The Effects of Search Tool Type and Cognitive Style on Performance During Hypermedia Database Searches

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This study investigated the effects of search tools and learner cognitive styles on performance in searches for information within a hypermedia database. Seventy-five students in a university English as a Second Language (ESL) program were blocked for field dependence and assigned to one of four treatments: browser, index/find, map, and all tools. Subjects searched the hypermedia database, EarthQuest, for facts to answer practice and posttest questions on science topics. Results revealed a significant interaction between search tool and cognitive style. Field-independent learners performed significantly better than field-dependent learners under the index/find and map treatments. Subjects in the four treatment groups accessed information from the database differently. Furthermore, cognitive style was significantly related to achievement, tool use, and attitude. Implications for the design and instructional use of hypermedia databases are provided.

□ The use of hypermedia systems for learning and information retrieval has grown very rapidly in recent years. Hypermedia cover a wide range of applications, from online documentation and help systems to authoring tools for instruction and learning (Jonassen & Grabinger, 1990).

Some educational researchers have been intrigued by the possibility that hypermedia can be structured to reflect the semantic network of a subject-matter expert's knowledge and then used for instruction to help learners acquire not only knowledge but also the expert's knowledge structures (Jonassen & Wang, 1993). Some others see different potentials for the use of hypermedia in education. Duchastel (1990) argues that the greatest impact will be for information retrieval, allowing easy access to the vast amount of information that will be available electronically in the very near future. In explaining his position, Duchastel stresses what he considers the essential characteristic of hypermedia: information organized in a network that provides the user with "the capability to quickly access additional information related to the information currently under consideration" (1990, p. 136).

However, accessing information from a hypermedia system is often not an easy task, especially for novices. As Hammond and Allinson (1989) indicate, users may encounter a number of common problems: They may have difficulty gaining an overview, finding specific information, or using the interface tools; they may wander without an orienting

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goal or strategy, or may even get lost. Such problems have prompted research on the manner in which users interact with hypermedia.

The focus of some research has been on the effectiveness of different tools for searching hypermedia databases. Jones (1989) investigated how graduate students, undergraduates, and other adult subjects used menus embedded in the text for browsing compared with indexes for searching encyclopedia articles in a hypertext system. Both success on finding facts and score on an incidental learning posttest indicated no advantage of one tool over the other. Using a hypermedia-based city guide, Hammond and Allinson (1989) studied exploratory and directed searches by university students under five tool use conditions: hypertext links alone, with maps added, with an index added, with tours added, and with all of these tools. A posttest on factual knowledge gained from exploration and a search for specific information in the database showed no significant effect for the tool used in either task. Wright and Lickorish (1990) had adult females use two hypertext databases, one with a book-like structure and the other with a hierarchical structure, which they searched using either a map or an index. No significant differences were found for the two tools in terms of successful searches.

Individual characteristics of users may account for differences in information retrieval from hypermedia. One of the most extensively researched user characteristics is field dependence, a psychological construct identified and elaborated primarily through the work of H. A. Witkin and his colleagues (Goodenough, 1986). Their field-dependence construct described differences in ability for perceptual and cognitive problem solving. One of the perceptual tasks which identified those individual differences involved finding a previously-seen simple figure within a field, that field being a larger, complex figure organized to embed or obscure the simple figure. On such tasks, *field-dependent* individuals tended to experience the parts of the field as *fused*, whereas *field-independent* individuals tended to experience the parts as *distinct* from the field as an organized whole (Witkin, Oltman, Raskin, & Karp, 1971). This stylistic tendency in perception was also displayed in intellectual functions, as what was termed *cognitive style*. An ability to dis-embed simple figures from complex designs was reflected in an ability to solve a cognitive problem by isolating a critical element and using it in a different context. Thus, as Witkin et al. (1971) argued, a field-independent person was capable of a more analytical cognitive functioning than a field-dependent person, who used a more global approach.

The few studies that have investigated cognitive style as a factor in use of hypermedia systems found performance differences between field independents and field dependents. Repman, Rooze, and Weller (1991) presented a hypermedia lesson on computer ethics to study the effects of advance organizers and structural organizers as a function of the cognitive style of junior high students. Although field-independent learners outperformed field-dependent learners in all treatments, the absence of any benefit from advance or structural organizers on the field-dependent learners was contrary to what the investigators expected.

When Jonassen and Wang (1993) investigated different methods for making structural knowledge of hypertext information accessible to undergraduates, they observed treatment differences by cognitive style. On a posttest recall task, field-independent learners did better than field dependents in treatments that either did not identify the semantic structure of the hypertext links or required learners to classify the link types themselves. The performance of the field independents was impeded in the treatment that identified the semantic structure of the links. The authors suggested that this result reflected the preference of field-independent learners for restructuring information rather than accepting the structure provided by materials.

Liu and Reed (1994) examined the different learning strategies of university English-as-a-second-language learners when using hypermedia vocabulary-learning courseware. They observed that the field-dependent learners watched video clips more often to understand the vocabulary than did the field-independent learners. The field independents used an index tool more often than the field dependents. The investigators attributed these differences to the tendency of field dependents to employ a global and spectator approach to learning, whereas the field independents were more comfortable manipulating the courseware to jump from one point to another. No significant differences in achievement scores were observed.

The purpose of the present study was to investigate the effects of search tool and cognitive style on performance in hypermedia database searches. The study utilized a factorial aptitude treatment interaction (ATI) design, with cognitive style as the aptitude variable and search tool type as the treatment. The cognitive style variable had two factors: field independent and field dependent. Search tool type had four levels: browser, index/find, map, and all tools. While Tobias (1987) indicates that there is little evidence to demonstrate that aptitude-treatment interactions generalize across content domains, the research cited above suggests that the field independence-dependence construct influences how learners use hypermedia systems.

Based on this research, we expected that the treatment search tools would interact with the cognitive styles of the learners. Field-independent and field-dependent learners were expected to be able to search the database with similar effectiveness in the browser, map, and all tools treatments. However, the field-independent learners were expected to be more effective than the field-dependent learners at searching the database in the index/find treatment.

These expectations reflect, in part, the comparatively greater benefit for field-dependent learners when material is encountered in a structured manner (Davis, 1991). The browser and map tools should provide a more consistently structured user-content interface than the index and find tools provide. The browser accesses contiguous screens which usually contain related content. The map schematically indicates content relationships. Thus, the field-dependent learners should not be at a disadvantage with the browser and map tools. On the other hand, use of the index and find tools involves disembedding words and concepts from their context at a screen and transferring these to other contexts at other screens. The field-independent learners, with their greater ability to isolate critical elements and use them in new contexts, should be at an advantage with the index and find tools. The expectation that field-dependent learners should not perform better than field-independent learners in any treatment also reflects the results of cognitive style research, which Davis (1991) found provided no evidence of an advantage for field-dependent learners except when the context had social relevance.

METHOD

Subjects

Subjects were 75 adult students (40 males, 35 females) enrolled in a pre-admission English as a second language (ESL) program at a large southwestern university. The subjects selected for this study were at the intermediate and advanced stages of the program and within two semesters of reaching the English proficiency required for regular admission to the university.

To obtain these subjects, we asked students to volunteer their participation in a study in which they would be using a computer program at their ESL computer lab. Their incentive was a daily class activity grade for each study session.

All subjects had at least 20 hours of experience using computers in the same laboratory where the investigation was conducted. This training involved a basic orientation to the Macintosh operating system, followed by use of a typing tutorial program.

Materials

Materials in this study included a HyperCard database, a print-based orientation packet, a print-based practice packet, and the Group Embedded Figures Test.

The content material for the study was a HyperCard database called *EarthQuest* (Stevens & Smith, 1990). This program was selected because it was designed for junior high school students with an eighth-grade reading level and had successfully been used by students at all levels in the university ESL program.

EarthQuest was designed for secondary social studies and science instruction. The content in *EarthQuest* is arranged hierarchically under five major headings: Earth (an earth science focus on planets, land, water, air, and life), Journey (a historical approach to invention and politics), Environment (interrelationships and ecological issues for land, water, air, and life), and World Tour (a geographical overview of nations by continent). Information is presented on over 80 screens by text, graphics, animation, and sound. Many of these screens include pop-up windows with scrolling text.

EarthQuest provides five basic tools for navigation and search within the database. Graphic/text buttons on each screen can be clicked to move to screens for the content they represent. For example, a graphic/text button for volcanoes would show a pictorial representation of a volcano labeled with the word *volcano*. Browser icons can be used to navigate between any contiguous screens at the same level and up or down the content hierarchy. For example, left and right browser arrows for a screen on problems with air pollution leads to related screens on water and land pollution. An up arrow leads to a screen with more general information about the environment while a down arrow leads to screens with more detailed information about air pollution. An index button leads to a list of the descriptive names of every screen in the database. A find feature searches the database for typed text strings. Maps display a hierarchical arrangement of the content and allow searching by section, subsection, and individual screen topic. For example, the map screen for the section on the environment displays the structure of the content in this section. Buttons labeled with subsection titles, such as the one for problems with air pollution, are arranged across the top of the section map screen, with buttons for the individual topic screens arranged below their respective subsection titles. Adjacent map screens display the structure of other database sections. Each of the five search tools can be used to reach any content screen in the database.

EarthQuest was modified for three of the four treatments in this study. The browser treatment had the index, find, and map tools disabled. The index/find treatment had the browser and map tools disabled. The map treatment had the browser, index, and find tools disabled. The all-tools treatment used an unmodified version of *EarthQuest*.

The orientation packet contained handout directions to familiarize learners with the search tools. The directions explained how to use each tool to conduct searches of the database to find specific information.

The practice packet contained handouts giving practice search directions and questions. For each treatment, the directions explained that the learner would be able to use only the tools available in that treatment and not the other tools, which were disabled and would not respond. The remaining directions and the questions were the same for all treatments. Each of the five search questions asked for the name of the database screen where information was located as well as the answer found there. The first three questions required searches for isolated facts. The other two were cause/effect and main point/support questions that each required information from two screens. Some of the search questions provided hints about options selection. One of the fact-finding questions was "Living things are found only in a very thin layer of the Earth's crust. How thick is that layer?" A cause/effect question, along with directions for it, was "Land can move and change shape, such as to make mountains and valleys. What are *two causes* of this kind of change? (Hint: Play movies.) Get your answers from *two screens*."

The Group Embedded Figures Test (GEFT) (Witkin, Oltman, Raskin, & Karp, 1971) was used to determine the cognitive style of each learner in the study. The GEFT measures the ability to locate a simple figure within a larger complex figure which has been designed to obscure or embed the simple figure. The GEFT is essentially nonverbal. After listening to brief directions, the subjects complete practice items and test items by using a pencil to trace simple geometric figures within more complex ones.

Researchers have demonstrated that the GEFT can be used as a cognitive measure with non-native English speakers of various cultural backgrounds (Abraham, 1985; Hansen-Strain, 1987; Jamieson, 1992; Mshelia & Lapidus, 1990).

A low score on this timed group-administered test indicates perceptual field dependence, whereas a high score indicates perceptual field independence. In broader terms, the GEFT assesses a global versus analytical dimension of cognitive style. The mean GEFT score for the college students used as a norming sample was 11.4 (SD = 4.2) (Witkin et al., 1971). For subjects in the current study, the mean was 10.9 (SD = 6.1).

Procedures

Instruction took place during two 75-minute class sessions for each of six classes within a five-day period.

The GEFT was administered to the participants at the start of the first session. Each learner then received an orientation packet. Using an overhead computer screen display of *EarthQuest*, the investigator led the learners through the orientation directions while the learners performed searches in the database at their individual computers. During this 45-minute orientation, all learners used an unmodified version of *EarthQuest*.

Before the second session, the GEFT scores were used to block the learners for assignment to the treatment groups. A randomized block design was used to ensure proportional distribution by field dependence of subjects into treatments. Learners were designated as field dependent if they scored from 0 to 9 on the GEFT (n = 31) or as field independent if they scored from 10 to 18 on the GEFT (n = 44). This grouping was based on the bimodal shape of the GEFT score distribution, which indicated a dichotomy of the learners. Equal numbers of learners were randomly assigned to each treatment: browser, index/find, map, and all tools. Due to the blocking for field dependence, cell sizes were unequal, with the four treatment cells for the field-dependent learners containing 9, 8, 7, and 7 subjects, respectively, and the four treatment cells for the field-independent learners containing 10, 10, 12, and 12 subjects, respectively.

For the second session, the learners were assigned to their respective treatment versions of *EarthQuest*. During the 30-minute search practice, they used the practice packet to search the database with their assigned treatment tools. They received feedback by turning to the following page in the handout, where the answer was given above the next question.

After the practice, a posttest was administered. The learners were allotted 30 minutes to search *EarthQuest* for answers to the posttest questions using their assigned tools. At the end of the second session, the learners completed an attitude questionnaire.

Criterion Measures

The dependent variables in this study were effectiveness in finding information on posttest searches, tool use during posttest searches, and learner attitudes.

The posttest was parallel in format to the practice searches but from a different content section in the database. Each answer received 1 point if the information was correct and another point if the location of that information in the database was correct, to give a total of 14 possible points for the seven items. Identification of the location increased the probability that learners would actually perform searches in order to answer the questions rather than rely on their prior knowledge of the content. The Cronbach alpha reliability coefficient of the posttest was .66.

Tool use during the posttest searches was recorded for each learner by means of a tracking script added to the *EarthQuest* program. This script captured data on the tool the learner selected to navigate to each screen and the time when each screen was accessed. The four measures for patterns of tool use were:

1. Number of screens accessed using treatment tools
2. Number of screens accessed using graphic/text buttons
3. Time at screens accessed using treatment tools, and
4. Time at screens accessed using graphic/text buttons.

Attitudinal data were obtained by a 4-point Likert-type questionnaire with 1 indicating strongly agree and 4 indicating strongly disagree. The 12 questions asked learners to respond to statements about the value of the lesson and their enjoyment of it, the ease of use of the database, and their understanding of the directions and questions. Two questions specific to each treatment asked about the usefulness and ease of use of the tools assigned for that treatment. The alpha reliability of the questionnaire was .85.

Design and Data Analysis

A 4 × 2 (Search Tool × Cognitive Style) posttest-only experimental design was used, with random assignment to treatment groups after blocking by cognitive style.

Because of unequal cell sizes in the study design, homogeneity of variance for the posttest scores was a concern. The Bartlett-Box F test (Glass & Hopkins, 1984) indicated that the scores were homogeneous in variance among cell groups, $F(7,4047) = 1.17$, $p = .25$.

An alpha of .05 was used to judge significance for all statistical tests. Posttest achievement was analyzed with Analysis of Variance (ANOVA); tool use and attitudinal data were analyzed with Multivariate Analysis of Variance (MANOVA). If multivariate significance was found on analysis of the tool use and attitudinal data, univariate tests were then performed. For any significant main effects found for the search tool variable, Tukey multiple comparisons followed.

Effect size estimates were calculated using Cohen's method (Cohen, 1977). According to Cohen, an effect size of about .20 is considered small, around .50 is medium, and greater than .80 is large.

RESULTS

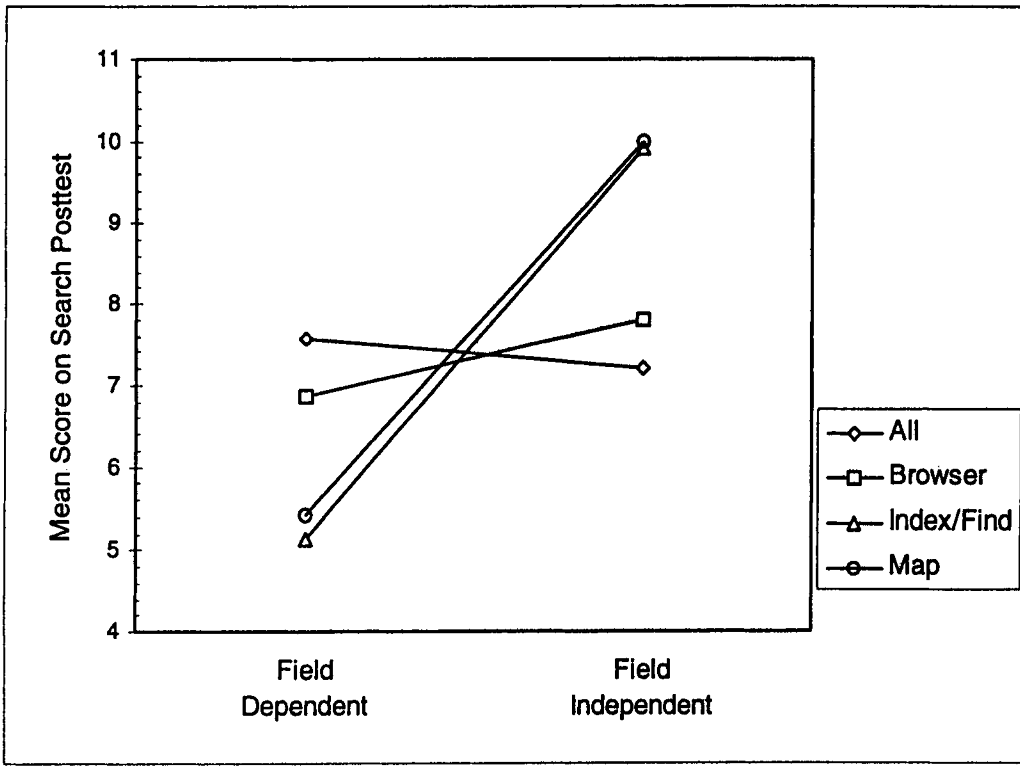
Achievement

Table 1 displays mean posttest scores by level of search tool and cognitive style. The mean posttest scores by level of search tool were 7.37

Table 1 ☐ Search Test Scores by Search Tool and Cognitive Style

		Search Tool				
Cognitive Style		*All*	*Browser*	*Index/Find*	*Map*	*Total*
Field Dependent						
	M	7.56	6.88	5.14	5.43	6.35
	SD	2.83	3.18	3.29	3.36	3.16
	n	9	8	7	7	31
Field Independent						
	M	7.20	7.80	9.92	10.00	8.84
	SD	3.99	2.82	2.61	1.59	3.00
	n	10	10	12	12	44
Total						
	M	7.37	7.39	8.16	8.32	7.83
	SD	3.40	2.93	3.66	3.23	3.28
	n	19	18	19	19	75

Figure 1 □ Effects of search tool and cognitive style on search test achievement.



for the all tools group, 7.39 for the browser group, 8.16 for the index/find group, and 8.32 for the map group. The mean scores by level of cognitive style were 6.35 for the field-dependent group and 8.84 for the field-independent group.

ANOVA revealed a significant interaction between search tool and cognitive style, $F(3,67) = 3.48$, $MSe = 8.74$, $p < .05$, $ES = .37$. This interaction is illustrated in Figure 1. A simple main effects test (Ferguson & Takane, 1989) suggested that within the index/find treatment, field-independent learners ($M = 9.92$) performed significantly better than field-dependent learners ($M = 5.14$), $F(1,67) = 12.27$, $p < .001$, $ES = .70$); within the map treatment, field-independent learners ($M = 10.00$) also performed significantly better than field-dependent learners ($M = 5.43$), $F(1,67) = 11.74$, $p < .001$, $ES = .68$. No other significant differences were found when simple main effects tests were conducted.

ANOVA also indicated that cognitive style was significantly related to achievement, $F(1,67) = 12.65$, $p < .001$, $ES = .41$. Field-independent learners performed significantly better on the posttest than field-dependent learners. ANOVA did not reveal a significant main effect for search tool treatment.

Tool Use

The four measures for patterns of tool use were:

1. Number of screens accessed using treatment tools
2. Number of screens accessed using graphic/text buttons
3. Time at screens accessed using treatment tools, and
4. Time at screens accessed using graphic/text buttons.

For these tool-use variables, MANOVA did not reveal a significant interaction between search tool and cognitive style. However, main effects were observed. MANOVA revealed that search-tool treatment had a significant effect on tool use, $F(12,108) = 3.85$, $p < .001$. Univariate analyses indicated that differences occurred for the number of screens accessed using treatment tools, $F(3,67) = 8.21$, $MSe = 111.9$, $p < .001$, $ES = .57$, and for the number of screens accessed using graphic/text buttons, $F(3,67) = 4.68$, $MSe = 168.5$, $p < .01$, $ES = .43$.

Tukey multiple comparison tests indicated that learners in the browser treatment ($M = 32.37$) accessed significantly more screens using their assigned tool than did learners in the index/find treatment ($M = 8.57$) and those in the all-tools treatment ($M = 14.33$), using their assigned tools. Tukey multiple comparison tests also indicated that learners in the browser treatment ($M = 38.12$) accessed significantly more screens using the graphic/text buttons than did learners in the index/find treatment ($M = 14.86$).

MANOVA also revealed that cognitive style was significantly related to tool use, $F(4,51) = 3.11$, $p < .05$. Univariate analyses indicated that differences occurred for the number of screens accessed using treatment tools, $F(1,67) = 14.13$, $MSe = 111.9$, $p < .001$, $ES = .43$. Field-independent learners ($M = 27.86$) accessed significantly more screens than did field-dependent learners ($M = 12.93$).

Learner Attitudes

Of the 75 learners, 3 were not included in the analysis of questionnaire data because of incomplete responses or unreturned forms.

Learner attitude results indicated a general liking for both the program and the tasks, with a mean response of 2.16. The highest response ($M = 1.70$) was to the statement, "EarthQuest is a good program." The lowest response ($M = 2.65$) was to the statement, "I had enough time to answer the questions."

MANOVA revealed that cognitive style was significantly related to attitude, $F(12,43) = 2.60$, $p < .05$. Univariate analyses indicated that significant differences occurred for 2 of the 12 items. Field-independent learners ($M = 1.93$) responded more positively than the field-dependent learners ($M = 2.33$) to the statement that the assigned treatment tool "was useful for finding the answers to the questions," $F(1,64) = 5.77$, $MSe = .33$, $p < .05$, $ES = .28$. However, field-dependent learners ($M = 1.44$) were more positive than the field-independent learners ($M = 1.89$) to the statement, "EarthQuest is a good program," $F(1,64) = 4.55$, $MSe = .36$, $p < .05$, $ES = .25$.

DISCUSSION

The purpose of this study was to investigate the effects of search tool and cognitive style on performance in hypermedia database searches. Learners assigned to one of four interface tool treatments searched for specific information in the *EarthQuest* database. Cognitive style was defined in terms of field dependence, as measured by the GEFT. The results of this study support the hypothesis for an interaction between search tool and cognitive style.

As expected, the search achievement in the index/find treatment was significantly better for the field-independent learners than for the field-dependent learners. This superiority may be owing to field-independent learners using more active approaches to learning, such as hypothesis testing and employment of verbal mediators, than field-dependent learners (Witkin, Moore, Goodenough, & Cox, 1977). In order to navigate from screen to screen in *EarthQuest* when using the index and find tools, the learners had to physically select a word or phrase by either typing it into the find dialog box or choosing it at the index. When the screen accessed by this action was in a different content section of the database, the learners encountered a new context. Therefore, it appears likely that active approaches, such as hypothesis testing or the use of verbal mediators, were important for searches employing the index and find tools.

The search achievement results also confirmed the expectation of no significant difference by cognitive style in the browser and all-tools treatments. Cognitive-style research offers an explanation for this. Field-dependent individuals tend to use "more intuitive spectator approaches" to learning (Goodenough, 1976, p. 676). When searches in *EarthQuest* were performed using the browser tool, a click of the browser icon accessed a contiguous screen at the same level, higher, or lower in the content hierarchy. Often there was no need to enter a different content section of the database. This less active style of interaction would better suit field-dependent learners than the more active interaction required for index and find searches.

The similarity of the all-tools-treatment results to those of the browser treatment for search achievement can be understood from the patterns of tool selection revealed by the tracking data. When the all-tools learners accessed screens by treatment tool, 70% of the time they used the browser, compared with 28% for the index and find tools and 2% for the map. Since the all-tools learners predominantly used the browser, it is not surprising that their performance was similar to that of the browser learners.

Search achievement results for the map treatment were contrary to expectation. The field- independent learners assigned to use only the map tool outperformed the field-dependent learners under this treatment with a difference and an effect size close to those found for the index/find treatment. We had hypothesized search achievement of the map users similar to that of the browser users. It was assumed that using the maps would provide the learners with a structured interface that could accommodate the more global approach of field-dependent learners. However, unlike the other tools, the maps were not available on every screen. The learners had to access them on separate map screens. To move through the map hierarchy from main sections to subsections in order to access individual screens, at least one additional map screen had to be selected. The map screens thereby took the learners out of the context of a content screen. Field-independent learners, with their greater ability to transfer concepts to new contexts (Witkin et al., 1971), appear to have an advantage at this kind of map interface.

Additional support for these explanations comes from information-processing research on cognitive-style differences. In a review of these studies, Davis (1991) concluded that little or no difference was found between field-independent and field-dependent learners when a limited amount of information was processed. However, field-independent learners were consistently more efficient in situations with higher information-processing demands. Reflecting Marchionini's observation that "it takes less cognitive load to browse than it does to plan and conduct an analytical, optimized search" (1987, p. 70), it appears that the browser tool placed less information-processing demands on learners than the other tools.

The results for patterns of tool use revealed that while using their treatment tools, the field independents accessed more screens than did the field dependents. This finding adds support to the suggestion that the field-independent learners were more actively engaged when searching the database than were the field-dependent learners.

The results of this study have implications for the design of hypermedia and its use in the classroom. Decisions about which interface tools to provide for database search and information retrieval should take into account the cognitive styles of users. Tools such as a browser, which can be used effectively without placing high information processing demands on the user, should be made available for field-dependent individuals. Index, text-string find, and other tools that allow more analytical and optimized searches would provide field-independent users with an efficient method for information retrieval. In a variety of settings, students with different cognitive styles could learn more, and perhaps be better motivated, if activities involving information retrieval accommodated the cognitive processing approaches of those students.

A potential limitation of the current study should be noted. The subjects were enrolled in a pre-admission ESL program and were in the process of improving their English skills. However, since the *EarthQuest* program was originally designed for use by junior high school students, the English-language proficiency of these subjects was sufficient for them to adequately use these materials.

Other possible limitations of this study are the small sample size and the size difference among cells. However, the result from the test of homogeneity of cell scores suggests that the statistical results identified as significant do maintain an error rate below the .05 alpha level.

Some researchers have questioned whether aptitudes such as field dependence exist as stable traits and whether they are different from general intelligence. More specifically, they have argued that cognitive style measures such as the GEFT are best interpreted as ability tests (McKenna, 1984; Tiedmann, 1989). When considered an ability, field dependence loses its bi-polar, value-neutral aspects.

Interpretation of field dependence as an ability would suggest that instructional procedures for hypermedia database use should focus on assisting field-dependent learners to improve their performance on analytical tasks. This instruction might focus on development of search skills similar to those needed for accessing information from library collections by using indexes.

On the other hand, interpretation of field dependence as a style would suggest an emphasis towards accommodating individual learning differences. This focus allows for a broader view of the implementation of hypermedia, a view that extends beyond the classroom. With hypermedia becoming an integral part of telecommunications in the not-too-distant future, we can expect demands for easy-to-use interfaces. Rather than asking for instruction in how to use analytical searches, users will want to be able to access information in a way that accommodates their aptitudes, or to put it another way, their cognitive styles. The design of interfaces to hypermedia should take into account the potential cognitive load placed on users during navigation, search, and exploration. By providing a variety of tools or other means for accessing the content in a hypermedia environment, the designer could help users with a more global style as well as those who are more analytical to effectively process the material they encounter.

An avenue of future research on cognitive style factors in the use of hypermedia could involve the formulation of criteria for interface tool design. Hutchins, Hollan, and Norman (1986) use the term *direct engagement* to identify the nature of user interaction with computers. When there is greater direct engagement, the computer interface becomes more transparent and the user more involved in the illusion of acting directly upon the objects in the task domain. Hutchins et al. suggest that this feeling of directness is "inversely proportional to the amount of cognitive effort it takes to manipulate and evaluate a system" (1986, p. 95). Perhaps a measure of direct engagement could be applied to the tools used in hypermedia systems. A tool which provided greater direct engagement would lessen cognitive effort, or information-processing demands, and would especially benefit those learners with a more field-dependent cognitive style.

The current growth in the use of hypermedia both in education and communications suggests that it deserves the attention of educational technologists. Jonassen and Grabinger (1990) envision the possibility of an extensive impact of hypermedia on our lives that would require a new form of literacy for hypermedia. Continued research on how different learners utilize hypermedia databases will help educational technologists shape this literacy. ☐

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