

Navigational aids and learner control in hypermedia instructional programs

By: Patricia A. Burke, [Jennifer L. Etnier](#), and Howard J. Sullivan

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Abstract:

This study examined the effects of learner control and navigational aids on performance in a hypermedia instructional program. Results indicated that students who were permitted to move freely within the program and had access to navigational aids, interacted more with the program and this was associated with higher performance on the posttest. The findings revealed that students who had control over the sequence of their instruction deviated from a linear path significantly more often when provided with navigational aids such as those used in this study. Navigational aids may provide a structure that promotes more explanatory behavior or interaction for students under learner control conditions.

Keywords: navigational aids | hypermedia instruction | learner control

Article:

A major problem with the use of hypertext and hypermedia is the user's disorientation while navigating through programs [1, 2]. Navigational aids may help reduce this disorientation [3]. In order to avoid problems of disorientation, navigational aids should be designed to help the learner develop a structural concept of the organization of the instruction which includes referential information for orientation within the program. Thus, these aids could serve as "orientation cues" [4]. Additionally, the aids should provide information to the learner about his/her progress through the material. Information provided could include such things as: an overview of the program content, an indication of the order of the content, an indication of material the learner has accessed previously, and an indication of the learner's current location within the program.

Rivlin, Botafogo, and Shneiderman suggest that to help users successfully navigate through hyperspace, semantically-related content material within a program should be aggregated so the user can see the aggregations and the underlying connections [5]. Similarly, Park recommends a browser to provide visual guidance for the user to overview the system structure and to determine sequential order for calling out content [6]. A combination of these recommendations,

the referential orienting function and the accumulation and provision of the learners' progress information, were used to develop navigational aids for this study.

PREVIOUS RESEARCH

Schroeder compared the use of graphical browsers, which provided information on the structure of the material within the instructional program, with the use of hotwords embedded in text [7]. Two groups had access to graphical browsers (the browsers differed by the amount of structural information provided) and one group had only hotwords. The students in the hotwords group had the poorest performance on all the dependent measures. It was suggested that the students in the graphical browser groups had an advantage over the hotwords group because the graphical browsers provided a structural framework for the instructional material.

Shin, Schallert, and Savenye assessed the effects of navigation aids (as part of an advisement variable) and learner control on achievement [8]. The students in this study were second grade students and the navigational aids provided information on sequence of instruction, previously accessed material, and current location within the program. Results indicated that there were no significant differences for performance as a function of the advisement variable. However, the qualitative path analyses and the attitude data indicated that students who had free access (versus limited access to move within the instructional program) with no navigational aids were confused about what to do and where to go. Students who had the navigational aids in the free access condition did not express the same confusion. These students' path data revealed that the advisement was helpful in preventing disorientation.

Trumbull, Gay, and Mazur conducted exploratory research to look at the effects of navigational and guidance tools in hypermedia programs [9]. There were three different navigational and guidance tools that could be used: index, browse, and guide. The index tool provided users a standard index (alphabetic ordering with thematic cross-referencing) of the information in the program. The browse tool included maps that users could use to orient themselves, to determine which areas they had visited, and to go to other places within the program. The guide tool provided online advisement (e.g., suggestions for where to go next in the program). Each subject could choose to use any of the tools as they navigated through the program. The outcome measures included the search strategies the students used (i.e., the tool they chose), the amount of relevant information located by their searches, and their attitudes about the program. The researchers found that students tended to use the browse tool most often, that it proved to be an effective way to locate relevant information, and that students' attitudes with regard to the browse tool were positive. Of the three tools, the browse tool most closely matched the navigational aids developed for use in the present study because the browse tool provided a visual navigational aid for conceptualizing the structure of the hypermedia program.

The inclusion of learner control as an independent variable in the present study allowed investigation of the effects of learner control crossed with navigational aids. Learner control has been extensively researched. Yet, the results of the research have been mixed [10]. Some studies have found that learner control is more effective than program control [11, 12]. Other studies have found program control to be more effective than learner control [13, 14].

Although learner control research as a whole has been inconclusive with respect to performance differences, it is difficult to standardize and compare results across learner control studies [15]. Difficulty arises because the term “learner control” is used in the research literature to refer to a variety of manipulations of a learner’s control over his/her instruction [16, 17]. One such manipulation, control of content sequencing, has produced favorable results [18] particularly in studies where learners were given guidance that could be used to help them make sequencing decisions [19-21]. Gray reported that providing college students with control of sequencing in a computer-assisted lesson had a positive effect on comprehension [18]. Hannafin and Colamaio reported that college students who controlled their sequence through an interactive video lesson and received guidance performed better than those who followed the prescribed linearly ordered lesson sequence [19].

Learner control has also been shown to be effective when it is the *amount* of instruction that the learner has the ability to manipulate. Freitag and Sullivan found that adult learners performed significantly better when they received the amount of instruction they preferred rather than when they received more or less than their stated preference for amount of instruction [22]. Other studies, in which learners had the capability to add to or subtract from the total amount of instruction, researchers found that learners do not typically take advantage of the ability to vary the amount of instruction they receive [15,23,24]. Therefore, as Hannafin suggests, it may be better for learners to have a “full” instructional program, with the option to bypass only that information that is not considered necessary for all learners, rather than a “lean” instructional program where learners have to opt to add essential instruction [24]. The full instructional program may provide learners with an implicit form of guidance.

The research on learner control indicates that providing learners with additional information with which to make content sequencing decisions during an instructional program may be beneficial. Research on navigational aids indicates they can help reduce disorientation in hypermedia instructional programs. There are no results on the crossing of navigational aids with learner control as operationalized in the present study. This study investigated the effects of navigational aids and learner control on performance in a hypermedia instructional program.

Research Questions

The research design permitted examination of the following research questions:

- What are the effects of navigational aids versus no navigational aids in hypermedia instructional programs?
- What are the effects of learner control versus program control in hypermedia instructional programs?
- Do navigational aids interact differentially with learner control and program control treatments?
- Do navigational aids influence students’ navigational behavior through learner-controlled instructional programs?

The following outcomes were anticipated based upon the research literature related to navigational aids and learner control of sequence. First, there would be a significant achievement

difference favoring those who received navigational aids over those who did not receive them. Second, subjects under learner control would perform better on the posttest than those under program control. Third, subjects who received the navigational aids and were in the learner control condition would perform better on the posttest than students in any of the other groups. Fourth, the navigational aids would influence learner control subjects' navigational behavior by increasing the number of deviations from the default linear instructional sequence.

METHODOLOGY

Subjects

Subjects were eighty-nine male ($n = 52$) and female ($n = 37$) fifth-graders ($M = 9.00$ yrs, $SD = 0.05$) from a public elementary school located in the greater Phoenix area. Each subject's achievement level was determined prior to the study using the Iowa Tests of Basic Skills administered by the school district.

Instructional Materials

The instructional software program was developed using a hypermedia authoring software program, Asymetrix Toolbook®. The content for the instructional program was the Solar System. The basic instructional content was the same for all conditions. This content was chosen because the instruction for each planet was independent of that for other planets. Therefore, a sequential path was not requisite to learning goals and objectives. Additionally, this content area was a part of the fifth grade curriculum and it had not been presented previously in the academic year.

The program included introductory pages which provided instruction on the use of the "toolbar" at the bottom of the computer screen. The introductory pages were tailored to the particular program version. The navigational aids and learner control options were presented to the students as buttons on their toolbars.

The instruction for each planet had a range of five to seven objectives, which were provided on the introductory screen in each unit. Six screens of instruction followed the introductory screen. The instructional screens were designed to present the material necessary to meet the objectives. For example, for the objective "Identify the way that energy travels from the Sun to the Earth," the instructional screen provided information on how the energy travels to the Earth in waves and provided an animated graphic example. The instructional screens were followed by six screens of four-choice multiple choice practice items. The nine units covering the planets provided instruction about each planet's position in the Solar System, its revolution, its rotation, and interesting things related to each planet. The unit on the Sun provided information on the Sun's composition, its energy, and its size relative to the planets. The program contained high resolution graphic images from NASA's Regional Planetary Image Facility. The practice items gave the students practice at mastering the objectives. The feedback on the practice items indicated the correctness of an answer (correct, incorrect) and, for incorrect answers provided the letter of the correct choice (i.e., A, B, C, D).

Each unit contained illustrative animations. These were instructional pages that contained animations such as a planet's rotation about its axis. The total number of animations (20) was the same for all experimental conditions. All students under both program control and learner control conditions could click to see an animation play as often as they wished.

Subjects in the navigational aids conditions had access to a graphical browser or navigational report (referred to in the program as the "Navigator") that provided information about the units, topics within the units, and practice items which were in the program (see Figure 1). The Navigator provided information as to which of the units, pages, and groups of practice items the learner had previously accessed. When a subject had visited all the pages within a unit, including practice item pages, the button representing that particular unit on the Navigator would turn bright red in color (from its previous color of gray). Navigational aids included the constant presentation of the page number within the unit (e.g. Earth page 1 of 6) and of an image of the planet that was currently being accessed in the upper right section of the screen.

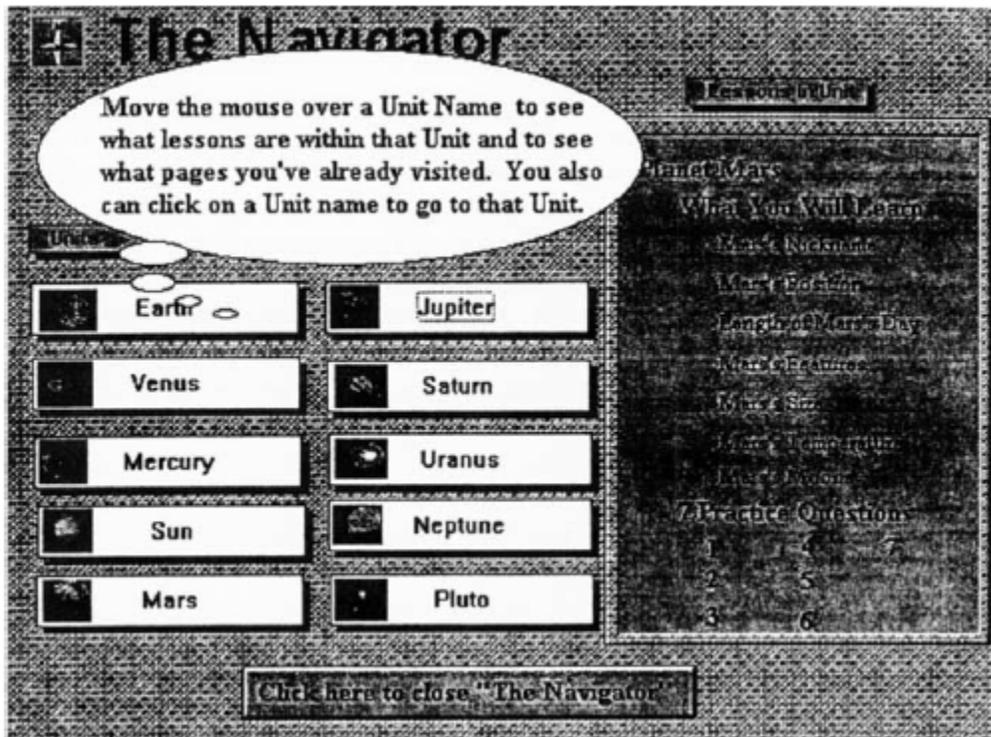


Figure 1. The Navigator popup page

Subjects in the learner control conditions could use a button called "another unit" to move to other units within the program at any time. Pressing this button caused a menu of ten buttons to appear at the bottom of the screen. Each button had a label and a picture of one of the planets or the Sun. Once a particular button on the menu was clicked, the first page of the selected unit would appear. Subjects in the learner control conditions had two additional buttons to allow them to move freely within the program. The "previous" button allowed them to move back one page in a linear manner (e.g., turning to the previous page in a book). The "back" button allowed them to move to the page they had visited just prior to the current page appearing on the screen. Therefore, students could move backward non-linearly through the program.

Subjects who had navigational aids *and* learner control could use the unit buttons on the Navigator to move to different units within the program. Subjects who had navigational aids and were under program control could not move freely within the program by pressing on the unit buttons on the Navigator. The program for these students presented instructional information in a prescribed hierarchically-arranged sequential format. Instruction began with the Earth unit and then proceeded in order of each planet's distance from the Sun.

Experimental Design

The 2 x 2 research design resulted from the crossing of the two levels of navigational aids (aids, no aids) with the two levels of control (learner, program). This resulted in the following four treatment combinations: learner control with navigational aids, learner control without navigational aids, program control with navigational aids, and program control without navigational aids.

Procedure

Subjects were classified as high achievement or low achievement based on a median split of standard achievement scores from *the* Iowa Tests of Basic Skills. Prior to entering the classroom, students *were* blocked by achievement level (high vs. low) and randomly assigned within blocks to one of the four conditions representing the crossing of the navigational aids and control variables. Subjects were blocked in order to balance the distribution of achievement evenly across treatment groups.

Students entered the computer lab and were given their computer station assignments. Each computer had the appropriate version of the program on it. Students were instructed to ask for assistance if needed. Additionally, they were told that they could go to the test at any time, but that their performance on the test at the end of the program would be reported to their teacher. Students started the program by entering their names, and from this point on each student's activities within the program were recorded. Students spent an average of fifty-six minutes thirty-six seconds in the program.

Criterion measures included a posttest and an attitude questionnaire. Data on each subject's progress pattern were accumulated on a hidden "data collector" page. The program which recorded the data was reprogrammed by the author from Dwyer and Leader's "Researcher's Toolkit II" Hypercard program [25]. The program recorded the actual paths that students took through the program.

Assessment Measures

A pool of seventy four-choice multiple questions were developed from the content material and adapted from the practice items. From these, forty were selected to comprise the posttest. The posttest was given as soon as students completed the instructional program.

Attitude Survey

Eight questions were designed to assess students' attitudes toward the program. In addition, four questions were designed to assess students' attitudes toward the Navigator and another four were designed to assess attitudes toward having learner control. These additional questions were given to the students' for whom the questions were relevant. All of these questions were scored on a Likert scale from one to four representing a range of responses from "strongly disagree" to "strongly agree."

Navigational Path Analysis

Learner control students' paths through the program were analyzed. The path which the subject took through the units and the items within each unit were recorded by the computer program. The navigational paths of students in the learner-control conditions were categorized as either "linear" or "nonlinear." A navigational path was declared "linear" if the students went through the units in the order they were arranged (according to their distance from the Sun) with no more than one deviation from the arranged order. If students "jumped around" or created their own path through the program (two or more deviations from the arranged sequence), their path was declared "nonlinear."

Data Analysis

Performance on the posttest and number of clicks on illustrative animations were examined using analysis of variance (ANOVA) with navigational aids (aids, no aids) and control (learner, program) as between-subjects variables. Correlational analyses were conducted to look at the relationship between posttest performance and the amount of time spent using the computer program (time) and the students' attitude toward the program (attitude).

The results from the attitudinal questions were examined individually using an ANOVA to determine if there were any differences among the groups. Questions one through eight were given to all students, so a two-way ANOVA was conducted with navigational aids (aids, no aids) and control (learner, program) as between-subjects variables. Questions nine through twelve, which dealt with attitudes toward learner control, were given to students who had learner control, so a one-way ANOVA was conducted with navigational aids (aids, no aids) as the between-subjects variable. Questions thirteen through sixteen, which dealt with attitudes toward navigational aids, were given to students who had navigational aids, so a one-way ANOVA was conducted with control (learner, program) as the between-subjects variable.

Finally, with regard to the path data, students in the learner control condition were classified as following "linear" or "non-linear" paths through the program and the distribution of the students into these categories was examined relative to the level of navigational aids. This frequency distribution was examined using a chi-square analysis. Additionally, posttest performance was examined using a two-way ANOVA in which linearity (linear, non-linear) and navigator (aids, no aids) were the between-subjects variables.

RESULTS

Achievement

The mean posttest scores for the navigational aids variable were 21.98 for students who had received navigational aids and 21.42 for those who did not receive them. The means for type of control were 22.18 for students under learner control and 21.22 for students under program control (see Table 1). The 2 x 2 ANOVA revealed that neither the main effect for navigational aids, $F(1,85) = 0.155, p > .05$, nor the main effect for learner control, $F(1,85) = 0.455, p > .05$, was statistically significant. The two-way interaction of control by navigation for performance on the posttest also failed to reach significance, $F(1,85) = 3.43, p = .067$.

Table 1. Achievement Scores as a Function of Learner Control by Navigational Aids

	Aids			No Aids			Total		
	<i>M</i>	<i>SD</i>	<i>N</i>	<i>M</i>	<i>SD</i>	<i>N</i>	<i>M</i>	<i>SD</i>	<i>N</i>
Learner Control	23.82	6.99	22	20.55	6.75	22	22.18	6.99	44
Program Control	20.14	7.34	22	22.26	6.40	23	21.22	6.88	45
Total	21.98	7.32	44	21.42	6.56	45	21.70	6.91	89

Use of Animation

The mean number of animation items which were clicked relative to the navigational aids variable was 46.05 for students who had received navigational aids and 40.93 for those who had not received them. The means relative to type of control were 43.59 for students under learner control and 43.33 for students under program control. Neither the main effect for navigation nor the main effect for control was significant. However, there was a significant two-way interaction for control by navigation, $F(1,85) = 6.36, p < .02$. Follow-up tests indicated that none of the simple effects achieved statistical significance. However, examination of the means indicated that students in the learner control conditions clicked on many more animation items when they had the navigational aids ($M = 54.50$) than when they did not ($M = 32.68$). In contrast, those under the program control clicked on more animation items when they did not have the navigational aids ($M = 48.83$) than when they did have the navigational aids ($M = 37.59$).

Use of Navigator

The use of the Navigator was also examined as a function of the half of the program in which the student was working. That is, each student's movement through the units was divided in half and the number of times that the student used the Navigator was recorded for each half. A 2 x 2 MANOVA with repeated measures for half of the program (1st, 2nd) and with control condition as a between-subjects factor indicated that there was a significant main effect for half, $F(1,42) = 13.40, p < .001$, such that students used the Navigator less in the second half ($M = 3.16$) relative to the first half ($M = 5.75$). None of the other effects was significant.

Linearity of Path

The mean posttest score for the learner control students who chose to follow linear paths was 23.50 and for those who chose to follow non-linear paths was 20.86. Within this learner control group, the mean performance for students who had navigational aids was 23.82 and for students who did not have navigational aids was 20.55. The two-way ANOVA indicated that both the

main effect for linearity, $F(1,40) = 4.37, p < .05$. and for navigational aids, $F(1,40) = 5.35, p < .03$, were significant. However, the interaction of linearity by navigational aids failed to reach significance, $F(1,40) = 2.29, p > .05$. Additionally, the distribution of the students who chose linear paths compared to the students who chose non-linear paths, across the two levels of the navigator condition, was significantly different from chance, $\chi^2(1) = 5.82, p < .02$. Examination of the distribution indicated that approximately 70 percent of the students who used nonlinear paths came from the group with navigational aids.

Learner Attitudes

Examination of the results from the ANOVAs for each of the attitude questions yielded two significant effects. For the item, "I would like to use programs like this one again," there was a significant main effect for control, $F(1,88) = 4.68, p < .05$. Subjects in the learner control condition had a more positive response ($M = 3.55$) than did students in the program control condition ($M = 3.20$). For the item "I knew I could choose my own path through the program," the main effect for navigational aids was significant, $F(1,42) = 6.11, p < .02$, indicating that students with navigational aids ($M = 3.64$) responded more positively than did students without navigational aids ($M = 3.19$).

A significant positive correlation existed between performance on the posttest and the students' overall attitude (questions 1 through 8) toward the program, $r(87) = .36, p < .001$.

Time in Program

The mean time in program for the navigational aids variable was fifty-eight minutes sixteen seconds for students who had received navigational aids and fifty-four minutes twenty-three seconds for those who did not receive them. The means for type of control were fifty-six minutes twenty-one seconds for students under learner control and fifty-six minutes sixteen seconds for students under program control. The ANOVA indicated that neither of the main effects for navigational aids nor the two-way interaction effect was significant. A significant positive correlation existed between performance on the posttest and the amount of time spent in the computer program, $r(87) = .29, p < .01$.

DISCUSSION

The purpose of this study was to examine the interactive effects of learner control variables with navigational aids. The results indicated that while these independent variables did not have a significant impact upon the achievement scores, they did impact the learners' use of animations in the program and their attitudes towards the program. Additionally, examination of the performers' paths through the program indicated that those students who chose to use a linear path and who had access to the Navigator performed significantly better than students in any other group.

The results of this study failed to support the proposed interactive effects of learner control variables with navigational aids. Failure to match the learners' preferences with the type of learner control which they were given may be the explanation for this. Hannafin and Sullivan

found that learners' self-reported preference for amount of instruction was a significant predictor of their option selection for amount of instruction within a program [24]. Perhaps the learners' preferences for amount of freedom to make sequencing choices within a program influenced their willingness to take advantage of the navigational aids and learner control features of the program. Preference for the ability to explore within a computer-based instructional program can influence the effectiveness of the instruction [26]. This possible mismatch of preferences was not assessed through any of our attitude measures. However, an examination of the use of animation clicks may provide insight into the plausibility of this explanation.

The results for the animation usage variable indicated that students in the learner control with navigational aids condition had significantly greater interaction with the program than did students in any of the other conditions. Thus, it is possible that those students who clicked more on animations were those who preferred the freedom of movement provided by the learner control condition. These students may have benefited the most from this condition and from the navigational aids and subsequently performed better at the posttest. While nonsignificant at the .05 level, the findings with regard to performance did approach statistical significance ($p = .067$). Strict adherence to statistical procedure prohibits us from discussing this finding. However, when the results from two separate analyses seem to provide the same information and to go in the same direction, it may be beneficial to entertain the idea that these findings are not spurious and that they support the same hypothesis. In this instance, the direction of the performance means and the animation usage means with respect to the independent variables is the same. The greater use of animations may suggest that students in the learner control with navigational aids condition had more interaction with the program and that this was associated with better performance at the posttest.

Further support for the idea that the learner control with navigational aids group may be exhibiting greater exploratory behavior comes from the linearity data. The results indicated that in the learner control with navigational aids group, significantly more students chose to use non-linear paths than linear paths. Thus, the animation data and the path data supports the idea that these students interacted more with the program.

Examination of navigator usage indicated that the learner control group used the Navigator consistently across their time in the program while the program control group used the Navigator more initially than during the second half of the program. An explanation for this may be that the Navigator was distracting or disappointing to students in the program control with navigational aids group. Subjects in this group may have been disappointed when they could not "go" to the planet whose button they clicked on in the Navigator and, therefore, stopped using the Navigator as frequently in the second half of the program. Perhaps, if they were disappointed, they were not as motivated as the other program control students (without navigational aids) to do well in the program.

The data on attitudes revealed that learner control students had more positive attitudes toward the program than did program control students. These findings are similar to those from previous research [8]. Students seem to prefer a program that enables them to make choices that allow them to interact more with the instruction. Learner control offers this advantage over program control. The other significant finding from the attitude data was that students in the learner

control with navigational aids group were more aware that they could jump around in the program. This finding is reflected in the fact that a greater percentage of learner control with navigational aids subjects chose to follow a non-linear path through the program.

CONCLUSION

Instructional designers and instructors with access to authoring systems can design programs for use in the classroom. Research on how to design these programs to avoid learner confusion and to facilitate achievement can lead to more effective computer-based instruction in the schools. Navigational aids may provide a structure that promotes more exploratory behavior or interaction for students under learner control conditions. The results from this study are inconclusive with regard to the effects of these conditions on learner achievement, but they certainly suggest that learner control with navigational aids does not have a negative effect on achievement. Perhaps future study should examine the efficacy of matching preference for amount of learner control of content sequencing with the design of the instructional program.

References

1. Nielsen, J. , The Art of Navigating through Hypertext, *Communications of the ACM*, 33: 3, pp. 296–310, 1990.
2. Jonassen, D. , Designing Structured Hypertext and Structured Access to Hypertext, *Educational Technology*, 28, pp. 13–16, 1988.
3. Anderson-Inman, L. , Electronic Studying: Information Organizers to Help Students to Study “Better” not “Harder”—Part 2, *The Computer Teacher*, 16: 9, pp. 21–29, 1989.
4. Search, P. , HyperGlyphs: Using Design and Language to Define Hypermedia Navigation, *Technical Communication*, pp. 414–421, 1993.
5. Rivlin, R., Botafogo, R., and Shneiderman, B. , Navigating in Hyperspace: Designing a Structure-Based Toolbox, *Communications of the ACM*, 37: 2, pp. 87–96, 1994.
6. Park, O. , Hypermedia: Functional Features and Research Issues, *Educational Technology*, 31: 8, pp. 24–31, 1991.
7. Schroeder, E. , Navigating through Hypertext: Navigational Technique, Individual Differences, and Learning, in *Proceedings of Selected Research and Development Presentations at the 1994 National Convention of the Association for Educational Communications and Technology*, pp. 789–822, 1994.
8. Shin, E., Schallert, D., and Savenye, W. , Effects of Learner Control, Advisement and Prior Knowledge on Young Students' Learning in a Hypertext Environment, *Educational Technology Research and Development*, 42: 1, pp. 33–46, 1994.

9. Trumbull, D., Gay, G., and Mazur, J. , Students's Actual and Perceived Use of Navigational and Guidance Tools in a Hypermedia Program, *Journal of Research on Computing in Education*, 24: 3, pp. 315–328, 1992.
10. Niemiec, R. P., Sikorski, C., and Walberg, J. J. , Learner-Control Effects: A Review of Reviews and a Meta-Analysis, *Journal of Educational Computing Research*, 15: 2, pp. 157–174, 1996.
11. Ross, S. M. and Morrison, G. R. , In Search of a Happy Medium in Instructional Technology Research: Issues Concerning External Validity, Media Replications, and Learner Control, *Educational Technology Research & Development*, 37: 1, pp. 19–33, 1989.
12. Shyu, H. and Brown, S. W. , Learner Control versus Program Control in Interactive Videodisc Instruction: What are the Effects in Procedural Learning? *International Journal of Instructional Media*, 19: 2, pp. 85–95, 1992.
13. Pollock, J. C. and Sullivan, H. J. , Practice Mode and Learner Control in Computer-Based Instruction, *Contemporary Educational Psychology*, 15, pp. 251–259, 1990.
14. Morrison, G. R., Ross, S. M., and Baldwin, W. , Learner Control of Context and Instructional Support in Learning Elementary School Mathematics, *Educational Technology Research & Development*, 40: 1, pp. 5–13, 1992.
15. Hicken, S., Sullivan, S., and Klein, J. , Learner Control Modes and Incentive Variations in Computer-Delivered Instruction, *Educational Technology Research & Development*, 40: 4, pp. 15–26, 1992.
16. Ross, S. M. and Morrison, G. R. , In Search of a Happy Medium in Instructional Technology Research: Issues Concerning External Validity, Media Replications, and Learner Control, *Educational Technology Research and Development*, 37: 1, pp. 19–33, 1989.
17. Butler, D. L. and Winne, P. H. , Feedback and Self-Regulating Learning: A Theoretical Synthesis, *Review of Educational Research*, 65, pp. 245–281, 1995.
18. Gray, S. H. , The Effect of Sequence Control on Computer Assisted Learning, *Journal of Computer-Based Instruction*, 14: 2, pp. 54–56, 1987.
19. Hannafin, M. J. and Colamaio, M. E. , The Effects of Variations in Lesson Control and Practice on Learning from Interactive Video, *Educational Communication and Technology Journal*, 35: 4, pp. 203–212, 1987.
20. Tovar, M. and Coldevin, G. , Effects of Orienting Activities and Instructional Control on Learning Facts and Procedures from Interactive Video, *Journal of Educational Computing Research*, 8: 4, pp. 507–515, 1992.

21. Tennyson, R. , Instructional Control Strategies and Content Structure as Design Variables in Concept Acquisition Using Computer-Based Instruction, *Journal of Educational Computing Research*, 2: 2, pp. 169–187, 1980.
22. Freitag, E. T. and Sullivan, H. J. , Matching Learner Preference for Amount of Instruction: An Alternative Form of Learner Control, *Educational Technology Research & Development*, 43: 2, pp. 5–14, 1995.
23. Hannafin, R. D. and Sullivan, H. J. , Learner Control in Full and Lean CAI Programs, *Educational Technology Research & Development*, 43: 1, pp. 19–30, 1995.
24. Hannafin, R. D. and Sullivan, H. J. , Preferences and Learner Control Over Amount of Instruction, *Journal of Educational Psychology*, 88: 1, pp. 162–173, 1996.
25. Dwyer, H. and Leader, L. , Educational Researcher's Toolkit II, *Proceedings of Conference of American Educational Communication and Technology*, Anaheim, 1995.
26. Fletcher-Flinn, C. M. and Suddendorf, T. , Computer Attitudes, Gender and Exploratory Behavior: A Developmental Study, *Journal of Educational Computing Research*, 15: 4, p. 369, 1996.