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Motivational and achievement effects of learner control of computer-assisted instruction

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MOTIVATIONAL AND ACHIEVEMENT EFFECTS OF LEARNER CONTROL OF COMPUTER-ASSISTED INSTRUCTION

by

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OF COMPUTER-ASSISTED INSTRUCTION

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ABSTRACT

This study investigated the effects of providing ninth-grade boys and girls with either learner or program control over content review within computer-assisted science instruction. The effects of providing subjects with a choice of control type were also examined. During each of two consecutive sessions, subjects completed learner and program controlled CAI and a unit posttest. At the end of the first session, one-half of the subjects were given a choice of control type for the second session, while the other half were assigned to the same type of control they had just experienced. At the end of the second session, all subjects were asked to select the control type they would like to have in the future. Subjects also responded to pre- and postmeasures of motivation for science study and computer use. Results indicated that males performed better with program control than learner control in session one, but not for session two. Females scored slightly, but not significantly, higher under learner control in both sessions. This sex difference in performance is discussed relative to a possible differential effort on the part of males and females. Females under learner control selected a greater proportion of possible reviews than did males for both sessions, though the difference was significant only for session two. Differences in time to completion also indicate the likelihood of differential effort by sex. The data reveal a strong preference both for learner control and for instruction via computers. Implications of the data for classroom practice and for possible longer-term effects are discussed.

The game is evolution and each of us is fully involved. Through our intentionality, we can change our bodies and the body politic in surprisingly effective and dramatic ways. We are doing so all the time, whether we acknowledge it or not. At the depths of our being, we do know everything. No matter how limited our situation seems, even in a prison cell or on our final plunge to death, we are rich in options as to how we experience the moment. Just by transforming the moment, to some extent we transform all of existence.

--George Leonard, *The Silent Pulse*

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CHAPTER I

Introduction

The widespread adoption of the microcomputer as an instructional medium has not only made delivery of individualized instruction feasible, but has provided opportunities for more flexible education. However, there has been no agreement regarding how such instruction should be controlled. Instructional control can range from complete external control (by the instructor or computer) to total internal, or learner control. A variety of instructional elements can be controlled along this continuum, including pacing, sequencing, difficulty, and the amount of practice received.

Some researchers and theorists, such as Merrill (1975, 1980), have asserted that the learner ought to be given control, as he or she may know best what is needed at any given point during instruction. Merrill has gone on to suggest that when students are allowed to exercise control, they have increased opportunity to learn how to learn. Students exercising instructional control make decisions, experience the outcomes, and in the process may discover the best tactics for differing instructional situations. Others have suggested that the value of learner control is related to an increase in student meaningfulness, self-evaluation, and motivation (Campbell & Chapman, 1967).

In fact, provision of learner control may have its most positive impact on students' continuing motivation. The construct of continuing motivation was first defined by Maehr (1976). It reflects a student's willingness to learn--continuing motivation is displayed when an individual returns to a learning activity at a later time without external pressure to do so. The primary reward is thought to be the activity itself. Continuing motivation has strong implications for promotion of lifelong learning. As Pascarella, Walberg, Junker, and

Haertel (1981) suggest, "...it is continued interest and participation in the activities of science, rather than just mastery of science content that fosters the scientist" (p. 440-1).

What is necessary for a learning activity to be intrinsically motivating? Curiosity, a desire for competence or self-efficacy, and challenge have been suggested, as has the perception of control (Bruner, 1966; deCharms, 1968; Deci, 1975; Lepper, 1985; Malone, 1981; Zimbardo, 1969). Personal control is linked closely with the elements of personal causation and competence. Control makes it possible for individuals to make certain choices in an activity, and effect certain outcomes. And when a person feels competent and self-determining, the activity he or she is involved in is thought to have greater personal meaning and intrinsic interest (Condry & Chambers, 1978; Lepper, 1985).

In their study of 785 elementary and junior high school students, Harter and Connell (1984) determined that students' perceived control was a critical variable at the beginning of a predictive chain involving both motivation and achievement. Numerous studies have examined the relationship between individual perceptions of locus of control and academic achievement. Such research has indicated a clear positive relationship between an internal locus of control and achievement (for reviews, see Findley & Cooper, 1983; or Stipek & Weisz, 1981). Conversely, external influences have been correlated with decreased achievement. When Connell and Ryan (1984) asked students in the fourth through sixth grades to report the reasons why they did their school work, they found a negative correlation between doing schoolwork for extrinsic reasons and performance on a standardized achievement test.

Despite the promise of increased motivation and achievement suggested by research examining students' perception of control, the provision of learner control opportunities within instruction has yielded equivocal results for student performance. Some studies suggest that certain forms of learner control can be beneficial, while others indicate that students cannot effectively control various elements of their instruction.

Wang and Stiles (1976) found that when second-grade students were given control over the order in which they completed their assignments in class and the time they would spend on each, they reported greater perceptions of self-responsibility and completed a significantly higher proportion of the assignments than when the teacher exercised this control. White (1974, reported by Perlmuter & Monty, 1977) found choice to be positively related to achievement in reading comprehension. Other studies suggesting that individuals can learn more when given control over their learning include those conducted by Kinzie, Sullivan, and Berdel, 1988; Gray, 1987; and Campanizzi, 1978.

Tennyson (1980, 1981; Tennyson & Buttrey, 1980) found learner control to be instructionally effective, but only when individuals were given advisement on their performance relative to program criteria. Research conducted by Fisher, Blackwell, Garcia, and Greene, 1975; Fry, 1972; and Atkinson, 1972, suggests that learners allowed to make certain instructional decisions don't learn as effectively as those who have those decisions made for them.

When the research focus has broadened to include student attitudes, use of learner control has generally resulted in more positive attitudes toward the instruction (Fry, 1972; Hurlock, Lahey, & McCann, 1974; Pascal, 1971). Learner control has also been related to greater student motivation (Campbell & Chapman, 1967) and higher engagement (Fisher, et al.; 1975). Gray (1987) found that students liked learner control less than linear control, but this may have been due to learner unfamiliarity with the type of control offered.

The motivation that learners have to control aspects of their instruction was illustrated in the results of study conducted by Kinzie and Sullivan (1988). In this study, students completed science-related CAI under either program control or learner control of content review. No significant performance differences were found on the posttest, but when given a choice of type of control in subsequent CAI, students in both groups overwhelmingly chose to return to learner-controlled rather than program-controlled CAI.

In the present research the effects of instructional control and choice were examined relative to their effects on both achievement and continuing motivation. The measures of achievement were student performance on 25-item posttests administered after each of two instructional sessions. Researchers in continuing motivation have used either return to an instructional task in a free choice situation, or the expressed desire to do so, as measures of student continuing motivation. Both continuing motivation measures were used in this research.

The type of instructional control employed was learner or program control of content review following incorrectly answered practice questions within CAI. Following an incorrect response to a practice question, subjects in the learner control treatment were told their answer was incorrect. They were then able to control whether or not they reviewed related content before attempting the practice question another time. Subjects under program control were also told their answer was incorrect, but were automatically routed to content review before attempting the question again.

Because theory and research have suggested positive effects for provision of choice, the second major independent variable in this research was choice versus assignment for the type of control (learner or program control) experienced in the second session CAI. After the first session, half of the subjects were provided a choice over the type of control they would receive in the second session CAI. The remaining subjects were assigned to the type of control they had previously received.

Also investigated was whether availability of computers for delivery of instruction in a particular subject influences student motivation to study that subject at a future time. Students were asked whether they would prefer to study science or another subject, science or another subject when both are delivered by computer, and science or another subject if only one or the other option were presented by computer.

Sex of subject was used as a blocking variable. Sex differences have long been apparent in science attitudes and achievement, as well as in computer use. Blocking enabled the examination of any such sex differences, as well as differential gender effects by treatment.

CHAPTER II

Method

Subjects

Subjects were 280 students from ninth-grade geography classes at a rural high school. The ethnic composition of this high school student population is approximately 52% Anglo, 36% Hispanic, and 12% Black, Native American, and Oriental. Due to a policy promoting microcomputer acquisition and use in local schools, all subjects had considerable prior experience using computers in school. This school experience began in the middle school years.

Data from 164 students were used in the analyses. Due to student absences for one of the two experimental sessions, data from 61 students were discarded. Since several of the teachers reported a routine and very pronounced problem with student attendance at the school, these absences were not considered to be related to the experimental treatment. Other students were dropped from consideration for several reasons: (a) They did not answer any practice questions incorrectly and therefore did not experience the experimental treatment, learner or program control over content review ($n = 40$: $n = 4$ in session one, $n = 36$ in session two); (b) there were no standardized test scores available for them ($n = 8$); or (c) they experienced computer malfunction ($n = 7$).

Elimination of these potential subjects and differing numbers of males and females resulted in an unequal number of subjects in the experimental groups. The element of choice for one-half of the subjects for session two control type also contributed to inequality of group size for that session.

The mean grade-equivalent reading score on a standardized test administered two months prior to the study (during month five of the ninth grade) was 9.8. This mean ability level was three months higher than the actual grade placement of 9.5 for the students at that time.

Procedures

Each subject participated for two class periods; one class period on each of two consecutive days. The study was conducted on Thursdays and Fridays of three weeks devoted to computer literacy and took place in the school's computer laboratory using Apple IIe computers.

Prior to the study, subjects were randomly assigned within sex to either learner control or program control treatments for the first experimental session. Next, half of the subjects in each of the four Sex X Control groups were randomly selected to be given a choice of control type for the second session CAI. The other half were automatically assigned to same type of control they had experienced in session one.

Subjects under both learner control and program control progressed through the same basic instruction. All had opportunities for appropriate levels of practice and feedback. While the learner control option allowed subjects to choose less content review than program control subjects, both learner-controlled and program-controlled instruction incorporated the principles of good instructional design.

To minimize subject knowledge of differing instructional treatments, assignment of subjects to computers was done by treatment type: all subjects assigned to a particular treatment group were assigned to a separate row or block of computers. The placement of the different treatment groups in the computer laboratory was rotated for each class period.

Session one. During the first class period, subjects responded to the continuing motivation premeasure on computer, which elicited their preferences for science study or study of another subject, with and without computer use. Subjects then completed their randomly assigned learner or program control versions of the CAI unit on Solar Energy.

On completion of the CAI, the unit posttest was administered by computer, as were two attitude questions. These questions dealt with liking for the instruction and how well they felt they did on the posttest.

One-half of the subjects in each of the four sex by control groups were then given a choice by the computer for the type of control they would have in the next day's CAI (either learner- or program-controlled science CAI). The other half of each group was told by the computer that they would receive the type of control they had just experienced for the next session's science CAI. Subjects who finished before the end of the class period were given paper and pencil word search and create-a-word activities to occupy the remaining time.

Session two. Subjects in each group who were given a choice of type of control received science CAI on Tarantulas with the control type they chose at the end of session one. At the beginning of session two, these subjects were reminded by the computer that the CAI they would be using would provide the type of control they had selected at the end of the previous day's session. Subjects who were assigned to the same control type for both days were reminded that they would have the same type of control for the day's instruction that they had experienced the previous day.

On completion of the CAI, subjects completed a posttest and the two attitude items on liking for the instruction and how well they felt they did. The continuing motivation post-measure was then completed on computer. Subjects were told that the experimenters might return for future activities with the students. They were then asked to express their preferences for study activities for this future time: science or another subject, with and without computer use. Preference for type of instructional control was also elicited by asking all subjects to choose between learner and program control if they were to engage in science CAI in the future. When subjects finished, they were given paper and pencil vocabulary activities to work on until the end of the class period.

Materials

The two units of computer-assisted instruction used as the instructional base were science-related. The CAI program used in the first session covers an introduction to solar energy. This program contains screens of text and graphics, interspersed with 25 multiple choice practice questions with four response options each. The content was developed from Energy Choices and Challenges (1984), part of The Energy Source Program, a nationally distributed energy education series. Contents of the Solar Energy program are contained in Appendix A.

The CAI program used in the second session provides information about tarantulas in a similar format. The unit is interspersed with 25 multiple choice practice questions, again with four response options each. This program was developed from materials used by Frison (1984) and Pollock and Sullivan (1988). Contents of the program on Tarantulas are contained in Appendix C.

The materials for the various treatments differ as to the type of instructional control assigned and, for some subjects, the type of control chosen for the second session CAI. As indicated above, the instructional control utilized in the CAI is control over content review following incorrectly answered practice questions. Subjects in the learner control treatment were told when their answers were incorrect, and they controlled whether or not they reviewed relevant content before attempting the practice questions another time. Subjects under program control were also told when their answers were incorrect, but these individuals were automatically routed for review before attempting the questions again. Subjects in both treatments were given three chances to answer each practice question. Opportunities or requirements for review followed the first two incorrect answers. On the third incorrect answer, the correct answer to the question was supplied. Correct answers were followed by correct answer feedback.

Criterion Measures

All criterion measures except time to completion were administered and recorded by computer. Time to completion was recorded by the experimenter. Measures administered during session one are contained in Appendix B. Those administered during session two are included in Appendix D.

Posttests of 25 items each were administered immediately following completion of the solar energy CAI and the CAI on tarantulas. The posttest items are parallel to the practice items contained within the instruction and are multiple choice in format, with four answer choices per question. The reliability coefficients of the posttests were calculated with Kuder Richardson formula 20 for inter-item consistency, using data collected in this study. The reliability coefficients are .72 for the solar energy posttest and .51 for the tarantulas posttest.

The low coefficient of inter-item consistency for the tarantulas posttest may be due in part to its relative ease. The test apparently lacked a sufficient number of difficult items to effectively discriminate differences in subject performance. Item difficulty levels for the tarantulas posttest ranged from .81 to .99, with a mean difficulty level of .95. In contrast, item difficulty levels for the solar energy posttest ranged from .53 to .95, with a mean item difficulty level of .78.

At the end of the first session, half the subjects were asked to select the type of control, either learner or program, they would exercise over CAI in the next session. Subjects who had initially experienced learner control were asked, "During class tomorrow, which type of science program would you like to use on the computer, one like you just finished, in which you can choose whether or not to review, or a program in which the computer automatically takes you to review?" A similar question was asked those who had experienced program control: "During class tomorrow, which type of science program would you like to use on the computer, one like you just finished, in which the computer automatically takes you to review, or a program in which you can choose whether or not to review?" These individuals were then able to select either learner or program control of content review.

Subjects assigned to learner control for both sessions were told, "Tomorrow as you learn on the computer, you'll be able to make the same decisions you made today about whether or not to review." Similarly, those assigned to program control were told, "Tomorrow as you learn on the computer, the computer will automatically take you to review, just like today."

At the end of the second session, all subjects were told that the experimenters may return in the future. They were then asked to indicate their preferences for either learner or program control of content review for this future session.

Students' motivation for instructional computer use was measured at the beginning of the first session and at the end of the second session. Students were asked to indicate their preferences for study of science or another subject, with and without the use of computers. Students were asked if they would rather study...

1) Science *or* another subject,

2) Science using computers *or* another subject using computers,

3) Science using computers *or* another subject without using computers, and

4) Science without using computers *or* another subject on computers.

Two student attitudes were measured: liking for the instruction and confidence in performance (how well subjects felt they did on the posttests). Students responded to these two items following the unit posttests each day.

Design and Data Analyses

A 2 X 2 X 2 (Sex X Control X Choice) posttest-only experimental design was used. Posttest performance for both days was analyzed with analysis of covariance

(ANCOVA) techniques. Previous research with the CAI materials used in this study indicated a high correlation between reading ability and posttest achievement. Therefore reading ability scores from the Gates-MacGintie standardized tests were used as a covariate in the achievement analyses.

All multivariate and univariate analyses of variance and covariance were conducted using the SAS/STAT statistical package (Version 6) General Linear Models (GLM) procedures. SAS GLM procedures use the method of weighted squares of means to analyze differences between unweighted means when there are an unequal number of subjects in experimental groups. This technique has been advocated by Barcikowski (1983) and Speed, Hocking, and Hackney (1978). It is thought to be superior to the method of unweighted means analysis, which does not yield exact F tests.

CHAPTER III

Results

Session One

Posttest performance. Mean scores for reading ability and session one posttest scores, both unadjusted and adjusted for reading performance, are reported by type of control and sex in Table 1. The overall mean score on the session one posttest was 19.43 correct out of 25 possible ($SD = 3.52$); the overall correlation between reading ability and session one posttest scores was .49 ($p<.0001$). Scores were analyzed to determine the existence of any differences that may have resulted from type of control or sex of subject.

Table 2 contains the summary table for the analysis of covariance. Adjusted mean scores were 19.21 for learner-control subjects and 19.61 for program-control subjects, a nonsignificant difference. The main effect for sex, however, was found to be significant, $F(1,159) = 4.11$, $MS_e = 9.10$, $p < .05$, with males ($M_{adj} = 19.89$) performing better than females ($M_{adj} = 18.93$).

A significant control by sex interaction was also found, $F(1,159) = 5.04$, $MS_e = 9.10$, $p < .03$. The interaction is depicted in Figure 1, using adjusted means. Analyses of simple main effects were then undertaken, as outlined by Keppel (1982). Results indicated that males performed better under program control ($M_{adj} = 20.62$) than learner control ($M_{adj} = 19.16$), $F(1,159) = 4.74$, $MS_e = 9.10$, $p < .04$. Females, on the other hand, performed better under learner control ($M_{adj} = 19.26$) than program control ($M_{adj} = 18.56$), but this difference was not significant.

Table 1

Session One: Reading Ability, Posttest Scores, and Posttest Scores Adjusted for Reading Ability as a Function of Type of Control and Sex

Variable	Male LC (n = 40)	Male PC (n = 41)	Female LC (n = 46)	Female PC (n = 37)
Reading Ability[a]				
M	10.10	9.96	9.53	9.65
SD	1.71	2.08	2.02	1.91
Posttest 1[b]				
M	19.43	20.76	19.02	18.46
SD	3.23	3.66	2.99	3.96
Adjusted Posttest 1[c]				
M	19.16	20.62	19.26	18.56
SE	0.48	0.47	0.46	0.50

[a]Scores are expressed as mean grade equivalents
[b]Scores are mean number correct (out of 25 possible)
[c]Mean scores are adjusted for reading ability

Table 2

Session One: ANCOVA Summary Table for Posttest Performance

Source of Variance	SS	df	MS	F	p
Control	6.45	1	6.45	0.71	0.41
Sex	37.37	1	37.37	4.11	0.05
Control X Sex	45.85	1	45.85	5.04	0.03
Reading Ability	461.27	1	461.27	50.71	0.0001
Error	1446.23	159	9.10		
Total	2022.12	163			

Contrast	SS	df	MS	F	p
PC vs LC in Males	43.08	1	43.08	4.74	0.04
PC vs LC in Females	9.02	1	9.02	0.99	0.33

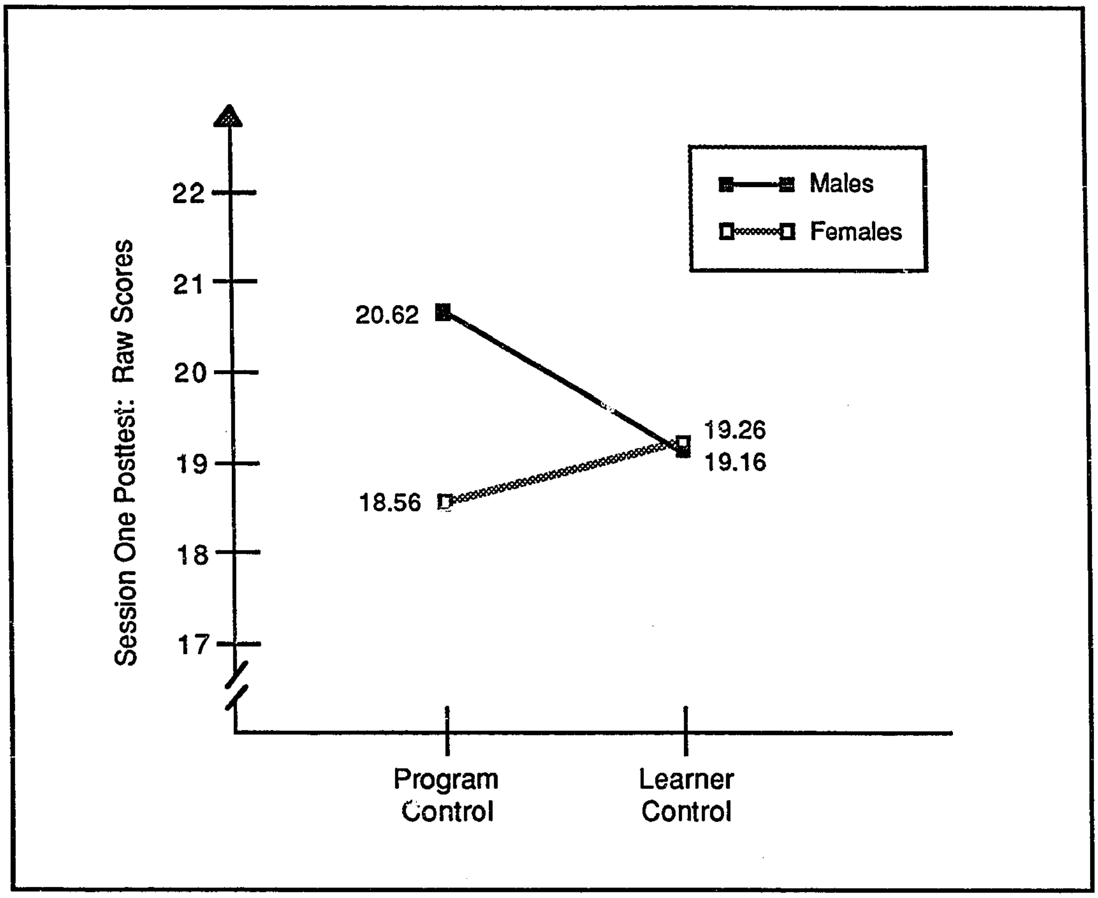

Figure 1. Session one posttest performance as a function of type of control experienced during session one and sex.

Continuing motivation for type of control. Continuing motivation for type of control, measured for choice subjects at the end of session one, was analyzed using chi square procedures for main effects and log-linear analyses for interactions (Sokal & Rohlf, 1981). These methods were selected because of the dichotomous nature of the measure, coupled with the unequal numbers of subjects in treatment groups. Yates' correction for discontinuity was also used, as the analyses had only one degree of freedom.

At the end of session one, the 78 choice subjects were allowed to select the type of control they would exercise in the second session CAI. Sixty-five percent (51 of 78) chose learner control and the remaining 35% (27 of 78) chose program control. These proportions were found to be significantly different from the 50% chance level, $\chi^2(1, \underline{N} = 78) = 6.78$, $\underline{p} < .01$.

Seventy-three percent (30 of 41) of the learner-control subjects and 57% (21 of 37) of the program-control subjects selected learner control for session two. Males (69%, or 27 of 39) selected learner control slightly more frequently than did females (62%, or 24 of 39). However, neither the difference by control type nor the difference by sex proved significant. The control by sex interaction effect was also nonsignificant.

Because learner-control subjects selected learner control in greater numbers than program-control subjects, the converse was also true: program-control subjects selected program control in greater numbers than learner-control subjects. However, the overall return rate of 59% (46 of 78) to the initial type of control did not differ significantly from the 50% chance level, $\chi^2(1, \underline{N} = 78) = 2.167$, $.50 < \underline{p} < .10$.

Attitudes: Liking and confidence in performance. Responses to the two attitude questions following the CAI for both sessions (liking for instruction and confidence in performance) were analyzed using MANOVA procedures. Univariate analyses followed identification of significant multivariate effects.

Attitudes expressed were generally positive, as indicated by an overall mean of 2.86 (1 = low, 4 = high) on these two items. The multivariate analysis yielded a significant main effect for sex, F(2,158) = 7.55, p < .0007. There were no significant multivariate effects for control or sex by control.

Univariate analyses were undertaken to determine the relationship between sex and responses to the attitude items. A significant univariate relationship was found for confidence in performance. Males (M = 3.17, SD = 0.65) felt they had done significantly better on the posttest than females (M = 2.78, SD = 0.65), F(1,159) = 14.91, MS_e = 0.41, p <.0002. Males (M = 2.83, SD = 0.85) also reported liking the CAI slightly better than females (M = 2.65, SD = .81), but this difference was not significant.

Proportion reviews selected by Learner-Control Subjects. During the instructional treatment, subjects under learner control had the choice of reviewing or not reviewing the relevant content for each practice item they missed. Differences in the proportion of reviews selected were analyzed with ANOVA. Glass, Peckham, and Sanders (1972) recommend the F test as being sufficiently robust to handle analysis of variables expressed as proportions, even though they are not normally distributed.

Learner control subjects chose to review content for 30% (SD = .35) of the practice items they missed and not to review it for the remaining 70% of missed items. Females exercising learner control selected 33% (SD = .35, n = 46), a larger proportion than did males in this treatment, who selected 25% (SD = .35, n = 40). This sex difference was not significant, however.

Time to completion. Time to completion was examined with ANCOVA techniques, using reading ability as a covariate. The overall mean time to completion for the instruction, posttest, attitude items, and choice or assignment of control type, was 36.4 min (SD = 5.1). Differences in time to completion were examined by type of control and sex. The correlation between reading ability and time to completion for session one was -.43 (p

<.0001). That is, subjects with higher reading ability took less time. Significant differences were found for type of control. Program-control subjects required an adjusted mean time of 37.5 min, significantly longer than the adjusted mean time of 35.5 min required by learner-control subjects, $F(1,159) = 8.12$, $MS_e = 20.12$, $p < .005$. Females, with an adjusted mean time of 37.1 min, took more time than males, with an adjusted mean of 35.8 min., but this difference only approached significance, $F(1,159) = 3.56$, $MS_e = 20.12$, $p < .06$. This sex difference persisted across control type, with females spending more time than males in both learner and program control conditions.

Prior motivation for science study. To determine if males and females had differing levels of motivation for science study coming into the experiment, frequencies of males and females selecting science on the first question of the continuing motivation premeasure (science versus another subject) were examined. Chi square analysis indicated that more males (36%, or 29 of 81) expressed a desire to study science than females (19%, or 16 of 83), $\chi^2(1, N = 164) = 5.18$, $p < .03$.

Proportion of variance accounted for. The relative magnitude of effects was calculated for all significant effects using omega squared (ω^2) procedures. Reading ability accounted for the greatest amount of variance in posttest achievement, 22%. The significant effects for sex and the sex by control interaction accounted for small proportions of variance, 1% and 2% respectively. The significant simple main effect for males under program control versus males under learner control accounted for 2%.

In subject attitudes, the univariate effect for sex in confidence in test performance accounted for 8% of the total variance. For time to completion in session one, the type of control which subjects experienced accounted for 3% of the variance.

Session Two

Posttest performance. As with session one, session two posttest performance was analyzed using reading ability as a covariate. Table 3 indicates reading ability, session two posttest scores, and posttest scores adjusted for reading ability for control by choice/assignment groups. The overall mean score on the session two posttest was 23.72 correct out of 25 possible (SD = 1.49), indicating a probable ceiling effect. The overall correlation between reading ability and session two posttest scores was .26 ($p<.0009$).

Group scores were examined to determine if any control or sex effects were present and to assess the effects of choice versus assignment to control type. When significance was not found for the three-way interaction of control by choice/assignment by sex, this term was dropped from the analysis. The summary table for the analysis of covariance appears in Table 4.

The adjusted mean score for program-control subjects on the posttest was 23.84, slightly higher than that for learner-control subjects, who scored 23.57. Individuals who were assigned to control type for session two had an adjusted mean score of 23.86 and those who chose control type had an adjusted mean of 23.55. Males (M_{adj} = 23.91) scored slightly higher than females (M_{adj} = 23.49), and both males and females scored higher under learner control than under program control. None of these differences were significant, however.

The interaction effect for control by choice/assignment approached significance, $F(1,156) = 3.76$, $MS_e = 2.03$, $p < .06$. Subsequent analyses of simple main effects indicated that under the assignment treatment, program control (M_{adj} = 24.21) was superior to learner control (M_{adj} = 23.50), $F(1,156) = 5.41$, $MS_e = 2.03$, $p < .03$. For subjects allowed to choose control type however, learner control (M_{adj} = 23.64) was slightly better than program control (M_{adj} = 23.47), but this difference was not significant. The fact that

Table 3

Session Two: Reading Ability, Posttest Scores, and Posttest Scores Adjusted for Reading Ability, for Control by Choice/Assignment Groups

	Assigned		Choice	
Variable	LC (n = 45)	PC (n = 41)	LC (n = 51)	PC (n = 27)
Reading Ability[a]				
M	10.00	9.63	9.78	9.77
SD	1.91	1.94	2.18	1.51
Posttest 2[b]				
M	23.56	24.17	23.63	23.48
SD	1.67	0.95	1.59	1.58
Adjusted Posttest 2[c]				
M	23.50	24.21	23.64	23.47
SE	0.21	0.22	0.20	0.28

[a]Scores are expressed as mean grade equivalents
[b]Scores are mean number correct (out of 25 possible)
[c]Mean scores are adjusted for reading ability

Table 4

Session Two: ANCOVA Summary Table for Posttest Performance

Source of Variance	SS	df	MS	F	p
Control	2.86	1	2.86	1.41	0.24
Choice/Assignment	3.52	1	3.52	1.74	0.19
Sex	6.89	1	6.89	3.40	0.68
Ctrl X Ch/Assign	7.62	1	7.62	3.76	0.06
Ctrl X Sex	0.11	1	0.11	0.05	0.82
Ch/Assign X Sex	0.47	1	0.47	0.23	0.64
Reading Ability	27.77	1	27.77	13.69	0.0003
Error	316.37	156	2.03		
Total	361.10	163			

Contrast	SS	df	MS	F	p
PC vs LC: Assigned	10.97	1	10.97	5.41	0.03
PC vs LC: Choice	0.52	1	0.52	0.26	0.62

the small performance difference between learner and program-control assigned subjects (0.71 out of 25) was significant appears to be due to the ceiling effect and the resulting small amount of performance variance on the posttest.

Continuing motivation for type of control. At the end of the second session, all subjects were told the experimenters may return at a future time for more learning activities with their class. Students were given a choice of the type of control they would exercise at this future time, either learner or program. Overall, 63% (104 of 164) of the subjects expressed a preference for learner control and 37% (60 of 164) for program control. These proportions were significantly different from the 50% chance level, $\chi^2(1, N = 164) = 11.27$, $p<.001$.

Eighty-six percent (83/96) of subjects under learner control for session two selected learner control for the future, as compared to only 31% (21/68) of the program control group. These proportions were significantly different from each other, $\chi^2(1, N = 164) = 41.37$, $p<.001$. Males chose learner control in slightly, but not significantly, greater numbers (70%, 57 of 81) than did females (57%, or 47 of 83). Rates of preference for learner control were nearly identical for choice (63%, or 49 of 78) and assigned (64%, or 55 of 86) subjects.

Overall, 79% (130 of 164) of all subjects elected to return in the future to the same type of control experienced for session two, a proportion significantly different from the 50% chance level, $\chi^2(1, N = 164) = 55.03$, $p<.001$. As might be expected, a high proportion of choice subjects (85%, or 66 of 78) elected to return in the future to the type of control they had chosen for session two. Assigned subjects also demonstrated a high return rate (74%, or 64 of 86) to the same type of control. The return rates for both choice and assigned subjects were significantly greater than the 50% chance level, $\chi^2(1, N = 164) = 41.37$, $p<.001$, and $\chi^2(1, N = 86) = 19.55$, $p<.001$, respectively.

Continuing motivation for computer use. To determine whether providing the option to work on the computer affects subjects' preferences for study activities, a series of chi square analyses were undertaken with the continuing motivation postmeasures. First, the obtained frequencies for question one (science or another subject) were used as expected frequencies in an analysis of obtained frequencies for question three (science on computers or another subject without using computers). This difference can be thought of as reflecting the increase in motivation for science study when only science is offered on computers and a competing subject is not. Expressed preferences for science study went from 24% (39 of 164) of the subjects when neither study option was available on computers to 69% (113 of 164) when science study alone was available on computers. The difference proved to be significant, $\chi^2(1, N = 164) = 173.80$, $p<.001$.

Next, obtained frequencies for question two (science on computers or another subject on computers) were used as expected frequencies for the analysis of question three (science on computers or another subject without using computers). This analysis was undertaken to determine if subjects who preferred study of another subject when both options were available on computer would switch to study of science when it was the only computer option available. Evidence of such a switch was found. Preference for study of another subject went from 77% (126 of 164) when both options were available on computers to 31% (51 of 164) when only science was available on computers, $\chi^2(1, N = 164) = 198.94$, $p<.001$.

The final analysis used obtained frequencies for question two (science on computers or another subject on computers) as expected frequencies for question four (science without using computers or another subject on computers). This analysis was intended to detect a switch from science on computers to another subject when only another subject was available on computers. Again, evidence of such a switch was found. Twenty-three percent (38 of 164) of the subjects expressed a preference for science study when both options were available on computers, but only 10% (16 of 164) did when another subject was the only option available on computers, $\chi^2(1, N = 164) = 14.67$, $p<.001$.

Pre-post differences in expressed motivation for science study, obtained by subtracting subject responses on the premeasure from their responses on the postmeasure, were all very small. Analyses indicated no significant main or interaction effects.

Attitudes: Liking and confidence in performance. Subjects reported very positive attitudes related to the activities for session two ($M = 3.32$, 1 = low, 4 = high). These attitudes were examined to determine if there were any differences due to control, sex, or choice/assignment. The multivariate analysis yielded a significant main effect for control, $F(2,159) = 3.50$, $p < .04$. There were no significant effects for sex or choice/assignment, nor were there any significant interaction effects.

Univariate analyses were undertaken for the two attitude items to determine the effects of type of control. A significant univariate effect was found for confidence in performance. Subjects experiencing program control ($M = 3.63$, $SD = 0.65$) felt significantly more confident about their performance on the posttest than did those experiencing learner control ($M = 3.45$, $SD = 0.54$), $F(1,160) = 5.59$, $MS_e = 0.36$, $p <.02$. Program control subjects ($M = 3.28$, $SD = 0.88$) also reported liking the CAI slightly more than did the learner control subjects ($M = 3.01$, $SD = 0.84$), but this difference was not significant.

Proportion reviews selected by Learner-Control Subjects. As in session one, subjects who experienced learner control had the choice of reviewing or not reviewing relevant content after each incorrectly answered practice question. Subjects who experienced learner control, either as the result of choice or assignment, selected 29% ($SD = .40$) of the reviews possible and declined the remaining 71%.

Analyses of sex and choice/assignment differences for learner control subjects indicated a significant sex difference in proportion of possible reviews selected. Females who experienced learner control chose 37% (SD = .44, n = 48) of possible reviews, a significantly larger proportion than males in this treatment, who chose only 21% (SD = .34, n = 48), $F(1,93) = 4.02$, $MS_e = 0.15$, $p < .05$. No differences were noted as a result of choice versus assignment to learner control.

Time to completion. The overall mean time to completion for the instruction, posttest, and continuing motivation and attitude items was 30.4 min (SD = 3.17) in session two. Analyses were undertaken to examine differences due to sex, control type experienced in session two, and choice/assignment, using reading ability as a covariate. The correlation between reading ability and time to completion for session two was -.33 ($p < .0001$). When significance was not found for the three-way interaction of control, choice/assignment, and sex, this term was dropped from the analysis.

None of the between-group differences in time to completion were statistically significant. Program-control subjects took slightly longer to finish (M_{adj} = 29.75 min) than did learner-control subjects (M_{adj} = 29.38 min). Those who had been given a choice of control type (M_{adj} = 29.89 min) spent slightly longer on the CAI than did those assigned to control type (M_{adj} = 29.24 min). Females (M_{adj} = 29.53 min) and males (M_{adj} = 29.60 min) had nearly identical times to completion.

A significant interaction effect was found for sex by control, $F(1,156) = 5.27$, $MS_e = 8.72$, $p < .03$. Males under program control (M_{adj} = 30.33) took more time than males under learner control (M_{adj} = 28.87) . Conversely, females under learner control (M_{adj} = 29.89) took more time than under program control (M_{adj} = 29.17). Analyses of simple main effects indicated that the within-sex differences for males and females were not significant.

Proportion of variance accounted for. As was done for session one, the relative magnitude of effects was also calculated for session two all significant effects using omega squared (ω^2) procedures. Reading ability accounted for 7% of the total variance in posttest performance. The control by choice/assignment interaction term accounted for 1.5% of the posttest variance, while the simple main effect for learner versus program control in the assigned treatment accounted for 2.5%.

In confidence in test performance, the main effect for type of control accounted for 3% of the variance. Sex of subject accounted for 3% of the variance in proportion of reviews selected during the session two CAI. The sex by control interaction was responsible for 2% of the variance in time to completion.

CHAPTER IV

Discussion

General results for achievement across the two sessions do not yield a strong effect favoring either program control or learner control. Program control was significantly better for males in session one but not in session two. Females did better under learner rather than program control in both sessions, but not significantly so.

That boys, but not girls, did better under program control in session one may be related to differential effort on their parts. Program control requires all subjects to review the content for all items answered incorrectly, but learner control does not. Under learner control, girls selected more of the possible reviews in both sessions than did boys, though the difference was significant only for session two. The fact that boys under learner control selected fewer reviews for missed items than girls placed them under a somewhat greater disadvantage relative to their program control counterparts who were required to complete all items. Differential effort may also be reflected by the data for time to completion. While not statistically significant, girls in both learner and program control groups spent more time on the session one CAI than did boys. During session two, a significant Sex by Control interaction reflected the fact that girls under learner control took more time on the CAI than did girls under program control, while boys took more time under program than learner control.

The fact that girls under learner control completed more reviews overall and tended to spend more time on the CAI is consistent with other research findings. That girls appear to try harder and tend to get better grades in school than boys has been explained in several ways. Data obtained by Harter (1975) indicate that boys are motivated by challenging tasks and girls by a need for approval. Maccoby and Jacklin (1974) suggest that girls may be able to maintain achievement motivation more easily than boys, who may require more competitive, ego-challenging conditions. Licht (1987) contends that females' lesser confidence in their intellectual abilities may prompt them to try harder to avoid failure across content areas. To the extent that it is true that girls try harder, this tendency to intensify effort may lead to more conscientious use of learner control features by females than by males.

It is difficult to draw any strong conclusions for session two test performance, a fact that appears to be at least partly influenced by the ceiling effect for this session. The advantage for males under program control over males under learner control found in session one was not found for session two. Subjects assigned to a control type performed somewhat better in program control than learner control, but this difference favoring program control was not evident for choice subjects.

The relatively small achievement differences between learner and program control were most likely influenced by at least two important factors. First, as previously indicated, subjects in both treatments were given appropriate levels of information and practice. Control of content review occurred only above and beyond this basic level of instruction. Second, the error rate data indicate that the two treatments did not differ substantially from each other with respect to opportunities for review. Learners had initial review opportunities on 24% of the practice questions during session one and on only 11% of practice questions during session two. Thus, the learner control procedure differed from the program control one only on these rather small percentages of practice items.

Based on the preferences for learner control expressed by choice subjects at the end of session one and by all subjects at the end of session two, it seems clear that students have a strong desire to exercise learner control. Sixty-five percent of the choice subjects in session one selected learner control for session two, and 63% of all 164 subjects in session two selected learner control as their choice for the future. These results appear to indicate that individuals prefer to exercise personal control over whether to review subject-matter content that they did not learn well, rather than have that decision made for them. This preference for learner control, of course, may also extend to other aspects of the learning environment.

In addition to the preference for learner control, subjects also showed an overall preference for a return to the same type of control they had just experienced. This pattern was very strong in session two, where 79% of the subjects elected to return to the same type of control, but less pronounced in session one, where a nonsignificant 59% chose the same type. A potential explanation for this preference for the same type of control is that, once they had experienced program control, subjects under this treatment may have realized that it is not a particularly onerous form of control and may therefore have been willing to return to it. In addition, the stronger preference in session two for the same type of control may be due to the fact that the CAI for this session was relatively easy. There were fewer opportunities for review than in session one, hence less chance to experience learner or program control of content review. The lesser impact of control type, coupled with the higher levels of student performance and more positive attitudes revealed on the posttest and attitude questions, may have influenced subjects to retain the same control conditions for the future.

It is clear from the data that students are attracted to instruction on the computer. Expressed desires to study science increased when science study was made available on computer. Students also changed their preferences for content areas dependent on computer availability. When computers were available only for the study of science, the number of students expressing a desire to study science increased significantly. Similarly, when computers were available only for study in another (non-science) subject area, the numbers of students desiring study in this other subject area significantly increased.

These results suggesting the strong appeal of the computer are consistent with those found by Kinzie and Sullivan (1988) and by Seymour, Sullivan, Story, & Mosley (1987). Clark (1983) attributed results such as these to a novelty effect associated with computers. However, computers were not particularly novel for subjects in these studies. In this study and the one by Kinzie and Sullivan, subjects were very computer literate, having had training in computer literacy as well as frequent experience with instructional applications of the microcomputer. Subjects from Seymour's study were also reported to have had considerable prior experience working with computers. Rather than a novelty effect, the positive results favoring computers appear to indicate a greater appeal of CAI over textbooks and other paper-based instructional materials. These results could be a function of the fact that CAI generally features more active student responding than other materials, or it may relate to other properties of the computer and/or CAI materials. In their reviews of related research, Levin, Glass, and Meister (in press) and White (1983) suggest general and long-range positive effects for instructional use of microcomputers.

While the performance effects of learner control in this study are not strong, students do show a preference for exercising learner control, as well as for computer use. Incorporation of these preferences in the design and delivery of instruction could yield greater return rates to instructional activities and more engagement with the subject matter on a long-term basis and, as a possible consequence, better achievement. This is a reasonable hope for computers and perhaps for learner control. Because of learner preferences and the possibility of improved long-term achievement, it seems appropriate to capitalize on opportunities to incorporate learner control options into instruction when the options do not allow students to bypass critical elements of the instruction such as practice and feedback. These types of options include control over the extent of guided practice or additional solo practice, sequencing in non-hierarchical learning, and the topics pursued in areas such as reading and composition.

Several possible areas for future research are suggested by this study. First, studies involving computer use should be undertaken over a longer time period to investigate the possibility of longer-term achievement and motivational effects. Second, future research should employ more extensive forms of learner control than the control over content review used here. Control over content review appears, on the basis of this study, to have limited potential for strong between-treatment differences and resulting performance effects. Additionally, researchers should continue to examine sex differences in research on learner control to determine if males and females benefit from differing levels and types of control.

Motivational theory suggests that provision of learner control can promote greater student motivation and achievement. Further research such as that described above can help us to identify the conditions that contribute to attainment of these goals.

REFERENCES

Atkinson, R. C. (1972). Optimizing the learning of a second-language vocabulary. Journal of Experimental Psychology, 96, 124-129.

Barcikowski, R. S. (1983). Computer packages and research design (Vol. 2). New York: University Press.

Bruner, J. S. (1966). Toward a theory of instruction. Cambridge, MA: Belknap.

Campanizzi, J. (1978). The effects of locus-of-control and provision of overviews upon response latency and achievement in a computer-assisted instructional sequence. Dissertation Abstracts International, 39(2-A), 830A. (University Microfilms No. 78-12, 325)

Campbell, V. N., & Chapman, M. A. (1967). Learner control vs. program control of instruction. Psychology in the Schools, 4, 121-130.

Clark, R. E. (1983). Reconsidering research on learning from media. Review of Educational Research, 53, 445-459.

Condry, J., & Chambers, J. (1978). Intrinsic motivation and the process of learning. In M. R. Lepper and D. Greene (Eds.), The hidden costs of reward: New perspectives on the psychology of human motivation. Hillsdale, NJ: Lawrence Erlbaum.

Connell, J. P., & Ryan, R. M. (1984, April). Motivation and internalization in the academic domain: The development of self-regulation. Paper presented at the meeting of the American Educational Research Association, New Orleans.

deCharms, R. (1968). Personal causation. New York: Academic Press.

Deci, E. L. (1975). Intrinsic motivation. New York: Plenum.

Energy choices and challenges. (1984). Washington, DC: Energy Source Educational Council.

Findley, M. J., & Cooper, H. M. (1983). Locus of control and academic achievement: A literature review. Journal of Personality and Social Psychology, 44, 419-427.

Fisher, M. D., Blackwell, L. R., Garcia, A. B., & Greene, J. C. (1975). Effects of student control and choice on engagement in a CAI arithmetic task in a low-income school. Journal of Educational Psychology, 67, 776-783.

Frison, C. G. (1984). Imagery, postquestions, and children's learning from prose. Unpublished doctoral dissertation, Arizona State University.

Fry, J. P. (1972). Interactive relationship between inquisitiveness and student control of instruction. Journal of Educational Psychology, 63, 459-465.

Glass, G. V., Peckham, P. D., & Sanders, J. R. (1972). Consequences of failure to meet assumptions underlying the fixed effects analyses of variance and covariance. Review of Educational Research, 42, 237-287.

Gray, S. H. (1987). The effect of sequence control on computer assisted learning. Journal of Computer-Based Instruction, 14, 54-56.

Harter, S. (1975). Mastery motivation and need for approval in older children and their relationship to social desirability response tendencies. Developmental Psychology, 11, 186-196.

Harter, S., & Connell, J. P. (1984). A model of children's achievement and related self-perceptions of competence, control, and motivational orientation. In J. Nicholls and M. Maehr (Eds.), Advances in motivation and achievement: Vol 3. The development of achievement motivation. Greenwich, CT: JAI Press.

Hurlock, R. E., Lahey, G. F., & McCann, P. H. (1974, April). Student controlled versus program controlled CAI. Paper presented at the meeting of the American Educational Research Association, Chicago. (ERIC Document Reproduction Service No. ED 089 681)

Keppel, G. (1982). Design and analysis: A researcher's handbook (2nd ed.). Englewood Cliffs, NJ: Prentice-Hall.

Kinzie, M. B., & Sullivan, H. J. (1988, November). The effects of learner control on motivation. Paper presented at the meeting of the Association for Computer-Based Instruction, Philadelphia.

Kinzie, M. B., Sullivan, H. J., & Berdel, R. L. (1988). Learner control and achievement in science computer-assisted instruction. Journal of Educational Psychology, 80, 299-303.

Lepper, M. R. (1985). Microcomputers in education: motivational and social issues. American Psychologist, 40(1), 1-18.

Levin, H. M., Glass, G. V., & Meister, G. R. (in press). Cost-effectiveness of computer-assisted instruction. Evaluation Review.

Licht, B. G. (1987, April). The interaction between children's achievement-related beliefs and the characteristics of different tasks. In D. H. Schunk (Chair), Student Beliefs and School Achievement. Symposium conducted at the meeting of the American Educational Research Association, Washington.

Maccoby, E. E., & Jacklin, C. N. (1974). The Psychology of Sex Differences. Stanford, CA: Stanford University Press.

Maehr, M. L. (1976). Continuing Motivation: An analysis of a seldom considered educational outcome. Review of Educational Research, 46, 443-462.

Malone, T. W. (1981). Toward a theory of intrinsically motivating instruction. Cognitive Science, 4, 333-369.

Merrill, M. D. (1975). Learner control: Beyond aptitude-treatment interactions. AV Communications Review, 23, 217-226.

Merrill, M. D. (1980). Learner control in computer based learning. Computers & Education, 4, 77-95.

Pascal, C. E. (1971). Instructional options, option preference, and course outcomes. The Alberta Journal of Educational Research, 17(1), 1-11.

Pascarella, E. T., Walberg, H. J., Junker, L. K., & Haertel, G. D. (1981). Continuing motivation in science for early and late adolescents. American Educational Research Journal, 18, 439-452.

Perlmuter, L. C., & Monty, R. A. (1977). The importance of perceived control: Fact or Fantasy? American Scientist, 65, 759-765.

Pollock, J., & Sullivan, H. J. (1988, April). Learner control, achievement, and continuing motivation in computer-based instruction. Paper presented at the meeting of the American Educational Research Association, New Orleans.

Seymour, S. L., Sullivan, H. J., Story, N. O., & Mosley, M. L. (1987). Microcomputers and continuing motivation. Educational Communication & Technology Journal, 35, 18-23.

Sokal, R. R., & Rohlf, F. J. (1981). Biometry. New York: Freeman.

Speed, S. M., Hocking, R. R., & Hackney, O. P. (1978). Methods of analysis of linear models with unbalanced data. Journal of the American Statistical Association, 73, 105-111.

Stipek, D. J., & Weisz, J. R. (1981). Perceived control and academic achievement. Review of Educational Research, 51, 101-137.

Tennyson, R. D. (1980). Instructional control strategies and content structure as design variables in concept acquisition using computer-based instruction. Journal of Educational Psychology, 72, 525-532.

Tennyson, R. D. (1981). Use of adaptive information for advisement in learning concepts and rules using computer-assisted instruction. American Educational Research Journal, 18, 425-438.

Tennyson, R. D. & Buttrey, T. (1980). Advisement and management strategies as design variables in computer-assisted instruction. Educational Communication & Technology Journal, 28, 169-176.

Wang, M. C., & Stiles, B. (1976). An investigation of children's concept of self responsibility for their school learning. American Educational Research Journal, 13, 159-179.

White, R. W. (1959). Motivation reconsidered: The concept of competence. Psychological Review, 66, 297-333.

Zimbardo, P.G. (1969). The cognitive control of motivation. Scott, Foresman: Glenview, IL.

APPENDICES

APPENDIX A

Session One: Computer Assisted Instruction

SESSION ONE: COMPUTER ASSISTED INSTRUCTION

Solar Energy: Promise from the Sun

The following is the text of the CAI which serves as the the instructional base for the first session in this study. Each screen-full of text (indicated here in separate paragraphs) is incorporated into a color-coded frame topped with the heading for the current topic. Informational screens are framed in orange and blue. Screens with practice and test questions are framed in green and purple. Graphics are incorporated as indicated, and range in size from 1/6 to 1/3 of the screen.

ENERGY

(Sun graphic)
The sun is our basic energy source. It provides light and warmth that people, plants, and animals need to live and grow. But most of the energy we put to use is in the form of fossil fuels.

Fossil fuels are taken from the ground. They include gas, oil, and coal. There is a limited amount of such fuels, and once they are gone, they cannot be replaced. So, once again, we are turning to the sun, as a means of replacing some of these fossil fuels.

CHECK YOUR UNDERSTANDING

The following practice questions cover the material you just read. Read the question and select the best answer. Enter your answer by typing the letter listed. (a, b, c, d).

1) What is the basic source of energy?

   a) fossil fuel
   b) sunshine
   c) oil
   d) light and warmth

SAMPLE FEEDBACK/REVIEW PROCEDURES:

Following a correct response, correct answer feedback is given. For example, in the case of question one:

That's right.
Sunshine is the basic source of energy.

On any incorrect response, the student in the Learner Control *condition is told:*

No, that's wrong. *or* No, that's not the right answer.
Do you want to review the material before trying to answer the question again? (Type y or n.)

At a "y" response, the student is directed to a review of content pertinent to that question. Following the review, the student attempts the question again.

At a "n" response, the computer presents the student with the identical question for a second or third attempt.

On any incorrect response, the student in the Program Control *condition is told:*

No, that's wrong. *or* No, that's not the right answer.
Let's review before you try to answer the question again.

The student is automatically branched to a review of related content, then back to answer the practice question a second or third time.

On the third incorrect answer, all students are provided with the correct response, in this case:

No, the answer is: b) sunshine.
Sunshine is the basic source of energy.

---

2) Which of the following can grow without sunlight?

a) volcanos
b) crops
c) animals
d) bugs

(Correct response is "a.")

---

3) Which of the following IS NOT a fossil fuel?

   a) oil
   b) wood
   c) natural gas
   d) coal

(Correct response is "b.")

4) Why can't we continue to use fossil fuels for our energy needs?

   a) Fossil fuels cost too much to process.
   b) Oil and gas are cheaper.
   c) There is a limited amount of fossil fuels.
   d) Fossil fuels are hard to produce.

(Correct response is "c.")

SOLAR POWER

(Sun graphic)
Solar power uses the sun's heat or light itself as the source of energy. One form of solar power that is well developed is solar heating.

Solar heating is being used in a growing, but still small number of houses and buildings, to heat both water and inside air. In many areas it can supply some or all of the necessary heat at a low cost. These solar heating systems can be active or passive.

CHECK YOUR UNDERSTANDING

5) What are most solar heating systems used for today?

   a) To store solar heat in the roofs and walls of buildings.
   b) For running solar water pumps.
   c) For heating water and inside air.
   d) For producing solar electricity.

(Correct response is "c.")

---

6) What are the two main types of solar heating systems called?

a) active and reactive
b) positive and negative
c) dynamic and passive
d) active and passive

(Correct response is "d.")

ACTIVE SOLAR HEATING SYSTEMS

Active solar heating systems contain moving parts, such as motors and pumps. They provide most of our solar heating today. At present, they are used mainly for heating water, and sometimes for heating inside air.

Active systems use solar collectors, which are panels made of metal, glass, or plastic. The solar collectors are installed on the roof or beside the building whose water or air is being heated.

(Graphic: Solar collector heating water)
The panels collect heat from the sun. The heat is absorbed by water or air moving through the panel. A pump or fan sends the heated water or air to a storage unit.

CHECK YOUR UNDERSTANDING

7) What is active solar heating?

a) A system that uses moving parts like pumps and motors.
b) A system that uses large southern windows to let in sun.
c) A system that doesn't use any moving parts.
d) A system that makes electricity from sunshine.

(Correct response is "a.")

8) What is an example of active solar heating?

a) Walls built to retain heat.
b) A solar cell.
c) Direct sunshine.
d) A solar collector.

(Correct response is "d.")

---

9) What provides most of our solar heating today?

a) Active solar systems
b) Passive solar design
c) Heating with solar wind
d) Solar cell based systems

(Correct response is "a.")

10) How does a solar collector work?

a) Large mirrors focus sunlight on a storage tank.
b) Water or air moving through panels collects heat.
c) Thick walls in buildings reflect sunlight.
d) Large windows admit solar heat and light.

(Correct response is "b.")

PASSIVE SOLAR HEATING SYSTEMS

(Graphic: Walls of a home absorbing and storing heat from the sun)
Unlike active solar heating, passive systems use few or no moving parts. To use passive solar heating, a building must fact or be exposed to the sun.

Features that take in as much of the sun's heat as possible in winter are built directly into the building. These features include large windows on the south side and inside walls that are built to store heat.

Because passive solar systems require major features such as large windows and thick walls to store heat, most passive solar systems are built only as part of new buildings.

There are fewer passive solar systems because there can only be as many passive systems as there are new buildings going up. Active systems, on the other hand, can be added rather easily to buildings already standing.

So, there are more active than passive solar systems in use today.

CHECK YOUR UNDERSTANDING

11) What is passive solar heating?

a) A system that uses a solar collector to heat water and air.
b) A system that uses moving parts like pumps and motors.
c) A system that doesn't use any moving parts.
d) A system that makes electricity from sunshine.

(Correct response is "c.")

12) What is necessary for passive solar heating?

a) The building must be exposed to the rays of the sun.
b) The temperature must be fairly warm.
c) The building must be as large as possible.
d) There must be at least 80% sunshine.

(Correct response is "a.")

13) What is an example of passive solar heating?

a) Use of a solar collector.
b) Walls built to store heat.
c) Use of solar cells to create electricity.
d) Walls painted light colors to reflect sunlight.

(Correct response is "b.")

14) Why is active solar heating used more often than passive?

a) Because it is more simple to use.
b) Because it makes more energy.
c) Because it costs less.
d) Because it can be added onto older buildings.

(Correct response is "d.")

SOLAR CELLS

Another form of direct solar energy is solar cells. These are special wafers that change sunlight to electricity. The most common solar cells are made from silicon, an easily found element in the earth's crust.

SOLAR CELLS (continued)

Sunlight hitting a solar cell makes electricity. The electricity is then carried away from the cell for use. Solar cells range from thumbnail size to several square inches in surface area.

(Graphic: Sunshine hitting bank of solar cells, electricity carried away on power lines)
A single solar cell produces only a little bit of electricity. However, cells can be linked together in large panels to supply a large amount of electricity.

To date, solar cells have not been used very often. Mostly they are used in far off locations where no other source of electricity exists. For example, solar cells have provided power for space vehicles, for offshore oil rigs, and for distant communication stations.

Several utility companies are now testing solar cells. Others are studying small projects that use solar cells to make electricity for consumers.

Solar cells have gotten cheaper in recent years. Even so, a big problem with the use of solar cells is their high cost.

Electricity from solar cells can cost up to ten times as much as power from the usual sources. Clearly, the cost must be reduced before solar cells can be used for our energy supply.

CHECK YOUR UNDERSTANDING

15) Which of the following best describes what solar cells look like?

   a) They are large sheets of meal, glass, or plastic.
   b) They have large, thick, south facing walls with large windows.
   c) They are small wafers made from silicon.
   d) They have pipes of water or air heating inside them.

(Correct response is "c.")

---

16) How do solar cells work?

a) Sunshine heats water or air passing through the solar cell.
b) Sunshine hitting the cell creates electricity.
c) Sunshine enters through large panes of glass to heat inside air.
d) Heat from sunshine is stored in small, thick wafers.

(Correct response is "b.")

17) How much electricity is generated by a single solar cell?

a) Quite a bit
b) We don't know yet
c) Only a little
d) None at all

(Correct response is "c.")

18) To produce a lot of electricity, how are solar cells used?

a) A single solar cell can be used
b) Two or three solar cells used together
c) Cells in groups of five
d) Large panels made of cells

(Correct response is "d.")

19) Where have solar cells been used, for the most part?

a) In far away areas
b) In poor countries
c) In airplanes
d) In solar water heaters

(Correct response is "a.")

20) What is a big problem with solar cells?

a) They are too large.
b) They don't make enough energy.
c) The raw materials they require are hard to find.
d) They cost a lot of money.

(Correct response is "d.")

THE FUTURE

(Graphic: Sun hidden by rain cloud)
How do you get energy from the sun when it isn't shining? That's a problem. A good system must supply energy whenever it's needed, even at night or on rainy days.

Thinking of good methods of storing energy will be one key to the future of solar energy. However, these storage systems could also make solar energy cost more.

Energy from the sun is nice for two reasons. First, it will be there for as long as we can use it. And second, it could provide a large amount of energy for future needs.

There are big questions about this future use. Can solar energy be developed to the point where it costs less? And, will it be available when and where we want it?

Use of active and passive solar heating systems is likely to increase in the near future. However, the use of solar cells is expected to still be very small by the year 2,000.

By the year 2,000, it is expected that solar cells will supply less than one percent of our total energy supply. Even so, some experts believe that more research and development could result in solar power becoming our main energy source during the 21st century.

CHECK YOUR UNDERSTANDING

21) How can you use energy from the sun when it's cloudy?

a) By using energy stored from sunny days
b) By burning off the cloud cover
c) By waiting for the sun to come out
d) It's not possible

(Correct response is "a.")

---

22) What is an advantage to solar energy?

a) It is low in cost and easy to use.
b) It will always be there for us to use and it may be able to meet many of our future energy needs.
c) It has more uses than other forms of energy.
d) It makes more power than other sources of energy.

(Correct response is "b.")

23) What is a major problem with electricity generated from the sun?

a) We don't know everything it could be used for.
b) It may replace fossil fuels.
c) There's no good way to store it, and it costs a lot.
d) We don't have a real need for that kind of energy.

(Correct response is "c.")

24) How widely will solar cells be used solar cells by the year 2,000?

a) They will no longer be used
b) They will be used, but not widely
b) They will be extensively used
c) They will be the main source of energy

(Correct response is "b.")

25) What form of energy do experts believe could become our main energy source?

a) Solar Cells
b) Geothermal
c) Nuclear
d) Coal and Oil

(Correct response is "a.")

The instruction concludes at this point. The student is presented next with the posttest.

APPENDIX B

Session One: Criterion Measures

SESSION ONE: PREMEASURE

Continuing Motivation for Computer Use

Questions included here are intended to measure the student's continuing motivation for computer use. In these questions, students are asked to indicate their study preferences for science activities or activities in another subject area, with and without computer use.

Hi *name of student.*

Before we begin, I'd like to know some things about you. I'm interested in knowing what sorts of things you like to study.

Please answer the next few questions to give me an idea of what kinds of study activities you prefer.

---

1) Would you rather study science or would you rather study another subject?

   a) Study science

   b) Study another subject

2) Would you rather study science on computers, or study another subject on computers?

   a) Study science on computers

   b) Study another subject on computers

3) Would you rather study science on computers, or would you rather study another subject without using computers?

   a) Study science on computers

   b) Study another subject without using computers

---

4) Would you rather study science without using computers, or study another subject on computers?

   a) Study science without using computers

   b) Study another subject on computers

After providing answers to the above questions, subjects are routed directly to the CAI for Session One, which deals with Solar Energy.

SESSION ONE: POSTTEST

Solar Energy: Promise from the Sun

This posttest is presented to subjects on completion of the Solar Energy CAI in Session One. The posttest contains 25 items which are parallel to the 25 practice items contained within the CAI.

CONGRATULATIONS! You've successfully completed the Solar Energy unit. A 25 question test on the unit follows. Try your best to answer the questions correctly.

Read each question, then select the correct response. Enter your choice by typing a, b, c, or d.

1) What are the main uses for active solar heating systems today?

   a) for producing electricity
   b) for heating water and inside air
   c) for heating outside walls of buildings
   d) for running large heating and cooling towers

(correct response is "b")

2) How much electricity can a solar cell generate?

   a) A little
   b) We are not able to measure the amount
   c) None at all
   d) Very large amounts

(Correct response is "a.")

3) Which of the following is the basic source of energy?

   a) electricity
   b) gasoline
   c) sunshine
   d) fossil fuel

(correct response is "c")

---

4) Where has most of the use of solar cells been?

a) In solar collectors
b) In passive solar heating systems
c) On tall buildings
d) In distant areas

(correct response is "d")

5) Which of the following is an advantage to solar energy?

a) It creates more heat than other forms of energy.
b) It requires little equipment.
c) It is very quickly produced.
d) We will always have it.

(correct response is "d")

6) Experts believe that the main energy source of the 21st century could be....

a) Natural Gas
b) Solar Cells
c) Nuclear
d) Geothermal

(Correct response is "b.")

7) Of the following sources of energy, which one is not a fossil fuel?

a) gasoline
b) coal
c) oil
d) fire

(Correct response is "d.")

8) To produce a lot of electricity, how many solar cells used?

a) Many cells are used in a panel.
b) Bands of five to ten cells
c) A group of two or three cells
d) A single solar cell is required

(Correct response is "a.")

---

9) Which of the following is an example of passive solar heating?

a) South facing windows used in a window to let sunshine in
b) Sunshine is changed to electricity which is used to run heaters
c) Solar collectors used to pump hot air into a building
d) Use of solar cells

(correct response is "a")

10) Which of the following is a major problem with solar generated electricity?

a) It may replace fossil fuels.
b) Solar systems are still too hard to operate.
c) It is still too costly and there's no good way to store it.
d) Sunlight causes skin cancer.

(correct response is "c")

11) What does passive solar heating require?

a) No more than 30% cloud cover.
b) The building must quite large.
c) Temperatures cannot fall below freezing.
d) Sunshine must hit the building surfaces.

(Correct response is "d.")

12) What is an active solar heating system?

a) A system that uses no moving parts
b) A system that uses sunshine to make electricity
c) A system that uses moving parts like motors and pumps
d) A system that uses a magnifying glass to focus sunlight

(correct response is "c")

13) What do solar cells look like?

a) Large surfaces with thick walls and south facing windows
b) Small silicon wafers, from thumbnail size to several inches in size
c) Large, thin sheets of glass or plastic that admit solar heat and light
d) Small pipes that carry water or air

(correct response is "b")

---

14) Which of the following describes why active solar heating is used more often than passive?

  a) Active systems make more heat than passive systems.
  b) Active systems cost less than passive systems.
  c) Active systems are smaller and lighter than passive systems.
  d) Active systems can be easily used in older buildings, passive systems cannot.

(correct response is "d")

15) By the year 2,000, what kind of use will solar cells receive?

  a) They will be the exclusive source of energy.
  b) They will not be used for energy.
  c) They will receive occasional use.
  d) They will be used, but only in outer space.

(Correct response is "c.")

16) Which best describes how a solar collector works?

  a) Water or air moving through large panels collects heat from the sun.
  b) Large south facing windows in a building let sunshine in.
  c) The outside walls of a building are painted dark colors to collect heat from the sun.
  d) Sunshine hits a solar cell. Special wiring makes the sunshine into electricity.

(correct response is "a")

17) Which of the following is a problem with solar cells?

  a) They don't store enough heat.
  b) They cost too much.
  c) Each cell produces only a small amount of electricity.
  d) They are hard to make.

(correct response is "b")

18) Which of the following is an example of active solar heating?

  a) A solar collector
  b) South facing windows to heat inside air
  c) Large mirrors to direct the sun's rays
  d) Sunshine heating a dark building surface

(correct response is "a")

---

19) How can you use energy from the sun on a cloudy cay?

a) It can't be done
b) By raising solar collectors to a higher elevation
c) By magnifying the sun's rays
d) By using solar energy stored in batteries

(Correct response is "d.")

20) What are the two main types of solar heating systems called?

a) passive and dynamic
b) passive and active
c) negative and positive
d) reactive and active

(Correct response is "b.")

21) Why are we looking away from fossil fuels to other sources of energy?

a) Fossil fuels are in limited supply.
b) Fossil fuels are too expensive.
c) Fossil fuels are hard to get out of the earth.
d) Fossil fuels take a long time to produce.

(correct response is "a")

22) Which of the following DOES NOT need sunlight to grow?

a) mountains
b) trees
c) men
d) insects

(Correct response is "a.")

23) What provides most of our solar heating today?

a) Active solar systems
b) Passive solar design
c) Heating with solar wind
d) Solar cell based systems

(Correct response is "a.")

---

24) Which of the following describes passive solar heating?

a) A system that uses moving parts like motors and pumps
b) A system that uses solar cells to create heat
c) A system that uses sunshine to make electricity
d) A system that uses no moving parts

(correct response is "d")

25) How do solar cells work?

a) Sunshine enters through a clear panel, and the heat is stored in small wafers.
b) Air or water heats as it moves through small pipes.
c) Sunlight hitting the solar cell creates electricity.
d) Sunshine enters buildings through windows to heat inside air.

(correct response is "c")

The posttest concludes at this point. The student is presented next with two attitude questions.

SESSION ONE: POSTMEASURE

Attitudes: Liking for the Instruction & Confidence in Performance

These two questions are presented to subjects on completion of the Solar Energy posttest in Session One.

You've finished the test. GOOD JOB! We'd like to know what you thought about this unit on solar energy. Your answers to the following two questions will help us improve the unit.

1) How much did you like learning about Solar Energy?

   a) Very much
   b) Some
   c) Not much
   d) Not at all

2) On the test questions, how well do you think you did?

   a) Very well
   b) Well
   c) Not too well
   d) Badly

After answering the above two questions, subjects are either assigned or given a choice as to the type of control they will exercise in the CAI for the following day.

SESSION ONE: POSTMEASURE/ASSIGNMENT

Choice of or Assignment to Type of Control for Session Two CAI

After answering the attitude questions, one-half of the subjects will be told they will receive the same type of control they just had (LC or PC) in the CAI they will complete the following day. The other half of the subjects will be provided a choice as to the type of control they'd like to have for Session Two.

CHOICE SUBJECTS :

For tomorrow, we'd like you to choose between two science activities on the computer.

Choice Subjects under Learner Control:

During class tomorrow, which type of science program would you like to use on the computer?

a) One like you just finished, in which you can choose whether or not to review

b) A program in which the computer automatically takes you to review

---

Choice Subjects under Program Control:

During class tomorrow, which type of science program would you like to use on the computer?

a) One like you just finished, in which the computer automatically takes you to review

b) A program in which you can choose whether or not to review

---

THANKS FOR DOING SUCH A GOOD JOB!

Please raise your hand so that the monitor knows you're done. (Keep your hand raised until the monitor brings you the next activity.)

Please remain QUIET, so you don't disturb other class members.

At the bottom of this last screen, the word "learner" or the word "program" is displayed, indicating the student's choice for the next day's CAI.

ASSIGNED SUBJECTS:

You've finished the computer program for today. Tomorrow, we'll be together again for some more some more learning activities on the computer.

Subjects Assigned to Learner Control:

Tomorrow as you learn on the computer, you'll be able to make the same decisions you made today about whether or not to review.

Subjects Assigned to Program Control:

Tomorrow as you learn on the computer, the computer will automatically take you to review, just like today.

Please raise your hand so that the monitor knows you're done. (Keep your hand raised until the monitor brings you the next activity.) THANKS A LOT!

Please remain QUIET, so you don't disturb other class members.

APPENDIX C

Session Two: Computer Assisted Instruction

SESSION TWO: COMPUTER ASSISTED INSTRUCTION

Tarantulas

The following is the text of the CAI which serves as the the instructional base for the second session in this study. Subjects have either chosen or have been assigned to the type of control to be exercised, learner control or program control. (Control here, as in the CAI for session one, is over content review.) Each screen-full of text (indicated here in separate paragraphs) is incorporated into a color-coded frame topped with the heading for the current topic. Informational screens are framed in blue and green. Screens with practice and test questions are framed in purple and orange.

First, subjects will be reminded of the type of control they will have for today's session.

Choice Subjects who Selected Learner Control:

Today, you'll be using the type of program you selected yesterday. You'll be able to choose whether or not to review as you go through the unit.

Choice Subjects who Selected Program Control:

Today, you'll be using the type of program you selected yesterday. The computer will automatically take you to review as you go through the unit.

Subjects Assigned to Learner Control:

Today, you'll be using the same type of program you used yesterday. You'll be able to choose whether or not to review as you go through the unit.

Subjects Assigned to Program Control:

Today, you'll be using the same type of program you used yesterday. The computer will automatically take you to review as you go through the unit.

During the following program, you'll be learning about tarantulas, a type of large spider. You'll read about tarantulas, and then you'll get a chance to check your knowledge about them by answering some practice questions.

INTRODUCTION

Tarantulas are spiders that live in the southwestern United States. They also live in Central and South America.

Have you ever seen a tarantula? (Type a y for yes, or a n for no.)

If yes:
Good. Then you know that...

If no:
No? Well, you need to know that...

...tarantulas are brown or black and have hairs all over. When these spiders have their legs stretched out, they can be ten inches across.

Many people are afraid of tarantulas. But there is no reason to be afraid. Tarantulas are really slow. They will attack people only if they are bothered.

The largest tarantulas live in hot jungles. The width of their bodies (not counting legs) can be 3.5 inches across. Counting their legs, they're as large as a dinner plate. These spiders have been seen eating small birds. People often call them bird-eating tarantulas.

INTRODUCTION (continued)

Tarantulas and other spiders belong to the class Arachnida. They have hard skins or skeletons on the outside of their bodies. Spiders have eight legs, and don't have feelers or wings like some other insects.

CHECK YOUR UNDERSTANDING

The following practice questions cover the material you just read. Read the question and select the best answer. Enter your answer by typing the letter listed. (a, b, c, d).

1) When will tarantulas attack people?

   a) when gathering food
   b) when bothered
   c) when molting
   d) when spinning their cocoon

SAMPLE FEEDBACK/REVIEW PROCEDURES:

Following a correct response, correct answer feedback is given. For example, in the case of question one:

That's right.
Tarantulas only attack people when they are bothered.

On any incorrect response, the student in the Learner Control *condition is told:*

No, that's wrong. *or* No, that's not the right answer.
Do you want to review the material before trying to answer the question again? (Type y or n.)

At a "y" response, the student is directed to a review of content pertinent to that question. Following the review, the student attempts the question again. At a "n" response, the computer presents the student with the identical question for a second or third attempt.

SAMPLE FEEDBACK/REVIEW PROCEDURES (continued):

On any incorrect response, the student in the *Program Control* *condition is told:*

No, that's wrong. *or* No, that's not the right answer.
Let's review before you try to answer the question again.

The student is automatically branched to a review of related content, then back to answer the practice question a second or third time.

On the third incorrect answer, all students are provided with the correct response, in this case:

No, the answer is: b) when bothered.
Tarantulas only attack people when they are bothered.

---

2) Where do the largest tarantulas live?

a) in California
b) in Arizona
c) in deserts
d) in jungles

(Correct response is "d.")

3) Where on their bodies do spiders have their skeletons?

a) down the center of their backs
b) down their stomachs
c) in their body and legs
d) on the outside of their bodies

(Correct response is "d.")

LUNGS

All tarantulas have two pairs of book lungs. These lungs are used for breathing. They are called book lungs because inside the spider they look like the pages of a book.

SILK AND SPINNING

Like all spiders, tarantulas spin silk. They make their silk in four organs called spinnerets. The spinnerets look like short small fingers. They are found on the end of the spider. Each spinneret the tarantula has makes a different kind of silk.

Tarantulas use their silk mostly for lining nests and for egg cases. Tarantulas don't make webs to catch food like other spiders.

But, when tarantulas line their nests with silk, some spills onto the ground. When a bug walks on this silk "doormat," the nest will shake a little. This tells the tarantula that food is near.

CHECK YOUR UNDERSTANDING

4) What do the lungs of a tarantula look like?

a) a spider's web.
b) book pages.
c) cylinders.
d) human lungs.

(Correct response is "b.")

5) What do the spinnerets of a tarantula look like?

a) fingers.
b) ears.
c) books.
d) feelers.

(Correct response is "a.")

6) When a bug walks on the tarantula's silk "doormat," what happens?

a) The nest traps the bug.
b) The nest falls apart.
c) Some silk spills out of the nest.
d) The nest shakes.

(Correct response is "d.")

SENSES

Tarantulas have eight eyes. They are all crowded together in one spot on the top of their heads.

Even though they have eight eyes, tarantulas are almost blind. They can see only light and dark. Tarantulas survive mostly by their sense of touch. Food must come to them.

Tarantulas do not have ears, so they cannot hear. Their body hairs help them tell what's going on around them.

Some hairs are used to feel vibrations. Hairs in the mouth are used for taste. Tarantulas throw off some hairs when they are fighting. These hairs are not poisonous, but they will keep an enemy from getting too close.

HOMES

Some tarantulas live in cracks in trees or under stones. But most live in the ground. Sometimes they dig their homes with their fangs. Other times, they move into homes that other tarantulas or animals are not using any more.

Tarantulas remain in their houses most of the time, going out only to find food. The male tarantulas, when they are old enough, go around looking for mates. The female tarantula may use the same house for as long as she lives.

CHECK YOUR UNDERSTANDING

7) How many eyes does a tarantula have?

a) 8
b) 9
c) 10
d) 11

(Correct response is "a.")

---

8) What does a tarantula taste with?

   a) lips
   b) fangs
   c) hairs
   d) tongue

(Correct response is "c.")

9) What do tarantulas sometimes use to dig?

   a) spinnerets
   b) fangs
   c) hairs
   d) legs

(Correct response is "b.")

10) Where do tarantulas spend most of the time?

   a) in the water
   b) out looking for food
   c) out looking around
   d) in their homes

(Correct response is "d.")

FOOD

Tarantulas eat all kinds of beetles. They also eat other bugs. Tarantulas use their fangs like straws when they eat. They put a liquid into the food which makes it soft so they can suck it up. Only the outside of their food is left when they are through eating.

Tarantulas can live for a long time without food. In winter they eat no food at all. But they do need water. If they have been without water, they will shrink. Then, if you put them in a dish of water, they will grow like a sponge.

LIFESPAN

Some tarantulas live longer than others. In North America, they live longer than in tropical areas. Some female tarantulas have been kept as pets. North American females have lived to be 25 years old. This is about twice as long as dogs usually live.

LIFESPAN (continued)

A male tarantula does not live long after he is fully grown. North American male tarantulas are fully grown when they are about 10 years old. Until that time, the males and females look alike, and both live in nests in the ground.

CHECK YOUR UNDERSTANDING

11) What body part do tarantulas use like straws?

a) feelers
b) fangs
c) spinnerets
d) tongues

(Correct response is "b.")

12) What happens to tarantulas if they have been without water?

a) They shrink.
b) They die.
c) The grow like a sponge.
d) They burrow in the ground.

(Correct response is "a.")

13) How long have North American female tarantulas lived?

a) 35 years
b) 30 years
c) 25 years
d) 20 years

(Correct response is "c.")

14) About how old is a fully grown North American male tarantula?

a) 5 years old
b) 10 years old
c) 25 years old
d) 30 years old

(Correct response is "b.")

MOLTING

Tarantulas shed the skeleton on the outside of their bodies. This is called "molting." Tarantulas grow a bit each time they molt. If they have lost a leg, they grow a new one. Molting takes about an hour. As it molts, the tarantula looks like it is rising up and out of its skin.

When he is fully, grown, the male tarantula sheds his skin for the last time. Then it is possible to tell the male from the female. He is now darker than the female. The male is almost black. He is also smaller than the female.

A female tarantula keeps on shedding her skin once a year for as long as she lives. When she is fully grown she gets a new dark brown coat. When the female is near the end of her life, it is hard for her to molt. This shows the age of the tarantula.

Remember that sometimes tarantulas lose hairs when they fight. This can also happen when they try to catch food. If tarantulas have lost hairs, they get new ones when they molt. The tarantula's body stays young by molting.

The male tarantula does not live long enough to shed after he is fully grown. After his last molt, the male begins to wander around. He does not live alone in his home any more. He may walk for miles looking for a mate.

CHECK YOUR UNDERSTANDING

15) About how long does it take a tarantula to molt?

a) one month
b) one week
c) one day
d) one hour

(Correct response is "d.")

16) What color is the male tarantula after he sheds his skin for the last time?

a) brown
b) black
c) grey
d) silver

(Correct response is "b.")

---

17) When is it hard for a female tarantula to molt?

a) after laying eggs
b) when she is in her home
c) near the end of her life
d) when she is young and small

(Correct response is "c.")

18) When do tarantulas get new hair?

a) when they molt
b) when they fight
c) in winter when it's cold
d) during mating season

(Correct response is "a.")

19) What does the male tarantula look for after his last molt?

a) more food
b) an enemy
c) a mate
d) a home

(Correct response is "c.")

MATING

Whether or not he finds a mate, the full grown male tarantula will die within the year. If he does not die from fighting, then he will die from old age. He will just stop eating and drinking, and his spinnerets will fall off. Then he will die.

Between the time when she is fully grown and the time she dies, the female tarantula will mate several times a year. Even though she mates in the fall, she does not lay her eggs until summer. She will lay up to 1,000 eggs each year.

THE COCOON

The female tarantula will spin a cocoon in which to place her eggs. In most cases she will put the cocoon at the opening of her home. Only a few tarantulas put their cocoon inside their nest. In most cases the nest is not large enough.

THE COCOON (continued)

It will take the tarantula more than twelve hours to finish the cocoon. As time goes by she works less and rests more. When she is done, she lays her eggs on the silk. Then she makes a cover for the cocoon.

When the female tarantula has finished the cocoon, she turns it over and sits on it. For six weeks she is ready to defend it. She keeps one or two feet on it at all times. The only insects she cannot fight are ants. Ants will eat the eggs in the cocoon.

CHECK YOUR UNDERSTANDING

20) How many eggs will the female tarantula lay each year?

a) 1,000
b) 2,000
c) 150
d) 15

(Correct response is "a.")

21) Where does the female tarantula put the cocoon in most cases?

a) inside her home
b) at the opening of her home
c) outside her home
d) far away from her home

(Correct response is "b.")

22) How long does it take the tarantula to finish the cocoon?

a) 1 day
b) 2 days
c) 20 hours
d) 12 hours

(Correct response is "d.")

YOUNG

After three weeks, the young tarantulas hatch from their eggs. They stay in the cocoon after they hatch, sometimes for several months. When ready, they get out by making round holes. After a week the babies will shed their first skin.

The babies stay around the mother tarantula for up to two weeks. Then they go off on their own. They will not eat any food for five months, until the following spring. By their first summer, only about fifteen or a tarantula's babies will be alive.

CHECK YOUR UNDERSTANDING

23) Which insect will eat the tarantula's eggs?

a) ants
b) beetles
c) flies
d) spiders

(Correct response is "a.")

24) Where do young tarantulas stay after they hatch from their eggs?

a) in the nest
b) in the cocoon
c) in trees
d) in their mother's pouch

(Correct response is "b.")

25) About how many of a tarantula's babies will be alive by their first summer?

a) only one
b) 1,000
c) 15
d) 150

(Correct response is "c.")

The instruction concludes at this point. The student is presented next with the posttest.

APPENDIX D

Session Two: Criterion Measures

SESSION TWO: POSTTEST

Tarantulas

This posttest is presented to subjects on completion of the CAI on Tarantulas in Session Two. The posttest contains 25 items which are parallel to the 25 practice items contained within the CAI.

CONGRATULATIONS! You've successfully completed the unit on Tarantulas. A 25 question test on the unit follows. Try your best to answer the questions correctly.

Read each question, then select the correct response. Enter your choice by typing a, b, c, or d.

1) It is hard for a female tarantula to molt when...

   a) she is very old.
   b) she is inside her home.
   c) she is very young.
   d) she has just laid her eggs.

(Correct response is "a.")

2) A North American male tarantula is how old when fully gown?

   a) 25 years old
   b) 20 years old
   c) 15 years old
   d) 10 years old

(Correct response is "d.")

3) What part of a tarantula's body is used to taste with?

   a) tongue
   b) hairs
   c) scales
   d) nose

(Correct response is "b.")

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4) How many of a tarantula's babies will survive until their first summer?

a) 300
b) 50
c) 100-200
d) 15

(Correct response is "d.")

5) Where does the female tarantula put her cocoon?

a) far away from her home
b) inside her home
c) outside her home
d) at the opening of her home

(Correct response is "d.")

6) How long does it take for a tarantula to make a cocoon?

a) 12 hours
b) 2 days
c) 4 days
d) 24 hours

(Correct response is "a.")

7) What happens when a bug walks on the tarantula's silk "doormat"?

a) The nest falls apart.
b) The bug is trapped by the nest.
c) The nest shakes.
d) Some silk spills out.

(Correct response is "c.")

8) Where do the largest of all tarantulas live?

a) in the mountains
b) in jungles
c) in forests
d) in deserts

(Correct response is "b.")

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9) How long does it take a tarantula to molt?

a) one hour
b) one day
c) one week
d) one month

(Correct response is "a.")

10) When the male tarantula sheds his skin for the last time, what color is he?

a) black
b) brown
c) silver
d) grey

(Correct response is "a.")

11) What do the spinnerets of a tarantula look like?

a) books
b) feelers
c) fingers
d) eyes.

(Correct response is "c.")

12) Tarantulas get new hair when...

a) it is cold in winter.
b) they fight.
c) they molt.
d) it is mating season.

(Correct response is "c.")

13) After his last molt, what does the male tarantula look for?

a) food
b) a home
c) his enemies
d) a mate

(Correct response is "d.")

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14) Which part of their bodies do tarantulas use like straws?

a) hairs
b) spinnerets
c) feelers
d) fangs

(Correct response is "d.")

15) The lungs of a tarantula look like...

a) human lungs.
b) spun silk.
c) pages of a book.
d) sponges.

(Correct response is "c.")

16) The female tarantula lays ________ eggs each year.

a) 10,000
b) 150
c) 15
d) 1,000

(Correct response is "d.")

17) Where do young tarantulas stay after they hatch from their eggs?

a) on their mother's back
b) in their own nests
c) in the cocoon
d) in the nest

(Correct response is "c.")

18) In North America, how long do female tarantulas live?

a) 15 years
b) 25 years
c) 30 years
d) 40 years

(Correct response is "b.")

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19) Where do spiders have their skeletons?

a) in their body and legs
b) on the outside of their bodies
c) down the center of their backs
d) in their stomachs

(Correct response is "b.")

20) How many eyes does a tarantula have?

a) 12
b) 10
c) 8
d) 6

(Correct response is "c.")

21) Tarantulas attack people when...

a) they are looking for food.
b) they are laying their eggs.
c) they are molting.
d) they are bothered.

(Correct response is "d.")

22) Sometimes, tarantulas use their _______ to dig.

a) fangs
b) spinnerets
c) legs
d) feelers

(Correct response is "a.")

23) If tarantulas have been without water, what happens?

a) They shrink.
b) They become ill.
c) The grow like a sponge.
d) They dig for water.

(Correct response is "a.")

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24) Which insect will eat tarantula eggs?

a) spiders
b) flies
c) beetles
d) ants

(Correct response is "d.")

25) Tarantulas spend most of the time ...

a) in their homes.
b) out looking for a mate.
c) out looking for food.
d) protecting their territory.

(Correct response is "a.")

The posttest concludes at this point. The student is presented next with two attitude questions.

SESSION TWO: POSTMEASURE

Attitudes: Liking for the Instruction & Confidence in Performance

These two questions are presented to subjects on completion of the posttest on Tarantulas in Session Two.

You've finished the test. GOOD JOB! We'd like to know what you thought about this unit on tarantulas. Your answers to the following two questions will help us improve the unit.

1) How much did you like learning about Tarantulas?

   a) Very much
   b) Some
   c) Not much
   d) Not at all

2) On the test questions, how well do you think you did?

   a) Very well
   b) Well
   c) Not too well
   d) Badly

After answering the above two questions, subjects are next presented with questions designed to assess their motivation for computer use and for type of control.

SESSION TWO: POSTMEASURE

Continuing Motivation for Computer Use and Type of Control

Questions included here are intended to measure the students' continuing motivation for computer use and type of control in CAI. In the first four questions, students are asked to indicate their study preferences for science activities or activities in another subject area, with and without computer use. Through their responses to the fifth question, students indicate their continuing motivation for type of control (learner or program) over content review in science CAI.

We may return in the future to work with your class. We'd like to know what kinds of learning activities you'd like to do when we return.

Your answers to the next few questions will help us to plan these future activities.

1) When we return, would you rather study science or would you rather study another subject?

   a) Study science
   b) Study another subject

2) When we return, would you rather study science on computers, or study another subject on computers?

   a) Study science on computers
   b) Study another subject on computers

3) When we return, would you rather study science on computers, or would you rather study another subject without using computers?

   a) Study science on computers
   b) Study another subject without using computers

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4) When we return, would you rather study science without using computers, or study another subject on computers?

   a) Study science without using computers
   b) Study another subject on computers

For subjects who exercised learner control in session two:

5) When we return, which type of science program would you like to use on the computer?

   a) One like you just finished, in which you can choose whether or not to review
   b) A program in which the computer automatically takes you to review

For subjects who exercised program control in session two:

5) When we return, which type of science program would you like to use on the computer?

   a) One like you just finished, in which the computer automatically takes you to review

   b) A program in which you can choose whether or not to review

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THANKS FOR DOING SUCH A GOOD JOB!

Please raise your hand so that the monitor knows you're done. (Keep your hand raised until the monitor brings you the next activity.)

Please remain QUIET, so you don't disturb other class members.

BIOGRAPHICAL SKETCH

Mable B. Kinzie-Berdel was born in Dallas, Texas, on November 23, 1953. She received her elementary and secondary education in the states of Illinois, Wisconsin, and Minnesota. From 1973 through 1975, she developed public education programs for the American Indian Movement on the Rosebud Sioux and Menominee Reservations. From 1975-1979, she worked in Wisconsin and Minnesota in the areas of conservation, the arts, and magazine production. In 1979, she moved to Tucson, Arizona, to attend the University of Arizona, where she earned a B.A. in Television Production in 1983, and a M.Ed. in Educational Psychology in 1985. During the years 1982-1985, she worked at the University of Arizona in instructional television production and as teaching assistant for the Department of Radio/Television. In 1984, she married Richard Lee Berdel, computer programmer, musician, and artist. From 1985-1988, she attended Arizona State University, where she pursued doctoral studies in Educational Technology, and served as research assistant, instructor, and manager of the Educational Technology Demonstration Laboratory.