EFFECTS OF COGNITIVE AND PROBLEM-SOLVING STYLES ON INFORMATION SEEKING BEHAVIOUR IN THE WWW

Hong Kian Sam
University Malaysia Sarawak
Sarawak, Malaysia

This study investigated how students with different cognitive and problem solving styles navigate a hypermedia environment (World Wide Web) differently in search of information. Nine subjects were categorized as (1) field-dependent learners with emotion-focussed problem-solving style (two female students), (2) field-mixed learner with emotion-focussed problem-solving style (one male student), (3) field-independent learner with emotion-focussed problem-solving style (two female students), (4) field-mixed learners with problem-focussed problem-solving style (two male students), and (5) field-independent learners with problem-focussed problem-solving style (two female students) based on their responses to the Problem-Solving Inventory and Group Embedded Figure Test. The subjects were asked to complete two different types of information search tasks: search for specific information (related to a course they were attending) and search for general information. The screen displays while the subject searched the Web were recorded using Lotus ScreenCam. Their navigation patterns and information-seeking strategies were examined to find relations between cognitive and problem-solving styles and the information-seeking behavior on the Web. Results indicate that there was no difference in the search pattern and information-seeking behavior between search for specific and general information.

INTRODUCTION

As technology advances, human beings invent and adopt new ways of delivering information. Hypermedia is one of the recently developed technologies and its use has been for developing an information system for different purposes. The World-Wide Web (WWW) is one of the hypermedia-

based systems, which is getting more popular and widely used since it allows users to access an amazing wealth of information available in the world.

Hypermedia can be characterized as a non-linear multimedia system that allows interaction with users. Due to its flexibility in structure and format, new to most users, hypermedia receives negative as well as positive evaluations from users. Users who are unfamiliar with the features of hypermedia constantly express frustrations, such as "disorientation" and "cognitive overload. These are the two challenging problems related to information access through hypermedia interface (Conklin, 1988). Many studies have been conducted to find out how people cope with this novel and distinctive characteristics of hypermedia.

Navigating in search of information, whether in the physical world or using the WWW is a process whereby people determine where they are, where everything else is, and how to get to that particular information. Standard web browsers support models of navigation which are similar, and some of the user disorientation problems arise from the limited navigation support they offer (Cockburn & Jones, 1996). Research on information-seeking and learning in a hypermedia environment has revealed several factors affecting user's mental process while seeking information and learning in a hypermedia system. Cognitive styles, experience of users, and type of tasks are some examples (Marchionni, Lin & Dwiggins, 1990; Campagnoni & Ehrlich, 1989; Korthauer & Koubek, 1994).

Cognitive styles refer to unconscious habits and conscious strategies of thinking in order to organize the information perceived in the environment. Findings from research on learning in various environments, including computer-assisted learning, support that cognitive styles should be considered as one of the important factors influencing learning. Learners with different cognitive styles tend to develop and use different strategies in a learning environment (Leader & Klein, 1996; Liu & Reed, 1995).

According to Foltz (1996), navigating a hypertext is more than just searching information. It is a problem-solving process requiring decision making as well as information recognition. How the problem-solving process affects the information-seeking in hypermedia is an area worthy of being studied.

Research investigating how a system is used by different users and identifying factors affecting the use is important since it can help developing more user-oriented systems for facilitating access and acquisition by the users.

PURPOSE OF THE STUDY

This study proposed to find how the user navigates the WWW when searching information and if and how the user's psychological factors including cognitive and problem-solving styles influence the navigation patterns. Specifically, this study investigated different navigational strategies adopted by field-dependent (FD), field-mixed (FM), and field-independent (FI) users when they searched information on the WWW. The study will also examined the effects of problem-solving styles, emotion focussed, (EF) versus problem-focussed (PF) on the information seeking behavior, the interaction between problem-solving and cognitive styles, and its effects on the information-seeking behavior. In addition, possible effects of types of search tasks will be investigated.

RESEARCH QUESTIONS

The research questions were:

1. What is the effect of a user's cognitive styles on the information search strategies on the WWW?
2. What is the effect of a user's problem-solving styles on the information search strategies on the WWW?
3. What is the interaction between users, cognitive styles and problem-solving styles, and how is it related in the information search patterns in the WWW?, and
4. Do types of search task influence the user's information search performance and strategies?

DEFINITION OF TERMS

Cognitive Styles

Cognitive styles refer to a manner of moving toward a goal, and a characteristics way of experiencing or acting. More specifically, it is the characteristic way in which the individual organizes and processes information. Cognitive style can be measured by several different dimensions. In this study the definition by Martens (1979) of cognitive styles as field dependence/field independence dimensions will be used.

Field Dependence/ Field Independence

Witkin, Moore, Goodenough and Cox (1977) characterized field-independent learners as (1) making more use of mediational processes such as analyzing and structuring, (2) adopting an active, hypothesis-testing role in learning, (3) less dominated by the most obvious or salient cues in learning, and (4) operating more from internally defined goals and reinforcements and thus more likely to be motivated by intrinsic or task-oriented forms of motivation. On the other hand, field-dependent learners are (1) less effective users of mediational process, (2) adopting a passive, spectator role in learning, (3) more dominated by salient cues in learning, and (4) better at learning and remembering information having social relevance or content.

Hypermedia

Hypermedia is a technology that is grounded in the major concepts of hypertext. Hypertext supports a non-linear structure and an interaction between the system and the user. Hypertext is a non-linear system consisting of nodes (chunks of information) and links (connecting the chunks of information). It allows an interaction between the system and the user; in a hypertext system, the users can jump between different nodes as they wish. They can also create and modify the links allowing the jump between nodes. Although terms "hypertext" and "hypermedia" are used interchangeably, they differ in a strict sense. In a hypertext system, information in a node includes only textual materials. A hypermedia system, on the other hand, can incorporate information in various forms of media, such as text, graphics, pictures, audio, video and animation.

WWW

The WWW is a hypermedia-based information system and allows users to access information available in the world. As it is based on a network technology, connecting computers all over the globe, the WWW can also be used as communication tool.

Problem-Solving Styles

Problem-solving can be defined as a goal-oriented sequence of cognitive operation. The problem-solving process comprises cognition as well as emotion and behavior. Skills of problem-solving include the ability to search for information, to analyze situations for the purpose of identifying the problem in order to generate alternative courses of action, to weigh alternative courses of action with respect to desired or anticipated outcomes, to select and implement an appropriate plan of action, and to evaluate the outcome with reference to the initial problem. As the term "problem" itself has different facets, there appears to be several aspects of problem solving process, among them, cognitive problem solving, personal problem solving, and social problem solving. Problem solving style in this study is defined as a tendency to respond in a certain way while addressing problems and not as the steps employed in actually solving problem. Two problem solving-styles defined in this study are emotion-focussed and problem-focussed coping style (Heppner, 1988).

Emotion-focussed vs. problem-focussed coping style

Individuals with an emotion-focussed coping style tend to make themselves feel better about a problematic situation without changing the problem itself or the perception of it. In contrast, individuals with problem-focussed coping styles tend to actually make changes on their situation or their perception of a situation in order to make it less or no longer stressful.

Search

Search refers to the process of locating specific information in a relatively large body of information, such as looking up facts in an encyclopedia and locating critical details in an airline schedule. The bigger the body of information from which information should be searched, the more effort is required for the search process.

Types of Search Tasks

Specific information search task refers to searching for information that is directly related to the course KMS2053 Introduction to Learning Technology that the subjects are following. In this study the subjects were required to look for information on Dick and Carey Instructional Design Model in the WWW. General information search task refers to searching for general purpose information. In this study the subjects were asked to search for information regarding the 1999 Fulbright Scholarships for Malaysian students.

List of Abbreviations

AA: Approach-avoidance factor of the PSI

CON: Problem-solving confidence factor of the PSI

EF: Emotion-focussed problem solving style

GEFT: Group Embedded Figure Test

FI: Field independence cognitive style

FD: Field dependence cognitive style

FM: Field mixed cognitive style

PF: Problem-focussed problem solving style

PC: Personal-confidence factor of the PSI

PSI: Problem Solving Inventory

URL: Uniform Resource Locator address system for the WWW

WWW: World Wide Web

RELATED LITERATURE REVIEW

Cognitive Process Related to the Use of Information Systems

Using an information system requires three different cognitive processes: (1) information-seeking, (2) knowledge acquisition, and (3) problem-solving. Information seeking is a goal-driven activity in which needs are satisfied through problem-solving (Brown, 1991). According to Krikelas (1983), information-seeking behavior begins with "a perceived need", which is like Belkin's (1980) "anomalous state of knowledge." The information-seeking

behavior required involve activities that will satisfy the information need. When the need is no longer perceived, the individual quits the chosen information-seeking process. The process is dynamic since methods of collecting information can vary in time and depend on the immediacy of results (Krikelas, 1983; Rouse & Rouse, 1984). The ways of collecting and selecting information are also related to the personal habits and styles of the searcher.

Knowledge acquisition is what one might normally call "learning." Through the learning process, an individual restructures the knowledge, organized by others, in order to make it fit in his or her own knowledge structure. While using an information system, individuals have to reorganize their knowledge structure based on either accidentally or intentionally retrieved new information.

Problem solving is another cognitive process required for using an information system. Problem-solving starts with a perceived problem. Once the problem is stated in terms that can be understood, individuals than apply their knowledge to the problem and attempt to try out possible solutions. Solutions obtained are evaluated with reference to initial problem definitions. When using an information system, individuals develop strategies that they believe will help to get the best result from the system. System users have to figure out how a system works, how to get a wanted result from the system, and how to select the "best" result from the retrieved information.

Cognitive Styles and the Use of Hypermedia Systems

Effective use of systems depends on the ability to orchestrate all of the aforementioned cognitive processes, and this ability varies according to cognitive styles. Cognitive style is defined as the individual's characteristic way of organizing and processing information (Goldstein & Blackman, 1978) and it has been shown to influence the manner in which individuals prefer to learn and receive instruction (Witkin, Moore, Goodenough & Cox, 1975).

Cognitive style can be measured by several different dimensions. Field-dependence/ field-independence is often studied since it is apparently one of the cognitive styles that have significant impacts on learning in different situations. Identified and intensively reported and researched into, field -

dependence vs. field-independence refers to an analytical vs. a global way of perceiving things.

In a study, Korthauer and Koubek (1994) evaluated the effects of an individual's cognitive style on the use of a hypertext system. Initially, participants were divided into two groups based on knowledge level of a subject: a group of experts on a subject (the experienced) and a group of novices (the naïve). The groups were divided again into four groups based on their cognitive style "field-dependence/field-independence." The four groups of participants were: (1) field-independent experienced, (2) field-dependent experienced, (3) field-independent novice and (4) field-dependent novice. Each group of participants was asked to answer questions on a topic under two different conditions: explicit and inherent conditions. Under both conditions, participants were asked questions on a topic. Under the explicit condition, a summary of the given topic was provided whereas no summary was provided under the inherent condition. Experienced field-independent participants performed better than experienced field-dependent participants, especially when questions were asked under an explicit condition. The results suggest an existence of complex interrelationships among knowledge structures and cognitive styles of users when using a hypertext system.

Ellis, Ford, and Wood (1993) attempted to examine effects of and possible interactions between user's cognitive and learning styles on the learning outcomes in a hypertext-based system, In their study, two standardized styles on the participants' cognitive style "field-dependence/field-independence" and learning style "serialist/holist." Holists are characterized as persons who prefer gaining an overview first while serialists are those who prefer establishing detail before gaining the overall picture. Jonassen and Grabowski (1993) describe the serialist as combining information in a linear fashion, focussing on small chunks of information at a time and working from the bottom up, which infers that these learners prefer part-to-whole processing of information. They describe holists as being able to focus on several aspects at the same time, having many goals, and working on topics that span varying levels of structure. It can be inferred from this that holists prefer to process information in a whole-to-part sequence. The participants were first asked to use a hypertext-based

learning system to learn about the given topics. After a learning period, participants' knowledge of the topics was evaluated. The results showed that the serialists attempted to answer a higher number of questions and scored a higher number of correct answers in recall tests that the holists. The holists tended to answer fewer questions but more accurately than the serialists. Field-independents participants tried larger number of access attempts to information nodes than the field-dependents. And the field-dependents were less successful in producing correct answers. Despite these differences, any effect of cognitive styles on the learning and the recall was minimal. In the initial phase of adjustment to the system, cognitive and learning styles affected ways of searching for information, but eventually all participants seemed to manage findings ways to adapt to the new situation and achieved similar end results.

Other Factors Affecting the Use of Hypermedia Systems

It is also often found that there exist individual differences among users' performance in and reaction to a system, which implies the effect of user characteristics on the user-system interaction. A number of researchers have investigated the relation between human-computer interaction and users' characteristics, especially those related to cognitive processes.

In order to examine how "expertise in a subject area" and "expertise in information searching" affect the process and the outcome of information seeking in a hypertext system, Marchionni et al. (1990) conducted an experiment. Participants were divided into three groups according to their level of expertise: (1) a group of novices, (2) a group of experts in a subject and (3) a group of experts in information search. They were all asked to retrieve information on a given subject in a hypertext system. Both expert groups (subject and search specialists) retrieve information better then the novice group; the former groups found more pertinent information more quickly than the later group did. However, no significant difference in the task performance was reported between the two expert groups. Apparently, individuals with experience in either subject area or search process have developed a mental model on a subject and information system respectively, and elaborated their problem-solving strategies.

However the researcher failed to find any related literature on the effects of problem solving styles on information seeking behavior in the WWW in particular and hypermedia system in general. However it was hypothesized that problem-focussed (PF) would be better information seeker in the WWW compared to the emotion-focussed (EF).

DESIGN OF STUDY

Dependent Variables

There are four dependent variables in this study.

Navigational path: The navigation path was coded according to the following rule. When the subject reaches the goal information, zero (0) was assigned. As he/she moved from the goal, increasing numbers were assigned. In this case the numbers were getting bigger, When he/she moved in the same level, the same number was assigned. The distance between the website where the subject was and the destination website where the target information was located were determined based on the minimum number of links that the subject should use to reach the destination. This distance information was used for coding the navigation path that the subjects followed when they search for a specific information. All URLs of websites visited by a subject were recorded and the navigation path was examined to determine navigation strategies used by the subject.

Navigated distance: The numbers assigned in the navigated path for each search task was totaled to represent the navigated distance.

Number of times using different navigation tools: The number of times that the subjects used navigation tools was counted. Here the navigation tools include embedded links, Backward/Forward buttons, Home button, Go button, Search Engines, Bookmark option, Keyword option and Location window to type URLs for jumping to a website.

Length of time for the completion of information search task: Time spent for completing the search task was measured.

Independent Variables

There are two independent variables in this study.

Cognitive styles: The subjects' cognitive styles were determined based on scores from the Group Embedded Figure Test (GEFT: Oltman, Raskin & Witkin, 1971). The test is a standardized paper-and-pencil test, which takes 20 minutes to complete. The score of the test ranges from 0 to 18. A high score indicates high field-independence while a low score reflects high field-dependence. The reliability of the test is 0.82. Based on their scores from the GEFT, the subjects were classified as one of the following: field-dependent (FD), field-independent (FI) and field-mixed (FM) learners. The mean and standard deviation used for the categorization of subjects were taken from the Manual of GEFT (Oltman, et al., 1971, p. 28). The subjects whose scores were one standard deviation (SD=4.2) above the mean (M=10.8) were categorized as FI, whereas those with scores one standard deviation below the mean were categorized as FD. The subjects with scores in between were categorized as FM.

Problem-solving styles: The subjects' problem-solving styles were determined based on score from Problem-Solving Inventory (PSI: Heppner, 1988). The PSI is a standardized paper-and-pencil test, which takes 15-20 minutes to complete. It contains 35 items which are rated on a 6-point scale. The total score is considered the best overall index of one's self-perceived problem-solving ability. The PSI consists of three factors: Problem-solving confidence (CON), Approach-avoidance (AA) and Personal-control (PC). Problem-solving confidence refers to "self-assurance while engaging in problem-solving activities." Approach-avoidance signifies "a general tendency of individuals to approach or avoid problem-solving activities" whereas personal-control means "the extent to which individuals believe that they are in control of their emotions and behavior while solving problems" (Heppner, 1988). Internal consistency for these constructs ranges from 0.72 to 0.91. Based on scores from the test, the subjects will be classified as either problem-focussed (PF) or emotion-focussed (EF) problem solvers. High scores in personal-control (PC) factor of the PSI indicate "emotion-focussed" (EF) problem-solving styles. High scores in approach-avoidance (AA) factor of the PSI indicate "problem-focussed" (PF) problem-solving style. Subjects with scores one standard deviation (SD=5.5) above the mean

(M=17) in PC scale will be assigned to the EF problem-solver group (PC>22.5) whereas those with scores one standard deviation (SD=10.9) above the mean (M=40.7) in AA scale are assigned to the PF problem-solver group (AA>51.6). The means and standard deviations used are taken from the manual of the PSI (Heppner, 1988, p. 5).

Sample

56 second year undergraduate students in the Human Development Programme at the Faculty of Cognitive Sciences and Human Development, Universiti Malaysia Sarawak, enrolled in KMS2053 Educational Technology course, were administered the PSI. Four students identified as "problem-focussed (PF)" and five students assigned as "emotion-focussed (EF)" were then asked to take the GEFT. The nine subjects were then based on their identified cognitive and problem-solving styles, assigned to one of the following groups:

1. field-dependent learner with emotion-focussed problem-solving style (FD-EF) - two female students
2. field-mixed learner with emotion-focussed problem-solving style (FM-EF) - one male students
3. field-independent learner with emotion-focussed problem-solving style (FI-EF) – two female students
4. field-dependent learner with problem-focussed problem-solving style (FD-PF) - none
5. field-mixed learner with problem-focussed problem-solving style (FM-PF) - two male students
6. field-independent learner with problem-focussed problem-solving style (FI-PF) – two female students

The category field-dependent learner with problem-focussed problem-solving style (FD-PF) was not included in this study because there was no corresponding subject. The ages of the students were between 20-21 years old. All students were competent in the use of computers and internet facilities having passed two generic courses on information technology, namely, TMX1012 End Users Computing and TMX2012 IT for Knowledge Workers.

PROCEDURE

First, the Problem Solving Inventory test was administered. The test was scored to identify students who were typically "emotion-focussed (EF)" or "problem-focussed (PF)" problem solvers: subjects with high PC score (PC>22.5) is the EF whereas those with high AA score (AA>51.6) are the PF problem solvers. Only those identified as typical EF or PF problem solvers were contacted individually and asked to participate in the study. Those who agreed to participate were asked to take the GEFT. Then the subjects had a brief session reviewing search tools available in a Web browser. In this study, Netscape was used as a Web browser. After the review session, the subjects were asked to complete two information search tasks. One was a search of information specific to KMS2053 and the other a search of general information, in the WWW. All screen displays consulted were recorded using the LOTUS ScreenCam software. The LOTUS ScreenCam also recorded the subjects' verbal reactions and comments as the subject conducts the search along with the screen displays.

ANALYSES OF DATA

The subjects' behaviours had been quantified and the data were analyzed to find out the general tendency of each subject. Verbal protocols of the subjects were transcribed and analyzed in case there was a need of additional information for explaining the subjects' information-seeking behavior.

RESULTS

Search of General Information

Navigation path

Search strategies used by a field-independent person with problem-focussed coping style (FI-PF) were the most efficient while the least efficient search strategies were employed by field-dependent person with emotion-focussed coping style (FD-EF). The FD-EF followed the longest navigation path (in this study, did not reach the desired information), took the greatest number of steps and used the most time. The most efficient navigation path, least steps and shortest time were demonstrated by the FI-PF. A comparison within the FI, shows that FI-PF was more efficient in searching for

information than FI-EF. However, FM-EF and FM-PF showed a tendency inconsistent with those exhibited by FI-PF and FI-EF. Results for FI-PF and FI-EF would suggest that FM-PF would perform better than FM-EF in searching tasks. However, results displayed in Table 1, indicate the reverse. The FM-EF was better information seeker than the FM-PF and was comparable even to the FI-EF. Other factors might have played a more important role than the cognitive styles and problem-solving styles in determining the search capabilities of a person. One such factor was gender. It should be noted that all the FMs are male students while all the FIs are female students. Further study with larger and gender-balanced sample is called for. Furthermore there may be a need to delve into the specifics of computer competency for the subjects though all the subjects were assumed to be sufficiently competent having passed the two compulsory generic Information Technology courses namely TMX1012 End Users Computing and TMX2012 IT for Knowledge Workers.

Table 1
Navigation of Various Users for General Information Search

Cognitive Styles	Problem Solving Styles	Navigational Path	Time of Completion (s)	Navigated Distance
FI	PF	5-3-2-1-0	120	11
		4-3-2-1-0	135	10
FI	EF	5-4-5-5-4-2-1-0	485	26
		5-4-4-3-2-1-0	540	19
FM	PF	8-7-7-6-7-7-7-7 *	720	56
		6-7-8-7-8-8-10 *	1140	54
FM	EF	5-4-4-3-2-1-0	360	19
FD	EF	8-7-8-6-4-6 *	900	39
		7-8-8-9-8-8-7-7-6-7 *	1200	75

*did not reach destination

When comparisons of navigation were done based on cognitive styles, FI performed best among the three cognitive styles. FD fared the worst with FM in the middle. Comparisons based on problem solving styles showed that PF was better at searching for information on the WWW than EF.

Table 2
Average Navigation Based on Cognitive Style for General Information Search

Cognitive Style	Time of Completion (s)	Navigated Distance	Steps
FD	1050.0	57.0	7.0
FM	758.0	43.0	6.3
FI	320.0	16.5	5.3

Navigated steps were transformed from the navigational path column in Table 1. As an example for FD, the navigated steps were (5+9)/2 = 7.0 [8-7-8-6-4-6 = 5 steps and 7-8-8-9-8-8-7-7-6-7 = 9 steps].

Table 3
Average Navigation Based on Problem-Solving Style for General Information Search

Problem Solving Style	Time of Completion (s)	Navigated Distance	Steps
PF	528.8	32.8	5.3
EF	697.0	35.6	6.6

USE OF SEARCH TOOLS

A comparison on the use of search tools based on cognitive styles (Table 4) yielded three interesting observations consistent with characteristics of different cognitive styles. The FD and the FM used Home keys frequently to indicate that they often got lost in the Web space. FD also used more of the Back keys than the other two cognitive styles. This was congruent with FD's lack of confidence in working alone and tended to backtrack after the initial step forward. FI also use more Keyword and Search Engines and this tendency is consistent with their characteristics of imposing structure to situation and problems. They tended to be active rather than passive learners.

Table 4
Use of Search Tools Based on Cognitive Styles for General Information Search

Cognitive Style	Link	Home	Back	Go	URL	Book mark	Key word	Search Engine
FD	3.0	0.5	3.5	0.0	0.0	0.0	1.0	1.0
FM	4.3	0.7	1.0	0.0	0.0	0.0	1.5	1.5
FI	2.5	0.0	1.0	0.0	0.0	0.0	2.0	1.8

With reference to Table 5, there was no obvious difference in the use of search tools for both groups of problem-solving styles. Thus it seems that though a problem-solving style can predict who is better at searching for information, it cannot differentiate in terms of which tools he/she will use.

Table 5
Use of Search Tools Based on Problem-Solving Styles for General Information Search

Problem Solving Styles	Link	Home	Back	Go	URL	Book mark	Key word	Search Engine
EF	2.6	0.2	1.8	0.0	0.0	0.0	1.8	1.6
PF	2.5	0.5	1.0	0.0	0.0	0.0	1.7	1.5

Search of Specific Information

Navigation path

Generally the navigation in search of specific information of the various problem-solving styles and cognitive styles users were the same as shown in the general information tasks. FI-PF was the most efficient information seeker, with FD-EF being the weakest. Again FM did not conform to the trend displayed by FI.

Table 6
Navigation of Various Users for Specific Information Search

Cognitive Styles	Problem Solving Styles	Navigational Path Completion (s)	Time of	Navigated Distance
FI	PF	4-3-2-1-0	80	10
		5-4-3-1-0	95	13
FI	EF	5-4-4-3-2-1-0	385	19
		6-4-4-3-2-1-0	450	20
FM	PF	7-7-6-5-6-4-3-2-1-0	840	41
		6-7-5-4-3-3-2-1-0	520	31
FM	EF	5-5-4-2-2-2-1-0	280	21
FD	EF	8-7-8-6-4-5-3-2-1-0		
		7-8-8-7-5-4-3-3-1-0	750	44
			1050	46

Again as in Table 2, Table 7 showed that the FI was the more efficient information searcher with FD the weakest and FM as the average efficient information seeker. Based on problem-solving styles, PF was again found to be a better performer compared to EF in searching for information (Table 8).

Table 7
Average Navigation Based on Cognitive Styles for Specific Information Search

Cognitive Style	Time of Completion (s)	Navigated Distance	Steps
FD	900.0	45.0	9.0
FM	546.7	31.0	8.0
FI	234.5	15.5	5.5

Navigated steps were transformed from the navigational path column in Table 6. As an example for FD, the navigated steps were (9+9)/2 = 9.0 [8-7-8-6-4-5-3-2-1-0 = 9 steps and 7-8-8-7-5-4-3-3-1-0 = 9 steps].

Table 8
Average Navigation Based on Problem-Solving Styles for Specific Information Search

Problem Solving Style	Time of Completion (s)	Navigated Distance	Steps
PF	383.8	23.8	8.3
EF	583.0	30.0	7.8

Use of search tools

As can be seen from Table 9, the FD tended to use the Home and Back buttons more frequently then the rest. This implies that FD user did not feel comfortable with using tools for jumping around different nodes and navigates the Web in a linear mode. FI on the other hand, tended to use URL more compared to the rest. FI tended to be able to remember the correct URL used in their previous lesson assignments and was able to utilize it to accomplish their topical information search. Though the FD attempted to use URL he/she did not succeed as the FD could not remember the correct URL.

Table 9
Use of Search Tools Based on Cognitive Styles for Specific Information Search

Cognitive Style	Link	Home	Back	Go	URL	Book Mark	Key word	Search Engine
FD	5.5	4.5	3.5	0.0	1.5	0.0	1.5	1.0
FM	4.0	1.7	1.0	0.0	1.0	0.0	1.7	1.7
FI	4.0	0.5	0.5	0.0	2.5	0.0	2.0	3.5

With regard to problem solving styles, the data indicated a more clear-cut trend. The PF used URL more frequently. The EF used the Home and Back buttons more than then PF. All these imply that the PF tended to feel comfortable with jumping among different nodes and actively approached the problem rather than passively browsing around whereas the EF adopted strategies opposite to those used by the PF.

Table 10
Use of Search Tools Based on Problem-Solving Styles for Specific Information Search

Problem Solving Styles	Link	Home	Back	Go	URL	Book mark	Key word	Search Engine
EF	3.4	2.4	2.0	0.0	1.4	0.0	1.8	2.4
PF	3.5	1.0	0.8	0.0	2.2	0.0	1.8	2.2

Comparison of General Information and Specific Information Search

On comparing Table 1 and Table 6, it can be seen that though the navigation use was the same for both types of tasks, for the various problem-solving styles and cognitive styles, two main differences occurred. All users managed to complete their task for the specific information search in contrast to the general information task where both the FM-PF and one of the FD-EF failed to complete their tasks after spending a considerable amount of time at the task. The specific information search was also more efficient in terms of time and navigated distance. Apparently users spent more time at each node in searching for general information than in searching for specific information, because they had to do more than search and recognize target information. They had to make decisions, which were linked to choosing, and whether the retrieved information was relevant or not.

DISCUSSION

Search Patterns for Information Seeking

Cognitive styles were found to affect information search strategies. FD information seekers were found to be dominated by salient cues and chosen tools that are salient (Home, Back and Links) but not necessarily useful or relevant to the task required. This is consistent with characteristics of the FD cognitive styles as reported by Witkin et al. (1977). The reason for this pattern was however beyond the scope of the present study. A weak knowledge of the web browser may be the source but a study that controls for the users' academic performance might prove useful to localizing the reasons for such search behavior. Furthermore both FD-EFs in this study are female subjects, raising the issue of whether this finding could be gender-

related. The two FD users were also EF, thus the result might also reflect the characteristics of EF. Frustrated by repeated failures in the search process, FD-EFs reacted emotionally and tried whatever tools available without stopping to think of their usefulness.

The FIs as predicted perform better than the rest of the cognitive styles. The FIs were more analytical and were able to impose structure where non-is given. Thus they are able to design beforehand a structure of searching information and impose the model to the search experience. In this study FI-PFs were the most efficient information seekers.

The FM was better than the FD as expected but surprisingly the FM-EF was better than the FI-EF. One of the causes of this twist in logic could be the gender perspective. In this study, all the FMs are males whilst the FI-EFs are female. Again the scope of this study does not permit an enquiry into the reason behind this pattern. A replication of this study with a larger and gender-balanced sample may elucidate whether gender plays a major role in this anomaly of search patterns.

The FD performed poorly in the search tasks and in general prescribed to the view of FD as more global in information processing and have difficulty extracting information from complex background or unstructured experience as the case of WWW (Witkin et al., 1977).

In conclusion, from the perspectives of cognitive styles, the FI was more efficient at searching as compared to the FM and the FM is better than the FD. From the perspectives of problem solving styles, the PF generally performed more efficiently then the EF. There were however some interaction effects between cognitive styles and problem-solving styles in terms of search patterns efficiency. Though generally it is expected that FI and PF will perform better, it was discovered in this study that FI-EF were worse off than the FM-EF but better than the FM-PF. The FD is the least efficient information-seeker.

The method of search pattern used could be classified as the "hub and spoke" method with a glaring lack of advanced level search strategies. This seems to be a common strategy used for navigating in an unfamiliar and complex environment such as a hypermedia system.

Task Orientation and Search Pattern

Task orientations do not seem to influence efficiency of navigation. In general, navigation patterns between searching information for general and specific tasks are the same. In this study, it was observed that there was time efficiency involved. Users seem to spend less time at a node in search for specific information as compared to general information. This could be that users needed less time assessing the content at a node as it was more recognizable for them whether the screen display is relevant or not relevant to his/her search quest and there is relatively less of the problem-solving and decision making process involved.

Search Tools

Findings seem to indicate that cognitive styles affect the choice of search tools. The FD used Home and Back keys more often because they tend to be distracted easily and got lost. The FI used Search Engines and URL more often than the rest. They tend to be task-focused and adopted analytic strategies. On the other hand, problem-solving styles seemed to have a minimal effect on type of search tools utilized. Though useful in predicting persons with what type of problem-solving styles will be successful with searching for information, it was not helpful in predicting the type of tools they will use. The problem-solving style may not be an important factor to consider in the design of the WWW whereas the cognitive style would deserve more consideration.

CONCLUSION

In conclusion, cognitive styles, problem solving styles and the type of information search task generally affect the search performance, navigation path and patterns as expected based on previous research findings and characteristics of the various styles. As this study had a limited number of samples, it was not possible to provide explanations as to why the results are not consistent with other findings or characteristics of the styles. To clarify the reasons or stability of the results, a larger study with larger sample is called for. More information regarding the user knowledge and experience interacting with computers and hypermedia may also be relevant. The sample should also be gender-balanced. With regard to search tasks, it may be not only the type of search task, which is required, that influences

the search patterns but also the taxonomy of the tasks (e.g.: application, problem-solving etc). As such future research should provide for a classification scheme of tasks in addition to task type.

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