Effects of Learner Control, Advisement, and Prior Knowledge on Young Students' Learning in a Hypertext Environment

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This study was an investigation of the effects of learner control and of advisement in a hypertext learning environment with second-grade students who had different levels of prior knowledge about the content. Four treatment conditions crossing two variables, learner control (free access representing network structuring of hypertext vs. limited access representing hierarchical structuring of hypertext), and advisement (advisement vs. no-advisement), were established. From the quantitative and qualitative data, results indicated that: (a) for low prior knowledge (PK) students, the limited-access condition was more effective than the free-access condition, whereas high-PK students were able to function equally well in both conditions; (b) the free-access group reported a higher positive attitude for advisement than for no advisement, but the limited-access group showed no such difference in preference; (c) the low-PK group completed the lesson more quickly without advisement than with advisement, whereas the high-PK group's completion times did not vary across advisement conditions; and (d) analysis of the path data indicated that advisement was helpful in preventing disorientation in the free-access condition.

☐ Computer-assisted instruction has evolved to a greater use of hypertext in learning situations. As this use of hypertext has increased, so has the need to develop lessons for different kinds of learners and increasingly younger learners. Determining effective ways of designing hypertext lessons brings us to issues that have not been resolved in the field: How much freedom should learners have in navigating through hypertext lessons? When would they benefit from advice about accessing information? Should learners with different levels of knowledge of the topic be provided with hypertext lessons with different design features? The purpose of this study was to investigate the effects of *learner control* and of *advisement* in a hypertext learning environment with second-grade students who had different levels of prior knowledge about the content.

Learner control is a commonly used label for a design feature that allows a learner to make instructional decisions while interacting with a computer-delivered lesson. In a hypertext environment, use of learner control is inevitable, because hypertext creates non-sequential, dynamic, and multiple structures of information that allow learners with different interests to navigate multiple pathways through the information. The units of information in a hypertext system, called *nodes*, are interlinked with each other. Usually, a node describes a single concept or topic and consists of one or more screen displays represented either as complete files or as database records in a file (Hashim, 1990; Nielson, 1990; Shneiderman & Kearsley, 1989). In the early days of hypertext, nodes contained only text. Now nodes can con-

tain various kinds of data: Text, graphics, audio, video, computer-generated animation, or other kinds of information.

One issue associated with hypertext systems, the link issue, involves decisions about how nodes in the system should be connected, thus creating different structures of hypertext. Generally there are two ways to connect nodes. Hierarchical structures connect each node to superordinate information and to subordinate information unless the node is a starting point or an end point. A node at one level can access only nodes directly above or below. This structure is also called a *hierarchical tree structure* (Shneiderman & Kearsley, 1989), *hierarchical hypertext* (Jonassen, 1986), *organizational links* (Locatis, Letourneau, & Banvard, 1989; Stevens, 1989), or the *structured approach* (Lanza & Roselli, 1991). By contrast, network structures (Shneiderman & Kearsley, 1989) connect any node to any other. In this kind of structure, multiple links between superordinate information and subordinate information can be made forming a network. This structure is also called *referential links* (Locatis et al., 1989), *prototype hypertext* (Bowers & Tsai, 1990), *node-link hypertext* (Jonassen, 1986), or the *hypertextual approach* (Lanza & Roselli, 1991). The link issue is intertwined with issues associated with learner control because learners interacting with a hypertext system that uses a network structure will necessarily have more decisions to make than learners using a hierarchical system (Misanchuk & Schwier, 1991).

Theoretically, the different structures of hypertext are supported by different models of cognition. Two general categories of models of knowledge representation are often debated, structure models such as schema theory that represent knowledge as interconnected structures, and connectionist models, sometimes called neural net models, that represent knowledge as sets of associations with differing strengths of connections. Hierarchical links in a hypertext system impose a scheme for knowledge representation that may be more compatible with a traditional view of schema theory. A network structure in a hypertext environment seems more consistent with connectionist models of cognition that explain information-processing as taking place through the interaction of excitatory and inhibitory connections among units (e.g., Alexander, Schallert, & Hare, 1991; Estes, 1988; Gluck & Bower, 1988; Levine, 1989; McClelland, Rumelhart, & Hinton, 1986; McClelland, Rumelhart, & PDP Research Group, 1986; Schallert, 1982).

The use of hypertext in instructional situations has generated much interest among instructional designers and technologists. The flexibility of the system and the fact that learners might be individually served as well as forced to take an active role in their own learning, make such a design attractive to educators who view the ideal learner as self-motivated and self-directed. According to constructivist philosophies of learning, ideal uses of hypertext systems involve sophisticated users searching for complex information to meet their own goals (Jonassen & Wang, 1992). Problems arise, however, in the use of hypertext when learners are at truly novice levels and lack knowledge even to know what they still need to learn. In fact, in most uses of computer-assisted instruction, exactly because the learner is often not knowledgeable enough to take on goals for the learning that are any more specific than the general goal of learning about this topic, the instructional goals of the educator/program designer are likely to prevail. Thus, a hypertext system used for typical instructional purposes is likely not to be used in a manner that reflects a true network structure in at least this one aspect—that the user is less likely to be idiosyncratically pursuing his or her agenda in interacting with the system. As Park (1991) noted, the use of hypertext for instructional purposes is very much related to the issue of what is called learner control.

Although research on hypertext environments reflecting different degrees of learner control is only now becoming available, the variable of learner control has received much attention in more traditional computer-assisted instruction. Results of these studies have been inconclusive and findings have varied widely. For example, learner control has been shown to be more effective than program control, not differently effective, and even less effective than program control. It has also been shown

that different kinds of control treatments may interact with learner characteristics, such as prior knowledge or aptitude. In a few studies, learner control had positive effects only for certain types of learners, such as those with high aptitude, high inquiry, or high prior knowledge (Fry, 1972; Gay, 1986; Ross & Rakow, 1981). When the research focus has included student attitudes, using learner control has typically resulted in more positive attitudes toward the instruction (Fisher, Blackwell, Garcia, & Greene, 1975; Fry, 1972; Hintze, Mohr, & Wenzel, 1988; Kinzie & Sullivan, 1989; Ross, Morrison, & O'Dell, 1989).

In some studies, instructional time was reported to be less in the learner control condition (Gay, 1986; Milheim, 1990), and high prior knowledge students were significantly more efficient than all other groups in their use of time (Gay, 1986). However, there are some indications that students in the learner control condition were working through fewer problems (Fisher, et al., 1975; Johansen & Tennyson, 1983). This suggestion leads to the concern that if students are allowed to make decisions about the amount of instruction, practice, or examples, they may choose to end their interaction with the program before receiving enough instruction. Then again, some researchers have reported that the learner control group took longer to complete the instruction than the program control group (Balson, Manning, Ebner, & Brooks, 1984–85; Belland, Taylor, Canelos, Dwyer, & Baker, 1985).

Exercising control over instruction can be meaningful and successful if students know what is best for them and make good choices. However, as indicated by Carrier (1984), students given learner control may not always make good choices. To improve students' choice under the learner control condition, a strategy of providing advisement has been used. Advisement can take many forms: recommendations for the number of practice items needed to reach mastery of each concept, number of examples, sequence to follow, content to be reviewed, or mode of display. This strategy allows control over instructional decisions by the learner as with conventional learner control, but the student is given advice for making some of those decisions. In other words, advisement in a learner control condition involves giving guidance to the student to help in making good choices.

The studies on learner control with advisement have reported in general that (a) students achieved higher scores than, or at least the same as, students in other control strategies on an achievement test (Holmes, Robson, & Steward, 1985; Johansen & Tennyson, 1983; Tennyson, 1980); (b) students in the learner control with advisement condition took longer to complete the lesson than students in the conventional learner control condition (Coorough, 1991; Goetzfried & Hannafin, 1985; Johansen & Tennyson, 1983), possibly because the advisement group received more instruction; and (c) students reported liking the advisement in the learner control condition (Laurillard, 1984). These studies suggest that learner control may become more instructionally effective when advisement is provided.

Particularly in hypertext instruction, learners encounter problems with making many decisions and with navigating where they are in the lesson. Especially when the lesson is in network structure, they may lose their way in hyperspace and get disoriented. Anderson-Inman (1989) indicated that "an important issue is whether students should be guided in their explorations through complex hypertext systems . . . especially at the elementary and secondary levels" (p. 29). In order to minimize navigational problems, many authors (Jonassen, 1988; Locatis, et al., 1989; Morariu, 1988; Shneiderman & Kearsley, 1989) have suggested different navigational aids. Navigational aids are a form of advisement to help students keep track of where they are in a hypertext environment, and of which sequence they should follow.

In the present study in which a hypertext learning environment was designed for young learners, three variables were manipulated, namely, amount of learner control, presence of advisement, and level of prior knowledge about the content. Amount of learner control can be represented on a continuum, with the early linear programs used in computer-assisted instruction at one end and the true

non-linear hypertext system at the other end. In this study, the variable of learner control was represented by two conditions that differentially varied amount of learner control. We saw the *free-access* condition as representing a higher degree of learner control and as being closer to the true non-linear hypertext end of the continuum than the *limited-access* condition which falls closer to, yet still above, the midpoint on the continuum.

The advisement treatment in the present study was intended to help learners navigate in the hypertext environment and make good choices. The advisement gave recommendations to the learners on the sequence to follow and visual aids for helping them know where they have been and where they are.

Finally, a third variable represented different levels of prior knowledge. In a situation where the goal is to acquire new information, prior knowledge about the content may affect how much a learner can control the instruction effectively. In previous research, it was found that high prior knowledge students benefitted from learner control, whereas low prior knowledge students did better with program control.

The subjects for the present study were second-grade elementary students. Most research on learner control has been conducted with college- or secondary-level students, and only a few studies have had younger students as participants (e.g., Fisher, et al., 1975; Gillingham, Garner, Guthrie, & Sawyer, 1989; Morrison, Ross, & Baldwin, 1992). Age as an individual difference variable may have a relationship to educational outcomes with learner control (Klein & Keller, 1990). In fact, Hannafin (1984) indicated that older students perform more effectively under learner control with advisement and younger students perform best under program control. For young students placed in hypertext learning environments that allow more learner control than traditional computer-assisted instruction, the navigation problem may be especially serious. Because the characteristics of hypertext permit many attractive features in allowing non-linear, dynamic information structures, it is inevitable that an increasing number of programs will be developed that make use of the learner control strategy. Therefore, the rationale for choosing elementary students is to increase knowledge about the generalizability of learner control findings for different age groups, and to provide useful information to developers of educational materials who are increasingly asked to reach a young audience.

A multiple set of dependent measures was included in the present study. Similar to previous studies, immediate and delayed posttests of achievement and a preference rating were included. To these outcome measures was added a difficulty rating that allowed for an evaluation of the lesson from the learners' perspective. In addition, it seemed important to gather data describing the students' actions as they interacted with the lesson, and not just outcomes. Thus, time-to-completion and the actual navigational paths traversed by each learner were automatically recorded by the computer program. The latter is a measure much less frequently reported in the literature though advocated as useful by researchers (e.g., Misanchuk & Schwier, 1991).

METHOD

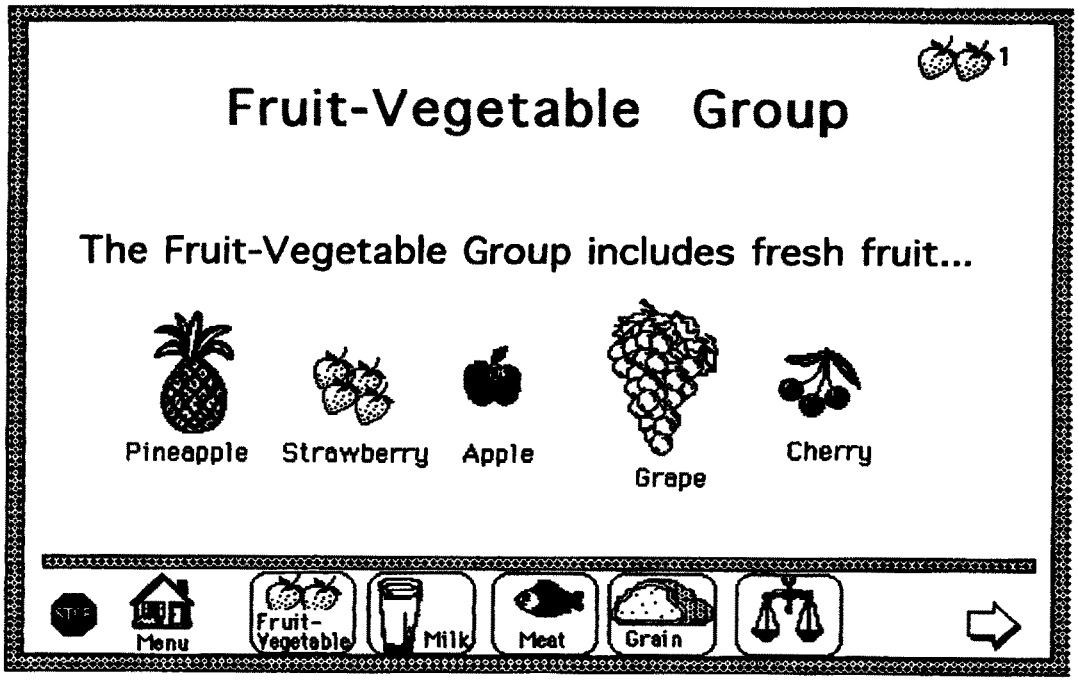
Subjects and Research Design

Subjects were 110 second-grade students in an affluent school district in the southwest. One concern in testing the effectiveness of learner control is that users need to have had experience with computers (Gay, Trumbull, & Smith, 1988). Accordingly, we chose these students because they were accustomed to using computer-assisted materials and they knew how to choose what they wanted from options presented on a computer screen. The study used a 2 (learner control: free access vs. limited access) × 2 (advisement: advisement vs. no-advisement) × 2 (prior knowledge: high vs. low) factorial design.

Instructional Materials

The content of instruction was "food groups," a topic that the children's teachers were

Figure 1. ☐ Sample screen in the free access with advisement condition



required to teach. We developed the computer-assisted lesson with a hypertext authoring tool, HyperCard, for Macintosh computers. The lesson began by providing instructions on how to use the program and how to interact with screen features. Because the students participating in this study were well acquainted with the use of computers, this section of the program did not need to be very extensive. The lesson then informed students of the objectives, which were to learn about the food groups and to use the food groups to plan a balanced meal. The coordinate concepts in the Food Groups lesson were milk, meat, grain, and fruit-vegetable groups. This information was delivered as four tutorial sections for each food group and followed by one transfer section, a discussion of what is needed to make up a balanced meal. Definitions of each concept were provided and instance pools that included both textual and pictorial examples for each concept were developed. In each food group tutorial section, students were taught the kinds of food items that belong to that food group. Then, practice items and feedback to students' responses were provided. Figure 1 presents an example of a screen display in one of the conditions. The concepts taught were reviewed with the teachers and a pilot testing of the lesson was administered with one group of second-graders who did not participate in the main experiment.

Treatment

The instructional materials were prepared in four different versions representing the crossing of two treatment variables: learner control (free access vs. limited access) and advisement (advisement vs. no-advisement).

In the free-access condition, a form of hypertext that represented a network structure was used and the student could choose as many options as desired. The information was linked to every possible topic in the lesson and each food group could be accessed in any order. However, because the balanced meal section represented a summation of all other parts of the lesson and allowed a test of how well the knowledge learned could transfer, it would ideally be accessed after all the food

groups had been seen. In order to allow as much freedom as possible, the free-access condition allowed the student to access even the balanced meal topic at any time.

In the limited-access condition, a form of hypertext that represents hierarchical structure, the student could only choose a topic that was directly related to the information just presented. Each food group could be tried in any order but the balanced meal section was available only when all food groups had been tried.

The other treatment variable was advisement. Students in the advisement condition received recommendations on the sequence to follow through the materials but were free to follow the advice or not. The advisement treatment was made up of four features, listed below. The advisement treatment group had all of these advisements, whereas the no-advisement treatment group had none of these.

1. *Advice to finish the current topic.* If students attempted to choose another topic before finishing the current one, they received advice to finish this topic first.

2. *Navigational functions.* Page numbers for each card in a section appeared with an icon of each food group. Also, highlighting of the topic on the menu screen that they had tried appeared, as well.

3. *Advice on the results of practice.* Depending on the result of practice, students were advised differently. If they had no or one error on the three or four practice items, the advice was to continue to another topic. If they made two or more errors, they were advised to repeat the section. The purpose of this advice was to help students choose the next sequence in their instruction.

4. *Advice on the menu screen in the free-access condition.* Although students had five options, four food groups and the balanced meal, they received advice to choose the food groups first.

Dependent Measures

Quantitative measures included posttest scores, delayed posttest scores, preference for the instructional method, self ratings of the difficulty of the instructional method, and time to complete the lesson. These variables were subjected to inferential statistical analyses. The paths that students navigated as they proceeded through the lesson were collected and subjected to qualitative analysis, with the goal of providing a general description of the navigation patterns in the different treatments. These outcomes were used to support and elucidate the underlying reasons for the quantitative findings.

The pretest, posttest, and delayed posttests were equivalent, parallel forms of paper-and-pencil tests, with different food examples used in items on the different forms. For example, one multiple-choice question on the pretest asked the students to circle the picture depicting the correct answer to the question, "Which food is in the milk group?" Choices included the words and pictures depicting fish, cheese, an orange, and eggs. On the posttest, the parallel item presented the same question but offered as choices words and pictures depicting cake, ice cream, an orange, and a pork chop. Each test consisted of four short-answer (e.g., "Name the food groups") and eight multiple-choice questions (e.g., "If you have chosen broccoli, cheese, and chicken, what group do you need to choose from to have a balanced meal? Circle on the picture") that tested comprehension and application of the concepts learned. Each of the 12 questions on each form of the test was worth one point. Content validity of the tests was established by a careful comparison of the lesson content and each test item and by asking the teachers of the children to evaluate the appropriateness of the items as measures for the lesson. Because the tests were parallel forms, only posttest inter-item consistency was assessed. Using the KR-20 formula on the entire sample, the reliability coefficient was .64.

A short questionnaire was used to assess students' preference for the instructional method and their ratings of its difficulty level.

Because the subjects were very young, pictorial response choices were developed. For the preference rating, the question, "Did you like the Food Groups program?" was presented. Students then saw the possible answers, *Yes*, *OK*, and *No* with corresponding icons (three faces, one with a smile, one with a neutral expression, one with a frown). If they chose Yes, they were asked another question, "How much did you like it?" If they liked it a lot, they were supposed to mark the big circle. If they liked it a little, they were supposed to mark the small circle. If they answered OK on the initial question, they were not asked any further question. If they answered No on the initial question, they were asked, "How much didn't you like it?" They were told to mark the big X if they did not like it at all and to mark the small X if they did not like it a little. Because the children were carefully walked through the procedure one step at a time by their own computer lab teacher, they found it very easy to understand and fun to do. From these steps, a 5-point scale was devised for the analysis, with a 5 representing the "like the program very much" option and a 1 representing the "didn't like the program at all" option.

For the rating of the difficulty of the lesson, the same method was used. The initial question "Was the Food Groups program difficult?" was presented. Possible answers were, "It was difficult," "It was just right," and "It was easy." If students chose either the "difficult" or "easy" option, they were directed to choose between "very" and "a little" options. Again, a 5-point scale was devised from the students' responses, with 5 representing "very difficult" and 1 representing "very easy."

Time to complete the lesson and the qualitative data, and the paths that students navigated as they proceeded through the lesson, were recorded automatically by the computer program.

Procedure

The 12-item pretest was administered in the classroom by the students' teachers. Using a median split of the pretest results, we divided the subjects into two prior knowledge groups: high (M=10.1, SD=1.1, n=58) and low (M=6.1, SD=1.7, n=52). The subjects in each group were randomly assigned to one of four treatment groups.

One week after the pretest, groups of approximately 10 students, including some who were in the high and some who were in the low prior knowledge groups, were brought to the computer lab in the school and given instructions by the computer lab teacher. Working at individual computer stations, students took between 15 and 20 minutes to complete the lesson.

Upon completion of the computer-assisted lesson, all students took the 12-item immediate posttest. They then filled out a questionnaire asking them to rate their preference for the lesson and the difficulty of the materials. The procedures for rating these features of the program was thoroughly explained to the students before they filled out the questionnaire. One week later, the students took the delayed posttest administered by their own teacher in their regular classrooms.

RESULTS

Quantitative Data Analyses

The dependent measures of posttest scores and delayed posttest scores were subjected to a four-way, mixed analysis of variance, with prior knowledge (high vs. low), learner control (limited access vs. free access), and advisement (with advisement vs. no advisement) as between subject variables and with time of test (posttest vs. delayed posttest) as a within-subject variable. The measures of preference ratings, difficulty ratings, and time to complete the lesson were subjected to separate three-way ANOVAs with prior knowledge (high vs. low), learner control (limited access vs. free access), and advisement (with advisement vs. no advisement) as independent variables.

Achievement scores. Results of the four-way ANOVA yielded two significant main effects. Students in the high prior knowledge group

Table 1 ☐ Means and standard deviations on achievement measures for the two-way interactions of learner control by prior knowledge

		Prior Knowledge		
		High PK	*Low PK*	*Total*
Learner Control				
Free Access	*M*	11.2	9.0	10.2
	SD	.8	2.0	1.8
	n	32	26	58
Limited Access	*M*	11.1	9.9	10.5
	SD	.7	1.2	1.1
	n	26	26	52
Total	*M*	11.2	9.5	
	SD	.8	1.7	
	n	58	52	

(M=11.2, SD=.8) had significantly higher overall scores than students in the low prior knowledge group (M=9.5, SD=1.7), $F(1,102)=46.0$, $p<.001$. Students' performance on the immediate posttest (M=10.7, SD=1.7) was better than their performance on the delayed posttest (M=10.0, SD=1.7), $F(1, 102)=26.3$, $p<.001$. All other main effects were not significant.

Two of the two-way interactions were significant, learner control by prior knowledge, $F(1,102)=4.0$, $p<.05$, and learner control by time of test, $F(1,102)=5.7$, $p<.05$. The first interaction, explored with multiple t-tests, indicated that students in the high prior knowledge group did not show any significant difference in their performance whether they were in the free-access or limited-access condition. However, students with low prior knowledge performed significantly better when they had limited access than when they had free access, $t(50)=2.0$, $p<.05$. Means and standard deviations are listed in Table 1.

The second significant interaction, learner control by time of test interaction, indicated that students in the limited-access condition (M=11.0, SD=1.2) had significantly higher posttest scores than students in the free-access condition (M=10.4, SD=2.0), $t(108)=2.1$, $p<.05$. However, there was no significant difference between the two learner control conditions on the delayed posttest (both Ms=10.0). All other interaction effects were not significant.

Preference for the instruction. Results indicated that, in general, students liked the program. The mean rating for all groups was 4.6 (5=liked the program very much; 1=did not like the program at all) with low variance (SD=.8). Even so, the ANOVA indicated that there was an interaction between learner control and advisement, $F(1,102)=4.59$, $p<.05$. In further analysis of the interaction using t-tests, the limited-access group showed no difference in preference whether they had advisement (M=4.5) or not (M=4.6) but the free-access group preferred to have the advisement (advisement=4.9; no-advisement=4.4), $t(56)=2.96$, $p<.01$.

Self ratings of the difficulty of the instructional method. No significant differences were obtained in the ANOVA performed on the self ratings of the difficulty level of the lesson. The overall average was 2.6 (1=very easy; 5=very difficult) with low variability (SD=.8).

Time to complete the lesson. Results of the 2×2×2 ANOVA indicated that there was an ordinal interaction between advisement and prior knowledge, $F(1,96)=7.11$, $p<.01$. The high prior knowledge group completed the lesson more quickly when they had advisement (12.8 min.) than when they did not (13.3 min.) although post-hoc analysis of the interaction using a t-test indicated that this difference was not significant. The low prior knowledge group on the other hand completed the lesson significantly more quickly (t (44)=2.2, $p<.05$) when they did not have advisement (11.9 min.) than when they had it (14.8 min.).

Qualitative Data Analyses

A final type of data analyzed involved the computer-collected record of the pathways that students had traversed as they worked on the lesson at the computer. The data from each of

Figure 2. ☐ Sample navigation path in the free access with no-advisement condition

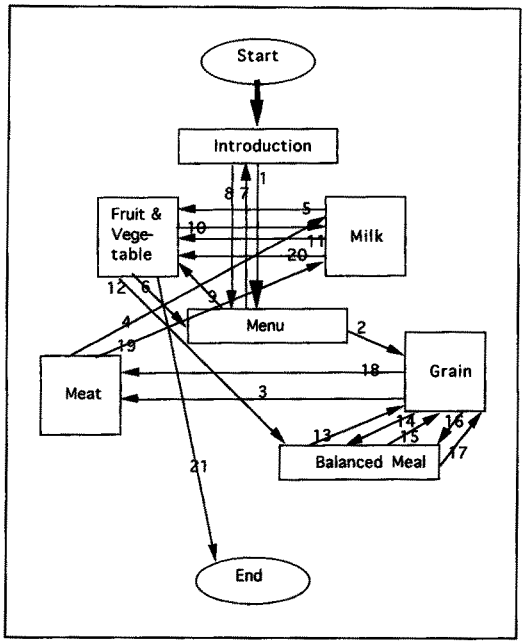
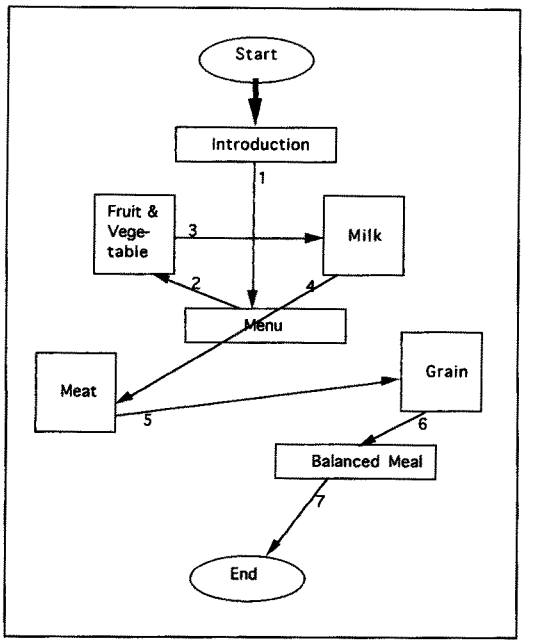


Figure 3. ☐ Sample navigation path in the free access with advisement condition



the eight groups formed by the three independent variables were analyzed separately. One general finding was that the navigational patterns for the high prior knowledge and low prior knowledge groups were very similar to each other in each of the four instructional conditions, although low prior knowledge students were shown to have less stable patterns than high prior knowledge students.

In the free-access-with-no-advisement condition, almost all students seemed to get confused about what to do at the beginning of the program. They moved to a new topic very often without completing the current one, and quit the program before completing many topics. A typical example of a path converted from computer-recorded data for one subject in this condition is given in Figure 2. The numbers on the figure indicate the order in which the student accessed each topic. Note that this student looked at the Introduction first, then went to the Menu, then chose Grain but looked only at the first screen and did not complete the unit. The student then did the same thing for the Meat and Milk sections and only went through a full section when reaching the Fruit-Vegetable section. The sequence of paths 13 through 17 shows the student going back and forth between two sections of the lesson for no apparent reason. It is possible that having completed the last segment of the lesson, the student was trying to finish the program but could not figure out how.

In the free-access-with-advisement condition, when students tried to jump to a new topic before having completed another, as did the students in the free-access-with-no-advisement condition, the screen would give them the advice to finish the current topic first. On more than 70% of the occasions when this happened, students followed the advice and completed the topic they had started before moving on. They seemed to keep track of the hypertext environment better than students in the free-access-with-no-advisement condition. For example, Figure 3 presents the record of a student who quite systematically went to each of the topics in the lesson and completed all parts of each topic before moving on to a new one.

In the limited-access conditions, high prior

knowledge students were able to function very well whether they did or did not have advisement. However, low prior knowledge students exhibited a less efficient navigation mode overall, missing more and repeating more topics when they were in the advisement condition

Table 2 ☐ Summary of analysis of navigational patterns in each condition

Advisement	*Learner Control*	*Prior Knowl.*	*# of topics missed*	*# of topics repeated*	*# of topics not completed*	*Advisement for Sequence*	
						Followed	*Not followed*
Advisement	*Free Access*	*High (n=15)*					
		Total	10	13	10	29	11
		Mean	.7	.9	.7	1.9	.7
		Median	0	0	0		
		Low (n=6)*					
		Total	2	17	1	7	2
		Mean	.3	2.8	.2	1.2	.3
		Median	0	1.5	0		
	Limited Access	*High (n=13)*					
		Total	0	23	1	0	1
		Mean	0	1.8	.1	0	.1
		Median	0	2	0		
		Low (n=14)					
		Total	6	27	5	4	5
		Mean	.4	1.9	.4	.3	.4
		Median	0	0	0		
No Advise ment	*Free Access*	*High (n=17)*					
		Total	10	54	100		
		Mean	.6	3.2	5.9		
		Median	0	2	4		
		Low (n=14)					
		Total	21	38	74		
		Mean	1.5	2.7	5.3		
		Median	1.5	1	4		
	Limited Access	*High (n=13)*					
		Total	0	26	0		
		Mean	0	2.0	0		
		Median	0	1	0		
		Low (n=12)					
		Total	3	12	5		
		Mean	.2	1.1	.4		
		Median	0	1	0		

*The path data for 6 students in this condition were lost due to a program recording error. Note therefore the unusually low sums for this condition across the variables.

than when they did not have advisement.

Finally, the qualitative analyses of the paths were summarized by deriving three variables. First, the number of topics that students did not try at all or did not complete before they had quit the program was counted. The highest possible number of topics for any one student was five. The second variable counted was the number of topics repeated, operationalized as the number of times a student completed a topic fully more than once. If a topic was not completed all the way through, it was not counted as a repeated topic but instead as an incompletion. The third variable, incompletions, was the number of times that a topic was attempted but not completed before the student had moved on to a new topic. A summary of the analysis of the path data, presented in Table 2, provides sums across all subjects in each condition, means, and medians for the three variables.

There were some interesting contrasts highlighted by the table. For example, the number of topics not completed is much higher for the free-access, no-advisement condition, with means and medians of 5.9 and 4 for the high prior knowledge group and of 5.3 and 4 for the low prior knowledge group. By contrast, the median number of topics not completed in all other conditions is 0 and the means are all below 1. In addition, in terms of the number of topics missed altogether, again the free-access, no-advisement condition stood out. Here, the low prior knowledge group had a mean and median of 1.5 topics never accessed. All other groups had medians of 0 and means below 1.

In terms of the first three variables indicated on Table 2, the free-access-with-advisement condition exhibited patterns of navigation that were very similar to the two limited-access conditions. Where this condition differed was in the students' response to advisement, shown in the last two columns of the table. Even though only six students' path data were recorded in the low prior knowledge group, there is a clear indication that students in the free-access condition needed advice more often than students in the limited-access condition and they were more likely to follow the advice they received.

DISCUSSION

This investigation of the effect of different conditions of a hypertext learning environment was unique in that such young learners, second-grade students, participated. In terms of learning outcome measures, results indicated that students who were in the limited-access condition answered more questions correctly on the immediate posttest than students in the free-access condition. These results differ from those of Lanza and Roselli's (1991) finding of no achievement difference between college student groups. One possible reason for these mixed results is the age difference of the subjects. According to Hannafin (1984) and Goetzfried and Hannafin (1985), older students perform better with more learner control, as was represented by the free-access condition in this study, and younger students perform more effectively with less learner control, the limited-access condition in this study.

However, the achievement results further suggested that any negative impact of learner control was less likely to occur for students with high prior knowledge. As supported by a significant interaction between learner control and prior knowledge, high prior knowledge students seemed able to function equally well in both conditions whereas low prior knowledge students seemed to learn more from the limited-access than from the free-access condition. This finding supports results from previous studies (Gay, 1986; Ross & Rakow, 1981) on the interaction between learner control and prior knowledge or aptitude. Thus, the interaction of age and learner control on retention indicated by other researchers (Goetzfried & Hannafin, 1985; Hannafin, 1984), where younger learners benefit from a more restricted learning environment and older learners show either no difference or better learning with a free environment, may not be predictably found if the comparison between older and younger learners is made for students with high prior knowledge.

The advisement in this study, which was intended to improve students' choices in controlling their learning, did not significantly influence how much they learned from the les-

son although, as we will discuss below, it did have an influence on other measures. In previously reported findings, advisement has been shown by some researchers to result in more effective learning (Johansen & Tennyson, 1983; Tennyson, 1980). However, when the type of learning environment investigated was closer to the limited-access condition represented in the present study, other researchers have also reported that advisement has little effect on students' achievement scores (Coorough, 1991; Goetzfried & Hannafin, 1985; Holmes et al., 1985).

Advisement did interact with prior knowledge on the time to complete the lesson, an effect that had not previously received attention. In this study, it was found that students with low prior knowledge finished the lesson more quickly when they did not have advisement than when they did. Without any hint from the program to let them know that there were segments of the lesson that they had yet to complete successfully, low prior knowledge often quit the program before they had fully explored the material. For students with high prior knowledge, the time to complete the lesson did not differ in the two advisement conditions.

As indicated by Shneiderman and Kearsley (1989), a hypertext program with a hierarchical structure is so well defined that it is easy to navigate in the hypertext. In the limited-access-with-no-advisement condition, overall, students did not seem to get confused as they navigated through the different segments of the lesson. Students tried one topic at a time and did not try to move to another section before completing the current one. This treatment is very close to the traditional learner control method, often incorporated in currently available computer-assisted instruction programs. Because the students in the present study had had experience with computer usage and computer-assisted instruction programs, it is possible that their previous experiences as well as the hierarchical structure helped them proceed through the program easily.

Well-defined structure is the advantage of the hierarchical hypertext. At the same time, it can become a disadvantage because of the limited flexibility of the links among nodes (Shneiderman & Kearsley, 1989). Hypertext with a network structure implements the full flexibility of the links among nodes. However, as expected, in the free-access-with-no-advisement condition, almost all students, especially those with low prior knowledge, seemed to get confused about what to do. In addition, students rated the free-access-with-no-advisement condition as the least favorable treatment and several students even quit the program after only three or four minutes, perhaps having lost their motivation to continue the lesson.

The navigation problems and frustrations in the free-access-with-no-advisement condition were corrected by providing advisement. One interesting finding in the preference ratings was the interaction of learner control and advisement. The limited-access group liked the program regardless of advisement condition whereas the free-access group liked the program more with advisement than without. In fact, the ratings suggested that the free-access-with-advisement condition was the most liked treatment whereas the free-access condition with no advisement was least liked. In previous studies, having learner control has typically resulted in more positive attitudes toward the instruction than not having it (Fisher, et al., 1975; Fry, 1972; Hintze, et al., 1988; Kinzie & Sullivan, 1989; Ross, et al., 1989). In the present study, the point is how much learner control should be provided, rather than whether it should be provided at all. Results indicated that students did not enjoy having too much learner control without guidance for navigating in the hypertext environment. However, when guidance was provided, the free-access-with-advisement condition was rated as the most favorable treatment. In contrast, the limited-access condition was so structured that additional guidance seemed to be redundant.

CONCLUSION

The research reported here can be the basis for making some recommendations about what might work to help young students learn. Note that these recommendations are restricted to

situations in which a hypertext system is used to help learners achieve a relatively clear and instructionally imposed goal. Future research with young learners is needed to establish how the variables represented in this study would influence the success of users working within a hypertext environment to fulfill goals that are different from a strict learning task such as brainstorming or database search tasks. For now, the following recommendations can be made, representing each of the independent variables in this study: learner control, advisement, and prior knowledge.

- Limited access, representing a hierarchical structure of hypertext, should be used to improve young students' achievement, particularly if they have limited prior knowledge relevant to the topic. However, if prior knowledge is high, a free-access condition, representing a network structure, can be as effective as a limited-access condition.
- Advisement does not seem necessary to help with navigation through the program in a limited-access condition. However, as indicated by navigational path data and preference ratings, advisement seems necessary in a free-access mode to prevent disorientation in hyperspace.
- Learners with different levels of prior knowledge require different kinds of instructional approaches. In the present study, high prior knowledge students achieved similar scores under both limited- and free-access conditions, managed their instruction time more efficiently under the free-access condition, and used the advisement efficiently to save themselves instructional time. Low prior knowledge students achieved higher scores under the limited-access than under the free-access condition, finished their lesson more quickly under the limited-access condition, and did not allow themselves exposure to the full lesson in the no-advisement condition.

Therefore, general strategies suggested for young children are to use limited access when they have low prior knowledge of the content. However, when children have a more developed sense of the content, as often happens when teachers have already introduced the material using conventional classroom instruction and are now choosing the computer to reinforce learning, lessons with a free-access design, possibly enhanced with advisement, are recommended. □

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