An Investigation of Learner Characteristics and Instructional Control on Grade Five Students

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Abstract: Eighty-five grade 5 subjects were randomly assigned to one of three treatment groups (learner-controlled, yoked-controlled, or program-controlled) In order to investigate if the type of control affects achievement when using computer-assisted instruction. The study used one independent measure, four covqriates, and three dependent measures. The independent variable was type of control which was the student's free choice (learner-controlled), or forced viewing of some (yoked-controlled), or all (program-controlled) of the five assistance options designed to enhance comprehension, The assistance options were aimed at improving the students' ability to answer multiple choice questions regarding four 150-300 word passages on software called "The Comprehension Connection." The first and second covarlate were ability as determined by the Verbal and Nonverbal Subtests of the Cognitive Skills Subtest of the Educational Development Series battery of tests. The third covariate was Age of the subjects at the time of the treatment, and the fourth covariate was the personality characteristic of Locus of Causality as measured on the Intellectual Achievement Responsibility Questionnaire. The dependent variables were achievement as measured on a post test, the results of an attribution test which determined thesubjects' causal belief about the computer situation, and the time required to complete all the passages in order to determine the efficiency of the three treatments. An analysis of covariance revealed a main effect for control, and the results indicated that program control produced higher achievement on the post test than for the learner controlled group. No other significant differences were found.

Resume: On a affecte au hasard 85 eleves de cinquieme annee a trois groupes de traitements differents. Un groupe, maitre de son propre apprentissage (learner-controlled), un autre dependant du premier c'est-d-dire des options appariees (yoked-controlled) et un troisieme dependant du programme lui-meme (program-controlled). Cette etude avait pour but de determiner si le type de controle affectait la performance dans l'apprentissage assists par ordinateur. Unemesure independante, quatre mesures preliminaires et trois mesures dependantes ont ete utilisees. La variable independante etait le type de controle libre-choix de l'eleve (learner-controlled), ou l'obligation de choisir certaines options appariees (yoked-controlled), ou, l'obligation d'utiliser chacune des cinq options offertes par le programme (program-controlled). Les options d'assistance visaient 6 ameliorer l'habilete de l'eleve a repondre aux questions a choix multiple sur quatre passages de 150 a 300 mots dans le logiciel Intitule "The Comprehension Connection." La premiere et la deuxieme mesures preliminaires etaient l'aptitude telle qu'elle avait ete determinee par les Sous-tests verbal et non verbal (Verbal and Nonverbal Subtests) du Sous-test des aptitudes cognitives (CognitiveSkills Subtest) de la serie de tests de developpement pedagogique (Educational Development Series). La troisieme mesure preliminaire etait l'age des sujets et la quatrieme, la caracteristique de la personnalite du Locus de causalite telle qu'elle a ete

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determines par le questionnaire Responsabilite de la Reussite Intellectuelle (Intellectual Achievement Responsibility Questionnaire). Les variables dependantes etaient la reussite telle qu'elle a ete mesuree par un post-test, les resultats d'un test d'attribution qui determine!) les convictions causatives dessujets en situation devant l'ordlnateur, et le tem ps requis pour com pleter tous les passages afin de determiner le rendement de chacun des trois traitements. Une analyse des mesures preliminaires a revele que le controle affecte la performance, et les resultats ont montre que legroupesoumis au controle program me a obtenu de meilleurs resultats lors du post-test que le groupe affecte au traitement libre choix. Aucune autre difference marquante n'a ete relevee.

With educational funding decreasing and class size increasing, it becomes essential to help overburdened teachers produce and select learning systems that will meet the needs and individual differences of various learner types. Learner-controlled instruction is an instructional strategy wh ich attempts to optimize the learning situation by allowing the learner to make one or more of the key instructional decisions or selections. The learner can select options such as the pacing, sequencing, content, timing, amount of practice, and/or the difficulty level. With this design the learner controls the instruction, while the instructor or programmer controls the environment, the set of conditions which will produce predictable learning results even though the learner makes one, some, or many of the learning decisions (Wydra, 1980).

Research on Learner-Control

Mager (1963) conducted early work in the area of learner control, and emphasized that learners come to a teaching situation with varying amounts of relevant knowledge regarding a lesson, and therefore shou Id be given control over the sequence, pace, length, and/or content of the curriculum in order to achieve specified objectives. Mager (1963) concluded that providing the learner with control increased learning effectiveness by reducing the length of formal training, while at the same time improving the competence and confidence of the learner.

Placing the control in the learners hands may appear to solve the problem of how to individualize instruction, but though some groups have been seen to strongly benefit from it in terms of performance (Mager, 1963; Campanizzi 1978; Kinzie et al. 1987) , the research has shown that other groups do not react favorably towards this control as learners were seen to be ineffective in managing their own instruction (Olivier, 1971; Judd, 1972; Fisher, Blackwell, Garcia, & Greene 1975; Lahey, 1978; Lahey et al., 1978; Reinking & Schreiner, 1985). Still other experiments found that providing learners with control had no effect on performance (Alpert & Bitzer, 1959; Judd, 1972; Merrill et al., 1980; Goetzfried & Hannafin, 1985; Holmes et al., 1985; Reinking, 1988).

It is clear from this research that the findings have yielded mixed results and generalizations are not yet possible, however to clarify this issue, it may be necessary to investigate not only the effectiveness of control, but also its efficiency. Results of studies that investigated the efficiency of learners on computer-assisted tasks which provided instructional control, however, have also been mixed. Research has found that providing learner's control of instruction

was a more efficient strategy (Alpert & Bitzer, 1970; Fredericks, 1976), more time consuming (Goetzfried & Hannafin, 1985), or was seen to make no difference (Lahey, 1978; Lahey et al., 1978).

The researchers who found that providing the learner control of instruction was more efficient than conventional program-controlled instruction, or that providing control made no difference in terms of time, carried out their research on the TICCIT and PLATO mainframe systems. These large computer systems allowed the learner to exercise choice over numerous facets of instruction such as choice of next content and display type, rule frames, examples, practice problems, and test items (Merrill, Schneider & Fletcher, 1980). It is difficult to determine which features of control were, or were not, efficient, and whether these findings can be generalized to microcomputer instruction. The researchers who found learner control more time consuming than program-controlled instruction (Goetzfried & Hannafin, 1985) conducted their study under more strict experimental CAI conditions, and investigated the use of control by providing learners control of review and selection of examples. Results of this study indicated that the linear control group, which was not provided with control, had comparable learning in less instructional time than learners provided with computer-controlled branching (adaptive control), or learner control with advisement. This study's results are interesting and merit further investigation, because if school children cannot efficiently utilize the control provided in microcomputer software they are likely not mastering the material, which could be magnified by the often restrictive lab or classroom time available for the student on the computer.

Another area of interest besides the effectiveness and efficiency of instructional control in CAI, is its effect on the attitude of the learner. If providing the learner with control of some aspect of instruction can foster positive feelings toward the learning experience, then it may serve as a motivational tool that may help to optimize the learning situation. Past research, however, provides conflicting guidance as some researchers have found that subjects developed a more positive attitude when provided with learner controlled instruction (Merrill et al, 1980; Kinzie et al, 1987), while others found this control had no effect on student's attitudes (Lahey, 1978; Lahey et al., 1978; Reinking, 1988).

It is clear from the review of the research that it is not yet possible to clearly determine how providing learners with instructional control affects performance, instructional time, and attitudes. Questions arise as to whether instructional control should be provided, and if it should be provided to all learners. It is well known that learners possess different characteristics, but it is unknown how students' attributes interact with different levels of instructional control. Student's attribution of the learning situation (their perceived causal relationship between their actions and the consequences that follow) as well as their ability will be the learner characteristics investigated in this study.

The Interaction of Student Characteristics and Learner Control

Attribution theorists propose that there are three major dimensions of causality — locus, stability and controllability- and that one's perception of these

dimensions affect one's emotional experiences (Weiner & Kakla, 1970; McMahan, 1973; Weiner, 1985). Locus of Causality is of particular importance to the educator because of its perceived relationship to an individual's self-worth and self-esteem. Attribution theorists claim that success attributed to internal causes, such as ability or effort, generates feelings of pride and positive self-esteem, while failure attributed to internal causes generates a negative self-image (Weiner & Kakla, 1970; McMahan, 1973; Weiner, 1985). These researchers also state that positive and negative outcomes attributed to external causes, such as luck or unfairness, do not affect self-esteem. It is especially important to investigate how children view their academic experience, as it is hypothesized that learners who attribute failure as being due to internal causes are less likely to consider adverse circumstances as surmountable, and will, perhaps, give up in the face of failure.

It is also important to investigate how instructional control and a learner's locus of causality *interact* in the learning environment. Holloway (1978) and Hannafin (1984) hypothesize that learners with internal attributions may achieve higher performance than those with external attributions, and that externals may perform better in situations where structure is provided for them, while internals may perform best when little structure is provided.

Research on the effect of locus of causality and learner control on performance, however, has yielded mixed results (Daniels & Stevens, 1976). Little research in this area, however, has investigated this issue in the context of computer-assisted instruction. One study of interest that did investigate this issue with CAI found that a learner's locus of causality did interact with the degree of instructional control provided to the learner (Carrier, Davidson, Higson, & Williams, 1984). Carrier et al. (1984) found that students high in externality performed better with fewer instructional elaborations in a computer-assisted task, while internals' performance was not affected by the extent of the instructional elaboration and performed best with a greater number of options. A later study by Lopez and Harper (1989), however, did not support these findings. Lopez and Harper found that internal locus of control subjects did not perform better than externals when provided with a high level of learner control in a CAI task. Other recent studies with CAI, found that while locus of causality significantly influenced performance, type of instructional control did not affect outcomes (Klein & Keller, 1990), and that high internals performed best whether instruction was in the control of the learner or largely under the program's control (Gray, 1989). Research on locus of causality as it affects performance, therefore, provides conflicting guidance. From the review of the attribution research, questions arise as to whether differences in performance would be evident in subjects with an internal or external locus of causality when provided with different levels of instructional control. Further research in this area is needed in order to gain information to help optimize the learning situation.

The second learner characteristic of interest in this study is the issue of ability and its relationship to instructional control. Researchers hypothesized that low achievers may not perform well when provided with instructional control. One

study found that low achievers did not select options that provided more instruction as needed, but rather were forced into elaborate feedback loops after making a series of errors (Belland, Taylor, Canelos, Dwyer, & Baker, 1985). These researchers also hypothesized that moderate external pacing might improve performance and overall time efficiency for task completion. They concluded that students may not be the best judges as to how much, or what type, of instruction they need for effective learning to take place.

Another interesting study found that young low-ability students provided with learner control with advisement required more time to complete the tasks, with no associated gain in achievement, while a linear control group had comparable learning in less instructional time (Goetzfried & Hannafin, 1985). Thus, for low ability subjects the most efficient strategy was to receive a set sequence of instruction with no advisement, no control of review or selection of additional examples, and no externally imposed program decisions based on the accuracy of responses.

The reason for the poor performance of low-ability subjects when provided with learner control has not been fully investigated, but it may be attributed to the student's lack of ability to determine when remedial help was needed; a skill which Judd (1975) stated was a reason for learner control being superior over program control in average and above average adults. Tobias (1981) and Bovy (1981) predicted similar results and stated that it is logical to expect an inverse relationship between prior achievement and the amount of instructional support the learner needs.

Snow (1980a) also supports this observation that low-ability subjects perform poorly when they are provided with instructional control. Snow (1980b) stated that "directed-learning", or program control, may do for low ability students what they cannot do for themselves, but that this type of control may be dysfunctional for more able students who are capable of organizing their own learning. Program-controlled microcomputer instruction may be a superior method in teaching young and less able learners, but further research must be conducted in order to gain support for these hypotheses.

The problem addressed in this study was what type of control should be provided to learners with various abilities and characteristics in order to create an effective, efficient, and motivating instructional environment? The issues investigated in this study are interesting and important because the designer of technologically-based instruction, especially computer-based instruction, has the potential to provide as much, or as little control, as is required by the learner in order to optimize the learning environment (Hannafin, 1984). Teachers and designers must, therefore, be provided with information in order to determine how control in a computer situation should be granted, to whom, and under what conditions.

The purpose of this study was to gather practical information by investigating the reading comprehension of grade five students with a computer program, and to examine this issue from the perspective of learner versus program-controlled instruction, and whether the use of this control was affected by perceived control,

the strategy used, or the learner's ability. It was hoped that this information would assist teachers and designers in clearly determining the reaction of different groups towards the types of control available in computer software.

Research Questions and Hypotheses

The questions this study attempted to answer were whether there was a difference in performance on a post test between groups provided with different types of instructional control, specifically learner-controlled, program-controlled, or yoked-controlled instruction. Each type of control is explained fully below. Another question dealt with the relationship between performance on the post test and the learner's characteristics: verbal ability, nonverbal ability, age and locus of causality.

The study also investigated whether there was a relationship between the time taken to complete the reading task, the type of instructional control, and a learner's ability and locus of causality. The last question investigated whether there was a difference in attitude between subjects in the learner-controlled, program-controlled, and yoked-controlled groups?

Hypotheses

It was hypothesized that:

- there would be an aptitude-treatment-interaction (ATT) between ability and program control.
- subjects with low ability would perform poorly in the learner-controlled treatment, and be out-performed by low ability subjects in the program-controlled treatment.
- subjects with high prior achievement would perform best in the learner-controlled treatment.
- subjects who took responsibility for their intellectual academic successes and failures (internals) would out perform those who failed to take responsibility (externals) on the post test.

METHOD

Subjects

The subjects in this study were 85 upper-middle and middle class children of mixed ability, between theages of 10 and 12 with a mean age of lOyears 7 months. They were drawn from four grade five classrooms in a public school. The elementary section of this school has used microcomputers for several years so no novelty effect was expected when the computer treatments were introduced.

Design

The study used one independent variable, four covariates, and three dependent variables in order to investigate computer-assisted instructional-control.

The independent variable in the study was control, and the subjects were randomly assigned to one of three treatments, either program-controlled (n = 27), learner-controlled (n = 29), or yoked-controlled (n = 29). The three treatments are discussed below.

The subjects in *the program-controlled group* were required to use a program designed to enhance reading comprehension, read an on-line passage, and then view five assistance options in a preset order. The assistance options were meant to aid the subjects in comprehending four reading passages in order to answer five multiple choice questions per passage.

The subjects in the *learner-controlled group* were able to select assistance options, and were required to read an on-line passage, and then choose the number and order of the five available assistance options. The assistance options were meant to help the subjects in comprehending the four reading passages in order to answer five multiple choice questions per passage.

The subjects in *the yoked-controlled group* were required to read an on-line passage, and then view a limited number of assistance options in a preset order to aid in comprehending the four reading passages and answer five multiple choice questions per passage. Each yoked-controlled subject was matched with a subject from the learner-controlled group, and the options which were presented to the learners in the yoked-controlled group were based on the strategies used by their matched subjects from the learner-controlled group. In other words if a learner in the learner-controlled group chose to view only the 'Return to Passage' option, and 'Graphics' option for passage number one, then the matched yoked-controlled subject would be provided with only these options for the same passage. Likewise, if a learner-controlled subject decided to view only the "Main Idea of the Passage' option then the matched yoked-controlled subject would be able to view only this assistance option for the specified passage. This procedure was applied to each of the matched subjects in the yoked-controlled group, and for all four passages.

The yoked-controlled group in this study was used in order to help answer the questions of whether perceived control of events would have an effect on; the attitude towards the computer experience, performance on an achievement test, and the amount of instructional time needed to complete the task. In order to answer these questions subjects in two groups, the learner-controlled group and the yoked-controlled group, were matched according to instructional strategies. The difference between these groups was that the learner-controlled group had the option to choose the strategy, while the yoked-controlled group was given the strategy used by his matched subject in the learner-controlled group, Therefore, the yoked-controlled group was used in an attempt to separate for analysis the effect of 'choice' from the 'strategy[1] employed. The use of the yoked-controlled group was used to determine if potential differences were caused by the learner-controlled group having the choice of options, or by the strategy used by the learners.

Four covariates were used in the study. The first and second covariates in the study were ability, which helped to determine if ability influenced achievement

in completing learner, yoked, or program-controlled software. Ability was determined by the results of the Verbal and Nonverbal subtests of the Cognitive Skills Subtest of the Educational Development Series (EDS) battery of tests (Scholastic Testing Service, 1984).

The third covariate was the Age of the subjects at the time of testing, and the fourth was the personality characteristic of Locus of Causality (I) as measured on the attribution style test: The Intellectual Achievement Responsibility Questionnaire (IAR). The LAR questionnaire is aimed at assessing children's beliefs that they, rather than other people, are responsible for their intellectual-academic successes and failures.

Three dependent variables were used in the study. The dependent variables were performance on a post test which tested the reading comprehension of the subjects following their treatment, an attribution test which determined the subjects' causal beliefs about the computer situation, and the time taken to complete the designated task. The reading comprehension post test contained the same reading passages and questions as those provided by the software, with the exception that the latter was in a pencil and paper format. The attribution test was made up of questions that looked at four factors shown to be important to children in achievement situations: ability, effort, task difficulty, and luck, as they relate to the microcomputer experience. Questions were also asked about the enjoyment of certain aspects of the treatments .

The time required to complete all the passages was also measured to determine the efficiency of the three treatments. This was done by simply noting down the time taken for each subject to complete the four passages after all instructions were provided.

Materials

The computer program which was used in the study was a program called "The Comprehension Connection" created by Milliken Publishing Company (1987). The software package contains a management disk and five passage disks (El - E5). Each passage disk contains four reading passages which range in reading level from grade 4.6 through to 5.9.

The program used in this study provides students with a 150-300 word passage which students read. The student then utilize five assistance options in order to comprehend the passage, and answer five mu Itiple-choice questions. The split-half reliability estimate for the test items is reported to be. 86 as determined by Reinking (1988) using the Spearman-Brown formula. The assistance options provided by the software were:

- an easier, less technical version of the original passage;
- context-specific definitions of difficult vocabulary;
- the main idea of each paragraph in the passage;
- graphic aids associated with the content of the passage; and
- the opportunity to reread the passage.

These assistance options were either learner-controlled in which the student chose to use whichever options needed to understand the passage, or computer-controlled, where the student was forced to see, some of (yoked-controlled), or all (program-controlled) of the available assistance options in a certain order before attempting to answer the multiple-choice comprehension questions. A student could not change the type of control and had no access to the management disk which had this function.

The ability test used in this study was the Cognitive Skills subtest of the Educational Development Series (Level 15A) which is made up of a Verbal test and a Nonverbal test. The reliability measures of the Verbal test is reported to be .82 - .88 and .74 - .83 for the Nonverbal test (Scholastic Testing Service, 1984).

The attribution test used in the study was the IAR scale which is composed of 34 forced-choice items that describe either a positive or negative, hypothetical achievement experience followed by two alternatives; one that states an event was caused by the subject's own behavior, the other which states that an event was caused because of the behavior of someone in the child's environment (i.e., parents, teachers, peers). The IAR scale provides the researcher with three scores; the subject's belief in personal responsibility for success (I+), the subjects internal responsibility for failure (I-), and the total self-responsibility score (I) (! = !+ + I-). The test-retest reliability of the IAR is .47-.T4, and the internal consistency is .54-.60 (Stipek & Weisz, 1981, p. 105).

Procedure

The type of control the subject was provided with was preset with the use of a management disk. The pre-settingprocedure was quite simple. A management disk was provided with the software package which allowed the researcher to make an assignment for a subject based on the availability of the five assistance options. This was possible by choosing a 'yes' or 'no' for each of the options listed in the computer menu. If a 'yes' was provided for an option then the learner would be able to view that option, if a 'no' was provided the learner would not have access to that option. In creating the treatment for each of the groups, therefore, a 'yes'' was provided for all assistance options for the learner-controlled group and program-controlled group, while the yoked-controlled group was provided with some 'yes' and some 'no' options which followed a pattern established by the learner-controlled subjects.

Before the start of the study the grade five students were provided with parental permission slips. Subjects who had received written parental permission were randomly assigned to treatment groups, dismissed from their regularly scheduled classroom activities, and asked to complete the Cognitive Skills subtest of the Educational Development Series, and the IAR scale. The subjects completed the tests individually and the only assistance provided were the instructions for each of the tests. The instructions for the Cognitive Skills Test were provided with the test and were carefully followed. The instructions for the IAR scale were; 'Tick the answer that best describes what happens to you or how you feel.'' The subjects were told that there were no right or wrong answers on the IAR, and that responses for either test would not be given to anyone at the school.

After completing the tests, 7 subjects from different groups were brought down to the computer room and told to sit at a computer. When all students were seated, one student per computer, they were instructed how to use the computer program and told they had as much time as they needed to complete the four passages, and that they could begin. The students were required to read four passages, each of which was on a separate disk, view assistance options, and answer the multiple choice questions for each passage. Once the student had correctly completed the comprehension questions within the predefined parameters on one disk, the student requested the next passage disk and repeated the procedure. The researcher circulated around the computers helping with any computer problems that arose, and answered questions regarding the program, but refrained from answering any questions which pertained to the information presented by the software. After completing the four passages, the subjects returned to their classrooms, and another group of subjects were brought down to the computers. This procedure continued until all the subjects of one class had been exposed to the computer treatment. After approximately two hours students were then asked to complete a pencil and paper attribution test which determined their beliefs about the microcomputer experience, and a pencil and paper achievement post test. The procedure was then repeated with the next class and continued until all four classes were exposed to the treatment and tested.

RESULTS

The cell means and standard deviations were calculated for the post test, verbal score, nonverbal score, age and time using SPSS-X and are reported in Table 1. The data were analyzed in three steps. First an analysis of covariance (ANCOVA) was conducted on post test scores. Three of the four covariates were found to be good predictors of achievement as measured on the post test: Verbal, $F(1,78) = 63.34, p < .05$; Nonverbal, $F(1,78) = 4.89, p < .05$; and Age, $F(1,78) = 4.60$, $p < .05$; while'T' (Locus of Causality) was not a significant predictor of achievement, $F(1,78) = 2.59$, $p > .05$. A significant main effect for achievement as measured on the post test was found, $F(2,78) = 3.41$, $p < .05$ between learner control and program control, $F(2,78)=2.31$, $p < .05$. Homogeneity of regression was tested and was found not to have been violated. These results are illustrated in Table 2. No other significant differences in achievement between the program-controlled, learner-controlled, and yoked-controlled groups were found. Second an analysis of covariance on the time required to complete the four passages found no significant difference between learner-controlled, program-controlled and yoked-controlled groups. Three of the four covariates were utilized and the results were: Verbal, $F(1,79) = 3.52, p > .05$; Nonverbal, $F(1,79) = .025, p > .05$; and Age, $F(1,79) = .029$, $p > .05$; while 'T' (Locus of Causality) which was not a significant predictor of achievement was not used. These results are illustrated in Table 3. Finally a one-way (ANOVA) between attribution and control found no significant differences.

TABLE 1
Cell Means and Standard Deviations

Factor	Mean	SD	*N*
Variable .. Post Test			
Learner-Controlled	13.76	3.897	29
Program-Controlled	16.07	3.463	27
Yoked-Controlled	14.86	3.739	29
For Entire Sample	14.87	3.785	85
Variable .. Verbal			
Learner-Controlled	26.66	9.370	
Program-Controlled	31.44	10.364	
Yoked-Controlled	29.38	9.966	
For Entire Sample	30.13	9.821	
Variable .. Nonverbal			
Learner-Controlled	33.45	8.588	
Program-Controlled	35.44	7.154	
Yoked-Controlled	35.90	8.789	
For Entire Sample	34.92	8.206	
*Variable .. Age**			
Learner-Controlled	10.61	.551	
Program-Controlled	10.72	.601	
Yoked-Controlled	10.73	.457	
For Entire Sample	10.68	.535	
Variable .. Time in Minutes			
Learner-Controlled	44.24	6.864	
Program-Controlled	42.56	8.126	
Yoked-Controlled	39.41	10.841	
For Entire Sample	42.06	8.914	

* Age is represented in years (i.e., 10) and the %-tage of months

Discussion

The findings of this study do not support the hypothesized aptitude-treatment interaction between ability and control. Regardless of prior ability, the program-controlled group was superior in terms of performance when compared to the learner-controlled group. This finding suggests that all students benefit from program control regardless of ability.

The findings suggest that the significant difference in performance found between the learner and program-controlled groups was caused by the effectiveness of the strategy which consisted of viewing all assistance options in a predetermined sequence. The effectiveness of the designer's strategy is sup-

TABLE 2
Analysis of Variance Post Test By Control with Verbal, Nonverbal, Age and I

Source of Variation	Sum of Square	DF Square	Mean	*F*	P
Covariates	689.089	4	172.272	28.403	<.01
Verbal	384.179	1	384.179	63.340	<.01
Nonverbal	29.680	1	29.680	4.893	<.05
Age	27.918	1	27.918	4.603	<.05
Locus of Causality	15.725	1	15.725	2.593	>.05
Main Effects	41.390	2	20.695	3.412	<.05
Control	41.390	2	20.695	3.412	<.05
Explained	730.479	6	121.747	20.072	<.01
Residual	473.097	78	6.065		
Total	1203.576	84	14.328		

TABLE 3
Analysis of Variance Time in Minutes by Control with Verbal, Nonverbal and Age

Source of Variation	Sum of Squares	DF Square	Mean	*F*	*P*
Covariates	370.948	3	123.649	1.649	>.05
Verbal	264.231	1	264.231	3.523	>.05
Nonverbal	1.865	1	1.865	.025	>.05
Age	2.171	1	2.171	.029	>.05
Main Effects	378.837	2	189.418	2.526	>.05
Control	378.837	2	189.418	2.526	>.05
Explained	749.784	5	149.957	1.999	>.05
Residual	5924.92	79	74.999		
Total	6674.706	84	79.461		

ported by the finding that there was a significant difference found between the program-controlled group which utilized the designer's strategy, and the learner-controlled group whose subjects utilized their own strategy. The effectiveness of designer's strategy is further supported by the means of the three groups in which the program-controlled group obtained the highest score (M =16.07), followed by theyoked-controlled group (M = 14.86) and then the learner-controlled group (M = 13.76). Though the difference between the program-controlled and yoked-

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controlled group was not significant, the trend in the means seems to suggest that utilizing the designer strategy is best in terms of performance.

To comprehend the information presented in the reading passages, readers needed to actively seek meaning from the text. The designer strategy may have been the most effective in developing active readers by encouraging them to monitor the degree to which they were understanding what they read, and applying these strategies to deal with any comprehension difficulties that arose. The options that were chosen by the designer to encourage active readers were supported by previous reading research (Milliken, 1987). Comprehension through vocabulary knowledge was encouraged by providing learners with a less technical version of the passage and an on-screen dictionary. Graphic aids were also used to encourage comprehension, and the presentation of the 'main idea' of the passage was used to help learners understand the passages by grasping the hierarchical relationships among ideas presented in the text (Kintsh & van Dijk, 1978). It appears that the assistance options, though powerful on their own, may complement on another as viewing all of them was most effective in helping students to comprehend the passages.

It also appears that perception of choice was not a fundamental factor in affecting performance as there was no significant difference found between the learner andyoked-controlled groups. As the only difference between these groups was the availability of choice, it appears that the perception of choice did not serve as a motivational factor. It also appears that having choice did not affect the learners motivation as measured on the attribution test as no difference was found for preference of the software program between groups.

The lower performance in the learner-controlled group may be because these young learners do not actively apply effective strategies when they are given control of instruction because they have not yet developed the cognitive skills required to make effective judgments. This conclusion is supported by Reinking and Schreiner (1985) who obtained similar findings, and concluded that perhaps younger learners are less adept at managing the contingencies of their reading and study and benefit from external control, in this case being forced to view all the assistance options instead of being given the choice of which options to choose.

These conclusions are also supported by Markham's (1977, 1979) research, which investigated elementary school children's comprehension, though without CAI. Markham concluded from her research with subjects in grade one through six, that children may be frequently misled into thinking that they understand information which in fact they fail to comprehend it.

This study may have implications for designers and users of educational software of this type with children. When attempting to promote reading comprehension there are many factors that could influence understanding, but the findings of this study suggest that providing young learners with a predetermined sequence to follow may be the most effective. Software designers, therefore, should not persist in providing software which is solely in the learner's control, but rather provide educationally sound versatile sequences which young learners should be encouraged to follow. In terms of classroom use of currently

available educational software teachers should be versatile and sometimes suggest routes for students to follow through complex software, or provide guidance and direction to students when it is requested. Itshouldbe kept in mind, however, that the learning that is measured in this study is a low level cognitive skill on a reading comprehension software, and that further research should be conducted to determine if similar guidance should be provided with problem solving computer tasks or other software packages. Future research should also investigate how young learners react when provided with more control of the learning situation in terms of sequence, timing of presentation, and the many other dimensions of the learning situation.

Locus of Causality was not found to be a significant predictor of achievement as measured on the post test perhaps because very few students (5/85) were truly external. Locus of Causality may be affected by social class, in which researchers have stated that there is a lesser-belief in social-responsibility among lower-class children (Battle & Rotter, 1963). Though Crandall, Katkovsky, and Crandall (1965) claim that social class only accounts for a small proportion of the variance in IAR scores, other scales which look at locus of control, such as the Locus of Control Scale and the Children's Picture Test of Internality-Externality (Crandall et al., 1965), state that social class is indeed a contributing factor. The difference between these scales and the IAR, however, lies in the finding that the IAR looks at very specific social situations (i.e., school associated situations), while the other scales look at general social experiences, and this may account for the difference in the effect of social class.

If social class was not a contributing factor, or the only contributing factor, to the lack of external students in the sample, it may have been that the students were pulled towards the internal responses on the scale due to the responses social desirability. Crandall et al. (1965) tried to eliminate this "pull" by carefully wording the internal and external responses, and determining the lack of correlation between the IAR and the Children's Social Desirability (CSD) Questionnaire. A pull, however, may have been evident and contributed to the lack of external individuals being identified.

The findings further suggest that the amount of time to complete the task was independent of the type of control provided. This does not support previous research (Alpert & Bitzer, 1970; Fredericks, 1976) which suggests that program control is more time-consuming, but supports the findings reported by Lahey (1978) and Laheyetal. (1978). The three groups spent the most time viewing the Graphics option of the computer program, and the learner control group often chose to view this option more than once per passage.

One interesting question for further research would be to introduce the issue of advisement, giving learners meaningful information regarding their learning development while they are performing a task, in order to see if learners need information about the progress of their learning in order to effectively utilize the control they are provided with (Holmes et al., 1985; Tennyson, 1980; Johansen & Tennyson, 19^3; Tennyson & Buttrey, 1980). These researchers feel that simply providing control to the learner is not sufficient because learners often terminate

the instruction too early, and make poor decisions. Providing advisement may help the learners utilize the control provided to them, thus helping to optimize the learningsituation. The results of these studies utilizing advisement suggest that providing learners with information regarding their progress made towards mastering an objective helped learners both learn faster and use less instruction than learner control groups without this advisement. It is unknown whether similar findings would be found with younger learners as the bulk of this research has been carried out with older learners.

Another interesting direction for further study would be to investigate the assistance options chosen by subjects in the learner-controlled group in order to identify unnecessary options, as well as those options that were most frequently used or avoided by effective versus ineffective learners (Hannafin, 1984). It would also be interesting to note whether the options were consistently chosen or differed depending on the difficulty of the reading passage. This would help to identify effective and ineffective learning strategies as well as help plan future lessons.

In summary, this study found that regardless of the type of control provided, or the ability of the subjects, the best performance on the reading comprehension post test occurred when the designer's instructional strategy was utilized. Time to complete the task was independent of the type of control provided, and according to the attribution test data most students found the computer software to be very enjoyable to use.

Continued research in the area of computer-assisted instructional control is needed in order to more fully understand the effect of control and its influence on learners with different characteristics. Future studies may also introduce the issue of advisement, and instructional strategies and their impact on optimizing the learning situation.

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