Effects on Children's Achievement and Curiosity of Variations in Learner Control Over an Interactive Video Lesson

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The purpose of this study was to evaluate the effectiveness of variations in learner control on children's level of curiosity and learning from computer-based interactive video (CBIV). The content was presented as a videodisc visit to an art museum and contained both facts and concepts. A posttest-only control group design was employed with 101 first- and second-grade subjects randomly assigned to one of three experimental conditions—Program Control, Learner Control, Learner Control with Advisement—or a control group. The dependent variables were achievement and three measures of curiosity. Children in the Learner Control with Advisement group scored significantly higher on the achievement posttest than the Learner Control subjects or control group. No differences were found between the Program Control and either of the Learner Control groups. For the curiosity measures, the Learner Control with Advisement subjects scored significantly higher than the control group on Content Exploration, and the subjects in the control group scored significantly higher than those in the Program Control group on Persistence.

☐ Increasing academic achievement while stimulating curiosity and encouraging a young learner's motivation to learn is an important task for educators. More and more interactive learning materials, such as computer-assisted instruction (CAI) and computer-based interactive video (CBIV) lessons, are being developed for learners of all ages. These CAI and CBIV environments enable learners to have more control over the content, structure, and sequence of their learning experiences. The literature, however, is lacking in empirical research reporting the effects of this control over interactive learning technologies on young children's achievement, curiosity, and motivation.

Most research involving interactive video and learner control has been conducted with sophisticated learners (Balson, Manning, Ebner, & Brooks, 1985; Gay, 1986; Gay, Trumbell, & Smith, 1988; Hannafin & Colamaio, 1987). Issues related to lesson control can have different implications for children (Hannafin, 1984). Although a completely unstructured format may prove challenging and acceptable for many adult learners, children with fewer cognitive strategies and less prerequisite knowledge may feel overwhelmed in an environment with so little guidance. On the other hand, overly restrictive conditions, whether in a classroom setting or a program-control interactive video lesson, leave little opporunity to stimulate the important scholarly attribute of curiosity. Research in the two separate areas of learner control in an interactive learning environment and curiosity was helpful in designing a study that combines these factors.

LEARNER CONTROL AND INTERACTIVE TECHNOLOGIES

Learner control has been defined by Milheim and Azbell (1988) as:

> the degree to which a learner can direct his or her own learning process. . . . [The term] most often describes the instructional choices made during a particular lesson. By definition these choices can be made either by the instructional program (as originally defined by the designer) or by the learner during the presentation of materials. (p. 3)

The literature cited herein includes studies that examined degrees of learner control, ranging from complete designer or program control, in which the learner makes no decisions about his or her learning process, to full learner control, in which the learner is in complete control of the available instructional options.

While some evidence exists that even secondary school-age students can make thoughtful decisions in learner-control situations (Robson, Steward, & Whitfield, 1988), Carrier (1984) states plainly that there is little confirmation that learners make good choices when given the chance. One study that substantiates this claim showed that students selected fewer than the optimal number of examples of math rules to support their learning when in a learner-control treatment (Ross & Rakow, 1981). The learner-control group did not perform as well as the program-control group, which received examples based on pretest results. Tennyson and his co-researchers suggest that time on task may be a factor contributing to poorer performance, as learner-control students tend to spend less time in the lesson (Johansen & Tennyson, 1983; Tennyson, 1980; Tennyson & Buttrey, 1980). This would indicate that students choose to exit the lesson before they achieve mastery. Another suggestion, offered by Steinberg (1989), is that beginning level students in a particular subject area may lack the discrimination skills and subject-specific learning strategies necessary for learner control to be effective.

Although studies such as those cited above have shown learner control to be associated with poorer performance, the addition of some form of *advisement* to a learner-control lesson has been associated with positive results in increasing achievement (Johansen & Tennyson, 1983; Tennyson, 1980, 1984; Tennyson, Christensen, & Park, 1984). Johansen and Tennyson (1983) used an advisement strategy that informed subjects of their performance relative to the mastery criterion and suggested the amount of instruction needed. Subjects then could make their own decisions about the sequence and the amount of instruction based on their perceptual understanding of their own needs. In the learner-control with advisement condition, subjects stayed on task longer than either the partial learner-control group or the learner-control group, and they exceeded the mastery criterion level established for the lesson. *Adaptive advisement*—informing learners of the amount and sequence of instruction needed to achieve objectives based on their performance level—was also found to be effective, appealing, and efficient in a study by Santiago and Okey (1990). In this study, 74 preservice teachers volunteered to participate in a CBI module on Gagné's nine events of instruction.

In addition to investigating adaptive advisement, Santiago and Okey (1990) reviewed various advisement strategies used in CBI lessons and found three others: advice on initial learning needs (amount and sequence), learning level for mastery, and pre-instructional advisement on the selection of instructional events. Milheim and Azbell (1988) also suggested three appropriate advisement strategies for CBIV: "suggestions for choosing a particular instructional sequence, suggestions for viewing a videotape/videodisc passage for more information, giving extra information concerning why a particular choice could be made" (p. 6).

In their study employing graduate and advanced level undergraduate students studying cardiopulmonary resuscitation (CPR), Hannafin and Colamaio (1987) found that students in either the learner-control or designer-control condition performed better than students in a purely linear control condition. Linear-control versions contained "no options for controlling the sequence of the lesson and no imposed decision for remediation or question repetition," whereas designer-control lessons contained "a predetermined path deemed most advisable by expert lesson designers including branched feedback" (p. 206). While no significant differences were found between learner control or designer control, students were *advised* of the recommended sequence in the learner-control treatment before they began studying the lesson. This could be why there were no significant differences in achievement between these two groups; essentially, all students in the learner-control treatment followed the recommended path through the lesson.

Kinzie, Sullivan, and Berdel (1988) found similar results for eighth-graders in a science lesson on solar energy; the students performed better under learner-control than under program-control conditions. In this study, the program-control treatment appears to be equivalent to the leaner linear-control treatment of the Hannafin and Colamaio (1987) study. The authors noted, however, that a high proportion of variance was attributable to individual differences in reading ability.

The appropriate level of learner control may be contingent on factors such as individual differences or prior conceptual understanding. In one study, subjects with low prior conceptual understanding of a content area made poor decisions relative to sequencing and learning strategies when presented with a high degree of learner control (Gay, 1986). Goetzfried and Hannafin (1985) also found a significant difference for prior achievement in a CAI mathematics lesson for low-achieving seventh-grade subjects. In the Santiago and Okey study (1990), one of the independent variables studied was locus of control. In comparing subjects who were considered internals (those who believe that outcomes are dependent on their own behaviors) with externals (those who believe that outcomes are generally beyond their control), internals had higher posttest scores regardless of which treatment they received, but had the highest scores with adaptive advisement. In a recent study, Burwell (1991) reported that subjects with a field-dependent learning style performed best in an interactive videodisc lesson in which the learner had control over the lesson but was provided with a degree of external guidance in the form of advisement.

With few exceptions, the studies cited above used college students or adult workers as subjects. Hannafin (1984) notes that older learners' more refined cognitive abilities may enable them to better utilize learner-control options. Younger subjects (elementary or junior high school age) may not yet have the necessary skills to make the most of such a lesson. Therefore, there is a potential problem in generalizing the results of the existing findings to the young learner. This exploratory study is an attempt to expand the base of empirical evidence in the area of learner control and children in a CBIV lesson.

CURIOSITY

There are those who would argue that stimulating curiosity in learning is even more essential than focusing on specific subject areas. One author writes of curiosity, "Without it we are condemned to be ordinary. With it we have a shot at being a part of the future" (Weintraub, 1986, p. 160). That children do well in situations in which they are allowed choices and encouraged to learn through active exploration are principles embraced by proponents of the Montessori method of teaching as well as by the National Association for the Education of Young Children (Calvert, 1986).

Curiosity is often associated with exploratory behavior. Berlyne (1960) identified two forms of exploratory behavior: specific exploration and diversive exploration. Diversive exploration occurs as a person seeks new experiences or relief from boredom, whereas specific exploration is encountered in situations in which there is conceptual conflict often resulting in curiosity arousal—the curiosity motivates exploration which resolves the conflict. According to Berlyne, the arousal state that motivates this "quest for knowledge" and is relieved when the individual attains that knowledge is epistemic curiosity (p. 274). Maw and Maw (1966) also described curiosity as an arousal state in which the individual desires to know more about self or environment. Cecil, Gray, Thornburg, and Ispa (1985) extend the definition of Maw and Maw and consider curiosity to be an arousal state that leads to and is a prerequisite for exploration, play, and creativity. In proposing a model of teaching and learning, Parker and Engel (1983) define curiosity as "the individual's desire to question or investigate."

In one part of a study in which children were asked to look at pictures and respond by asking questions about the picture, Maw and Maw (1964) found that high-curiosity children asked more questions and had more independent ideas (multiple questions that represented the same idea were counted only once) than low-curiosity children. Another study tested whether epistemic curiosity could be intensified by pre-questioning subjects and determined that there was a significant difference in mean scores between subjects who received questions and those who did not (Berlyne, 1960). Not only did questions heighten epistemic curiosity, but they also served to facilitate retention of facts when subjects subsequently encountered the questions associated with the facts.

Stimulating curiosity is an important responsibility of both parents and educators. The hypothesis that high-curiosity children show better overall social adjustment than low-curiosity children was accepted in one study of 577 fifth-graders from New Castle County, Delaware (Maw & Maw, 1965). Other findings of the same study concluded that high-curiosity children tend to be more consistent in thought processes as well as more creative and flexible, and that they seem to be more self-sufficient than low-curiosity children.

LEARNER CONTROL AND CURIOSITY

Selecting the appropriate level of learner control to cultivate curiosity, however, is a challenging issue. For example, if the child is given a learner-control lesson in order to facilitate curiosity and exploration, might he or she flounder for the lack of direction? Given a totally designer-control lesson, might the child's potential to be curious about learning be stifled? Can interactive learning technologies such as CBIV be utilized to both stimulate curiosity and provide adequate direction and guidance for achievement? The purpose of this study was to investigate the comparative effectiveness of variations in learner control on children's curiosity and learning about art.

To operationalize the construct of curiosity, the authors of this study used Maw and Maw's (1964) definition as it relates to school children. Maw and Maw went to great lengths to define the construct, including informal and formal inquiries, review of the literature, and an examination of the historical development of the term. The construct, as defined by them, incorporates the elements discovered by other researchers, especially Berlyne (1960). As such, Maw and Maw (1964) defined curiosity as demonstrated by the elementary school child who:

1. reacts positively to new, strange, incongruous, or mysterious elements in his environment by moving toward them, by exploring, or by manipulating them.
2. exhibits a need or a desire to know more about himself and/or his environment.
3. scans his surroundings seeking new experiences.
4. persists in examining and exploring stimuli in order to know more about them. (p. 31).

The present study investigated the aspects of curiosity as defined in the first, second, and fourth elements above. The third element is associated more with diversive curiosity, whereas this study was more concerned with epistemic curiosity and its relation to variations in learner control.

METHOD

Subjects

The sample consisted of 101 first- and second-grade students who attended a public elementary school in upstate New York. Only individuals who were given parental permission participated in the study. No attempt (beyond randomization) was made to group subjects by ability or reading level. Computer error in recording the data resulted in use of only 91 subjects for the Content Exploration measure and 92 subjects for the Persistence measure.

Description of Lesson

An interactive video lesson of a visit to an art museum was developed using a Sony Laservision™ videodisc player interfaced with an MS-DOS-compatible computer, a touch-sensitive screen, and headsets. The lesson, programmed using ICON Author™, used a combination of motion video, slides, and computer graphics in the presentation. The subject matter expert, who had previously served as a Curator of Education for the museum, provided the content for the lesson and acquired many visuals for the treatments. Prior to the formal lesson, a practice section in using the touch screen was provided for all four groups. The lesson itself included a general introduction and three segments on ceramics, sculptures, and paintings. The content involved both facts and concepts, and the lesson provided opportunities for practice, feedback, and remediation. The lessons were designed for subjects with limited reading experience and contained no text. A narrator was used where text would have been necessary. The use of a touch screen in place of a keyboard further simplified the young learners' task of responding.

CBIV Instructional Treatments

Three treatments were developed which varied the level of learner control over the lesson: Program Control, Learner Control, and Learner Control with Advisement. All treatments contained the same essential content and all provided opportunities for practice, remediation, and feedback. Practice items were designed to reinforce learning of the concepts and facts presented in the lesson. For example, in a practice item related to "still life," the subject was asked to select a nonexample from among examples. Practice items were different from the items presented on the posttest. Two instructional designers provided judgments regarding the appropriateness of the treatments to reflect the three constructs as described below.

Program Control

Subjects receiving the Program Control lesson followed a linear path through the lesson. These students received practice items, feedback, and were automatically branched to a remediation segment after a second incorrect response. Following remediation, the practice question was posed again; if the student still responded incorrectly, he or she was given the correct response and moved to the next item.

Learner Control

In the Learner Control lesson, subjects were given control over sequencing, pacing, stopping, remediation, and exiting. Subjects could sequence the material in any way they preferred. Whether to review segments where practice items were missed was also a decision left to these subjects. Students had the opportunity to omit entire sections or subsections, or opt out of the lesson altogether, if they so desired. Students controlled their own pace through the lesson. Additionally, subjects in this group could freeze images on the screen. This was called a "STOP and LOOK" routine, since whenever a particular icon was present, the subject could freeze the image on the screen to explore it more closely.

In a pre-lesson warm-up, all of the learner-control options and icons were explained by the narrator. Control options also were explained when they first appeared or were embedded naturally in the narration. For example, for the opportunity to sequence the material, the narrator stated, "What would you like to see first?" For pacing, the narrator would state, "Touch the screen when you are ready to go on."

Learner Control with Advisement

Subjects in the Learner Control with Advisement group received the same opportunities to explore the lesson as the Learner Control group. However, certain "advisement" strategies that provided guidance and encouraged curiosity were also employed. For example, a student who decided to skip a section would receive this advisement: "Are you sure you want to end the lesson? This next section is very interesting. You might really enjoy it" or "Aren't you going to wonder about what you'll be missing?" Care was taken not to instill fear of evaluation as the motivation to continue the lesson, since it would not be conducive to stimulating curiosity.

While subjects in the Learner Control group could take advantage of the "STOP and LOOK" routine whenever they saw the associated icon appear on the screen, subjects in the Learner Control with Advisement group were advised by the narrator to take advantage of the "STOP and LOOK" routine to explore the images more closely. The final type of advisement was in the form of a "STOP and THINK" routine, which generally was preceded by a question to arouse curiosity. For example, after presenting some interesting information about a painting that generally intrigues young children, this question was posed: "Do you wonder how you can tell this from looking at the painting? STOP and THINK about it! Then, touch the screen when you are ready to find out." All audio and visuals were programmed to freeze at that point and would resume only when the subject touched the screen to proceed. Since the learner had no control over the freezing of the screen, this was considered an advisement strategy and not a learner-control option. Other than the advisement, the instructional content remained the same as for all other groups.

Procedures

There were three complete interactive video stations set up at the school, which allowed three students to participate at one time, although subjects were administered the treatments individually. In a pre-lesson exercise, a treatment administrator familiarized subjects with how to use the touch screen and introduced several icons they would encounter during the lessons. The control group received the same practice in using the touch screen as did the experimental groups. Subjects then took the lesson or were administered the posttest. Posttest responses were recorded both on audiotape and noted on a paper and pencil instrument. In one subsection of the posttest, the computer was used to track responses.

Several provisions were made to protect the study's internal validity. Subjects were blind to which treatment they were receiving and were not informed about the nature of the experiment. So that all subjects would have the sense that they had received the same experience, all subjects, including the control group, were individually presented the same entertaining video following the posttest. The video showed the child how to make a simple animated cartoon and lasted approximately three minutes. Since all the treatments were somewhat novel (i.e., all were interactive) and all ended with the same entertaining video, the possibility for the Hawthorne effect was reduced. To control for experimenter bias, the authors of the study did not administer the treatments.

Three administrators were selected to introduce the children to the lesson and to interview them for the posttest. All administrators participated in a training session on treatment and posttest procedures prior to the experiment. The administrators were assigned treatments on a rotating basis so that no one was responsible for just one treatment. The lessons and the posttest were reviewed by experts for evidence that the constructs defined in the study were adequately represented in the lessons and instruments. Finally, since the posttest was being evaluated by three administrators, a beta test was conducted to assess their interrater reliability. Raters came to 100% agreement on the rating by the end of the training session.

Dependent Measures

Part of the challenge of designing measures to test the effectiveness of the treatments had to do with the type of content that was presented. Pure recall or "pat" answers would be inappropriate in an area such as art education and museums. In measuring *achievement*, an instrument was needed that gave the child the opportunity to be more expressive while demonstrating that he or she had indeed acquired the new information. In measuring *curiosity* toward the content, an instrument was needed that gave the child more freedom to explore possible answers.

Achievement

The first section of the posttest consisted of eight open-ended, previously unencountered questions that measured achievement. For these questions, the subject was presented still video images of aspects of the museum encountered in the lesson, such as paintings, sculptures, textures, and ceramics. For each item, the administrator asked the subject to relate everything he or she knew about the picture. Responses were recorded on a paper-and-pencil scoring sheet and were also audiotaped. The rationale behind using this type of open-ended question was that, prior to the treatments, the subjects would demonstrate little knowledge of the material and have limited vocabulary, while following the treatment, the subjects should be capable of generating more and richer responses. For example, in the control group, a student might refer to a painting of Niagara Falls as "some waterfalls," whereas a post-treatment response in the experimental condition might be, "That's a landscape painting. It shows the natural scenery." Using content analysis, a master list of all possible appropriate lesson-related responses was created. Items were scored based on the number of responses that matched that list.

Because of the open-ended nature of the questions, it was necessary to distinguish between responses that were specific to the lesson (achievement) and those that were not (general). Subjects in each group could list a high number of responses which had no bearing on the actual instruction, and as such the resulting score would not be representative of achievement of the content of the lesson. For example, in an item that represented a concept such as "portrait," subjects could increase their scores merely by stating the various objects in the picture. As a result, only lesson-related scores were used to compare achievement between the groups.

To control for order effect and fatigue, the computer was programmed to randomly generate the test items for each subject.

The subject matter expert reviewed the posttest for content validity and determined that it adequately represented the content presented in the lesson.

Curiosity

Based on the three elements defined by Maw and Maw (1964), three instruments measuring curiosity toward art in museums were developed. The first measured Content Exploration: curiosity toward museums. The second measured Questioning: the number of questions the child generated when presented with a previously unencountered image. The third measured Persistence: the time the child persisted in exploring new stimuli, as indicated by the length of time he or she examined a new image before moving on to the next.

To measure Content Exploration, or curiosity toward museums, the subjects were asked to pretend they were explorers who were going to take a friend to some special places. After being presented with a full-frame image of a museum, the subjects were then asked to tell the administrator everything they would want to show their friend if they brought him or her to the museum. For this one question, a score was calculated based on the number of items the child would show to the friend. The higher the number of items, the greater the inclination to explore the museum environment.

For the Questioning measure, the subjects were presented with five previously unencountered images and were asked to indicate what they would like to know about them. Two scores were generated for this measure: the total number of questions asked about the five images and the number of independent ideas those questions represented. In other words, the more questions and more ideas, the more curious the subject had become toward the content area. Since the subjects had never encountered the specific images in the treatment, the increase in questions should not have been related to the increase in information they had acquired, but rather to an increase in curiosity brought about by the treatment of the content.

The third element of curiosity, Persistence, was measured by the amount of time the subjects spent attending to a new art image. During the posttest, the subjects were given control of the videodisc and instructed to examine each of five images for as long as desired. When they were finished exploring the image, they touched the screen to go on to the next image. The time they persisted in exploring each image was recorded by the computer.

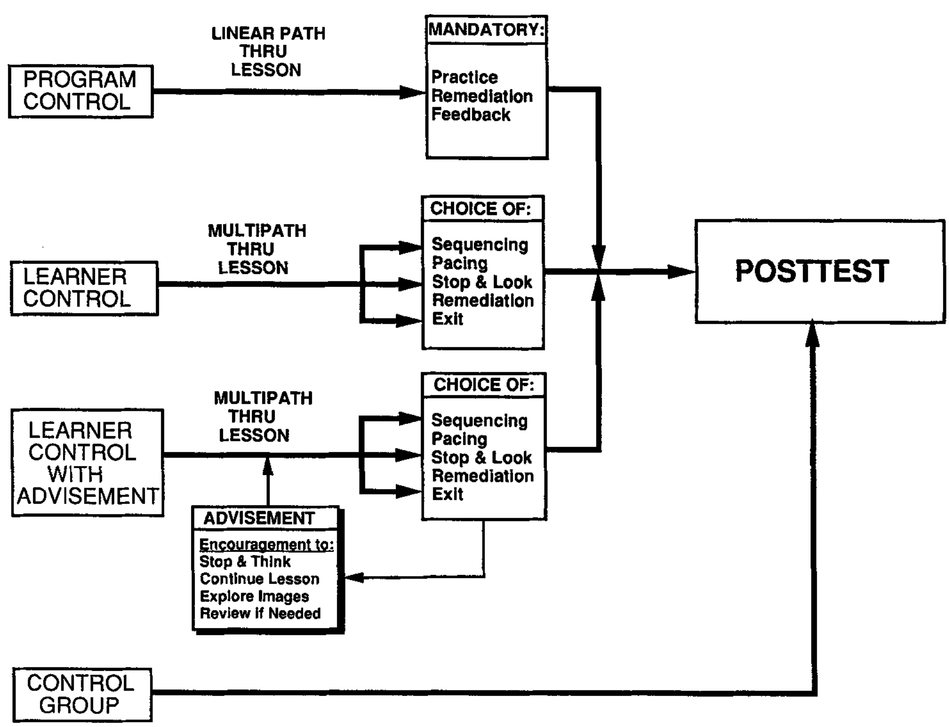
As in the achievement section of the posttest, the computer was programmed to randomly generate the test items for the Questioning and Persistence measures. It should be noted that the number of items for each curiosity measure (1, 5, and 5) was not large. This was a decision based on Maw and Maw's (1964) discovery that the more items asked, the fewer the number of questions elicited from the learner.

Research Design and Data Analysis

Subjects were randomly assigned to one of three experimental conditions, in which they received a lesson followed by a posttest, or to a control group, in which they received only the posttest. The research design is diagrammed in Figure 1.

Random assignment and the control group were used to control for differences in prior knowledge of museums and ability level. One-way analysis of variance was used to test for significant differences between the four groups on achievement and curiosity. A .05 probability level was selected to determine significance. Tukey's Least Significant Differences (LSD) test was selected to analyze the differences between means in the follow-up tests.

FIGURE 1 □ Research Design



RESULTS

Achievement

Descriptive results for achievement are reported in Table 1. Means ranged from 5.0 for the control group, 13.35 for Learner Control, 13.89 for Program Control, to 16.08 for Learner Control with Advisement.

Results from the ANOVA indicated an overall significant difference between treatments ($p < .0001$). Follow-up tests were then conducted using Tukey's LSD procedure to pinpoint specific differences. These results showed that significant differences were found between the control group and all three experimental groups, indicating that, irrespective of treatment conditions, the interactive video lesson did enhance achievement. No differences were found between the Program Control and either the Learner Control or Learner Control with Advisement groups. A significant difference ($+2.731, p < .05$) was found between the Learner Control and the Learner Control with Advisement groups. In this comparison, the Learner Control with Advisement group scored significantly higher than the Learner Control group.

Time data were also recorded for each of the three experimental groups. Computer error resulted in loss of time for several subjects in each group. In the Learner Control with Advisement group, 21 subjects spent an average of 18.02 minutes; in the Learner Control group, 18 subjects spent an average of 17.83 minutes; in the Program Control group, 16 subjects spent an average of 13.54 minutes. Results from a one-way ANOVA indicated an overall significant difference between groups ($F = 113.77, p < .0001$). A follow-up Scheffe F-test revealed that a significantly greater amount of time was spent in the Learner Control and Learner Control with Advisement groups than in the Program Control group. No difference was found between the Learner Control and Learner Control with Advisement groups.

Curiosity

Descriptive results for all curiosity measures are reported in Table 2. Results from the ANOVA revealed a significantly higher level of curiosity as measured by the number of items to explore on the Content Exploration instrument for the Learner Control with Advisement group ($M = 3.74$) than the control group ($M = 2.60$). A significantly greater level of persistence, as measured by time in seconds, was found for the control group ($M = 75.97$) than for the Program Control group ($M = 52.70$). No significant differences, however, were found between the Program Control, the Learner Control, and the Learner Control with Advisement groups on any of the three curiosity measures.

Learner Options

Options that the subjects chose in the Learner Control and Learner Control with Advisement lessons were also tracked. Computer error resulted in missing data for several subjects in each group; however, general trends can be reported. First, when given the option to sequence the information, 17 out of 21 subjects in the Learner Control with Advisement treatment and 14 out of 18 subjects in the Learner Control treatment selected at least two of the four main menu items out of the linear sequence. Also, 15 out of 21 Learner Control with Advisement subjects and 14 out of 17

TABLE 1 □ Means and Standard Deviations for Achievement Scores by Treatment Group

Treatment Group	*N*	*M*	*SD*	*Range*
Learner Control	27	13.35	4.49	3–23
Learner Control with Advisement	25	16.08	6.54	4–35
Program Control	25	13.89	4.98	4–22
Control	24	5.0	2.38	1–9

TABLE 2 □ Means and Standard Deviations for Curiosity Measures by Treatment Group

	Content Exploration (# Items)			*Questioning: # Questions Generated*			*Questioning: # Independent Ideas*			*Persistence (in seconds)*		
Treatment Group	*N*	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*
Learner Control	26	3.42	1.77	27	13.38	7.17	27	12.89	6.81	24	57.58	37.20
Learner Control with Advisement	23	3.74	2.32	25	16.76	6.39	25	15.56	6.06	23	55.57	29.25
Program Control	22	3.18	1.33	25	14.60	9.48	25	13.96	9.22	23	52.70	23.21
Control	20	2.60	1.14	24	15.90	9.24	24	14.93	7.98	22	75.97	45.02
TOTAL	91	3.26	1.74	101	15.12	8.13	101	14.30	7.50	92	60.25	35.16

Learner Control subjects selected at least two of the four sub-menu items out of sequence. In the Learner Control with Advisement group, 16 out of 19 subjects exercised the option to "STOP and LOOK," with a mean of 3 stops and 13 seconds per stop. In the Learner Control group, 14 out of 21 subjects stopped to look, with a mean of 2 stops and 17 seconds per stop. Three subjects from both groups exercised the exit option, and all subjects selected the remediation option whenever it appeared.

The one difference between these two groups was the advisement to "STOP and THINK" in the Learner Control with Advisement group; 18 out of 21 subjects followed this advice, taking an average of 55 seconds for the activity.

DISCUSSION

This study proved useful in examining links between achievement and learner control among very young children and between learner control and curiosity relative to specific content. The Learner Control with Advisement lesson resulted in the greatest amount of learning and achievement was significantly higher than the Learner Control group. Time on task is a common explanation in the literature for these differences, as learner-control subjects often quit the lesson prematurely (Tennyson, 1980); however, in this study, the average time spent in both groups was virtually the same (18.02 minutes as compared to 17.83). What this seems to indicate is that providing some structure to a lesson in the form of advisement was better than allowing this age group free rein in discovering the content. For this study, Learner Control with Advisement also provided the most opportunity for interaction. Although this variable could not be isolated in this study, it has been shown in previous studies to result in greater learning of factual information (Schaffer & Hannafin, 1986) and would warrant further research.

It was expected that the Learner Control group, which had no guidance whatsoever, would have the lowest achievement scores, but in actuality, this group's scores were only marginally lower than those of the Program Control group. This was an interesting finding, given that the Program Control group spent less time in the lesson (only 13.54 minutes) than the Learner Control group. One explanation is that the opportunities for exploration in the Learner Control lesson stimulated enough interest and motivation to overcome the lack of structure that was provided in the Program Control lesson. These variables also cannot be isolated in this study and would suggest an area of further exploration.

An alternative explanation is that although subjects in all treatments received the same essential content, the Program Control subjects did, in fact, receive a leaner version of the lesson than the other groups, as demonstrated by the less time spent in the lesson. Perhaps there would have been a greater difference between the Program Control and Learner Control groups if the Program Control group had received a full version containing the learner-control options (e.g., opportunities to explore images by freezing the screen) but making them required rather than optional. Future research on this issue should include this type of program control treatment to determine whether this is the case.

There were no significant differences between the groups on curiosity measured by Questioning, although the young learners who took the Learner Control with Advisement lesson generated the most questions and the most independent ideas. There are several possibilities for the overall lack of significant results on these curiosity measures. Perhaps the construct was not adequately captured in the measures that were designed specifically for this study (although they were adapted from previous studies). It could also be that additional strategies that encourage curiosity need to be incorporated into the lessons themselves, and that the differences between treatments with respect to those strategies need to be strengthened in order to increase the chances of sensing an effect. Since curiosity has often been linked with giftedness, it could be that the amount of variance attributable to this factor was not accounted for, and controlling for this in future studies may allow the true differences between the groups to be revealed.

There were two interesting significant differences related to curiosity. The first was between the control group and all other groups involving Persistence. This result initially seemed counterintuitive. The most curious students on this measure were the control group subjects, who had not even been exposed to the lesson treatment. The least curious were the Program Control subjects, who had the greatest amount of instructional control imposed upon them. These results indicate that students who were not exposed to the art education content were more apt to attend longer to stimuli that were totally new to them. That is, although all students were attending to new stimuli at this point in the posttest, the other groups had at least been exposed to the subject matter area in the treatment and thus the type of stimuli was at least familiar. Naturally, one might argue a rival hypothesis that this result was attributable to fatigue or even boredom. The students in the control group were given the posttest only, while the others had been through a lesson as well and may have been ready to move on by that time. Further investigation is warranted to determine whether learners do, in fact, persist less in attending to new stimuli as instructional control increases, as such a finding would suggest potential instructional strategies for young learners.

The second interesting significant difference for curiosity was found for Content Exploration. The Learner Control with Advisement subjects demonstrated more exploration curiosity toward museums than the control group. It may be that the advisement to "STOP and LOOK" and "STOP and THINK" prompted subjects to become intrigued with the museum content. Subjects who had no instruction may not have had enough familiarity with museums, or may have had prior attitudes that affected their desire to explore museums. This may also be the case with structured lessons, or free exploration, which would not directly stimulate curiosity toward specific content when none already exists. Future research that examines familiarity and initial interest in the content may help unravel the underlying causes of these results.

Possibly, a future study using the same interactive video materials, with modifications, could be conducted in which existing validated reliable measures of general curiosity are taken. A study of this sort would provide the opportunity to investigate the differences between high-curiosity and low-curiosity children regarding their preference for and achievement in various learner-control conditions. The findings of such a study could provide information to designers of CAI and CBIV relative to tailoring instruction and providing opportunities for learner control based on the individual characteristics of the students. For example, hypothetically a low-curiosity student may perform better in a more structured format such as Program Control, but certain strategies might then be embedded in that treatment specifically to *encourage* curiosity in the low-curiosity child.

Is there an optimal balance between amount of instructional control and achievement and curiosity? Are other factors involved in maximizing achievement or stimulating curiosity, such as cognitive styles, general curiosity, preferences, and so on? What can educators and designers of interactive learning technologies do to encourage children's quest for knowledge and intrinsic motivation to learn? The significant differences that were found in this study indicate that more research with young learners is warranted in the area of learner control as it relates to achievement and curiosity. □

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