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ABSTRACT

A study was made: (1) to determine whether children allowed to choose the difficulty levels of their arithmetic problems in a Computer Assisted Instruction (CAI) task would show greater engagement in learning than children who were not given a choice, (2) to discover possible patterns in the choices made, and (3) to determine the relationship of locus of control (LOC) attributions to engagement in the task. The subjects were 4th and 5th grade students, mostly Mexican-Americans, in a low-income school. Pairs of subjects were matched on age, sex, and initial achievement level in math. Subjects in both conditions used a modified form of the Math Drill and Practice program by Suppes, et al, 1974. Task specific attention or inattention and locus of control were measured. Among the major finds were: (1) that the choice group was significantly higher in engagement, (2) for both groups, engagement decreased significantly over a 15 day period; and (3) distinctive choice patterns did occur. The findings also showed that children will choose problems that result in poor academic performance; if performance in choice situations is to be improved, training methods that use information about children's unique patterns of choices should be designed. (Author/WCM)

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IN TEACHING

Technical Report No. 41

STUDENT CONTROL AND CHOICE: THEIR EFFECTS ON STUDENT ENGAGEMENT IN A CAI ARITHMETIC TASK IN A LOW-INCOME SCHOOL

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Introductory Statement

The Center's mission is to improve teaching in American schools. Its work is carried out through five programs:

- Teaching Effectiveness
- The Environment for Teaching
- Teaching Students from Low-Income Areas
- Teaching and Linguistic Pluralism
- Exploratory and Related Studies

This Technical Report represents part of the work of the program on Teaching Students from Low-Income Areas.

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Abstract

The purposes of this study were (a) to determine whether children who were allowed to choose the difficulty levels of their arithmetic problems in a CAI task would show greater engagement in learning than children who were not given a choice, (b) to discover possible patterns in the choices made, and (c) to determine the relationship of locus of control (LOC) attributions to engagement in the task. The subjects were fourth- and fifth-grade students, mostly Mexican-Americans, in a low-income school. Thirty-eight subjects were assigned to either a choice or a yoked control condition. Pairs of subjects were matched on age, sex, and initial achievement level (IAL) in math. The choice condition allowed the students to select problems at whatever level of difficulty they wanted; the yoked control condition presented the students with problems at preselected difficulty levels. Subjects in both conditions used a modified form of the Math Drill and Practice program, 1974, by Suppes, Searle, and Lorton.

Each subject participated in 15 CAI sessions. Task-specific attention or inattention was measured by an engagement/disengagement observation instrument used by observers during every CAI session to record the behavioral responses of each subject. A 28-item LOC measure with four dimensions (stable/unstable, control/no control, internal/external, and self/other) was administered three times to all subjects.

The major findings were as follows: (a) the choice group was significantly higher in engagement than the yoked control group; (b) for both groups engagement decreased significantly and disengagement increased significantly over the 15 days of the study; (c) a linear relationship was found between the difficulty levels of the problems worked by the choice group and the engagement levels of that group, i.e., the highest engagement levels were associated with the easiest problems and the lowest engagement levels were associated with the most difficult ones; (d) distinctive choice patterns ("maximizing" and "minimizing" patterns) did occur; (e) Maximizers chose problems below their IAL and had a high level of success in solving them, whereas Minimizers chose problems above their IAL and had a low level of success; (f) significant differences found between the choice and yoked control groups on three out of four LOC dimensions indicated that the choice condition produced more positive attributions; and (g) no significant correlations occurred in the choice group between LOC attributions and engagement, and only one such correlation was found in the yoked control group.

These findings show that children will choose problems that result in poor academic performance. It appears that if performance in choice situations is to be improved, training methods that use information about children's unique patterns of choices should be designed.

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Introduction

The initial purpose of this study was to identify curriculum difficulty levels associated with high and low levels of student engagement and disengagement in a computer-assisted instruction (CAI) task. The term engagement is used in this report to refer to positive behavioral indicators of student attention to the experimental task. Disengagement refers to behavioral indicators of inattention or nontask behavior.

After preliminary results from pilot data were analyzed, choice of difficulty level and perception of control were included as variables in the design. The study then focused on (a) the effects of difficulty level and choice of difficulty level on the engagement of students working CAI math problems, (b) possible patterns of student choices, and (c) the relationship of locus of control measures to choice of difficulty levels and engagement levels.

Difficulty Levels

The selection of CAI materials was complicated by the general lack of empirically validated criteria for selecting ranges of difficulty levels in curriculum programs. The program finally selected was the highly structured Math Drill and Practice program developed by Suppes, Searle, and Lorton (1974). The program presents basic arithmetic skills organized into fourteen types of problems (strands). Each strand contains problems labeled with grade levels that range from 1.0 to 7.5, approximations of the positions of similar problems in popular elementary mathematics curriculum sequences. The grade levels assigned to problems in the Math Drill and Practice program thus became the indicators of difficulty level for the present study.

Choice

The choice variable was operationalized by allowing some students in the sample to select their own problems from the CAI program and to decide, within limits, how long they would work with the computer. The assumption for the self-selection procedure was that children would choose problems with difficulty levels that produced optimal environmental stimulation (Berlyne, 1960; Fiske & Maddie, 1961). Hunt (1961) has said that those problems which are optimally stimulating will produce the correct match between a child's understanding and the difficulty levels of the curriculum. He also has argued that the Montessori method is effective simply because it allows children to choose problems to match their current state of knowledge and their level of intrinsic motivation, thus solving the "problem of the match" (Hunt, 1964).

Introducing choice in this manner made it possible to identify the self-selected difficulty levels that were related to the highest engagement levels. On the basis of Hunt's statements about the matching process (1961, 1964), it was predicted that students would initially choose problems with grade level designations similar to their current achievement grade levels, and would then choose more difficult levels later in the task. It was therefore hypothesized that children would use choice strategies to optimize their learning--for example, gradually selecting more difficult problems and correctly responding to a relatively high percentage of these problems. Such a choice strategy might be expected to yield feelings of success in working "hard" arithmetic problems and hence lead to improved engagement and academic status. The strategy would be reflected on the computer program by the choice of more difficult problems following a high percentage of correct responses and by the choice of easier problems following a low percentage of correct responses. A student who used this strategy might substantially improve his arithmetic achievement level and also maintain high levels of engagement.

In addition to providing a means for identifying highly engaging arithmetic difficulty levels, this study also permitted determination of whether the choice variable per se was associated with high engagement levels.

Student choice is an important feature of the current interest in open education models as a method of improving student motivation and performance (Hearn, Burdin, & Katz, 1972; Silberman, 1970). There is some evidence that educational settings in which students control their classroom goals and activities increase motivation to solve academic problems (Alschuler, 1969). The choice condition in this study simulated one aspect of the open school setting--the selection of curriculum difficulty levels. The effect of choice on engagement levels in this study was determined by comparisons between subjects who chose difficulty levels of problems and others who were required to work problems at the same difficulty levels. If engagement is viewed as a behavioral indicator of motivation, the results here are directly applicable to open education models.

Perception of Control

Student choice can affect another important subject variable--the source to which students attribute responsibility for their performance in academic situations. De Charms (1972) found that students in classrooms that present opportunities for making choices were likely to believe that they, rather than the teacher or other external source, had control of their learning.

The term locus of control is used here to refer to factors which the student sees as responsible for his performance in a learning task. A Locus of Control measure (LOC) was constructed for this study; it contained four dimensions of attribution of outcome in the learning task. In addition to the usual dimension of internal/external attributions, a stable/unstable dimension and a control/no control dimension were included. A self/other dimension, which was unique to this study, was also examined. The measure is in Appendix F.

Experimental Questions

The current interest in applying open education models to low-income area schools (Silberman, 1970) should elicit research to investigate how these settings affect student motivation and engagement. Researchers have stated that "disadvantaged" children can learn more effectively in classrooms where independent activities are encouraged (Hunt, 1967; Kohlberg, 1968). Although Hunt and Kohlberg concentrated on how the Montessori method increased intrinsic motivation and attention among preschool children, other choice situations at higher grade levels might also produce improvement. The present investigation of locus of control attributions, choice variables, and their effects on engagement may be particularly important for understanding the effects of open education models on students in low-income area schools.

Five questions were designed to determine the relationships between student choice, problem difficulty levels, locus of control attributions, and engagement.

1. Does the opportunity to choose difficulty levels of arithmetic problems increase engagement and decrease disengagement for subjects on a CAI task?
2. Is engagement highest when subjects choose difficulty levels that match their initial achievement levels and lowest when they select difficulty levels that are most different?
3. Do identifiable choice patterns emerge from the selections of subjects in a CAI task?
4. Does giving subjects a choice of difficulty levels affect the locus of control attributions they make?
5. Is there a correlation between the locus of control attributions and the engagement or disengagement of subjects on a CAI task?

Design

Two groups of 19 subjects were selected from fourth- and fifth-grade students with no previous CAI experience. The first group (choice group) was randomly selected; subjects for the second group (yoked control group) were selected to form pairs matched on age, sex, and initial achievement level in math with the choice group subjects. The computer program was modified so that choice group subjects were allowed to request problems that were harder, easier, or the same level of difficulty during the CAI lessons. Problems for subjects in the voked control group were tied to the difficulty levels chosen by their choice group counterparts. All subjects worked on the computer a maximum of 35 minutes per day for 15 days. Observers recorded engagement and disengagement levels for individual students in ten-second intervals on an Engagement/Disengagement Observation Instrument designed for this study (see Appendix D). The Locus of Control measure was administered to each subject before the third and eighth day on the computer and during a follow-up interview at the completion of the series.

Methods

The Sample

This research was conducted at an elementary school in California. The district administration considered the attendance area surrounding the school to be low-income, and the school received Title I funds which were applied to maintaining a separate building for language arts instruction. Grade levels at the school ranged from first through fifth. Approximately 90 percent of the students in these grades were from Mexican-American families.

Contact with the principal and teachers began in the fall of 1971 when the research staff met with them to describe plans for the study. As a result of this meeting, the research was permitted, and an informal contract specifying conditions of reciprocity between the school and research staffs was drawn up (Appendix A). During 1972 a computer program that would be responsive to the students' choices was developed, and the experimental procedures to be used in the study were designed. The study was conducted between January and June 1973

Subjects for the study were selected from three fifth-grade and two mixed fourth- and fifth-grade classes. Nineteen students were randomly selected to form the choice group from a pool of 100 who had no previous CAI experience. A matching procedure was then used to select 19 more students from the pool for the yoked control group. Each subject in the yoked control group was matched to a subject in the choice group on sex, age, initial achievement level in math, and, where possible, ethnic background and classroom teacher assignment. The assumption was that these variables (age, sex, etc.) could significantly affect performance on a CAI task.

Data for the initial achievement levels (IAL) used in matching subjects were based on achievement test scores from the computation sections of the Metropolitan Achievement Test or the Stanford Achievement Test, which had been administered during the fall of 1972. It was impractical to readminister tests immediately before the study began. Both achievement tests measured the same types of arithmetic skills, and norming procedures were similar. IAL's used in the actual matching process were adjusted by adding one-tenth of a point to the achievement test scores for each month that had elapsed from the time of test administration to the time the students began working on the computer. This procedure yielded an estimate of IAL congruent with the assumptions on which the tests are based, i.e., that achievement scores normally increase by one-tenth of a point per month during the school year.

After matching on sex, age, and IAL, the attempt was made to match subjects on ethnicity and classroom assignment. The ethnic background of the students and the classrooms from which they were selected are listed in Appendix C. Twelve pairs of choice and yoked control subjects were Mexican-American, two pairs were Black, and the remaining five pairs included students from two different ethnic backgrounds. In ten of the pairs, the two subjects were from the same classroom. Demographic characteristics of the choice and yoked control groups are shown in Table 1. The IAL for each subject is given in Appendix B.

Experimental Settings and Apparatus

The CAI teletypewriters used in this study were located in a room which was separated from the classrooms. Two machines were placed next to each other near one end of the room and three-sided partitions were set up around each machine. A subject could observe both teletypewriters upon entering the room, but it was difficult for him to see the adjacent machine once he was seated.

TABLE 1

Demographic Characteristics of the Sample

Characteristics	Choice Group Mean	Choice Group s.d.	Yoked Control Group Mean	Yoked Control Group s.d.
School Grade	4.8	.42	4.8	.42
Initial Schievement Level	3.7	.68	3.7	.70
Males	10		10	
Females	9		9	
Age (in months)	128		130	

A previous investigation by Hess and Tenezakis (1970) demonstrated that CAI had intense attracting influences on students. Preliminary research during the six months prior to the present study indicated that competing stimuli might counteract these influences and provide increased and more variable disengagement scores for the CAI task. Pictures and toys were placed in the CAI room to provide competing stimuli for the attraction and novelty of the teletypewriter. Pictures of farm animals and pets were hung along the sides of each partition where they could be seen by the subject. A large poster of nursery rhyme characters and a mobile of bird figures were placed in front of the subjects at an angle which was approximately 30 degrees above their line of vision. Strings run between the mobile and the teletypewriters allowed subjects to activate the bird figures. Two finger puppets and a battery-operated toy slot machine were placed on tables to the left of each teletypewriter. Subjects received no tangible rewards (such as money or candy) for playing with the toys; the only observable incentive was the point score accumulated on the slot machine for various combinations of oranges, cherries, and lemons.

The CAI room furniture also included chairs for observers behind each student and mirrors in front of each teletypewriter. The mirrors were attached to platforms approximately five feet high and tilted so that the observers could see the teletypewriters and the subjects easily.

The CAI Task

The basic curriculum in this study was the Math Drill and Practice program described by Suppes, Searle, and Lorton (1974). This program was selected because it represents a highly structured means for teaching fundamental arithmetic skills. Suppes et al. (1974, p. 3) described the major stipulations of the program as follows:

1. A student should master subordinate skills and concepts before moving on to those of greater complexity or difficulty, regardless of his grade placement in school. This implies that the set of problems comprising a single topic should be arranged in ascending order of difficulty and complexity.
2. The rate at which a student moves through a set of problems should depend on his level of performance, faster movement accompanying higher performance levels.
3. Progress through each part of the curriculum should be independent of performance on other parts.

In order to meet these criteria, the program was organized into 14 strands or classes of arithmetic concepts taught in grades one through six. The strands are listed in Table 2. Problems for each strand were designed after examining three popular textbooks used extensively in elementary schools across the United States, and grade levels were assigned to serve as labels for problem types and to describe the order in which problem types were placed in a strand (Suppes et al., 1974, pp. 5-6). These grade level assignments represent approximations of the position of the problems in the program; they are subject to change as more student performance data are obtained.

The Math Drill and Practice program is organized to present problems which gradually change in difficulty level as a function of student performance. Two modifications of the program were made so that the effects of difficulty levels requested by the choice subjects could be studied: (1) difficulty levels of problems were controlled by the requests of choice group subjects, and (2) the problems remained at a particular difficulty level until the subject selected a higher or

TABLE 2

Arithmetic Strands Worked by the Subjects

Strand	Grade Level Lowest	Grade Level Highest
Number Concepts	1.0	7.5
Horizontal Addition	1.0	3.5
Horizontal Subtraction	1.0	3.0
Vertical Addition	1.0	5.5
Vertical Subtraction	1.5	5.5
Equations	1.5	7.5
Measurement	1.5	7.5
Horizontal Multiplication	2.5	5.0
Laws of Arithmetic	3.0	7.5
Vertical Multiplication	3.5	7.5
Division	3.5	7.5
Fractions	3.5	7.5
Decimals	4.0	7.5
Negative Numbers	6.0	7.5

lower one. These modifications provided a curriculum setting that produced data concerning the choices of difficulty levels made by choice subjects, the difficulty levels of the problems they worked, the number and type of problems worked by all subjects, and the percentage of correct responses to problems for all subjects. This information was produced at a much faster rate and in greater detail than would be possible in the usual classroom setting.

Choice group program. At the first CAI session, problems began at the first difficulty level (grade level 1.0) so that choice group subjects could attain a high level of initial success and thus reduce their anxiety about the task. The program then presented problems of ascending difficulty levels if the subjects asked for more difficult problems. During each subsequent session, choice group subjects worked the problems presented by the computer for approximately 15 minutes before they were given a choice of difficulty levels. At the end of 15 minutes, a series of questions appeared on the typewriter.

> Do you want more problems? Type Y or N.
>
> Do you want harder, easier, or the same types of problems? Type H, E, or S.
>
> Do you want a little, a medium amount, or a lot harder/easier problem? Type 1 - a little, 2 - a medium amount, or 3 - a lot. (Difficulty level was adjusted by .3, .6, or .9 of a grade level for the last request.)

If a subject typed N for the first question, the lesson was terminated for that day. If a subject continued working, he/she received a new series of problems for approximately five minutes, followed by another set of the questions. Three more five-minute periods could be worked if the subject elected to continue. Time intervals during question periods varied somewhat because the subjects controlled the time when the new problems would appear; the problems appeared only after the return key on the teletypewriter was pressed. The maximum time for working problems was approximately 35 minutes.

The problems were divided into one 15-minute period and four five-minute periods to provide the most effective conditions for measuring student engagement and disengagement. Preliminary research with CAI indicated that behavior would become relatively stable over a 15-minute period, and that a question period preceding each subsequent five-minute period would provide a reasonable number of opportunities for choosing problem difficulty levels.

Choice group subjects could select difficulty levels ranging from 1.0 to 7.5; if a subject was working at level 1.0, he could ask to receive easier problems during the next period, but he would still receive level 1.0 problems since these were the easiest ones available. Similarly, subjects working at level 7.5 would continue to receive problems at this level when they requested harder ones.

Information concerning the cumulative number of problems worked and the difficulty levels of these problems was printed at the beginning of each lesson, about every five minutes during the 15-minute period, at the beginning of each subsequent five-minute period, and at the end of each lesson. The cumulative number of problems worked was computed daily.

Subjects typed their answers to the problems on the teletypewriter. If the solution was correct and was typed in during a 20-second response interval, the words "Good," "Okay," "All right," or "Correct," appeared. An incorrect response was followed by "No, try again." If the subject gave an incorrect answer the second time, the correct solution appeared and the problem was presented a third time to elicit the correct response. If there was no response during a 20-second pause, "Time is up, try again" appeared on the printout.

After the first session, subjects began each day with problems at the difficulty level of the ones they had last worked. All subjects worked 15 daily lessons on the computer.

Yoked control program. The starting point for these subjects in the first session was also the difficulty level of 1.0. Problems for this group were also divided into an initial 15-minute period followed by five-minute blocks of problems, but there were no options to stop working or to select difficulty levels. The time intervals between five-minute periods were filled with "machine chatter" which continued for approximately the same length of time as the questions and responses on difficulty levels for the choice group subjects. Yoked control subjects worked for the same length of time as their choice counterparts had each day, and at about the same difficulty levels.

Experimental Procedures

A detailed description of the procedure followed by the observers in introducing subjects to the task is presented in Appendix E. The primary goal was to show the subjects how to operate the teletypewriter, and to explain what types of information they would receive from the computer. Subjects were informed that they would work on the computer for 15 days, that they could play with the toys any time they wanted to, and that the observers would be seated behind them to record their responses while they worked on the teletypewriters. They were also shown how the mirrors and a beeper box for timing the ten-second observation intervals worked. All subjects were given this information either individually or in groups of two immediately before the first lesson.

The LOC measure (Appendix F) was administered in the CAI room before the third and eighth days. It was readministered during an interview after the subjects finished working on the CAI program. The major purpose of the interview was to ascertain why certain types of choice patterns appeared among the subjects in the choice group.

The observers started each day by bringing two of the subjects into the CAI room. If one subject stopped working on a lesson sooner than the other one, a third subject was brought from a classroom. Each subject followed the same daily time schedule for working lessons, and approximately eight worked on the teletypewriters each day. Pairs of choice and yoked control subjects did not work their lessons at the same time, but an attempt was made to arrange the schedules so that their 15 days on the computer fell within a four- to five-week span.

Instruments

Engagement/Disengagement Observation Instrument and Observer Training

The behavioral responses of each subject were recorded on an observation instrument which included ten engagement and four disengagement categories (Table 3). Appendix D contains the definitions of these categories. At ten-second intervals, the observers checked all of the engagement and disengagement response categories which a subject had evidenced during that interval. Since the children were allowed to play with any of the various toys (finger puppets, toy slot machine, mobile) while they worked on the computer, their responses to the toys were also incorporated into the Engagement/Disengagement Observation Instrument. It should be noted that this instrument was not a measure of student response rates because only the first response which

TABLE 3

Behavioral Categories for the Engagement/Disengagement Observation Instrument

Engagement	Disengagement
1. Eyes on teletype paper (EP)	1. Looks away from the teletype (LA)
2. Eyes on teletype paper while playing with toys (EP-T)	2. Looks away from the teletype to play with toys (LA-T)
3. Touches teletype keys (TK)	3. Turns away from the teletype (TA)
4. Touches teletype keys while playing with toys (TK-T)	4. Turns away from the teletype to play with toys (TA-T)
5. Pulls closer to teletype (PC)	
6. Touches teletype paper (TP)	
7. Reads the arithmetic problems silently (RS)	
8. Talks to self about the problems (TS)	
9. Counts on fingers (CF)	
10. Surprise (S)	

occurred within each category during a ten-second interval was recorded by the observers.

Three observers were trained to use the Engagement/Disengagement Observation Instument in practice sessions at the Stanford Center for Research and Development in Teaching. Sessions were approximately two hours long and occurred three days per week for a month. Observers practiced recording the engagement and disengagement of students on videotaped CAI lessons. Feedback was given concerning the accuracy of these observations from a research assistant who supervised this phase of the training. Further practice sessions and feedback were also provided in the school during a two-month period prior to the beginning of the study. The observers worked with several of the fifth-grade pupils who were not included in the study during this time; they also rehearsed the experimental procedure to be followed with the choice and yoked control groups.

Reliability. Reliability data for the Engagement/Disengagement Observation In trument was obtained by recording interobserver agreement for ten-second intervals. Reliability measures were obtained on twelve different occasions from January through May of 1973 and were based upon the observations of three different observer pairs. Table 4 shows the average percentage of agreement among all 3 pairs of observers.

TABLE 4

Percentages of Interobserver Agreement for Engagement/Disengagement Observation Instrument Categories

Categories	Mean Agreements First 15 Minutes (n = 12)	Five-Minute Blocks (n = 7)
Engagement		
Eyes on paper - plays with toys	.99	.80
Touches keys - plays with toys	.95	.70
Pulls closer	.99	1.00
Touches paper	1.00	.98
Reads silently	.95	.97
Talks to self	.93	.93
Counts on Fingers	.98	1.00
Disengagement		
Looks away - plays with toys	.95	.95
Turns away - plays with toys	.99	.99

Some categories were combined in order to give single measures of interobserver agreement. This procedure was followed because these combined categories included similar behaviors. The Surprise category responses were not analyzed since so few of them occurred.

Engagement/disengagement rating scale. In order to measure the intensity of subject behaviors, every ten-second observation interval was assigned two separate ratings, one for engagement and one for disengagement. Ratings ranged from zero to four for both categories. To determine ratings for various combinations of behaviors, six members of the research staff and the three observers rated each combination that occurred in the data; high agreement levels were established after several periods of discussion and rating. Examples of behavior combinations and ratings are shown in Table 5.

Ratings assigned to each ten-second interval on the Engagement/Disengagement Observation Instrument were summarized by computer into average engagement and disengagement levels during the five-minute periods and the 15-minute periods the subjects worked on the CAI task. The 15-minute periods were also divided into three five-minute periods for this and other data analysis. The five-minute period data were used to calculate mean engagement and disengagement levels per day for the subjects; daily engagement and disengagement levels were then used in the statistical analysis.

The Locus of Control Measure

The LOC measure contained 28 items; each item contained a stem followed by two possible responses. For example:

> If I do well on my computer math problems, it is because
>
> ________ I tried hard
>
> ________ Just good luck, I guess

Four stems were used; two described successful outcomes and two described failure. The success stems were: "If I do well on my computer math problems, it is because . . . ," and "When I finish a computer math problem quickly, it is because . . . ." The failure stems were: "If I don't do well on my computer math problems, it is because . . . ," and "When it takes me a long time to do a computer math

TABLE 5

Examples of Behavior Combinations and Engagement/ Disengagement Scale Ratings

Behavior	Rating
Engagement	
No indicators	0
Pulls closer and touches keys <u>or</u> Eyes on paper and touches key(s) with toy	1
Eyes on paper and touches key(s) <u>or</u> Eyes on paper and pulls closer	2
Eyes on paper, touches key(s), and pulls closer <u>or</u> Eyes on paper, touches key(s) and touches paper	3
Eyes on paper, touches key(s), pulls closer, and touches paper <u>or</u> Eyes on paper, touches key(s), pulls closer and reads silently	4
Disengagement	
No indicators	0
Looks away	1
Turns away <u>or</u> Looks away to play with toys	2
Turns away to play with toys <u>or</u> Turns away and looks away to play with toys	3
Looks away to play with toys and turns away to play with toys <u>or</u> Turns away, looks away to play with toys, and turns away to play with toys	4

problem, it is because . . . ." Each stem was used for seven items. Pairs of alternatives followed each of the two stems for success and each of the two stems for failure. The pairs of responses involved attributions of effort, ability, task difficulty, luck, and choice.

The response alternatives for success and failure on effort, for example, were: "I tried hard," and "I didn't try hard enough."

The alternatives for choice attributions were different for the yoked control subjects than they were for the choice subjects. Choice subjects received the alternatives: "I asked for the right problems," and "I didn't ask for the right problems." Yoked control subjects received: "I let the computer give me the right problems," and "I didn't let the computer give me the right problems." The LOC measure is in Appendix F.

Locus of control scores. Frequencies of effort, ability, task difficulty, luck, and choice attributions were tabulated separately for success and failure alternatives for each subject. These frequencies were then combined to produce attribution for success and attribution for failure scores on each of four dimensions: stable/unstable, control/no control, internal/external, and self/other.

The stable/unstable dimension was found by Weiner (1972) to be related to changes in expectations of success or failure. It can be confounded with the internal/external dimension for some LOC measures. Stable refers to the attribution of an outcome to stable, unchanging factors; unstable refers to attribution of the outcome to variable factors. In this study, the score for the stable/unstable dimension was the number of attributions to ability when the alternative was effort, luck, or task difficulty (six comparisons).

Control was defined as the attribution of outcomes to factors that can be changed; no control as the attribution to random or predetermined factors. The control/no control dimension score was obtained from the number of attributions to effort or task difficulty when the alternative was either ability or luck (eight comparisons).

The internal/external dimension is the one tapped by most LOC measures. Attribution of outcome in this dimension is either to something about the subject himself (internal) or to a source outside the subject (external). In this study an internal/external score was assigned on the basis of the number of attributions to ability or effort when the alternatives were task difficulty or luck. Separate scores were derived for success and for failure alternatives; eight comparisons were used for each score.

The self/other dimension was unique to this study. The attribution of outcome to factors under the subject's own control were considered self; attributions to controllable factors where control lies with someone or something other than the subject were considered other. The self/other score was based on the number of attributions to choice or effort when the alternative was task difficulty (four comparisons).

A test-retest reliability analysis of the LOC measure showed that the average measure of internal consistency calculated by the Spearman-Brown formula for the four dimensions was .77. Appendix G contains the details of this analysis.

Results

Performance Data

Both the choice and the yoked control groups of subjects spent an average of 4.3 five-minute periods per session on the computer (s.d. = 1.2). Some discrepancies in difficulty levels between the pairs of subjects were apparently caused by a slight upward drift of the problems when choice group subjects requested problems of the same difficulty. The average difficulty level of problems worked by the choice group was 2.5, for the yoked control group it was 2.3. Table 6 shows mean difficulty levels of problems worked, percentages of correct responses, and number of problems worked per five-minute period for each of the 19 pairs of subjects.

The percentage of correct responses and number of problems worked for the two groups were compared using a t test. Significant differences were found in both instances ($p < .01$); means for the choice group were lower than those for the yoked control group ($t = -2.63$ and $t = -4.97$ for percentage correct and number of problems, respectively).

Engagement and Disengagement Levels

To test the construct validity of the engagement and disengagement

TABLE 6

Mean Difficulty Levels, Percentage of Correct Responses, and Number of Problems Worked in Five-Minute Periods

	Choice Group			Yoked Control Group		
Pair Number	Difficulty Level	Percentage Correct	Problems Worked	Difficulty Level	Percentage Correct	Problems Worked
1	3.7	60%	16	3.7	62%	25
2	1.3	92	38	1.0	98	48
3	1.3	89	43	1.0	97	53
4	1.2	95	45	1.2	86	55
5	1.2	94	51	1.1	92	55
6	1.6	84	30	1.5	90	36
7	1.1	94	49	1.0	96	47
8	1.5	84	44	1.3	96	58
9	1.2	87	34	1.1	87	52
10	6.7	45	10	6.7	53	15
11	2.1	93	26	1.9	98	35
12	2.1	81	24	1.9	91	47
13	6.9	51	15	7.0	59	14
14	3.3	70	17	3.2	76	22
15	1.4	90	35	1.2	93	52
16	1.5	88	39	1.0	93	55
17	1.8	78	33	1.6	98	38
18	2.2	95	36	1.6	81	30
19	5.5	41	11	5.6	50	16
$\overline{X}$	2.5	80%	31	2.3	84%	40
s.d.	1.9	18	13	2.0	16	15

measurements, correlations between average engagement and disengagement levels across the 15 days of the CAI sessions were computed. For the choice group subjects, mean engagement and disengagement levels were correlated -.60 ($p < .01$); for the yoked control subjects the correla- was -.25. These negative correlations appear to support the construct validity of both the Engagement/Disengagement Observation Instrument and the Engagement/Disengagement Rating Scale, since they indicate the expected relationship between the two dependent variables. High engagement levels were more likely to be associated with low disengagement; and low engagement levels tended to be associated with high disengagement levels.

The first experimental question asked whether the opportunity to choose problems of various difficulty levels would increase engagement and decrease disengagement levels for subjects on a CAI task. Comparisons of engagement levels for choice and yoked control subjects showed that students who chose difficulty levels displayed higher levels of engagement than students who had no choice.

Two procedures were used to compare levels of engagement and disengagement for the two groups of subjects. First, levels for the ten-second observation intervals within the five-minute periods were arranged for inspection. Table 7 shows these levels for the two groups; the choice group appears consistently higher in engagement than the yoked control group. No statistical tests were applied to these figures because the number of subjects in periods four through seven varied as a function of the choice group subjects' decisions to terminate or continue after the first 15 minutes.

The second procedure used to compare levels of engagement and disengagement for choice and yoked control groups employed an analysis of variance. One ANOVA was done with difference scores obtained by subtracting the engagement level mean of each yoked control subject from the engagement level mean of the choice member of the pair for each of the 15 days on the computer. A second ANOVA used disengagement difference scores.

TABLE 7

Mean Engagement and Disengagement Levels for
Five-Minute Periods on the CAI Task

Levels	Periods 1	2	3	4	5	6	7
Engagement							
Choice Group	2.20	2.17	2.17	2.19	2.16	2.10	2.15
Yoked Control Group	2.06	2.06	2.07	2.06	1.98	1.96	1.96
Disengagement							
Choice Group	.20	.20	.20	.19	.24	.19	.19
Yoked Control Group	.20	.18	.17	.29	.17	.18	.22

The ANOVA model used here is analogous to a t test for paired data. It should be noted that the difference scores represent different experimental conditions and are not pretest-posttest comparisons. ANOVA results for engagement difference scores are summarized in Table 8;

TABLE 8

Summary of the Analysis of Variance of
Engagement Difference Scores

Source	Sum of Squares	Degrees of Freedom	Mean Square	F
Groups	3.96	1	3.96	5.03*
Sex	0.31	1	0.30	0.39
Pairs (within sex)	13.39	17	0.79	
Days	1.06	14	0.08	0.62
Days x Sex	2.65	14	0.19	1.46
Days x Pairs (within sex)	31.04	238	0.13	

*p < .05

disengagement results are in Table 9. Main effects tested were group (choice or yoked control), sex of subjects, and days on the CAI task (15); the error terms were pairs within sex and the interaction of days and pairs within sex. Only the main effect for group was significant ($F = 5.03$, $p < .05$). There were no significant main effects for sex or days.

TABLE 9

Summary of the Analysis of Variance of Disengagement Difference Scores (Logarithms)

Source	Sum of Squares	Degrees of Freedom	Mean Square	F
Groups	0.11	1	0.11	0.02
Sex	7.96	1	7.96	1.17
Pairs (within sex)	115.98	17	6.82	
Days	3.05	14	0.22	0.76
Days x Sex	5.04	14	0.36	1.24
Days x Pairs (within sex)	70.09	238	0.29	

Disengagement difference scores were subjected to logarithmic transformations for the ANOVA. No significant effects were shown in this analysis (Table 9).

Mean engagement and disengagement levels for the two groups are shown in Table 10. The mean engagement level for choice subjects is clearly higher than that for yoked control subjects. This difference is underscored by the finding that 16 of the 19 choice group subjects showed higher average engagement levels than their yoked control counterparts.

Another issue in the engagement and disengagement data was whether the engagement and disengagement levels for all subjects would change over the 15 days of CAI experience. The ANOVA model used here included days as the main effect and subjects repeated over days as the error

TABLE 10

Means and Standard Deviations of Engagement and Disengagement Levels for the 15 Days of CAI Experience

	Choice Group		Yoked Control Group	
	Engagement	Disengagement	Engagement	Disengagement
Mean	2.17	.21	2.05	.21
s.d.	.22	.17	.21	.16

term. This analysis indicated that a significant decline occurred in the engagement scores (Table 11) and a significant increase occurred

TABLE 11

Summary of the Analysis of Variance for All Engagement Scores from Days 1-15

Source	Sum of Squares	Degrees of Freedom	Mean Square	F
Subjects	37.60	18	2.09	
Days	4.14	14	0.30	2.12*
Subjects x Days	35.19	252	0.13	

*p < .05

in the disengagement scores (Table 12). In addition, the average number of five-minute periods worked on the computer declined between day 1 and day 15 (Table 13). These results suggest that there was a general lessening of interest in the CAI task for both groups of subjects.

TABLE 12

Summary of the Analysis of Variance for All Disengagement Scores from Days 1-15

Source	Sum of Squares	Degrees of Freedom	Mean Square	F
Subjects	8.63	18	0.48	
Days	5.94	14	0.42	5.09*
Subjects x Days	20.99	252	0.08	

*$p < .05$

TABLE 13

Summary of the Analysis of Variance of the Number of Five-Minute Periods Worked from Days 1-15

Source	Sum of Squares	Degrees of Freedom	Mean Square	F
Subjects	407.13	18	22.62	
Days	112.72	14	8.05	6.76*
Subjects x Days	300.30	252	1.19	

*$p < .05$

<u>The Relationship Between Engagement and Difficulty Levels</u>

The second experimental question was whether there would be a curvilinear relationship between engagement and the difficulty levels of the problems chosen by the students, i.e., were extreme discrepancies between initial achievement and the difficulty levels selected related to the lowest engagement and moderate discrepancies associated with the highest engagement? In order to determine how these variables were related, the average engagement levels per day were grouped into eleven categories, each category representing the difference between the IAL and the average difficulty level of the problems worked for one day. Statistical analysis was not used because the engagement means were not derived from completely independent data sources, i.e., the engagement scores for a subject could be included in more than one difference category.

The relationship between difference scores and engagement levels seemed to be more linear than curvilinear, i.e., the positive difference scores were generally associated with higher engagement levels and lower disengagement levels than were the negative difference scores. The choice group data in Table 14 indicate that engagement in the CAI task was highest when the difficulty levels of the problems worked were considerably lower than the subject's IAL. Similar results were found for the yoked control group. Hunt's (1961) statements about the problem of the match do not appear to be supported in these data; however, the choice patterns found for some of the subjects do shed some additional light on the choice-of-difficulty-level issue.

Choice Patterns

The third experimental question was whether patterns of student choice would emerge from the choice group data. Two such patterns were identified; one was shown by students who consistently chose to work easier or the same difficulty level problems while maintaining a high percentage of correct responses (mean of 91 percent). These subjects were labeled Maximizers since their choices had the effect of maximizing task performance.

A second pattern was shown by subjects who performed at much lower levels (mean of 53 percent correct responses) and consistently requested harder or the same difficulty level problems. Subjects who showed this second pattern were labeled Minimizers, since their choices had the effect of minimizing their performance levels on the task. Some of the choice group subjects made so few choices that no patterns could be seen; subjects who made fewer than nine choices during the 15 days were labeled Few Choice subjects.

TABLE 14

Relationship Between Difference Scores and Means and Standard Deviations for the Engagement and Disengagement of the Choice Group

Ranges of Difference[a] Scores	N	Engagement[b] Mean	Engagement[b] s.d.	Disengagement[b] Mean	Disengagement[b] s.d.
4.00 to 3.01	11	2.50	.30	.07	.10
3.00 to 2.51	55	2.35	.46	.12	.17
2.50 to 2.01	46	2.13	.33	.22	.25
2.00 to 1.51	61	2.13	.22	.18	.26
1.50 to 1.01	45	2.11	.15	.15	.13
1.00 to -0.01	21	2.18	.40	.30	.40
0.00 to -0.99	7	2.30	.19	.20	.28
-1.00 to -1.99	2	1.99	.03	.17	.08
-2.00 to -2.99	26	2.04	.32	.27	.28
-3.00 to -3.99	1	1.77	---	.42	---
-4.00 to -4.99	11	1.64	.29	.80	.23

[a]Difference scores were obtained by subtracting the average daily difficulty level of the problems chosen by each subject from that subject's IAL. The range 4.00 to 3.01, for example, means that the average difficulty level of the problems chosen by N subjects was between 3.01 and 4.00 levels lower, i.e., easier, than their IAL. Each difference interval is 1.00 grade wide except in those cases in which the N in the interval was large enough to justify its being further divided into two intervals of .50 each. N is the number of daily averages from which the engagement and disengagement means for the interval were calculated.

[b]The range of possible engagement and disengagement scores was 0 to 4.

These patterns emerged from a fairly complex analytical procedure. The choices of difficulty levels made by choice group subjects were first tallied according to (a) the percentages of correct responses prior to a particular choice and (b) the program option chosen by the subject, e.g., a lot harder, a little easier, etc. The choices made after the first 15-minute period on the computer were initially tallied separately from the other choices because it was believed that the types of decisions made then might have differed systematically from those which occurred after later periods. All of the choices were subsequently combined into one matrix, however, because no distinct difference in choice pattern was found.

Choices made by each choice group subject were tallied in three categories. All choices involving a request for harder problems (a little, a moderate amount, or a lot harder) were classified as minimizing. In addition, choices of "same" following zero to 70 percent correct were also classified as minimizing responses. Similarly, all requests for easier problems, and choices of "same" following 86 to 100 percent correct, were classified as maximizing responses. Choices of "same" following performance levels between 71 and 85 percent correct were classified as neither.

The rationale for classifying the same choices in the preceding manner is as follows: It was assumed that a same selection subsequent to 100 to 86 percent correct performance was motivated by the desire to continue receiving "easy" problems, and therefore maintain a high level of performance. In contrast, the choice of same after 70 to zero percent correct performance might have been caused by the desire to receive more "hard" problems in order to continue working on either a challenging or socially appropriate lesson. The same choices which occurred in the 71 to 85 percent range were considered as being neither maximizing nor minimizing because they followed performance levels that were not extremely high or low.

It appears that this classification method does not unduly combine one kind of choice following 100 to 86 percent with another kind of choice occurring after 70 to zero percent performance because the actual choice behavior of most of our subjects was usually associated with a specific percentage correct range. Thus, the harder choices most frequently occurred in conjunction with the lower percentage correct range while the easier choices were usually associated with the higher range.

After the individual tallies were complete, seven subjects were classified as Maximizers because at least 70 percent of their choices were in the maximizing category. One subject was added because the majority of his choices were maximizing and the pattern seemed clear (29 maximizing, 9 minimizing, and 15 neither).

Four choice group subjects were classified as Minimizers, using the same (70 percent) criterion, and another was included because of a clearly minimizing choice pattern (6 minimizing, 1 maximizing, and 3 neither). Six subjects made too few choices to demonstrate any patterns. Performance data for the three subject classifications are in Table 15.

TABLE 15

Performance Data for the Maximizers, Minimizers, and Few Choice Subjects

	Initial Achievement Level		Difficulty Level		Percentage of Current Responses	
Subjects	Mean	s.d.	Mean	s.d.	Mean	s.d.
Maximizers (N=8)	3.39	1.23	1.41	.34	91%	4.22
Minimizers (N=5)	4.06	.70	5.22	1.49	53	11.72
Few Choice (N=6)	3.83	.37	1.67	.34	86	6.11

Although the numbers of subjects here are small, it seems clear that distinct types of choice patterns are represented because of the consistency of the minimizing and maximizing patterns, especially after the second and third days of CAI. These results also parallel those of the pilot work in this area.

The Relationship Between Engagement and Choice Patterns

The relationships between engagement levels and difference scores (IAL minus chosen difficulty level) for Maximizers, Minimizers, and Few Choice subjects are shown in Table 16. The highest engagement levels appear to have been associated with high positive difference

TABLE 16

Relationship Between Difference Scores and Means and Standard Deviations for the Engagement and Disengagement of Maximizers, Minimizers, and Few Choice Subjects

Ranges of Difference Scores		Maximizers Eng.	Maximizers Dis.	Minimizers Eng.	Minimizers Dis.	Few Choice Subjects Eng.	Few Choice Subjects Dis.
4.00 to 3.01	$\bar{X}$	2.46	.03	2.12	.19	2.66	.05
(N=3,2,6)[a]	s.d.	.13	.02	.27	.25	.27	.03
3.00 to 2.51	$\bar{X}$	2.20	.14	2.46	.04	2.52	.11
(28, 5, 22)	s.d.	.67	.21	.17	.03	.51	.11
2.50 to 2.01	$\bar{X}$	2.05	.26	2.54	.04	2.19	.19
(28, 1, 22)	s.d.	.36	.32	---	---	.27	.14
2.00 to 1.51	$\bar{X}$	2.15	.18	---	---	2.10	.19
(31, 0, 29)	s.d.	.29	.27	---	---	.38	.25
1.50 to 1.01	$\bar{X}$	2.08	.14	2.32	.11	2.11	.21
(30, 4, 11)	s.d.	.42	.13	.09	.06	.14	.15
1.00 to 0.01	$\bar{X}$	2.06	.12	2.22	.36	---	---
(5, 16, 0)	s.d.	.07	.07	.45	.44	---	---
0.00 to -0.99	$\bar{X}$	---	---	2.30	.20	---	---
(0, 7, 0)	s.d.	---	---	.19	.28	---	---
-1.00 to -1.99	$\bar{X}$	---	---	1.99	.17	---	---
(0, 2, 0)	s.d.	---	---	.03	.08	---	---
-2.00 to -2.99	$\bar{X}$	---	---	2.04	.27	---	---
(0, 26, 0)	s.d.	---	---	.32	.28	---	---
-3.00 to -3.99	$\bar{X}$	---	---	1.77	.42	---	---
(0, 1, 0)	s.d.	---	---	---	---	---	---
-4.00 to -4.99	$\bar{X}$	---	---	1.64	.80	---	---
(0, 11, 0)	s.d.	---	---	.29	.23	---	---

[a]N denotes the number of daily averages from which the engagement and disengagement means for the Maximizers, Minimizers, and Few Choice subjects, respectively, were calculated.

scores, indicating difficulty levels considerably below IAL. Since low difficulty levels were selected both near the beginning and near the end of the CAI experience, this phenomenon does not appear to be a function of boredom toward the end of a task.

The Maximizers most frequently chose difficulty levels lower than their IAL (difference scores between 1.00 and 3.00). Thus, their highest engagement levels were associated with the most frequently selected difficulty levels. This relationship was not found among the Minimizers, however, since they most frequently selected difficulty levels that were associated with the lowest engagement levels (difference scores between -4.99 and 1.00). Thus, despite the fact that their engagement was higher when they chose easier problems, Minimizers consistently chose the harder ones.

Choice and Locus of Control Attributes

The fourth experimental question asked whether giving subjects a choice of difficulty levels would affect their LOC perceptions. This question was answered by comparing the scores of the choice and yoked control groups on the four LOC dimensions. The scores used in this analysis were derived from the difference between raw scores for members of each subject pair. Separate scores were computed for the success and failure items of each of the four dimensions and three administrations of the LOC measure. The scores were then organized by treatment (choice or yoked control), choice pattern shown by the choice subjects (Maximizers, Minimizers, and Few Choice subjects), type of score (success or failure), and day (first, second, or third administration of the LOC measure). A separate ANOVA was performed for each dimension of the LOC measure.

The mean difference scores and F ratios for the treatment main effect are presented for each dimension in Table 17. Full summary tables are in Appendix H. The F values indicated that the choice and yoked control subjects were significantly different on the stable/unstable, internal/external, and self/other dimensions. Subjects in the yoked control group made significantly more stable/unstable and internal/

external attributions than did subjects in the choice group; the reverse was true for the self/other dimension attributions. The means for choice and yoked control subjects are presented in Table 18.

TABLE 17

Mean Difference Scores and F Values for Each LOC Dimension

	Stable/ Unstable	Control/ No Control	Internal/ External	Self/ Other
Mean Difference Scores	-.78	.48	-.81	.39
F Values (df = 1/16)	24.93**	2.63	8.70**	6.35*

*p < .05
**p < .01

TABLE 18

Group Means and Possible Ranges of Scores on the Four LOC Dimensions

	Stable/ Unstable	Control/ No Control	Internal/ External	Self/ Other
Choice Group	2.28	4.84	4.46	2.65
Yoked Control Group	3.06	4.36	5.28	2.26
Possible Score Range	0 - 6	0 - 8	0 - 8	0 - 4

The choice pattern main effect in the stable/unstable dimension was also significant (F = 8.68, p < .01); difference scores for the Maximizers, Minimizers, and Few Choice subjects and their yoked control counterparts were -1.44, -.37, and .25, respectively. A Newman-Keuls multiple comparison test revealed that the Maximizer difference score of -1.44 was significantly greater than the two other difference scores (p < .01). Maximizers obtained the lowest mean score on this dimension while their yoked control counterparts showed the highest mean (Table 19).

TABLE 19

Means for Choice and Yoked Control Subjects on the Stable/Unstable Dimension

	Maximizers	Minimizers	Few Choice
Choice Group	1.94	2.04	2.95
Yoked Control Group	3.34	2.40	3.20

Note: The terms Maximizers, Minimizers, and Few Choice apply only to the subjects in the choice group, but the table is arranged in this manner to compare yoked control subjects with their choice counterparts.

The analyses of variance showed no significant effects for choice pattern, type of score, or day on the control/no control, internal/external, and self/other dimensions. A significant F ratio was associated with a type-of-score and choice-pattern interaction in the analysis of the internal/external dimension ($F = 14.9$, $p < .01$). The mean difference scores for this dimension and the averages from which they were derived are given in Table 20.

TABLE 20

Means for the Choice and Yoked Control Choice Patterns on the Internal/External Dimension

	Success			Failure		
	Choice Group	Yoked Control	Difference Score	Choice Group	Yoked Control	Difference Score
Maximizers	3.50	4.12	- .62	4.56	6.83	-2.25
Minimizers	3.93	5.53	-1.60	4.67	3.67	1.00
Few Choice	4.67	4.50	.17	5.61	6.67	-1.06

A Newman-Keuls test showed that the difference score of 1.00 for the Minimizers on the failure items was significantly different from the other choice pattern scores. In four of the comparisons between patterns, the yoked control subjects had higher scores than the choice subjects for failure items; the opposite result was found for Minimizers and their yoked control counterparts on failure items. The magnitude of the difference between Few Choice subjects and their yoked control counterparts was much less than for the other choice pattern subjects. One way to summarize these results would be to say that the subjects yoked to the Minimizers seem to have the most different scores; they show the highest mean for success and the lowest mean for failure on the internal/external dimension.

Correlations Between Engagement Levels and Locus of Control Scores

The final experimental question was whether LOC attributions and engagement scores were correlated. Engagement and disengagement scores for this analysis were obtained by averaging levels for the first five days, the middle five days, and the last five days of CAI for each subject, so that they would be roughly comparable in time to the three administrations of the LOC measure. Pearson correlations were then calculated between engagement levels and success attribution scores and between engagement levels and failure attribution scores of the two groups of subjects (choice and yoked control). The correlations were calculated separately for success and failure items because there is some evidence that attributions for failure and success may at times be independent (Crandall, Katkovsky, & Crandall, 1965) and because there is considerable evidence that success and failure LOC attributions are differentially related to variables similar to engagement, e.g., persistence and intensity or speed of performance (Weiner et al., 1972).

Success items on the stable/unstable, control/no control, internal/external, and self/other dimensions for the first administration of the LOC measure were correlated separately with the engagement and disengagement means for the first five days of CAI. Correlations were also calculated for the third administration of the LOC measure and the engagement and disengagement means for the last five days of CAI. For success items, there were thus 16 correlations for each of the choice and yoked control groups. The same variables were correlated for failure items.

The critical level for significance on the correlations was set at .46 (two-tailed test with $p \leq .05$ and $df = 17$). No significant correlations were found in the choice group data between engagement and LOC attributes for either LOC administration. Two significant correlations for the choice group were found between disengagement and LOC attributions: the correlation between control/no control scores on the first LOC administration and disengagement means for the first five days of CAI was .54 for failure items. For the success items, the correlation between internal/external scores on the third LOC administration and disengagement means for the last five days of CAI was .48.

In the yoked control group data for the third LOC administration, a significant correlation of .49 between stable/unstable dimension scores and engagement means for the last five days of CAI was found for success items. A correlation of .49 was also found between self/other scores on the third administration and disengagement means for the last five days of CAI on failure items.

These findings are somewhat puzzling. It was expected that there would be more correlations in the choice group data, particularly on the self/other dimension. The expectation was based on the assumption that the self/other dimension scores and the engagement scores would show increases or decreases in the same dirrection over time because of emerging individual differences in subject responses to the treatment.

Discussion

A number of interesting features in the data merit further discussion.

1. The yoked control group worked significantly more problems on the computer than did the choice group. This may have been because the yoked control subjects worked problems at lower difficulty levels and

answered a higher percentage of the problems correctly--that is, easier problems could be responded to faster, and thus more problems could be worked per day. However, this explanation does not account for all of the differences in the number of problems worked by the two groups. Some of the pairs who were matched closely on difficulty levels and whose percentages of correct responses were almost identical (pairs 1, 5, and 9) still differed in the number of problems worked--the yoked control subjects working substantially more problems per day than their choice counterparts. One of the yoked subjects (in pair 4) did about ten more problems per day than his choice counterpart, although his percentage of correct responses was nine points lower. These comparisons between the choice and yoked control subjects suggest that the differences in the number of problems worked might have resulted from some factor or factors other than the lower difficulty levels and higher percentages of correct responses obtained by the yoked control subjects.

One highly speculative explanation is that because the choice group was significantly higher in engagement than the yoked control group, the lower number of problems worked by the choice group might have resulted from the effects of the experimental treatment--i.e., the higher engagement levels could indicate more involvement in solving each problem, resulting in response rates that were slower than those of subjects who did not choose problems. An alternative explanation is that the choice group subjects were not accustomed to making the decisions required in the CAI situations and were therefore slower and more cautious in responding to the problems than were the yoked control subjects.

2. Another interesting feature of the data was the significant difference found between the engagement levels of choice and yoked control groups. One might argue that this difference is educationally unimportant because the means of these groups were only .12 points apart. However, it should be noted that the choice group was consistently higher in engagement than the yoked control group across all of the five-minute periods. Although the period-by-period data were not tested statistically, these consistent differences indicate that the subjects in the choice condition maintained higher levels of engagement

over longer periods of time than did subjects in the yoked control condition. Therefore, the significant difference between the overall mean engagement levels of the two groups may be educationally important because this difference appears to be based upon an effect that is stable over time. However, the educational implications of this finding for classroom learning are unclear at present, since it is not known how engagement levels are related to academic achievement on standardized tests. If future investigations demonstrate that choice situations lead to higher engagement levels which in turn produce higher achievement scores than do nonchoice situations, then the educational effects of giving students choices over certain parts of their curricula will be more clearly demonstrated. Since the present study does not provide such information, what bearing do these engagement results have upon understanding the academic effects of choice situations? In our opinion, they suggest that choice settings might improve achievement levels by causing students to attend more closely to each problem. The significantly higher mean engagement level found for the choice subjects is educationally important because it demonstrates how the initial attentional phase of the classroom learning process can be improved. In this regard, increased engagement per se is a desirable educational goal, and investigations of variables that can increase student engagement levels should not have to be directly linked to achievement test measures in order to prove their educational significance. Learning situations that increase engagement levels might have important affective influences upon student attitudes toward studying different types of curricula, and these affective influences might be just as important as increased achievement levels.

3. The finding that student engagement levels decreased as the difficulty levels of the chosen problems increased from 1.0 to 7.5 is particularly relevant to educational practices. These results are not congruent with Hunt's theory of the match (1961, 1965), since engagement was not highest for problems most similar to the initial achievement levels of the subjects, nor lowest for problems that were most different. It appears that some factors other than a need or desire

to select problems similar to current achievement level influenced the subjects' choices of problems. The Maximizer and Minimizer choice pattern findings indicate that the problems most frequently selected by the Maximizers were about two grade levels below their IAL, while those most frequently chosen by the Minimizers were about three grade levels above their IAL. These findings suggest that the identification of optimally stimulating difficulty levels involves more complex processes than Hunt's theory predicted. Optimally stimulating problem difficulty levels seem to be related more to the choice patterns of the subjects than to one theoretical motivation curve that can be applied to all learners. In this experiment, the difficulty levels most frequently chosen by Maximizers were related to their highest engagement levels. However, the opposite result was found for the Minimizers; their least frequently selected difficulty levels were most engaging for them.

Interviews

Maximizers and Minimizers were interviewed to determine whether school-related factors such as classroom pressures caused them to choose certain difficulty levels. The interview responses are included in this section of the report because they were used to provide some post hoc information about why the subjects showed certain choice patterns. We expect to use this information to design future studies. In the interview, students were asked, "Why would a boy or girl select easier problems almost all of the time while working on the computer?" and "Why would a boy or girl keep asking for harder problems?" The responses fell into three categories:

1. Academic responses centered around classroom activities, e.g., "The student chose these problems so he would know them if they were given in class."
2. Intellectual responses related to the desire to engage in an intellectually stimulating activity, e.g., "The student selected these problems to test his skills."
3. Physical responses related to a physical condition or motive, e.g., "The student selected these problems in order to move through the program faster."

Both Maximizers and Minimizers gave more intellectual than academic or physical responses. A breakdown of the intellectual category into positive responses (problems selected to test one's skill or chosen out of curiosity, etc.) and negative responses (problems selected to avoid failure or chosen out of habit) revealed that the Minimizers gave more positive intellectual responses to the two questions than did the Maximizers; the reverse was true for the negative intellectual responses. If we assume that the students' responses to these questions are indicators of their own motives for selecting problems, then it appears that the Minimizers were directed by more achievement-oriented motives than were the Maximizers. Although a need-for-achievement pretest measure was not used in this study, the performance of the Minimizers resembles that for high need achievers described by Atkinson (1964), i.e., their performance was in a range which he suggested was most desired by high need achievers. The performance of the Maximizers also seems to fit Atkinson's theory; their high percentage of correct responses resembles the performance of low need achievers. Further research, using appropriate pretest measures of student motivation, is needed to determine whether these post hoc statements about achievement motives are valid.

Specific Locus of Control Attributions

Additional analyses were also done on the LOC data. Choice and yoked control group differences in the specific attributions within the four dimensions were analyzed: attributions to ability, effort, difficulty of the problems as chosen by the computer, difficulty of the problems as chosen by the student, and luck. This analysis indicated that subjects in the choice group attributed more of their performance results to their choice of problem difficulty levels and less to their ability than yoked control subjects did. The significant differences between choice and yoked control subjects on the self/other, stable/unstable, and internal/external dimensions may have been caused primarily by differences in attributions to sources controllable by the self.

The types of choices made or received by the subjects had a significant relationship to LOC attributions on the stable/unstable dimension. The mean difference between choice and yoked control groups in stable (i.e., ability) attributions was greater for the Maximizers than for either the Minimizer or the Few Choice subjects. Choice subjects and the subjects yoked to the Minimizers were low on stable attributions, and those subjects yoked to the Maximizers were high on stable attributions, especially for failure. As might be expected, then, subjects who did not have control over the problems they received (and so were not likely to attribute their performance to their choice of problems) and who received easy problems (and so were not likely to attribute failure to the difficulty of the problems) attributed failure to lack of ability more often than did subjects who were given hard problems or who chose their problems.

Because there were significant differences between choice and yoked control subjects on three of the four LOC dimensions (stable/unstable, internal/external, and self/other), and no significant main effects for day, one might conclude that the attribution differences were due to initial differences between the subjects who were subsequently assigned to the two conditions rather than to the treatment itself. However, since the subjects in the choice group were randomly chosen, and the subjects in the yoked control group were closely matched to them, it seems unlikely that any systematic prior differences between subjects could account for these attribution differences. The first LOC measure was not administered until subjects had spent two days on the computer, and it may be that the experimental treatment had already influenced perceptions and attributions of choice and control to some extent. Although the changes in attributions over time were not significant, most of the changes that occurred were in the expected direction, e.g., yoked control subjects decreased and choice subjects increased self attributions over time for failure; and the differences between the groups tended to increase over time. Those subjects who were more disengaged during the first five days on the computer attributed their failures more to lack of effort, although this attribution did not result in less disengagement on succeeding days.

The significant positive correlation between disengagement during the last five days and the self attributions on the third LOC administration for yoked control subjects also seems to be due to the positive correlation between disengagement and attributions to lack of effort; subjects who were more disengaged more often attributed their failure to lack of effort. It is important to note, however, that both of these correlations involving lack of effort attributions were associated only with the disengagement measures. Apparently, the engagement measures were not reciprocally (negatively) related to lack of effort attributions.

For subjects in the choice group, the significant positive correlation (.48) between internal/external dimension scores on the third administration success items and disengagement on the last five days was almost entirely due to a positive correlation (.45) between disengagement and attributions for success to ability. There was no such relation between disengagement and the other component of the internal/external dimension--effort. Thus, choice group subjects who were highest in disengagement tended to attribute their success more frequently to a factor that does not directly involve engagement or disengagement behavior, i.e., ability, which (unlike effort) is not an attribution to actual behavior. In contrast, the yoked control group showed a significant positive correlation between stable attributions and <u>engagement</u> (.49). Thus, the yoked control subjects who were more engaged in the computer task on the last five days attributed their success to their ability more often than the less engaged yoked control subjects. This ability-engagement correlation suggests that in nonchoice situations, students who feel more competent in a learning task will become more involved in it.

The study yielded disappointingly little direct evidence of relationships between LOC attributions and engagement or disengagement. Only two of the 16 correlations for the choice group and two for the yoked group were significant. It may be that the LOC-engagement relationship differs for the various choice patterns and was obscured by the overall correlation. A more important factor may have been the low variability in engagement and disengagement means, because this small range of scores makes it difficult to find substantial correlations between engagement or disengagement and the LOC variables. The low variability was probably caused by choosing subjects who were from the same school, and had similar teachers, achievement scores, ages, and ethnic backgrounds.

Only one of the significant correlations was found for the first administration of the LOC measure (after 2 days on the computer); for subjects in the choice group, attributions for failure to controllable sources as opposed to random or predetermined ones were positively correlated (.54) with disengagement on the first five days, i.e., the more failure was believed to be controllable, the more disengagement was shown. Analysis of the correlations between disengagement and the specific attributions within the control/no control dimension (i.e., effort, task difficulty as selected by the computer) suggested that this significant correlation between disengagement and control scores was mostly due to a positive correlation between attributions for failure to lack of effort and disengagement for a subject. Thus, it seems easier to understand a subject's LOC attributions at the beginning of the computer task in terms of his attempts to explain his engagement and disengagement behavior rather than in terms of the LOC attributions influencing engagement.

Overall, the relationship between LOC attributions and the choice and yoked control conditions was much as expected and tended to provide construct validity for the four LOC dimensions. If attributions to sources controllable by the self are regarded as desirable in themselves, the choice treatment can be regarded as beneficial. However, there was little correlational evidence supporting the notion of a mediating effect of LOC attributions upon engagement and disengagement, though there were some suggestions of relations between effort and ability attributions (primarily to disengagement) and some indication that these relations might differ depending on the presence of choice in a learning situation. The differential correlations between specific attributions (e.g., effort, ability) within LOC dimensions and engagement and disengagement supports the contention by Weiner (1972) that it is important to specify the particular sources of control to which a subject attributes his performance rather than the general category of such attributions such as internal/external.

Summary

This investigation showed how some educational variables of current interest to researchers can be studied in an experimental setting. One of these variables was choice of curriculum difficulty levels, and comparisons between choice and nonchoice conditions indicated that the choice condition produced significantly higher engagement levels and lower academic performance. Apparently, the choice subjects were not learning as much from their lessons as might be expected from their higher engagement levels. These findings suggest that educational variables other than student choice should be studied in order to identify those which can improve academic performance. Two variables that might affect academic performance are the reinforcement schedules used in the learning task, and the manner in which the curriculum is organized and presented to students.

The distinct choice patterns found in this study may have important implications for classroom instruction. If these patterns are also observed in classroom situations, different instructional techniques for Maximizers and Minimizers might increase their academic performance. Research on how to optimize learning for Maximizers and Minimizers is needed to design such techniques. The results of the present study demonstrate the importance of conducting research to identify individual differences in learning styles and to discover how these differences can be used as a basis for improving academic motivation and achievement.

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APPENDIX A

CONTRACT WITH THE SCHOOL

December 14, 1971

Proposal: To cooperate with Dr. Maurice Fisher and his associates at the Research and Development Center in Teaching of Stanford University in conducting a research study. The Effects of Choice Situations upon Maximizing Engagement in computer assisted instruction.

(Refer to Study Proposal dated October 1971 for specifics on design and procedures.)

Conditions: The following conditions which pertain to the conduct of the study agreed upon by an Ad Hoc faculty committee, the Principal, and Dr. Fisher:

1. Screening of pupils to be selected for the study shall be done using data from tests administered by the school in October. After selection, pupils may be tested by instruments selected by the Research Center to gather additional data on pupil skill levels. Screening will be done using fourth and fifth grade pupils. Third grade pupils may be used to complete the study N of 120.

2. The entire costs and management of the study shall be borne by the Research and Development Center.

3. The School will provide space in a room presently used by our counselor to accommodate (2) two teletype machines. The cost of relocating the counselor's telephone in our resource center and returning the phone to the counselor's room at the close of the study shall be borne by the Research and Development Center.

4. Use of computer line and programs will be available to the staff cooperating in the study at all times except between 9:30 a.m. to 1:00 p.m. on days school is in session. The time may be programmed according to needs defined by the staff.

5. Results of the research and interpretation of results shall be made available to the school staff.

6. Adjustments that appear necessary during the course of the study shall be discussed at such times by Dr. Fisher and representatives of the R & D Center and staff participating in the study. Staff shall have decision making power over such adjustments.

7. If at any time the school professional staff finds cause to question the advisability of continuing the study, a meeting of parties identified in #6 above shall be set to discuss the nature of the concern. Staff may discontinue participation in the study if they deem it either in conflict with school program and/or injurious to participating students.

8. Stanford R & D Center will provide sufficient personnel and time to train school personnel in use of teletypes and computer programs.

9. Stanford R & D Center staff will be available in the teletype center from 8:30 a.m. through 1:30 p.m. on school days.

APPENDIX B

CHRONOLOGICAL AGES AND ACHIEVEMENT TEST SCORES OF SUBJECTS IN THE CHOICE AND YOKED CONTROL GROUPS

Pair No.	Choice Group Age (Mos.)	Choice Group Initial Achievement Scores (Adjusted)	Yoked Group Age (Mos.)	Yoked Group Initial Achievement Scores (Adjusted)
1	123	3.90	122	4.00
2	115	4.00	131	4.10
3	126	4.20	145	4.10
4	123	4.00	122	4.10
5	117	3.70	126	3.60
6	120	3.00	128	3.00
7	117	3.00	123	3.00
8	121	3.20	125	2.60
9	141	3.20	139	3.60
10	130	3.00	128	3.40
11	131	3.60	134	4.10
12	131	4.10	126	4.10
13	130	4.70	127	5.00
14	142	4.00	138	3.70
15	126	2.60	133	3.00
16	138	2.70	134	2.30
17	134	3.90	128	3.90
18	134	4.90	137	4.80
19	117	4.70	136	4.30
$\overline{X}$	128.47 (10 yrs. 8 mos.)	3.71	130.71 (10 yrs. 10 mos.)	3.72
s.d.	.72 yrs.	.68	.58 yrs.	.70

APPENDIX C

ETHNICITY AND CLASSROOM ASSIGNMENTS OF PAIRS OF SUBJECTS

	Classroom		Ethnicity	
Number	Code	Match	Identification	Match
1	A	Same	Mexican-American	Same
2	B	Same	Black	Same
3	A & B	Different	Mexican-American	Same
4	A & C	Different	Mexican-American	Same
5	E	Same	Anglo & Black	Different
6	E	Same	Mexican-American & Black	Different
7	B & E	Different	Mexican-American	Same
8	B	Same	Mexican-American	Same
9	A & C	Different	Mexican-American	Same
10	A & D	Different	Black	Same
11	A & D	Different	Mexican-American	Same
12	C	Same	Mexican-American	Same
13	C & D	Different	Mexican-American	Same
14	C & D	Different	Mexican-American	Same
15	D	Same	Mexican-American	Same
16	D	Same	Black & Anglo	Different
17	D	Same	Black & Mexican-American	Different
18	C & D	Different	Mexican-American	Same
19	C	Same	Black & Mexican-American	Different

APPENDIX D

CATEGORY DEFINITIONS FOR THE ENGAGEMENT/ DISENGAGEMENT OBSERVATION INSTRUMENT

Note: Only one occurrence of a behavior category was noted for each interval on the instrument; repeated or continuous behavior in a category was not marked more than once in any interval.

Engagement

1. EP : Eyes on Paper - Subject looks at the paper of the teletype printout.
2. EP (T) : While looking at the paper, subject has a toy (finger puppet or slot machine) within his grasp.
3. TK : Touches Keys - Subject touches key(s) of the teletype with fingers, etc.
4. TK (T) : Touches key(s) with puppet.
5. PC : Pulls Closer - Subject adjusts his plane of perception forward (towards the keys). In order for this movement to be counted, the subject must move forward and become stable at a new base line for at least 3 seconds.
6. TP : Touches Paper - Subject touches the teletype paper.
7. RS : Reads Silently - Subject appears to read the teletype printout by moving his lips without making any audible sounds.
8. TS : Talks to Self - Subject makes audible noises perceived by the observer. These may be reading aloud or actually talking to himself about a problem solution.
9. CF : Counts on Fingers - Subject counts on his fingers either silently or aloud.
10. S : Surprise - Subject shows sudden change in behavior associated with intense verbal response to a problem.

Disengagement

1. LA : Looks Away - Subjects looks away from the paper emerging from the teletype either with his eyes or his head and neck.

2. LA (T) : Looks away to play with the toys.

3. TA : Turns Away - Subject turns his torso away from the teletype.

4. TA (T) : Turns away to play with the toy.

APPENDIX E

EXPERIMENTAL PROCEDURES FOLLOWED BY THE OBSERVERS

Experimental Group

1. In classroom: Ask children if they will agree to work on the machines for 15 days in a row. Explain that they will work arithmetic problems on the computer.

2. At the beginning in the CAI Room: Tell the children they have control over choices. They can "go on" or "stop" and can choose harder, easier, or the same types of problems.

3. ON THE FIRST DAY:

   A. Tell the children what questions they will receive and show them these questions. Tell them to choose "y" after the first question because we want them to see what happens next. But, following this first question, they can stop after any interval when the question appears again.

   B. Go through the other questions. Also, tell them about the time intervals for receiving the questions.

   C. Explain to them that they can tell how many total problems they answered correctly from looking at the numbers on the printout. Show these numbers to them as an example.

   D. Say, "Everyone starts at group 100. If you choose 'harder' at the beginning, the number goes up. Then, if you choose 'easier,' the number will go down. If you choose the 'same,' the number will stay the same."

   E. Time on the Machine -- Tell them that they can work on the machines up to 35 minutes per day. Be sure to say that they should not stop working because the other pupil has stopped. . . . "Your program is different from your classmate's. Do not stop just because your classmate stopped. Only stop when you want to." When they stop each day, ask them why they stopped. Record information on observation sheet.

   F. Toys -- Say that they can play with the toys anytime they want to. Demonstrate the use of the slot machines, finger puppets, and string-on-mobile.

   G. Then, tell them about your job (no test or grade) and not to worry about the mirrors.

H. Children's responses after 15 minutes -- After they have worked on the teletype for 15 minutes, ask them to type in "y" following, "Do you want more problems?"

I. Typing errors -- The children will most likely have problems typing in the answers for the first few days. Always be brief and to the point when giving directions in order to encourage the emergence of independent work on the teletypes. Tell them to type in the answers "just like you write them on paper." Horizontal problems, left to right; vertical problems, right to left.

J. At the end of the first day, check to see if the children can read their group numbers and number of problems correct on the printouts.

4. At the beginning of the 2nd and 3rd days, say, "Remember, you can 'stop' or 'go on' when you get the first question--you decide whether you want to 'stop' or 'go on'. Do you understand?"

5. Beginning of day three:

   A. Administer Form II of the Locus of Control test to the subjects in this group.

   B. After they have worked on the machines for 5 more days, readminister the Locus of Control test.

   C. Then, the subjects will continue for another 8 days (total time on the machine = 15 days). Then they will be interviewed following the completion of their computer work.

Yoked Control Group

1. In classroom: Ask children if they will agree to work on the machines for 15 days in a row. Explain that they will work arithmetic problems on the computer.

2. ON THE FIRST DAY:

   A. Explain to them that they can tell how many total problems they answered correctly from looking at the numbers on their printout. Show these numbers to them as an example.

   B. Say, "Everyone starts at group 100. Sometimes the problems will go to a higher group number, and then a lower group number. Sometimes the numbers will stay the same as they were before."

   C. Time on the Machine -- Tell them that the machine will run up a maximum of 35 minutes per day. The teletype will sign off when it is finished with the daily lesson. They must work the full time that the machine is running.

D. Say that the machine will "chatter" for about a minute after they have worked on the problems for different amounts of time. Then it will present new problems.

E. Toys -- Say that they can play with the toys anytime they want to. Demonstrate the use of the slot machines, finger puppets, and string-on-mobile.

F. Then, tell them about your job (no test or grade) and not to worry about the mirrors.

G. Typing errors -- The children will most likely have problems typing in answers for the first few days. Always be brief and to the point when giving directions in order to encourage the emergence of independent work on the teletypes. Tell them to type in the answers "just like you write them on paper." Horizontal problems, left to right; vertical problems, right to left.

H. At the end of the first day, check to see if the children can read their group numbers and number of problems correct on the printouts.

3. Beginning of day three:

A. Administer Form I of the Locus of Control test to the subjects in this group.

B. After they have worked on the machines for 5 more days, readminister the Locus of Control test.

C. Then, the subjects will continue for another 8 days (total time on the machine = 15 days). They will be interviewed following the completion of their computer work.

APPENDIX F

LOCUS OF CONTROL MEASURE

Note: The form shown here is the one given to choice group subjects. On the yoked control subjects' form, the statement "I didn't ask for the right problems" is replaced by "I didn't let the computer give me the right problems," and "I asked for the right problems" is replaced by "I let the computer give me the right problems."

1. If I do well on my computer lesson, it is because

   ______ I tried hard.

   ______ I'm good at math.

2. If I don't do well on my computer lesson, it is because

   ______ I didn't ask for the right problems.

   ______ The computer didn't give me the right problems.

3. When I finish a computer math problem quickly, it is because

   ______ The computer gave me just the right problems.

   ______ Just good luck, I guess.

4. When it takes me a long time to do a computer math problem, it is because

   ______ I didn't try hard enough

   ______ Just bad luck, I guess

5. When I finish a computer math problem quickly, it is because

   ______ I'm good at math.

   ______ The computer gave me just the right problems.

6. If I don't do well on my computer lesson, it is because

   ______ I didn't try hard enough.

   ______ The computer didn't give me the right problems.

7. When I finish a computer math problem quickly, it is because

   ______ I'm good at math.

   ______ Just good luck, I guess.

8. When it takes me a long time to do a computer math problem, it is because

   ______ The computer didn't give me the right problems.

   ______ Just bad luck, I guess.

9. If I do well on my computer lesson, it is because

______ I tried hard.

______ Just good luck, I guess.

10. If I don't do well on my computer lesson, it is because

______ I'm just not very good at math.

______ The computer didn't give me the right problems.

11. If I do well on my computer lesson, it is because

______ The computer gave me just the right problems.

______ Just good luck, I guess.

12. When it takes me a long time to do a computer math problem, it is because

______ I didn't ask for the right problems.

______ The computer didn't give me the right problems.

13. If I do well on my computer lesson, it is because

______ I asked for the right problems.

______ The computer gave me the right problems.

14. When it takes me a long time to do a computer math problem, it is because

______ Just bad luck, I guess.

______ I'm just not very good at math.

15. When I finish a computer math problem quickly, it is because

______ I tried hard.

______ I'm good at math.

16. If I don't do well on my computer lesson, it is because

______ The computer didn't give me the right problems.

______ Just bad luck, I guess.

17. If I do well on my computer lesson, it is because

______ I'm good at math.

______ The computer gave me just the right problems.

18. If I don't do well on my computer lesson, it is because

______ I didn't try hard enough.

______ Just bad luck, I guess.

19. When I finish a computer math problem quickly, it is because

______ I asked for the right problems.

______ The computer gave me the right problems.

20. When it takes me a long time to do a computer math problem, it is because

    ______ I didn't try hard enough.

    ______ The computer didn't give me the right problems.

21. When I finish a computer math problem quickly, it is because

    ______ I tried hard.

    ______ Just good luck, I guess.

22. When it takes me a long time to do a computer math lesson, it is because

    ______ I'm just not very good at math.

    ______ The computer didn't give me the right problems.

23. If I do well on my computer lesson, it is because

    ______ Just good luck, I guess.

    ______ I'm good at math.

24. If I don't do well on my computer lesson, it is because

    ______ I'm just not very good at math.

    ______ Just bad luck, I guess.

25. If I do well on my computer lesson, it is because

    ______ I tried hard.

    ______ The computer gave me just the right problems.

26. When it takes me a long time to do a computer math problem, it is because

    ______ I didn't try hard enough.

    ______ I'm just not very good at math.

27. When I finish a computer math problem quickly, it is because

    ______ I tried hard.

    ______ The computer gave me just the right problems.

28. If I don't do well on my computer lesson, it is because

    ______ I didn't try hard enough.

    ______ I'm just not very good at math.

APPENDIX G

RELIABILITY OF THE LOCUS OF CONTROL MEASURE

The LOC instrument was constructed using two parallel stems; an estimate of the internal consistency reliability for the instrument was obtained by comparing the responses to the two stems. In April 1973 the LOC measure was administered to a group of 21 students from the school where the study was done. These students were ineligible for the experiment since they all had previous CAI experience. All of them received the yoked form of the instrument on two separate occasions, two days apart. The internal consistency analysis was done separately for each administration of the instrument; results were then averaged. Responses to the two stems were considerably more consistent on the second administration than on the first (Table G-1).

Each pair of items containing different stems and the same response alternatives were examined. The two responses for each pair were tallied as either the same or different, and the percentage of the same responses was calculated for the whole instrument, for success and failure pairs of items separately, and for those pairs of items in each of the four LOC dimensions within success and failure categories. The results are shown in Table G-1.

TABLE G-1

Percentage of the Same Responses

Item Categories	First Administration	Second Administration	Mean %
Total	74%	82%	78
Success	76	84	80
Self/Other	76	74	75
Internal/External	75	88	81.5
Control/No Control	75	88	81.5
Stable/Unstable	76	89	82.5
Failure	71	80	75.5
Self/Other	74	83	78.5
Internal/External	68	74	71
Control/No Control	73	79	76
Stable/Unstable	71	89	79

In a second analysis, the instrument was divided in half by the two stems, and the appropriate items within each half were used to obtain scores on each of the four dimensions. The two scores (one for stem 7 and one for stem 2) were then recorded as the same or different, and the percentage of the same scores was calculated for all four dimensions for both success and failure. The results are shown in Table G-2.

TABLE G-2

Percentage of the Same Scores

Item Categories	First Administration	Second Administration	Mean %
Success			
Self/Other	62%	52%	57
Internal/External	33	71	52
Control/No Control	38	76	57
Stable/Unstable	48	86	67
Failure			
Self/Other	67	67	67
Internal/External	29	43	36
Control/No Control	43	52	47.5
Stable/Unstable	67	81	74

Finally, Pearson product moment correlations were calculated between the scores for stem 1 and the scores for stem 2 for success and failure items in all four dimensions (separately). The Spearman-Brown formula was then applied to these correlations; the resulting estimates of internal consistency are shown in Table G-3.

TABLE G-3

Internal Consistency Reliability

Item Categories	First Administration	Second Administration	Mean %
Success			
Self/Other	.18	.48	.33
Internal/External	.77	.93	.85
Control/No Control	.80	.87	.835
Stable/Unstable	.88	.98	.93
Failure			
Self/Other	.69	.82	.755
Internal/External	.63	.85	.74
Control/No Control	.78	.87	.825
Stable/Unstable	.83	.96	.895

APPENDIX H

SUMMARY TABLES FOR LOCUS OF CONTROL DATA

TABLE H-1

Summary of Analysis of Variance of Difference Scores on the LOC Stable/Unstable Dimension

Source	Sum of Squares	Degrees of Freedom	Mean Square	F
Treatment	51.453	1	51.453	24.93*
Choice Pattern	35.822	2	17.911	8.68*
Pairs within Choice Pattern	32.973	16	2.064	---
Type of Score	1.048	1	1.048	0.240
Type of Score x Choice Pattern	23.641	2	11.821	2.708
Type of Score x Pairs within Choice Pattern	69.833	16	4.365	---
Day	1.405	2	.702	.136
Day x Choice Pattern	5.141	4	1.285	.248
Day x Pairs within Choice Pattern	165.587	32	5.175	---
Type of Score x Day	3.697	2	1.849	.229
Type x Date x Day x Choice Pattern	10.675	4	2.669	.331
Type x Date x Pairs within Choice Pattern	258.362	32	8.074	---

*p < .05

TABLE H-2

Summary of Analysis of Variance of Difference Scores on the LOC Internal/External Dimension

Source	Sum of Squares	Degrees of Freedom	Mean Square	F
Treatment	58.008	1	58.088	8.704*
Choice Pattern	31.478	2	15.739	2.358
Pairs within Choice Pattern	107.911	16	6.674	---
Type of Score	.187	1	.187	.061
Type of Score x Choice Pattern	91.599	2	45.799	14.904*
Type of Score x Pairs within Choice Pattern	49.172	16	3.073	---
Day	6.170	2	3.085	.218
Day x Choice Pattern	6.999	4	1.750	.124
Day x Pairs within Choice Pattern	451.859	32	14.121	---
Type of Score x Day	6.657	2	3.329	.52
Type of Score x Day x Choice Pattern	4.491	4	1.123	.176
Type of Score x Day x Pairs within Choice Pattern	204.447	32	6.388	---

*p < .05

TABLE H-3

Summary of Analysis of Variance of Difference Scores on the LOC Control/No Control Dimension

Source	Sum of Squares	Degrees of Freedom	Mean Square	F
Treatment	17.846	1	17.846	2.63
Choice Pattern	24.109	2	12.054	1.778
Pairs within Choice Pattern	108.519	16	6.78	---
Type of Score	1.527	1	1.527	.205
Type of Score x Choice Pattern	.712	2	.356	.048
Type of Score x Pairs within Choice Pattern	119.097	16	7.444	---
Day	1.483	2	.741	.085
Day x Choice Pattern	26.115	4	6.529	752
Day x Pairs within Choice Pattern	277.941	32	8.686	---
Type of Score x Day	9.308	2	4.654	.754
Type of Score x Day x Choice Pattern	21.489	4	5.372	.871
Type of Score x Day x Pairs within Choice Pattern	197.521	32	6.17	---

TABLE H-4

Summary of Analysis of Variance of Difference Scores on the LOC Self Dimension

Source	Sum of Squares	Degrees of Freedom	Mean Square	F
Treatment	25.427	1	25.427	6.352*
Choice Pattern	25.765	2	12.882	3.218
Pairs within Choice Pattern	64.041	16	4.003	---
Type of Score	2.820	1	2.820	1.064
Type of Score x Choice Pattern	14.556	2	7.278	2.741
Type of Score x Pairs within Choice Pattern	42.478	16	2.655	---
Day	13.642	2	6.821	1.565
Day x Choice Pattern	17.788	4	4.447	1.020
Day x Pairs within Choice Pattern	139.453	32	4.358	---
Type of Score x Day	8.558	2	4.279	2.152
Type of Score x Day x Choice Pattern	.889	4	.222	.112
Type of Score x Day x Pairs within Choice Patterns	63.600	32	1.988	---

*$p < .05$