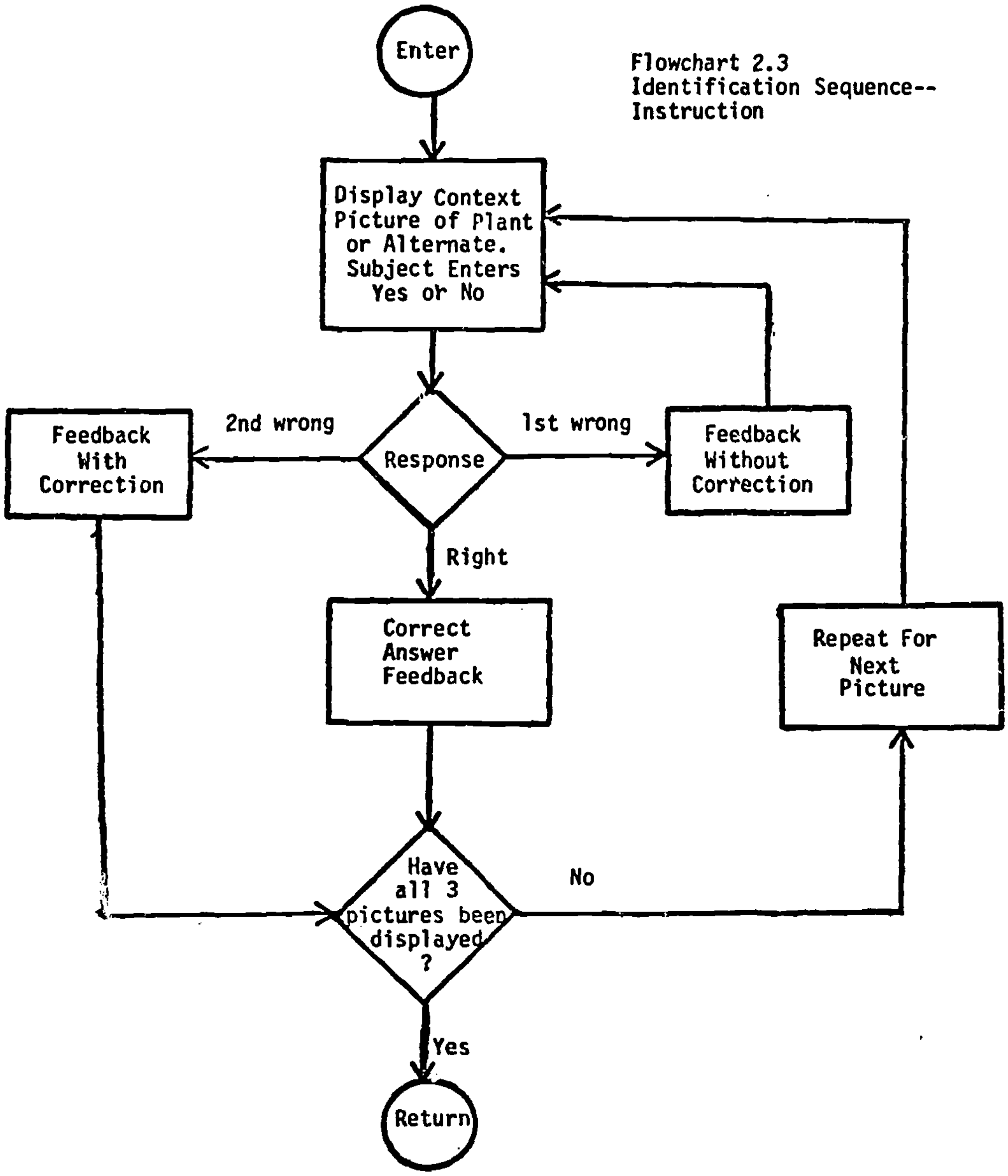


Flowchart 2.1.
Memory Aid Sequence



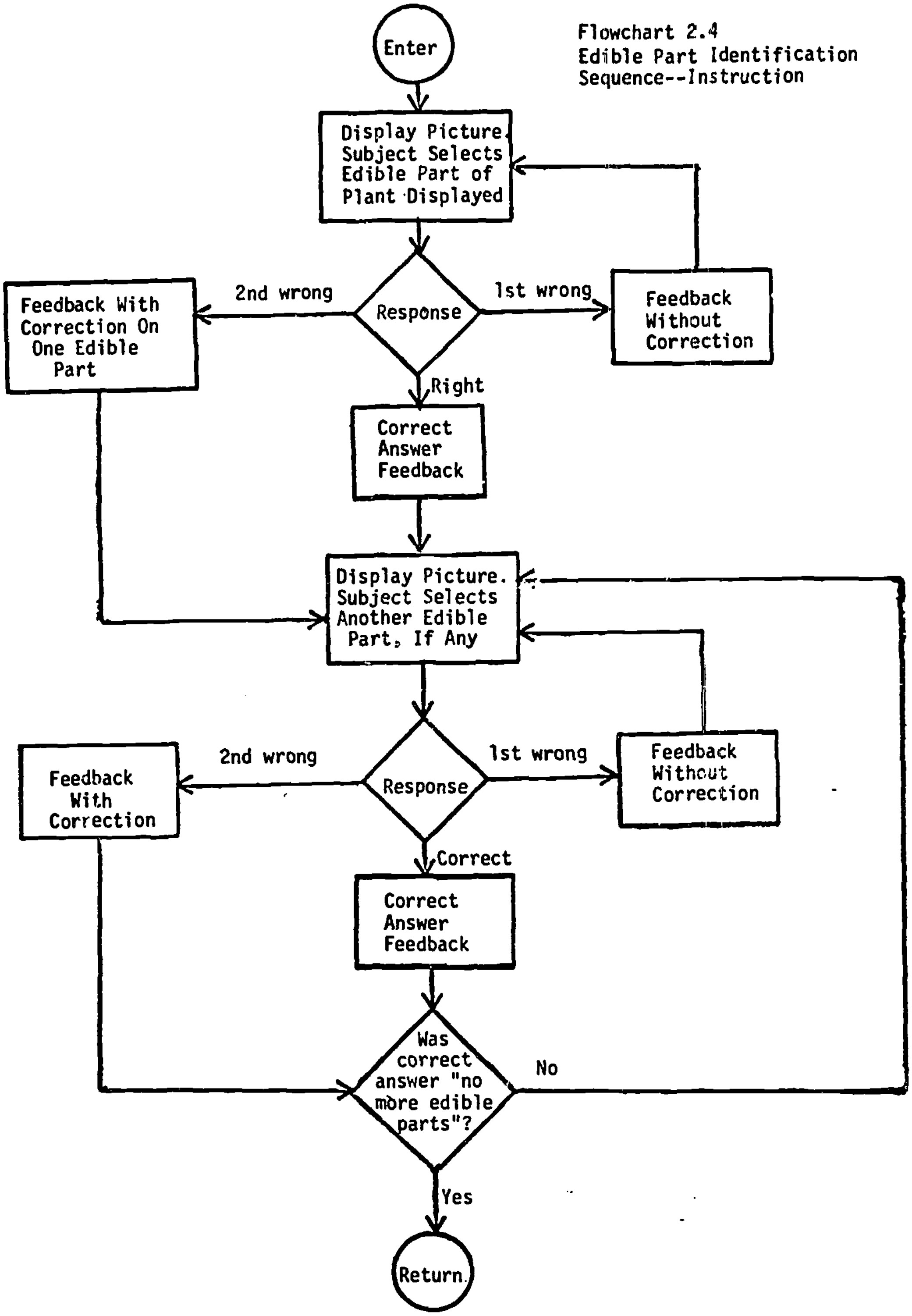


Flowchart 2.2
Picture Identification--
Instruction

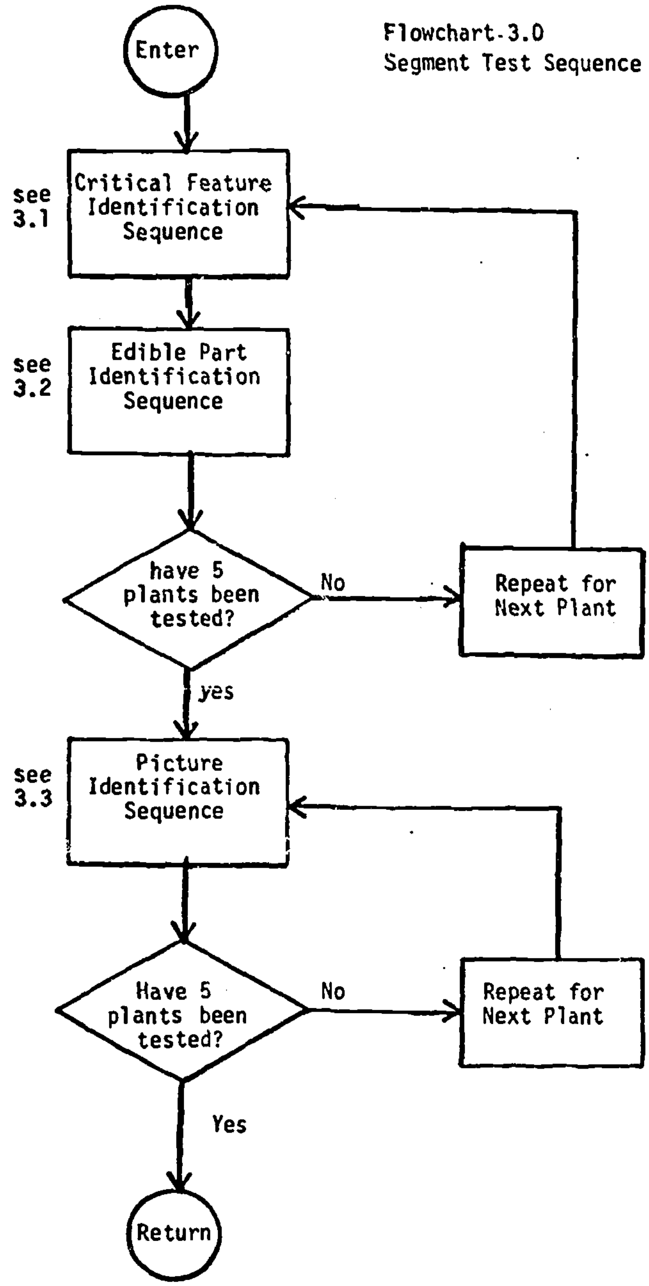


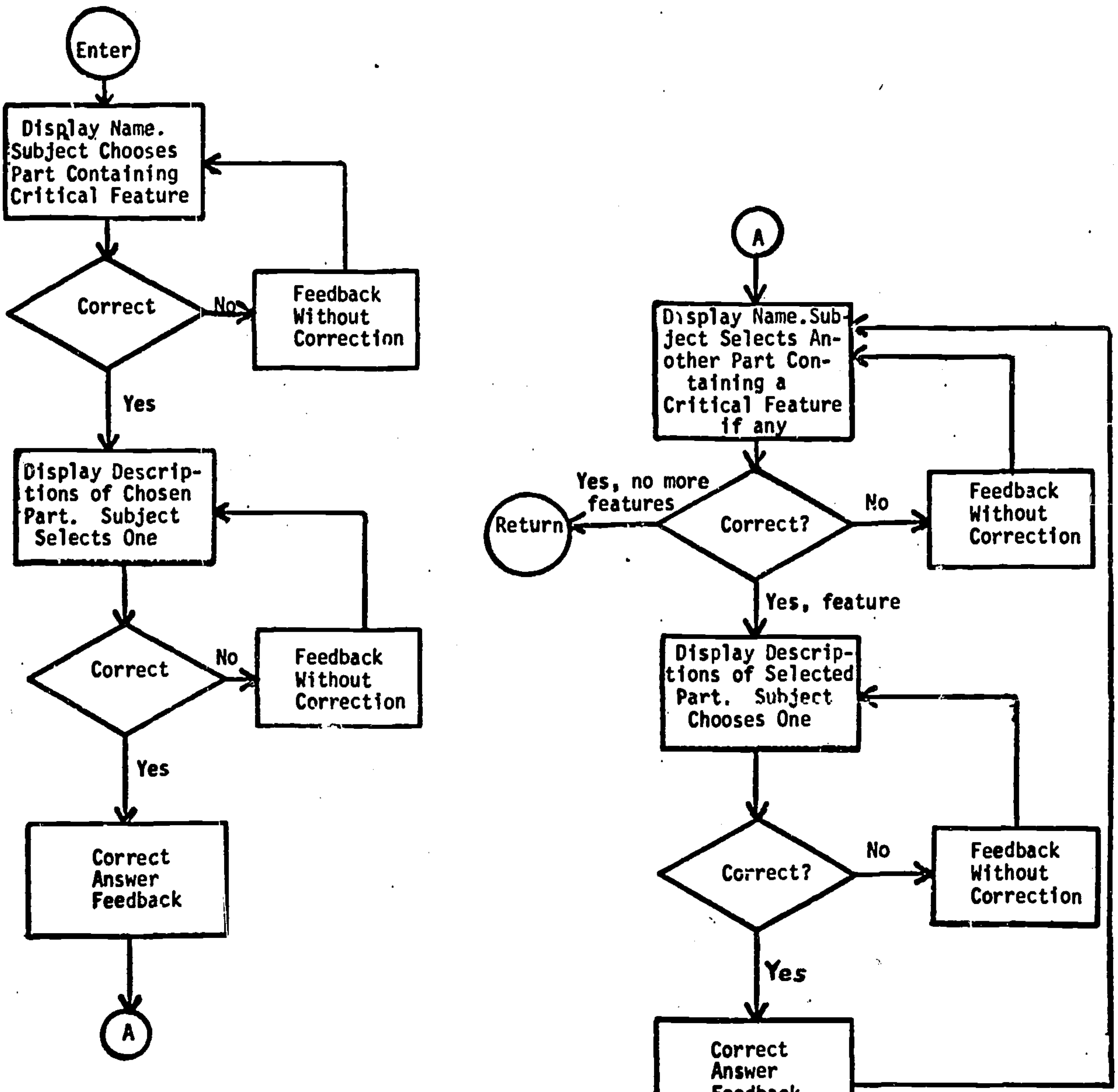
Flowchart 2.3
Identification Sequence--
Instruction

Flowchart 2.4
Edible Part Identification
Sequence--Instruction



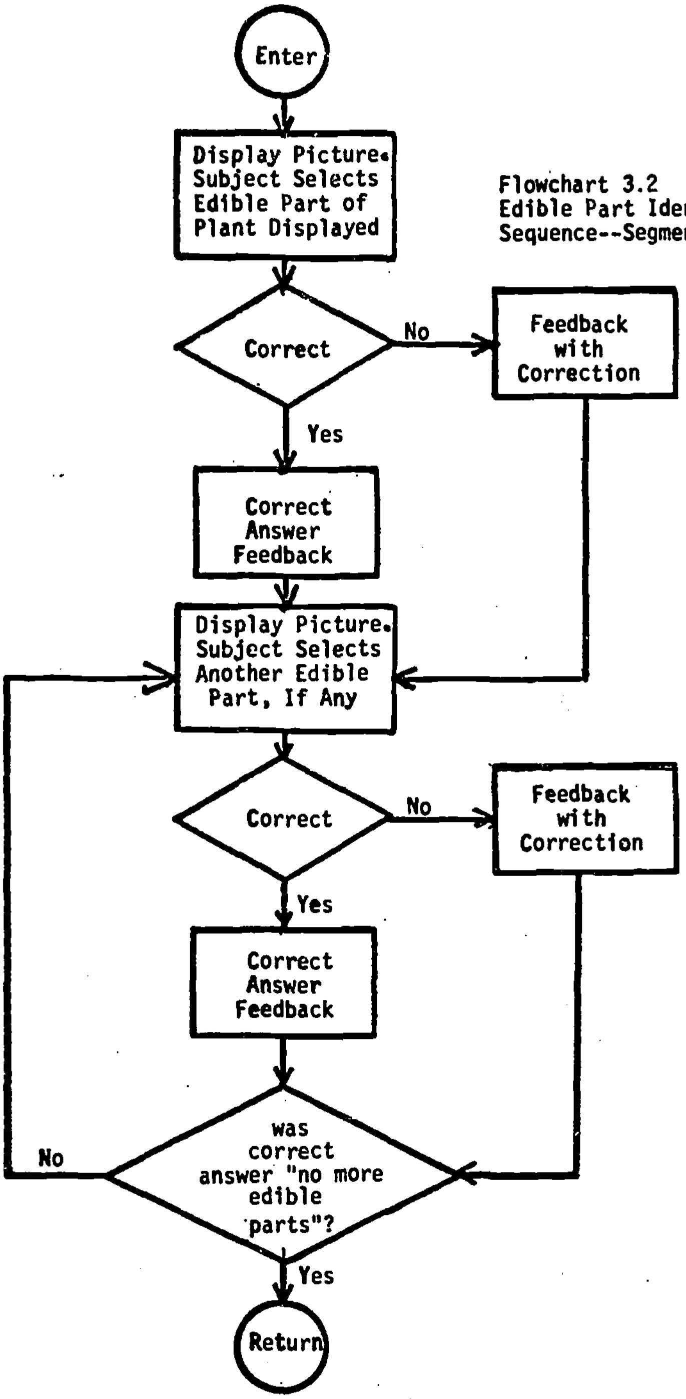
Flowchart-3.0
Segment Test Sequence



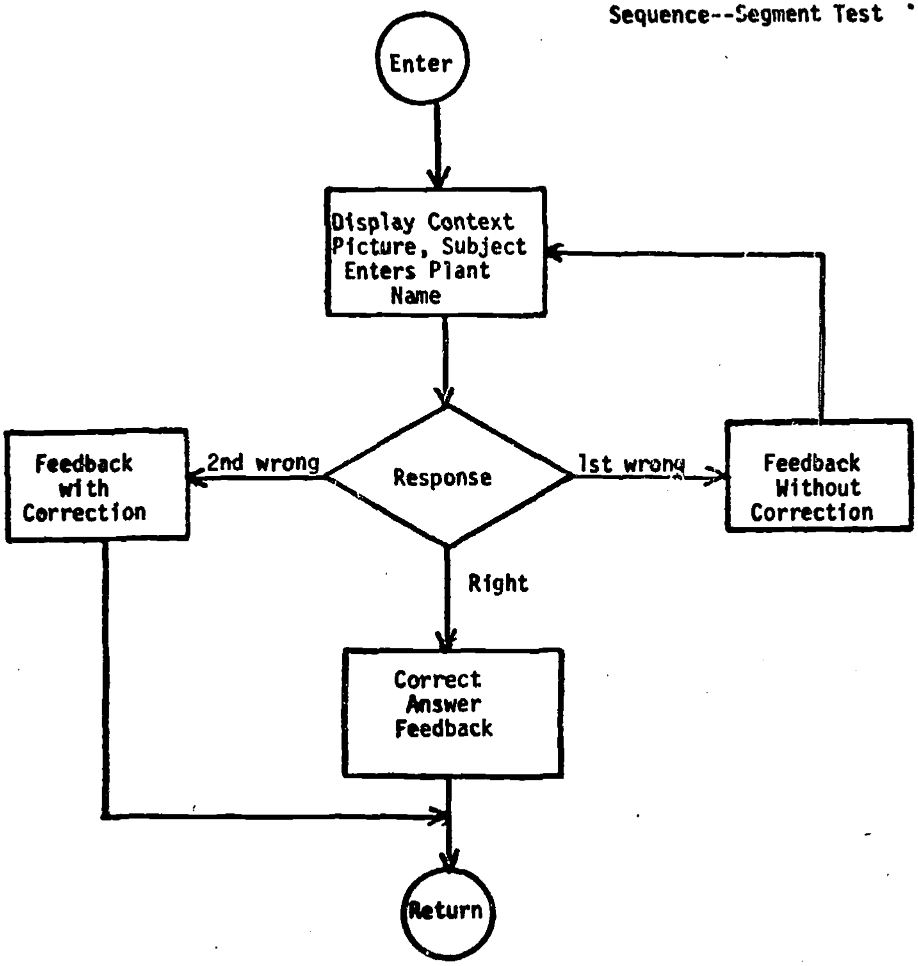


Flowchart 3.1
Critical Feature Identification
Sequence--Segment Test

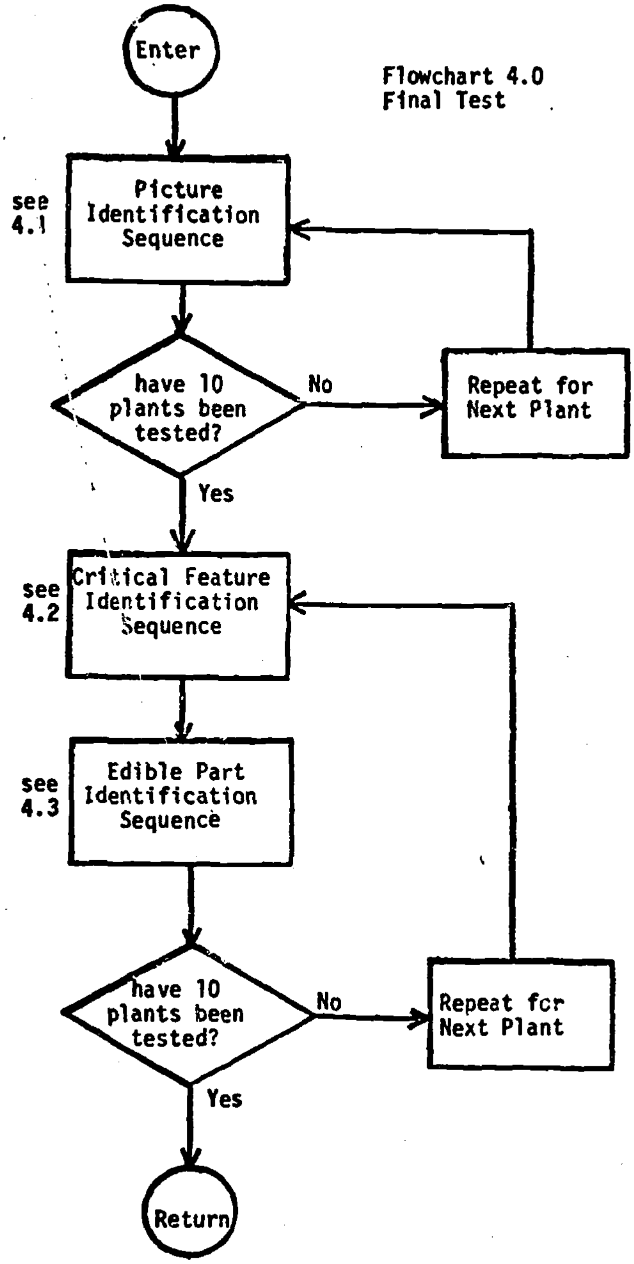
Flowchart 3.2
Edible Part Identification
Sequence--Segment Test



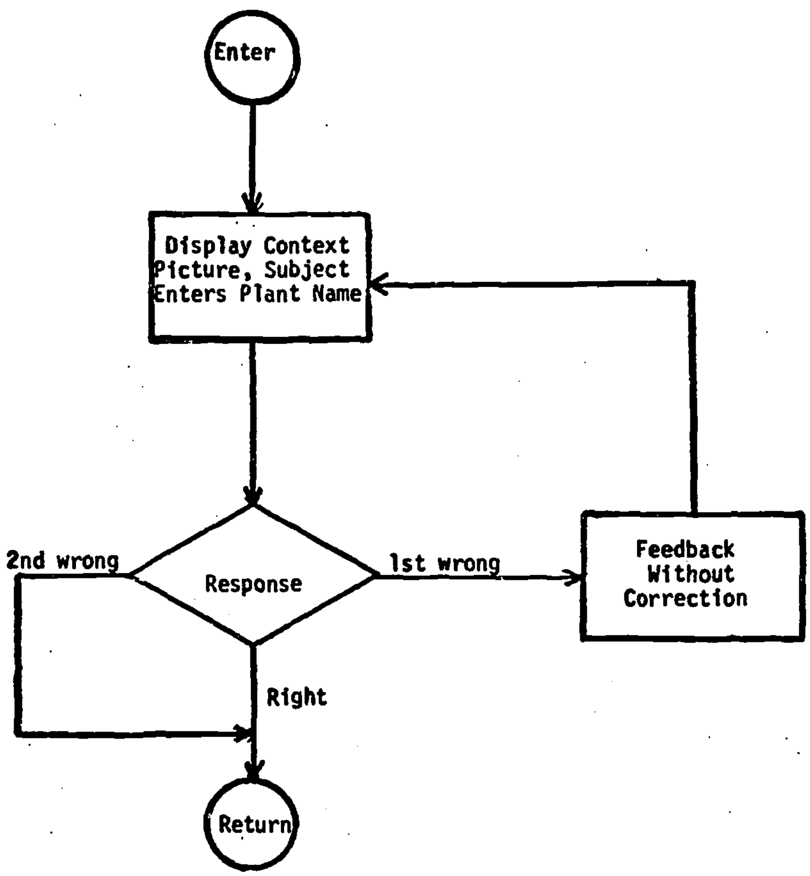
Flowchart 3.3
Picture Identification
Sequence--Segment Test



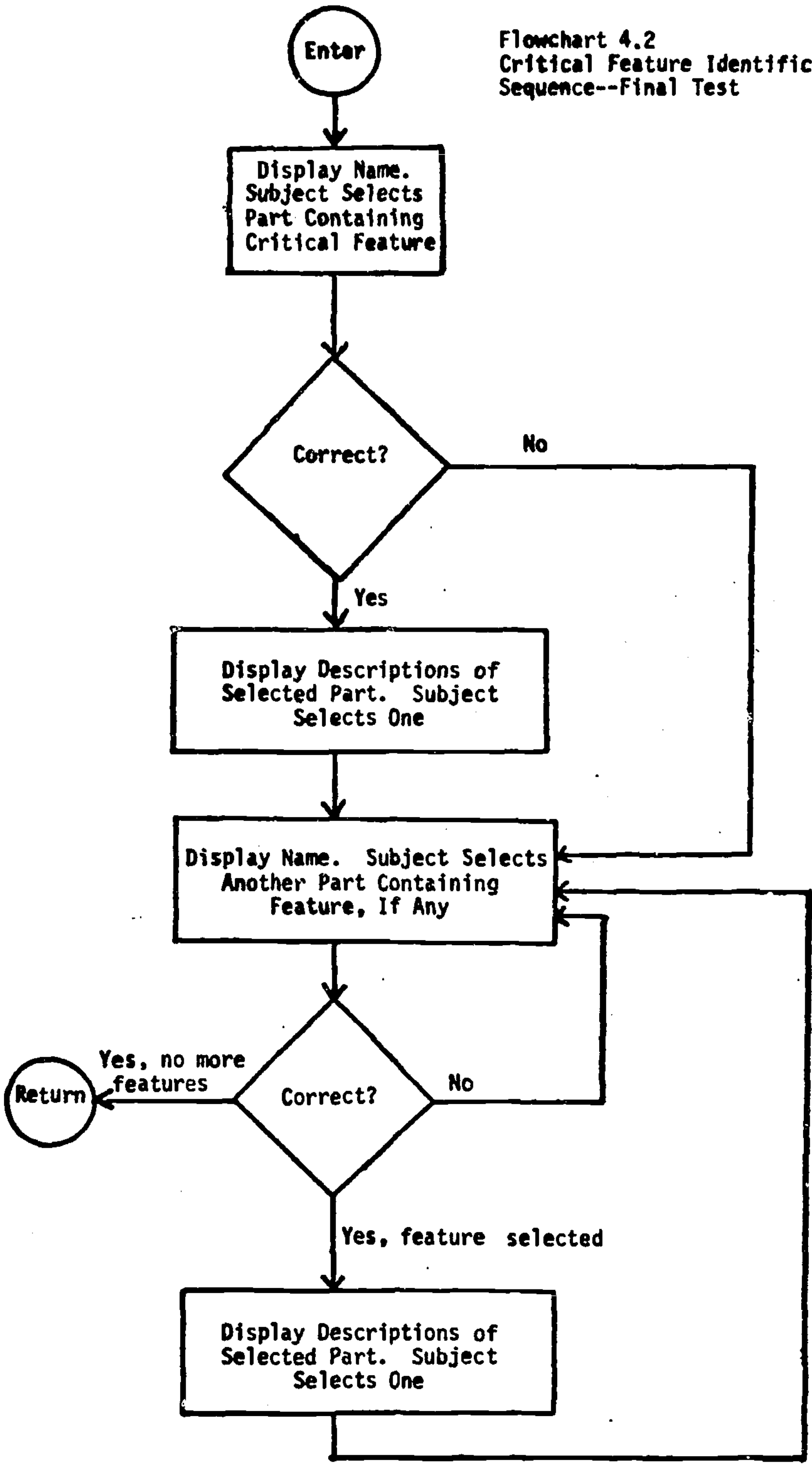
Flowchart 4.0
Final Test



Flowchart 4.1
Picture Identification
Sequence--Final Test



Flowchart 4.2
Critical Feature Identification
Sequence--Final Test



Flowchart 4.3
Edible Part Identification
Sequence--Final Test