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Effects of Navigation Tools and Computer Confidence on Performance and Attitudes in a Hypermedia Learning Environment

YUYAN SU AND JAMES D. KLEIN
Arizona State University
USA
Yuyan.Su@asu.edu
james.klein@asu.edu

The purpose of the study was to investigate the effects of navigation tools and computer confidence within a hypermedia environment. Twelve course sections containing 354 undergraduate college students were blocked by ability and randomly assigned to an embedded hyperlink group, a content list group, or a concept map group. Results indicated that students in the content list group scored significantly higher than those in the embedded hyperlink group on the achievement posttest and had more positive attitudes toward the program. Navigation patterns indicated that students in the content list group and the map group visited more distinct pages than those in the embedded hyperlink group. Furthermore, high computer confidence students scored better on the posttest than low computer confidence students. Implications for designing hypermedia instruction are provided.

Hypertext is viewed by some researchers as a promising medium to facilitate learning in a computer environment (Jonassen, 1986). Information in a hypermedia system is presented in a nonlinear way by through hypertext by interconnecting knowledge nodes into a network. It has been suggested that the use of a hypertext system can improve learning by representing an expert's knowledge structures and presenting them to learners (Shapiro & Niederhauser, 2003). Hypertext also offers learners more control over a learning system, allowing them to make choices about how to proceed and creating a unique path through the text. Learners are able to make their choices based on their prior knowledge and learning experience. Opportunities for choice may increase their willingness to interact and use hypertext (Gall & Hannafin, 1994). Another potential benefit brought by multiple accesses to information in hypertext is the possibility of coming at a topic from various perspectives, which makes the achieved knowledge become more flexible and transferable (Sprio & Jehng, 1990).

However, the use of hypermedia is accompanied by many problems. According to Conklin (1987), learners may feel disorientation or get lost in a display hypertext network, having difficulty knowing where they are and how to get to other places. Since the hypertext system allows more learner control and cognitive flexibility, it places additional cognitive requirements on learners. They have to spend their cognitive resources on choosing what to read next and deciding the sequence of their learning. Making these decisions may increase a learner's cognitive burden and decrease resources spent on knowledge processing (Jonassen, 1988). One approach to remedy these problems is to provide the learner with a navigation tool to facilitate them moving through the system.

Navigation tools, such as indexes, content lists, and concept maps, usually externalize part of or all of the hypertext structure and present it to the learner to show them an overview of the structure. Content can be displayed by selecting corresponding topics from the overview. The tools can also be designed to inform the learner of their current position in the hypertext system and highlight nodes that have been traversed (Allinson & Hammand, 1999; Brinkerhoff, Klein, & Koroghlanian, 2001; Dee-Lucas & Larkin, 1995; Edwards & Hardman, 1999; Farrell & Moore, 2000; McDonald & Stevenson, 1998; Puntambekar, Stylianou, & Hübscher, 2003). These tools may have an impact on alleviating disorientation and reducing a learner's cognitive load.

Researchers have found that navigation tools increase navigation efficiency, reduce the feeling of being lost, improve learning performance, or change learner navigation patterns (Allinson & Hammand, 1999; Dee-Lucas & Larkin, 1995; McDonald & Stevenson, 1998; Puntambekar et al., 2003). On the other hand, navigation tools may impose a simplified structure over the existing knowledge structure in the hypertext (Gall & Hannafin, 1994), impeding the cognitive flexibility and transfer of underlying knowledge structures without forcing the learner to fully interact with the hypertext (Jonassen, 1986).

Hierarchical content lists are often used as navigation tools in hypertext environments. A content list is like a table of contents in printed text, listing knowledge nodes in the hypertext system in a hierarchical manner. The hierarchical structure places constraints on the hypertext structure and presents the learner with a minimized number of connections among knowledge nodes (McAleese, 1999). A study conducted by Dee-Lucas and Larkin (1995) revealed the usefulness of providing hypertext users with a content list. They found that the content list improved both navigation and memory for text topics. McDonald and Stevenson (1998) also found that the performance of students given a content list was superior to those without a navigation tool. However, Brinkerhoff et al. (2001) reported no significant difference on achievement between a content list group and a no tool group. But they did find that students who received navigation tools spent significantly more time using the hypertext program and had significantly more positive attitudes than participants who did not receive a tool.

In addition to content lists, students using hypertext systems can be provided with concept maps. According to Novak and Gowin (1984), concept maps are intended to represent meaningful relationships between concepts by linking two or more concepts in a knowledge area. It has been suggested by Novak (1990) that concept maps can be used to offer an overview of the hypertext structure, without imposing an external sequential order on the hypertext system (Jonassen, 1986). Compared with hierarchical content lists, concept maps may allow more learner control and cognitive flexibility. Puntambekar et al. (2003) found that students who used the map version of a hypertext system performed significantly better in a concept mapping test as well as an essay test, and their navigation was more focused compared with peers in the group using a content list version. McDonald and Stevenson (1998) also found that the performance of students in a map condition was better than those in a content list group and a no tool group. However, Chen and Rada (1996) found no significant difference on effectiveness among indexes, tables of contents, and graphical maps.

Since research suggests conflicting results on the use of navigational tools, further study should be conducted. In addition, as suggested by Shapiro and Niederhauser (2003), much of the research examining the effects of different types of user interfaces on user disorientation have been concerned predominantly with promoting navigation efficiency rather than the effects of such structures on learning. Thus, the effects of navigation tools on learning should be studied.

The main purpose of this study was to investigate the use of navigation tools in a hypertext environment. Two types of navigation tools, a hierarchical content list and a concept map, were examined in this study. The two tools vary in the level of representing underlying knowledge structures and level of learner control.

In addition to navigation tools, the learner's computer confidence may influence learning and navigation in hypertext environments. Shapiro and Niederhauser (2003) argued that "reader's past experience and prior knowledge led them to make choices about the sequence for reading information in the hypertext in ways that are not possible when reading printed text" (p. 607). They further suggested that since hypertext places additional cognitive requirements on the students, less proficient computer users must use cognitive resources to operate the system leading to a decrease in their resources spent on learning knowledge. This was supported by Brinkerhoff et al. (2001) who found that students with high computer experience learned more from a hypertext program than those with low computer experience.

Other studies also suggested that computer experience may promote recognition of hypertext structure. Ayersman and Reed (1998) found that participants with higher levels of computer experience recognized hypertext structure more easily and quickly than those with less experience. This supports the idea that learners with more hypermedia experience might be able to use the nonlinear structure more effectively and take more advantage from the structure than those with less experience.

The purpose of current study was to investigate following questions:

1. What are the effects of three levels of navigation tools (embedded hyperlinks, hierarchical content list, and concept map) and computer confidence on learning from a hypermedia program?
2. What are the effects of the three levels of navigation tools and computer confidence on learner attitudes?
3. What are effects of the three levels of navigation tools on learner's navigation patterns?

METHOD

Participants

Participants were 354 undergraduates enrolled in 12 class sections of a computer literacy course at a large southwestern university. The course was offered through the College of Education as a general studies elective to undergraduate students at the university. Most of the students enrolled in the course came from a noncomputer major. About 75% of the students were female.

Materials

Materials used in this study contained an online instructional program and a computer confidence survey. The instructional program was a self-directed, online hypermedia program designed to introduce students to 12 basic concepts related to the Internet and the World Wide Web (WWW or Web). These concepts were network, Internet, protocol, IP address, web browser, FTP, HTTP, HTML, chat and instant messaging, e-mail, hypertext, and plug-in.

The program consisted of a total of 14 web pages. The first web page provided an introduction to the program and informed students of the program's overall objectives. The second web page gave directions on how to navigate through the program. These directions varied across the three treatment conditions to explain how to navigate using embedded hyperlinks, the hierarchical content list, or the concept map. The program also included 12 instructional web pages containing text and graphics related to the 12 concepts covered in the program. Each instructional page covered one concept.

To emphasize the nonlinear feature of hypermedia, all instructional web pages in the program were not delivered in a linear order. Instead, they were connected together by embedded hyperlinks. Each time the name of any of the 12 concepts appeared on an instructional page, it was hyperlinked and the link pointed to its own web page. Thus, students could jump from the current page to another by clicking on an embedded hyperlink or they could continue to study the current page. Figure 1 shows the embedded hyperlinks for the instructional webpage related to the concept of *Internet*.

> The computer communicates with the printer via cable, sending it information More complicated computer networks aren't much different. They come in many forms They also vary in how they communicate and the types of devices necessary to manage them. But they are all essentially just devices communicating over common links A network may consist of one or a few machines sharing a common printer or file storage device within an office. It may also cross international boundaries and incorporate shared computational power and file storage devices distributed over geographically dispersed locations connecting hundreds or thousands of computers Networks may be physically connected through a network cable or they may rely upon wireless communication They may be a single network or several interconnected networks (an Internet).

Figure 1. Embedded hyperlink

Three versions of the program were developed to correspond to the instructional treatments under study (embedded hyperlinks, content list tool, and concept map tool). They varied in the presence or format of a navigation tool. In the embedded hyperlink treatment, students moved through the program by clicking on hyperlinks found on each page; they did not receive any navigation tools. In the content list treatment, students received a navigation tool consisting of a hierarchical content list added to the left of all instructional web pages. The content list was a hierarchical list of names of the 12 concepts covered in the program. Each concept in the list was hyperlinked to its own instructional web page. In this version of the program, students moved through the program by clicking on the embedded hyperlinks or by clicking on the content list navigation tool (Figure 2). In the map treatment, students received a navigation tool in the form of a concept map added to the left of all instructional web pages. The map consisted of the same 12 concepts found on the content list tool. In addition, the map showed the relationship among the concepts by using arrows to link related concepts. In this version of the program, students moved through the program by using either the embedded hyperlinks or the concept map tool (Figure 3).

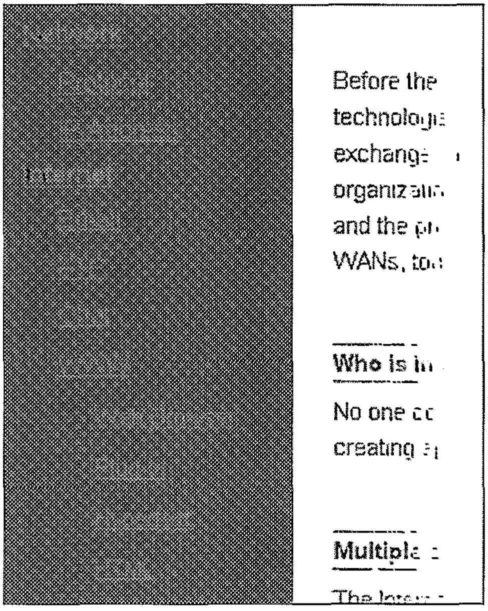

Figure 2. Content list

The computer confidence survey contained 12 Likert-type questions. The questions measured students' history of using the computer and Web, prior experience on using computers, e-mail and Web, as well as their feeling of confidence and comfort level when using the computer and Web. All survey questions included a 5-option scale ranging from "strongly disagree" to "strongly agree."

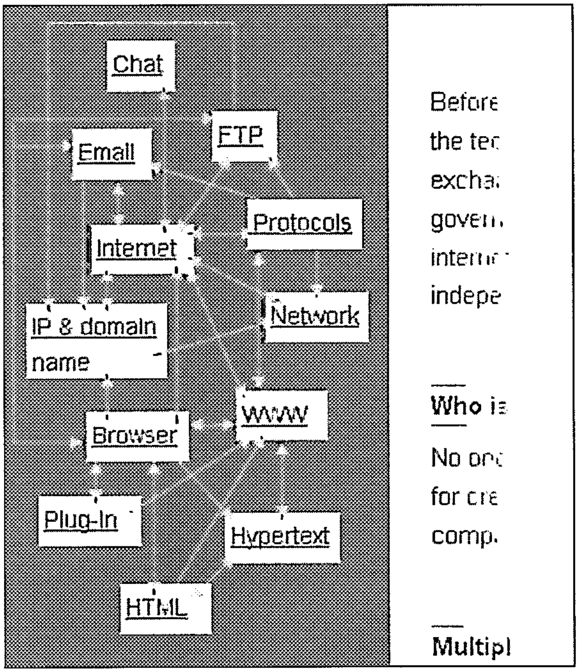

Figure 3. Concept map

Criterion Measures

The criterion measures in this study were an achievement test and a student attitude survey. In addition, the frequency of navigation tool use, frequency of embedded hyperlink use, and number of distinct pages visited were recorded as en route measures.

The achievement test consisted of 23 multiple-choice items to assess students' mastery of the concepts taught in the hypermedia program. Twelve of the items were designed to test the definition of each concept, one item for each concept. The other eleven items were used to test relationships among those12 concepts. The posttest was available on a campus-wide course management website. Students were directed to the test by an icon at the left bottom corner of all instruction screens. Scores for each student were recorded and reported by the website.

The attitude survey for students in all treatment groups consisted of seven Likert-type items assessing attitudes toward the program. The reliability estimate for the survey was .80. The survey measured participants' general feeling toward the program, their feeling of being lost in the program, their perception of the program structure, and self-reporting regarding whether they finished all the instruction pages in the program. In addition, the survey for students in the content list group and the map group had four more items to evaluate their attitudes toward the navigation tools. All survey questions included a 5-option scale ranging from "strongly disagree" to "strongly agree." Students completed the attitude survey online after the posttest. Responses for each student were recorded and reported by the website.

Each student's navigation pattern was tracked as an en route measure. The en route data included frequency of using the navigation tool, frequency of using embedded hyperlinks, and total using frequency (tool using plus hyperlink using). In addition, the number of distinct pages visited by each student was recorded.

Procedures

The procedures in the study were the same for students in all treatment groups. One week before using the hypermedia program, students in all sections of the course were given the achievement test to measure their prior knowledge of the concepts covered in the program ($M = 13.16$, $SD = 2.98$) and the computer confidence level ($M = 4.21$, $SD = .62$). Scores on the pretest were used to block the 12 course sections by prior knowledge and to randomly assign each intact section to one of the three treatments. A one-way ANOVA conducted on pretest scores indicated no difference between treatment groups for prior knowledge, $F(2, 335) = .20$, $p = .81$. In each treatment group, the students were divided into two computer confidence levels (high and low) by the group median computer confidence score. The median score for all treatment groups was 4.20. The average score for high computer confidence students was 4.70 and the average score for low computer confidence students was 3.73.

On the day of the study, each student was assigned to one computer that was connected to the Internet. The students were directed to one of the three versions of the program by providing them with the web address where the program could be found. Before starting the program, students were notified that they would use a self-directed, online program to learn about the Internet and the World Wide Web. They were also told that they could take the posttest after they felt that they had completed all content. The students were informed that their scores were counted toward their final course grade. After finishing the hypermedia program and posttest, students were directed to complete the online attitude survey.

Design and Data Analysis

This study used a 3 × 2 research design resulting from the crossing of the three levels of navigation tools (embedded hyperlinks, content list tool, and map tool) with the two levels of computer confidence (low computer confidence and high computer confidence). This resulted in the following six treatment combinations: embedded hyperlinks for low computer confidence students, embedded hyperlinks for high computer confidence, content list tool for low computer confidence, content list tool for high computer confidence, map tool for low computer confidence, and map tool for high computer confidence.

The data analysis for student's achievement was carried out as a 3 (treatment) × 2 (computer confidence) ANOVA with follow-up pair-wise comparisons to identify the source of significant differences. The Modified Shaffer method was used to adjust the family-wise error rate for all the follow-up comparisons in this study. A 3 × 2 MANOVA was conducted on data for the seven Likert-type items in the attitude survey. Another 2 × 2 MANOVA test was performed for the four additional questions in the content list group and map group. Two correlations were calculated to examine the relationship between the tool using frequency and the posttest score, and between the hyperlink using frequency and the posttest score. For students in the content list and map group, two more 2 × 2 ANOVAs were performed on the data for frequency of tool use and frequency of link use. A 3 × 2 ANOVA was also conducted on the number of distinct pages visited.

RESULTS

Achievement

The first research question examined the effect of the navigation tools and computer confidence on learning from the hypermedia program. Mean posttest scores and standard deviations for the three treatment groups and for computer confidence level are shown in Table 1. These data revealed that the average posttest score was 17.01 (SD = 3.30) for the students in the embedded hyperlink group, 17.94 (SD = 2.58) for the content list group, and

17.55 (SD = 2.96) for the map group. The average posttest score was 17.94 (SD = 2.70) for students with high computer confidence and 17.05 (SD = 3.19) for those with low computer confidence.

Table 1
Posttest Means and Standard Deviations by Navigation Tool and Computer Confidence

Group		Computer Confidence		
		Hi (*n*=176)	Low (*n*=178)	Total
Embedded hyperlink (*n*=129)	*M*	17.36	16.66	17.01
	SD	3.04	3.52	3.30
Content List (*n*=124)	*M*	18.47	17.42	17.94
	SD	2.37	2.69	2.58
Map (*n*=101)	*M*	18.02	17.08	17.55
	SD	2.53	3.30	2.96
Total (*n*=354)	*M*	17.94	17.05	17.49
	SD	2.70	3.19	2.98

Note: Maximum possible score on the posttest was 23.

A 3 (navigation tool) × 2 (computer confidence) ANOVA test identified a significant main effect for navigation tools, $F(2, 348) = 3.22, p < .05$. Follow-up pairwise comparisons revealed that students in the content list group scored significantly higher on the posttest than those in the embedded hyperlink group $F(1, 348) = 6.36, p < .05, ES = .31$. No significant differences were found between the map group and embedded hyperlink group and between the content list group and the map group.

The 3 × 2 ANOVA also yielded a significant main effect for computer confidence level. Students with high computer confidence scored significant higher on the posttest than those with low computer confidence, $F(1, 348) = 8.13, p < .05, ES = .30$. There was no significant interaction between type of navigation tool and computer confidence level.

Attitudes

The next research question examined the effect of the navigation tools and computer confidence on student attitudes. Mean scores for all 11 items on the attitude survey are shown in Table 2. The first seven items on the survey were written so that comparisons could be made between students in the three treatment groups. A 3 × 2 MANOVA conducted on these seven items yielded a significant main effect for navigation tool, $F(14, 652) = 1.98, p < .05$. MANOVA on the attitude scores revealed no significant main effect for computer confidence and no interaction between the type of navigation tool and confidence level.

Table 2

Mean Scores for Attitude Items by Navigation Tool

Items	Navigational Tool		
	None *n*=123	List *n*=120	Map *n*=95
1. I liked the "Internet and WWW" program.	3.42	3.58	3.48
2. I learned a lot about the Internet and the WWW from this program.	3.70	3.83	3.74
3. The program was well designed. *	3.49	3.77	3.75
4. I always knew where I was when using this program. **	3.21	3.78	3.77
5. I always knew where to go for the next step when using this program. *	3.26	3.59	3.56
6. I understood how the content in the program was organized. **	3.50	3.80	3.83
7. I think I went through all the pages in this program. *	3.89	4.14	4.24
8. The navigational panel on the left hand side of the screen helped me to go through this program.	-	4.18	4.02
9. I used the navigational panel frequently when learning in the program. *	-	4.05	3.77
10. The navigational panel gave me a clear overview about how the content was organized. **	-	4.02	3.56
11. I navigated in the program using the hyperlinks on the navigational panel more than the hyperlinks embedded inside the content.	-	3.61	3.64

Note: A total of 338 participants completed the attitude survey; 1 = Strongly Disagree and 5 = Strongly Agree; * $p<.05$. ** $p<.01$

Follow-up univariate tests revealed significant differences related to type of navigation tool on the following five attitude items:

- The program was well designed, $F(2, 332) = 3.24$, $p < .05$;
- I always knew where I was when using this program, $F(2, 332) = 11.09$, $p < .01$;
- I always knew where to go for the next step when using this program, $F(2, 332) = 3.60$, $p < .05$;
- I understood how the content in the program was organized, $F(2, 332) = 4.86$, $p < .01$; and
- I think I went through all the pages in this program, $F(2, 332) = 4.33$, $p < .05$.

Pairwise comparisons indicated that participants in the content list group and those in the map group had significantly more positive attitudes than participants in the embedded hyperlink group on all of the items listed. There were no significant difference between the content list group and map group for these items.

Items 8 - 11 on the attitude survey were constructed to make comparisons between students who received one of the two navigation tools. A 2 × 2 MANOVA conducted on these four items yielded a significant main effect for the navigation tool, $F(4, 208) = 3.37$, $p < .05$. MANOVA showed no significant differences related to computer confidence and no significant interaction between navigation tool and confidence level.

Follow up univariate tests revealed that participants in the content list group had significantly more positive attitudes than those in the map group on the following two survey items:

- I used the navigational panel frequently when learning in the program, $F(1, 211) = 4.46$, $p < .05$, and
- The navigational panel gave me a clear overview about how the content was organized, $F(1, 211) = 12.37$, $p < .01$.

The attitude survey included an open-ended question that asked participants what they liked best about the program. As shown in Table 3, the most frequent response for students in all treatment groups was that they liked learning about the content. The second most frequent response was different for students who received navigation tools and those who did not. Students in the content list group ($n = 32$) and in the map group ($n = 23$) mentioned that the information was understandable and clear while many in the embedded hyperlink group listed that the hyperlinks made information easy to find ($n = 27$). Furthermore, students in the content list group ($n = 25$) and those in the map group ($n = 16$) responded that the materials were well organized and easy to navigate.

Table 3
Student Responses to Open-ended Attitude Items

Item Responses	Navigation Tool		
	None	List	Map
What did you like best about the program?			
Learning about the content	42	37	38
Hyperlinks made information easy to find	27	6	3
Information was understandable and clear	17	32	23
Material was well-organized and easy to navigate	8	25	16
What did you like least about the program?			
Being confused by links and feeling lost	39	13	6
Too much information	26	43	41
Boring content	8	17	5

The survey also asked participants what they liked least about the program. The most frequent response for students in the content list group ($n = 43$) and those in the map group ($n = 41$) was that there was too much information to learn. However, the most frequent response mentioned by students in the embedded hyperlink group related to being confused by the links and feeling lost ($n = 39$).

Participants in the two navigation tool treatments were also asked to list their reasons for using the navigation tool. The most frequent response for students in the content list group ($n = 39$) and for those in the map group ($n = 30$) related to the idea that the tool prevented them from getting lost by giving them an understanding of how the content was organized.

Navigation Patterns

The final research question examined the influence of navigation tools on learner's navigation patterns. Participants in all treatment groups could navigate by using embedded hyperlinks found throughout the program. Table 4 indicates that on average, the embedded hyperlink group used the hyperlinks 17.7 times, the content list group used the links 8.6 times, and the map group used the links 8.8 times. A 3 × 2 ANOVA yielded a significant main effect for navigation tool, $F(2, 348) = 44.94$, $p < .05$. Follow-up pairwise comparisons revealed that students in the embedded hyperlink group used the hyperlinks significantly more times than those in the content list group, $F(1, 348) = 70.86$, $p < .01$, and those in the map group, $F(1, 348) = 60.35$, $p < .01$. However, the correlation between hyperlink use and posttest scores, $r = .05$ was not statistically significant.

Table 4
Means for Navigation Tool Use

Group	Use of Links	Use of Tool	Total
	M	*M*	*M*
Embedded hyperlink (*n*=129)	17.7	-	17.7
Content List (*n*=124)	8.6	10.8	19.4
Map (*n*=101)	8.8	10.7	19.4

In addition to hyperlinks, participants in the navigation tool treatments could use either the content list or the map to move throughout the program. On average, students in the content list group used their navigation tool 8.6 times and those in the map group used their tool 8.8 times. A 2 × 2 ANOVA revealed no significant differences for navigation tool, computer confidence, or the interaction between navigation tool and computer confidence. A small, significant correlation was found between frequency of navigation tool use and posttest scores, $r = .15$, $p < .05$.

Student navigation efficiency was evaluated by examining the number of distinct pages each student visited. The average number of pages visited was 8.91 for participants in the embedded hyperlink group, was 11.12 for those in the content list group, and was 11.02 for those in the map group. A 3 × 2 ANOVA conducted on these data indicated that the type of navigation tool had a significant effect on the number of pages visited, $F(2, 348) = 29.77$, $p < .01$. Follow-up pairwise comparisons indicated that participants in the content list group and those in the map group visited significantly more pages than those in the embedded hyperlink group, $p < .01$. ANOVA yielded no significant difference for computer confidence and no significant interaction between navigation tool and computer confidence. However, two significant correlations were found. One was a correlation between frequency of tool use and the number of distinct pages visited, $r = .44$, $p < .01$, and the other was found between the number of pages visited and posttest scores, $r = .27, p < .01$.

DISCUSSION

The purpose of this study was to investigate the effects of navigation tools and computer confidence in a hypermedia learning environment. Students were assigned to one of three treatment groups -- an embedded hyperlink group, a content list tool group, or a map group. Posttest achievement, student attitudes, and navigation patterns were examined.

Results indicated that students in the content list group scored significantly higher than those in the embedded hyperlink group on the achievement posttest and had more positive attitudes toward the program. High computer confidence students scored better on the posttest than low computer confidence students. Furthermore, navigation patterns indicated that students in the content list group and the map group visited more distinct pages than those in the embedded hyperlink group.

One possible reason why students in the content list group achieved more than those in the embedded hyperlink group is that students given the content list were able to allocate more cognitive resources on learning. The content list panel may have assisted students to navigate through the program so they could spend less cognitive load on navigation and more cognitive resources to learning. This explanation is also supported by the data from the attitude survey which showed that students in the content list group reported significantly less feeling of being lost and more perception of their current position in the hypermedia environment than those in the embedded hyperlink group. The answers to open-ended questions also facilitate the lower cognitive load explanation. Students in the content list group and map group thought the program was well-organized and easy to navigate in numbers of 25 and 16 respectively, while only 8 students in the embedded hyperlink group held the same idea. And when being asked what they liked least about the program, 39 students in the embedded hyperlink group reported they were confused by links and felt being lost, while only 13 students in the content list group had the same feeling. For those students who self-reported a preference on using the content list tool, when asked the reason for this preference, 39 students in the content list group reported that the tool prevented them from getting lost by giving them an understanding of how the content was organized. McDonald and Stevenson (1998) also demonstrated that students given a content list had less feeling of being lost and performed better than those in a no tool group. Other studies have demonstrated the idea that students felt it was easy to follow a content list navigation panel (Brinkerhoff et al, 2001; Dee-Lucas & Larkin, 1995).

Another explanation is that the content list may have offered students a checklist to review the content so that students in that group were able to cover more instructional pages. The en route data showed that students in the content list group covered significantly more distinct pages than those in the embedded hyperlink group. Furthermore, positive correlations were found between the number of distinct pages visited and navigation tool use and between the number pages visited and posttest score. It appears that the more distinct pages the student covered, the higher posttest score was achieved. Dee-Lucas and Larkin (1995) reported that readers in their study were most likely to use the hierarchical content list to review the content. Allison and Hammand (1999) had a similar finding that the most popular tool used for browsing and learning content was a content list which they called a hierarchical map.

Another possible reason for the effects of the content list concerns its benefits on the recall of the content topics. The content list provided all topics available in the program. These topics may have been perceived as important by students and may have caused them to pay more attention to topics. They might also have signaled part of the content structure to students (Jonassen, 1986; Lorch & Lorch, 1996). Dee-Lucas & Larkin (1995), they found that readers with a hierarchical content list overview recalled more unit titles than those with a traditional text.

Although the content list group outperformed the embedded hyperlink group on the posttest, no significant differences were identified between the map group and the other groups. These results were different than those reported by McDonald and Stevenson (1998), who found a map group outperformed a no tool group on the achievement test. Results from the current study may have occurred because the map tool was too complex. Arrows were presented on the map to label the relationship between concepts, which gave it a more complex look than the content list. The attitude data showed students in the map group had a lower score than the content list group on the items "I used the navigation tool frequently when learning in the program" and "the navigation panel gave me a clear overview about how the content was organized."

There was also no performance difference between the map group and the content list group. This differed from the results in the studies conducted by McDonald and Stevenson (1998) and by Puntambekar et al. (2003). Again, this might be explained by the map used in the current study. The concept map in Puntambekar's study labeled the relationship between two concepts explicitly along with the arrow which linked two concepts, while the relationship was not presented as labels in this study. According to Novak (1990), the relationship-linking label is the key point in the concept map, which together with concepts, can represent human knowledge. However, due to the lack of space on the navigation panel, this relationship label was not shown in this study.

While the map tool did not influence achievement as anticipated, results indicated that students who received the map had significantly less feeling of disorientation and more perception of the content structure than those in the embedded hyperlink group. They also had a significantly higher rating than the embedded hyperlink group on the question "I think I went through all the pages in this program". This is consistent with the navigation pattern data, which showed that students in the map group visited significantly more distinct pages than those in the embedded hyperlink group. The results suggest that the concept map tool did have a positive influence on the student attitudes.

In addition to the navigation tool, computer confidence also yielded a significant main effect. Students with high computer confidence scored significantly higher on the achievement test than those with low computer confidence. Brinkerhoff et al. (2001) explained a similar effect by noting that some studies that students with low computer confidence experienced more difficulty moving through the program so their cognitive load was increased and their learning of the content was decreased. The more exposure students have to hypermedia, the more efficient one might be in locating information (Ayersman & Reed, 1998). However, the explanation was not supported by the attitude data in this study, which indicated that both high computer confidence and low computer confidence students had the same feeling toward the program and the same amount of feeling of being lost. Low computer confidence students did not feel that it was harder to navigate the program than high confidence students.

Examining the nature of the learning program may reveal the reason why confidence was related to achievement. The topic of the program was about the Internet and WWW. Students with high computer confidence likely had more prior knowledge of the content than those with low confidence because they may have experienced the computer and the Internet more. Thus, they may have been more familiar with concepts taught in the program. A small, but significant positive correlation between computer confidence and pretest scores ($r = .24, p < .01$) tends to support this point.

A possible explanation for no effects of the computer confidence on attitudes is the high overall computer confidence among all subjects. The average computer confidence for all subjects was 4.20 on a 5-point scale. The average computer confidence for high level students was 4.70 and the average computer confidence for low level students was 3.73. The data suggest that both groups may have good experience with using the computer and the Internet.

There was a difference in hyperlink use related to presence of the navigation tool. Students in the embedded hyperlink group used hyperlinks more than those in the content list group and the map group. Obviously, without a navigation tool, hyperlinks were the only choice to students in the embedded hyperlink group. They were forced to use hyperlinks to navigate through the content. Thus, their use of hyperlinks was higher than those in the tool groups.

The present study has implications for instructional designers developing hypermedia learning environments. With the development of the Internet and distance education, more and more learning is delivered by the Web. As a main medium on the Web, hypermedia should be designed to facilitate students' learning. Results of this study suggest that learners should be provided a content list navigation tool to help them navigate through the learning program even though the content can be accessed from embedded hyperlinks.

In addition, designers should consider the impact of the navigation behavior on learners' information processing. Too much cognitive load expended on the navigation may decrease learners' cognitive resources available for learning; resulting in lower achievement. Since learners may use the navigation tool as a checklist for review purposes, the design of the navigation tool should put more emphasize on facilitating content review. It is important for the navigation tool to present topics in a structured way and for the links to differentiate those which have been selected from those not yet selected. Furthermore, designers may consider putting important items on the navigation tool because that may help learners to recall those items.

The study also indicated that current undergraduate college students may have good computer confidence because they are more exposed to the computer and the Internet than in the past. This suggests that future hypermedia programs may benefit more students.

Future research should continue to investigate the usability of navigation tools. Qualitative data from interviews and observations should be collected to further explain how students use navigation tools and their decisions in a hypermedia environment. The current study was conducted with a well-structured and relatively simple program. Future studies should include some longer programs in less well-structured subject domains to examine the effects of navigation tools.

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