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ABSTRACT

The purpose of this study was to identify the strategies used by learners in an open-ended hypermedia information system. Four participants were drawn from an introductory technology-for-teachers course incorporating a unit on telecommunications. Participants completed a survey measuring reported knowledge in three domains (metacognitive, system, and subject) as well as self-efficacy toward technology. They searched for information using Netscape, thinking aloud as they searched. Data was collected and analysis was undertaken in several phases: scripting the search; reading through the data; segmenting according to research question; and encoding. Three major findings related to hypermedia information systems resulted from the study: a variety of strategies are used by learners; reported knowledge does have an effect on the strategies used; and perceptions of disorientation and level of perceived self-efficacy have an effect on the strategies used. Implications related to emerging information technologies, open-ended learning environments, and the ways learners think are considered. (Contains 45 references.) (Author)

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**Title:**

**Cognitive Strategies and the Use of a Hypermedia Information System:  
An Exploratory Study**

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### Abstract

The purpose of this study was to identify the strategies used by learners in an open-ended hypermedia information system. Four participants were drawn from an introductory technology course incorporating a unit on telecommunications. Participants completed a survey measuring reported knowledge in three domains (metacognitive, system, and subject) as well as self-efficacy toward technology. Participants searched for information using *Netscape*®, thinking aloud as they searched. Data were collected; analysis occurred in several phases: scripting the search, reading through the data, segmenting according to research question, and encoding. Three major findings related to hypermedia information systems resulted from this study: a variety of strategies are used by learners; reported knowledge does have an affect on the strategies used; and perceptions of disorientation and level of perceived self-efficacy have an affect on the strategies used. Implications related to emerging information technologies, open-ended learning environments, and the ways learners think are considered.

### INTRODUCTION

Interest in creating productive and stimulating learning environments is an enduring theme in the educational arena. Recent attention has focused on open-ended learning environments (OELEs). In OELEs, experience and context are critical for cultivating cognitive processes that support understanding. These environments are learner-centered, with the instructor adopting the role of facilitator as opposed to presenter. The learner is encouraged to explore and experiment; problem solving, critical thinking, and perspective-building are inherent processes in these environments. While learning outcomes remain important to knowing, processes are the focal point of growth in understanding (Hannafin, Hall, Land, & Hill, 1994; Papert, 1993).

The emphasis on cultivating processes and strategies increases the requirement for learner-supplied structure. While the instructor or system can assist by guiding and facilitating, the learner determines which tools and resources to access and manipulate; that is, how to navigate to promote learning (Bransford et al., 1986; Spiro, Feltovich, Jacobson, & Coulson, 1991). The individual determines what s/he wants or needs to know, for accessing the information in the system, and for deciding whether or not the system contains the needed information (Perkins, 1993; Roth & Roychoudhury, 1993).

Numerous information systems exhibit some characteristics of OELEs. These systems blur traditional distinctions between educational systems and information retrieval systems. They have become increasingly transparent and user-centered. Emerging information systems provide the user with more control through "point and click" technology, and expand the retrievable resources to include multiple media.

Emerging information systems do more than archive and retrieve data; they support the individual's efforts to learn, think, and understand (Hannafin, 1992). These systems are no longer the exclusive domain of information scientists. They are readily accessible and usable by the consumer, creating both extraordinary opportunities for student-centered learning, as well as formidable challenges for those who design and develop such systems.

The challenges associated with creating electronic information systems that function as OELEs are considerable. Some systems are simplistic and focused; others are complicated and virtually limitless in breadth and depth. Designing and developing electronic information systems that empower the user, are intuitive and self-evident, and inclusive in orientation is a formidable challenge (Norman, 1988). It has also proven difficult to assist and support the learner in their uniquely individual goals as they use such systems. Learners accustomed to interacting in environments that are prescriptive and directed are often inefficient and ineffective in their use of and interactions within open-ended, learner-centered environments. They may lack the orientation, mental model, or strategies necessary for the environments (Hill, Lebow, Driscoll, & Rowley, 1994).

Another concern is that emerging information systems have evolved despite the absence of a strong theoretical or research foundation. We lack a solid understanding as to how or why the systems are being used. In addition, we lack a clear conceptualization of the capabilities and/or features that are needed or desired.

The purpose of this study was to identify the strategies used by learners seeking information in an open-ended hypermedia information system. The following questions provided a framework for this study.

#### Primary Question

What strategies are employed in open-ended hypermedia information systems?

#### Secondary Questions

1. Does metacognitive knowledge affect the strategies employed?
2. Are perceptions of disorientation influenced by the strategies employed?
3. Does perceived self-efficacy affect the strategies employed?
4. Does system knowledge affect the strategies employed?

## 5. Does subject knowledge affect the strategies employed?

### METHODOLOGY

#### Selection and Description of Participants

The population of this study were current and prospective educators enrolled in a university-level technology for educators course. This included Pre-K through 12 public school teachers as well as college/university instructors. This sample and population was chosen for several reasons: a lack of research examining adult use of hypermedia information systems, willingness to participate in an intensive study, and diversity of the participants. The university serves both undergraduate and graduate students from the state, region, and nation, as well as international students. The students reflected a broad range of experiences and backgrounds, assuring diversity in the population.

#### The Course: Technology for Teachers

"Technology for Teachers" attempted to create the conditions under which people typically understand things: first they develop a need to learn, then subsequently satisfy the need through progressive experiences. The course operated under several important premises. First, within educational settings, technologies are not so much a curriculum as sets of tools which can be put to productive uses. The course worked to help learners to establish what those productive uses might be.

Another premise was that productive use is influenced by context, audience, and activity. Problems presented during the course were anchored in everyday classroom teaching and learning contexts for which various technologies can be employed for, and with, students, teachers, and communities. The goal was not to become an expert in technology, but to become more facile in teaching through technology.

The final premise was that it was critical to understand the processes associated with various technology applications. Technology continues to advance at an exponential rate. Existing technologies will inevitably be replaced by systems that are faster, and more powerful. Therefore, problem solving and cognitive strategies for the use of technology were highlighted, rather than mastery of specific software and hardware.

Technology for Teachers was chosen for several reasons:

- Since the course was an elective, most students, both undergraduates and graduates, entered with a high level of interest and motivation.
- Given the recent movement to integrate technology into the classroom, the learners entered with a high degree of interest in learning various technologies, as well as diverse techniques for applying technology in their individual settings.
- The course itself reflected the assumptions and principles associated with open-ended learning environments (OELEs), including the development of cognitive strategies and higher-order thinking skills (see, for example, Hannafin, Hall, Land, & Hill, 1994). An inherent aspect of OELEs is that the learners establish goals they want to accomplish, as well as determine the steps needed to attain the goals. The course naturally supported the participants in the use of hypermedia information systems.
- Telecommunication technologies were integral to the course activities. A major focus of the unit was the Internet. Most learners were aware of the Internet, even if they did not understand what it was or how it could be used in an educational setting. The majority had a high degree of curiosity and motivation to learn about the Internet, what it can do, and the ways in which it can be used.

#### The Information System: Netscape®

The system selected for the study was Netscape®, a hypermedia information system built upon World Wide Web(W3) technologies. The system displays the following characteristics:

- open-ended in nature, providing access to a variety of information and media
- requires generative activities, placing the learner in the driver's seat
- necessitates an orientation toward discovery, where the learner is free to explore vast resources
- control of the environment centers around the user, both in terms of the information requested and the steps taken to retrieve the information

The World Wide Web is an interconnection of computer sites on the Internet. The main difference between World Wide Web technologies and traditional Internet programs is that W3 allows for the transmission of pictures, sound and motion along with traditional textual information. It also differs from traditional Internet programs in that it creates

a point and click interaction environment, where a mouse or track ball can be used to retrieve information. This creates an environment where hypertext and/or hypermedia capabilities are readily accessible.

Netscape® is a front-end browser used to interface with the Web. Netscape® and W3 operate in a client/server environment: the program that resides on the local computer is the client, while the server is the remote location accessed. Netscape® is the browser that displays the information retrieved from the Web.

#### Method and Design

An embedded case study approach was employed, involving the use of multiple cases, or embedded units, within a larger context. The unit of study in this case was the individual user of the system from whom several data sources were gathered. A unique strength of the case study strategy is the ability to deal with multiple sources of evidence. Various sources of evidence from the embedded units allowed for triangulation of the data, as well as serving to address concerns with construct validity (Yin, 1994).

The methods combined exploratory, descriptive, and analytical approaches. The study was exploratory in that several of the methods have not been previously used to examine the use of strategies in hypermedia information systems. The research was descriptive in that the goal was to describe the strategies employed from the evidence gathered, including the perspectives of the participants and the researcher. Information gathered during the research was manipulated iteratively through analytical induction. Initial definitions and explanations were developed at the beginning of the study. These definitions and explanations were then contrasted with the data collected and refined based on analysis of the evidence (Bogdan & Biklen, 1992).

#### Measures and Instrumentation

A combination of rationalistic and naturalistic techniques was used. Rationalistic (quantitative) techniques, including surveys and questionnaires, were used to generate individual difference measures for each case, and audit trails were used to track the participants' movements as they searched using Netscape®. Naturalistic (qualitative) techniques, included think-aloud protocols and interviews. These methods were used to monitor the participants' search, as well as to capture their thoughts both during and after the search process.

A fundamental theme in naturalistic studies is the element of continuous improvement. It is a widely held belief in qualitative research that research is a process that occurs on a continuum, one moving ever closer to a contextual reality. In keeping with this theme, and to assist the researcher in creating a more complete picture of contextual reality, the techniques described below were first used in a developmental study.

Figure 1 illustrates the progression of the activities throughout the study. Several activities took place during the study, which can be divided into three main components: pre-search activities, activities during the search, and post-search activities. Five techniques were used to gather data: pre-search surveys, think-aloud protocols, audit trails, post-search questionnaires, and stimulated post-search interviews.

**Pre-search survey.** The pre-search survey measured the learners initial perceptions of the three domain areas (metacognitive, subject, system) as well as their perceived self-efficacy.

**Think-aloud protocols.** Think-aloud protocols were recorded on both audio and video tape as the learners worked in the hypermedia information system. Learners were encouraged to verbalize whatever came to mind as they worked in the system.

**Audit trails.** Video was used to record the learner's path in the World Wide Web. The recordings were used to generate audit trails of the search.

**Post-search questionnaires.** Like the pre-search survey, the post-search questionnaire measured the learners perceptions of the three domain areas (metacognitive, subject, system) as well as their perceived self-efficacy. In addition, the questionnaire examined the learner's perceived strategies as they worked in the system.

**Stimulated post-search interviews.** Following the transcription of protocols and the creation of audit trails, learners were interviewed to garner their reflections, reactions, and comments on the search task.

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See Appendix B of the 1996 AECT Proceedings

The techniques enabled the researcher to establish a rich orientation to the individual's search process, procedures used, and strategies engaged. Those techniques were used to determine the five self-reported knowledge areas: disorientation, perceived self-efficacy, metacognitive knowledge, system knowledge, and subject knowledge.

**Disorientation.** Disorientation refers to a loss of one's bearings. Disorientation is often associated with a lack of understanding, or an inability to recognize how to use the system to accomplish one's goals.

**Perceived self-efficacy.** Self-efficacy refers to a person's perceptions of ability to succeed on a given task. Perceived self-efficacy refers to a person's judgments of her or his capabilities to organize and execute action required to attain designated performance (Bandura in Olivier & Shapiro, 1993). Perceived self-efficacy transcends knowing what to do or awareness of one's skills; it is a judgment of how well one can perform using particular knowledge or skill.

**Metacognitive knowledge.** Metacognition refers to awareness about cognition. Metacognitive knowledge enables an individual to reflect, evaluate and direct cognitive activities more effectively (Perkins, Simmons, & Tishman, 1990). In this study, metacognitive knowledge referred to the participant's self-reported awareness of their cognitive processes. Users with extensive metacognitive knowledge were presumed able to monitor their learning needs, leading to purposeful system use.

**System knowledge.** System knowledge refers to the participant's reported knowledge about electronic information systems in general, as well as Netscape®, in particular. System knowledge was felt to influence the ability to search successfully in an information system. Users with extensive system knowledge, such as reference librarians, are often able to use it to maneuver through information systems, despite a lack of significant prior subject or domain knowledge.

**Subject knowledge.** Subject knowledge refers to estimates of existing knowledge and experience related to the subject for which searches were conducted. Subject knowledge was presumed to influence the strategies participants employed as they searched using Netscape®.

#### METHODS, ANALYSIS AND PROCEDURES

Data analysis was conducted at several stages. The developmental study provided an opportunity to test the clarity of the questions and terminology, the techniques employed with the think-aloud protocol, and the accuracy of the technology employed to gather data. It also provided insight into the strategies being employed as people work in these systems.

#### Primary Research Phase

##### Preliminary Organization and Analysis

Most of the collection, organization, and analysis of data occurred concurrently. This helped to indicate gaps in data as they were gathered and organized, allowing adaptations in the process and indicating the need for additional information (see, for example, Glaser & Strauss, 1967; Hert, 1992). Formal analysis, comprising several reviews of the data, took place toward the end of data collection (Bogdan & Biklen, 1992). Overall organization of the data gathered in relationship to the research questions is illustrated in Table 1.

Table 1. Research question, data sources, and methods

Research Question	Data Gathered	How Obtained	When	Who
1. Does metacognitive knowledge affect the strategies employed?	Written responses to several questions	Pre-Search Survey	Pre-search	Participant
	Protocol	Think-Aloud Protocol	Search	Participant
	Audit Trail	Video tape	Search	Participant
	Written responses to several questions	Post-search Question.	Post-search	Participant
	Verbal responses to several questions	Stim. Post-Search Inter.	Post-search	Participant & Researcher



Table 1. (continued)

Research Question	Data Gathered	How Obtained	When	Who
2. Are perceptions of disorientation influenced by the strategies employed?	Protocol	Think-Aloud Protocol	Search	Participant
	Audit Trail	Video tape	Search	Participant
	Written responses to several questions	Post-Search Question.	Post-search	Participant
	Verbal responses to several questions	Stim. Post-Search Inter.	Post-search	Participant and Researcher
3. Does perceived self-efficacy affect the strategies employed?	Written responses to several questions	Pre-Search Survey	Pre-search	Participant
	Written responses to several questions	Post-search Ques.	Post-search	Participant
	Verbal responses to several questions	Stim. Post-Search Inter.	Post-search	Participant and Researcher
4. Does system knowledge affect the strategies employed?	Written responses to several questions	Pre-Search Survey	Pre-search	Participant
	Protocol	Think-Aloud Protocol	Search	Participant
	Audit Trail	Video tape	Search	Participant
5. Does system knowledge affect the strategies employed?	Written responses to several questions	Post-search Questionnaire	Post-search	Participant
	Verbal responses to several questions	Stimulated Post-Search Interview	Post-search	Participant and Researcher
6. Does subject knowledge affect the strategies employed?	Written responses to several questions	Survey	Pre-search	Participant
	Protocol	Think-Aloud Protocol	Search	Participant
	Audit Trail	Video tape	Search	Participant
	Written responses to several questions	Post-search Questionnaire	Post-search	Participant
	Verbal responses to several questions	Stimulated Post-Search Interview	Post-search	Participant and Researcher

Table 1. (continued)

Research Questions	Data Gathered	How Obtained	When	Who
Overall Question: What strategies are employed in open-ended hypermedia information systems?	Written responses to several questions	Survey	Pre-search	Participant
	Protocol	Think-Aloud Protocol	Search	Participant
	Audit Trail	Video tape	Search	Participant
	Written responses to several questions	Post-Search Questionnaire	Post-search	Participant
	Verbal responses to several questions	Stimulated Post-Search Interview	Post-search	Participant and Researcher

Transcripts of the think-aloud protocols, as well as the video-taped search sessions, were generated. Think-aloud protocol transcripts provided a verbatim translation of the audio tape. Transcription of the video tapes involved a step-by-step recounting of the participant's movement through the information space. The information gathered from the video tapes was transformed into a search trail generated using the program Inspiration®. Locations visited by the participant during the search are represented as nodes in the map.

Preliminary analysis took place as transcriptions were generated. A participant summary sheet was used to summarize this analysis and to assist in organizing the data (McGregor, 1993; Miles & Huberman, 1984). The summary sheet addressed each research question according to the instrument examined, directing the researcher to summarize the main points from the survey in relation to: metacognitive knowledge, perceived self-efficacy, system knowledge, and subject knowledge.

Stimulated post-search interviews were scheduled one week after completion of data collection. Initial analysis of the think-aloud protocols and search trails helped to guide the formulation of additional questions appropriate for individual interviews. Video tapes were shown during the interview to stimulate the participant's recall of particular instances in the search process.

Data were examined with an orientation toward both breadth and depth. In order to obtain breadth and depth, the initial pool of 14 participants was reduced to four for in-depth analysis. The researcher reviewed the participants' data in relation to the research questions, the performance of each participant in the think-aloud process, and the need to represent the range of participants in the study. The four participants chosen for in-depth analysis were Mick, Bill, Marsha, and Alyssa. As shown in Table 2, each reflected different estimates of the various knowledge described previously. The high, mid, and low designations for the participants reflects an overall ranking ("average") based on level of disorientation, perceived self-efficacy, and self-reported knowledge in the areas of metacognition, system and subject. Names of the participants were changed to protect their identify.

Table 2. Summary of participants reported knowledge, overall ranking, and "success"

Participant	Metacognitive	Disorientation	Self-Efficacy	System	Subject	Overall Ranking	Success Rating
Alyssa	mid	high	low	low	mid	low	no
Bill	high	mid	mid	low	mid	mid	yes
Marsha	low	mid	mid	low	low	mid	no
Mick	high	low	high	low	high	high	yes



### In-Depth Analysis

Given the variety and volume of evidence gathered, techniques of examination, categorization, tabulation and re-combination were used throughout the analysis. Copies of original data sets, as well as records of each transformation, were used to maintain the integrity of the data during analysis iterations. The data were reviewed and triangulated several times by the researcher; each time the data were examined, additional relevant information and related findings were revealed.

The initial in-depth analysis was driven by the need to combine the think-aloud protocols and the search trails. A "script" format, often used in screen plays, movies, and television was used to merge the elements. The scripts were used throughout the remainder of the analysis to aid the researcher in identifying themes, patterns, and strategies.

The next round of analysis involved several stages, including reading through the data, highlighting instances in the data related to the research questions, and generating case reports for individual participants (Bogdan & Biklen, 1992; Harmon, 1992; Yin, 1994). "Reading through the data" involved a review of all data elements, "reading" the instruments like a book. Initial themes and patterns were identified.

Data were marked-up (segmented) in accordance with the research questions during the next phase of analysis. As the researcher read the data, multi-coloured highlighters were used to mark-up the data according to research questions (see, Ericsson & Simon, 1984, for a description of the mark-up process).

The sections of the scripts related to specific research questions were then coded. A mixture of established and data-driven codes were used during this stage. The "established" codes were derived from other information seeking studies, including information-processing research, information-seeking models, and interactive strategy research. These codes relate to strategies and actions taken by users of information systems. Themes and patterns not readily applicable to established categories were assigned a new category.

At this point, the researcher asked participants to confirm the validity of themes, patterns, and strategies (Bogdan & Biklen, 1992; Mathison, 1988). Inclusion of the participant in the research process is a fundamental element in qualitative research. To facilitate feedback from each participant, individual case reports were generated. Each participant was asked to review the report and to generate questions or concerns for discussion with the researcher. Verification from the participant is valuable in improving the validity and reliability of a study.

One week after the reports were distributed, the researcher met with each participant to discuss the case reports. Results of these meetings indicated a high degree of researcher-participant agreement. Recommendations from each participant were noted during the interviews; where indicated, changes and/or additions were made to the data sets for each participant.

The final stage of analysis involved the collation of data according to the corresponding research questions. Each data source, organized according to research questions, was re-analyzed to match and clarify patterns. Pattern matching involves examination for similarities in the thoughts and/or actions of the participants. Codes were assigned to the strategies in the transcribed protocol. Examination of the coded protocol was undertaken to identify trends in the data. This process, repeated for each participant as well as across participants, enabled the researcher to identify trends in strategies as they related to each research question.

In order to interpret the meaning of participants' actions, the technique of explanation building was used. Explanation building involves returning to the data to seek explanation for why participants thought or acted during the search process. Returning to the data for explanation helped to establish the creation of assertions related to the study.

Analysis of global patterns and trends was necessary to address the overall research question. To assist the researcher in theorizing on a global level, two methods of aggregation were used (Ericsson & Simon, 1984): aggregation by episode and aggregation by process. In aggregating the data, the researcher merges individual cases into one instance. In this study, aggregation was completed around two data points: similar episodes in each search and similar processes used by each learner.

The final stage of the analysis process involved cumulative data analysis, where all trends, issues, and themes generated during the analysis are examined as complete units relating to each research question. From these data, the researcher generated speculations and explanations of the strategies used by learners as they search in hypermedia information systems.

### FINDINGS AND RESULTS

The results of the study were constructed from the theoretical foundations of grounded theory. Grounded theory involves building explanations from the data themselves (Glaser & Strauss, 1967). Pattern matching techniques were employed during the iterative analysis process as a way of making sense of the data. Analysis of the data yielded several assertions.

### Assertions By Research Area

Assertion 1: Perceptions of disorientation affect the strategies employed in a hypermedia information system. Several learners reported feeling "lost," or "being in the middle of nowhere" when they were using the system. This disorientation, in turn, affected search decisions.

Assertion 2: Prior subject knowledge is directly related to concept recognition and affects the strategies employed. Learners with high subject knowledge readily recognized terms related to the search topic. This impacted what they pursued in the system and how they used the program.

Assertion 3: System knowledge has direct impact on the strategies the learner is able to develop as they seek information in a hypermedia information system. What the user is able to do with the system is directly tied to their knowledge and experience with the system. Development of strategies takes time; learners with higher system knowledge were able to develop strategies easier and quicker.

Assertion 4: Level of metacognitive knowledge influences strategy refinement. Learners with high levels of metacognitive knowledge were able to reflect on their process. This reflection enabled them to refine their actions and make better use of the system.

Assertion 5: Self-efficacy affects willingness to engage in hypermedia exploration. Learners with high levels of self-efficacy engaged in more exploration of the system. This increased exploration afforded more opportunities, increasing prospects of finding the desired information.

### Results By Research Questions

Overall Research Question: What strategies are employed in open-ended hypermedia information systems?

This "meta-question" was informed by the secondary questions. However, the findings can be summarized into three trends:

- A variety of strategies are used by learners as they seek information in a hypermedia information system.
- Metacognition, system and subject knowledge affect the strategies used.
- Perceptions of disorientation, as well as perceived self-efficacy, affect the strategies used.

Specific findings are presented as they relate to each research question.

Research Question One: Does metacognitive knowledge affect the strategies employed?

Of the prior knowledge areas examined, metacognitive knowledge most influenced the strategies used while searching using Netscape®. Level of metacognitive knowledge seemed to corresponded to success in system use. Learners who used the system effectively were active information processors and comprehenders who monitored their learning activities (Osman & Hannafin, 1992). They also experienced less disorientation. Mick consistently monitored his thinking and revised his actions accordingly, and also made significant progress with the strategies used and understanding of the search process. Mick engaged in several metacognitive tasks described by Wang, Haertel, and Walberg (1990): comprehension, monitoring, use of self-regulation, self-control strategies, and use of the strategies to facilitate generalization.

All learners reported metacognitive experiences during their search tasks. According to Flavell (1979), a metacognitive experience is any conscious cognitive experience that accompanies and pertains to an intellectual enterprise. His illustration of a metacognitive experience directly relates to what the participants experienced while searching using Netscape®: "To illustrate, you may experience a momentary sense of puzzlement that you subsequently ignore, or you may wonder for some time if you really understand what another person is up to" (p. 908). Both the sense of puzzlement and wondering about understanding were experienced by all of the learners in the study.

Interestingly, the manner in which metacognitive experiences were processed influenced whether, or how, metacognition influenced the search task:

Some metacognitive experiences are best described as items of metacognitive knowledge that have entered consciousness. As one example, while wrestling with some stubborn problem, you suddenly recall another problem very like it that you solved thus and so. Some metacognitive experiences clearly cannot be described that way, however. For instance, the feeling that you are still far from your goal is not in itself a segment of metacognitive knowledge, although what you make of that feeling and what you do about it would undoubtedly be informed and guided by your metacognitive knowledge... (Flavell, p. 908).

This differentiated Mick from the other learners: not only did he have prior experience, his actions were informed and guided by his high level of metacognitive knowledge.

While the importance of metacognitive knowledge is clear, the implications are not. Some advocate teaching metacognition knowledge for skill (Osman & Hannafin, 1992; Wang, Haertel, & Walberg, 1990); others have trained students to effectively monitor their learning (Brown & Palincsar, 1989; Paris, Cross, & Lipson, 1984). Still, the results are inconsistent; recommendations for teaching or training are often suspect. While results of this study confirm its importance, further investigation is needed to determine the best ways to instruct learners in the use of these skills.

Research Question Two: Are perceptions of disorientation influenced by the strategies employed?

The perception of disorientation yielded one of the strongest influences on the strategies employed. High levels of disorientation can lead to dysfunction as well as overall dissatisfaction with the search process. This is not only debilitating, but also serves to elevate frustration.

Alyssa's high level of disorientation and dissatisfaction with the search process provides the most compelling evidence for this conclusion. Her failure to retrieve relevant information, in addition to her use of low-end, basic strategies, suggests disorientation has a seriously detrimental influence in the use of emerging information systems.

This study provided more evidence for the phenomenon: "lost in hyperspace." This occurred independent of the level of reported knowledge. Several researchers have discussed its negative consequences on usability (see, for example, Jonassen & Grabinger, 1989; Marchionini, 1988). Newby (1992) proposed a way to help orient the user, reducing the perceptions of disorientation: involve the user directly in the retrieval process. Newby's "navigable systems" open up the black box, taking the user "behind the scenes" instead of leaving them "in front of the curtain," waiting for the system to return results. According to Newby, easily navigable systems enable the user to directly engage in the retrieval process, which, in turn, reduces the level of disorientation.

Marchionini's (1993) techniques of zooming and browsing are similar to Newby's navigable system space. Like navigable systems, zooming and browsing involve the user directly in the retrieval process: the system zooms into a relevant area of the information space, offering several suggestions that may or may not be relevant to the learner's needs. After moving closer, the learner is better able to browse and select the desired information from what is available. The system does not supplant entirely the effort of the learner, but instead engages them directly in the process of determining relevance.

In some ways, Netscape® provides zooming and browsing capabilities for the World Wide Web. The learner submits a request, after which the search engine scans the Web information space and returns a list of "hits." At this point, the concepts of zooming and browsing break down in several important ways. A primary way that it breaks down is in what is returned. As currently structured, the listing of relevant documents can range from titles of the documents to http:// addresses to ftp sites. Obviously, this makes the list less intuitive and transparent.

One way to overcome this problem might be to standardize how the systems provide feedback to the learners. Several systems have already been developed, such as the standardized retrieval scheme developed by the Library of Congress, which has been tested and evaluated for several years. Standardized searching on the Web, adapting the LC retrieval model, might help to reduce disorientation.

Marchionini's (1993) techniques of zooming and browsing also lose validity in Netscape® in how information is ultimately presented to users. Zooming and browsing can invoke images of movement in a three-dimensional space. As Netscape® is currently designed, a space that may be perceived as three dimensional is flattened to two dimensions. The information space is represented on a flat screen without elements of depth.

This potential "warping" of the learner's mental model can be very disorienting, leading the learner to look for "clues" in the environment to re-orient themselves. Alyssa looked to a map to improve her orientation to the information available. This coincides with Forsyth's (1988) recommendation of a "multi-sensory" approach for facilitating memory -- as well as improving user orientation.

Several options are available, but the theoretical "best" option remains elusive. It is clear, however, that guidelines need to be established if we are to optimize use of emerging information systems (Jones, 1993). The establishment of guidelines, and maintenance within certain parameters, is crucial if learners are to establish useful mental models that assist them in their understanding (Norman, 1983). Until learners are able to engage in natural mapping of these information systems (Norman, 1988), and guidelines are established that ensure consistency and predictability (Wadlow, 1990), disorientation will persist.

### Research Question Three: Does perceived self-efficacy affect the strategies employed?

Perceived self-efficacy affected both the number as well as the types of strategies which were engaged. Those who reported mid-to-high perceived self-efficacy (Bill, Marsha: mid; Mick: high) engaged in more strategies and at a higher level than Alyssa who reported low perceived self-efficacy. This is consistent with studies examining the relationship between self-efficacy and performance (Ashton, 1984; Kinzie & Delcourt, 1991; Murphy et al., 1988), where high positive correlations were reported between self-efficacy and performance.

Perceived self-efficacy not only affects the learner's interactions, but also perceptions of control. System interactions with Bill and Mick confirm this finding; both had higher levels of perceived self-efficacy and were successful in their task. Although Marsha was not successful in her target task, she was able to find useful information; her confidence and high perceived self-efficacy helped elicit this result. Alyssa, in contrast to the others, demonstrated lower perceived self-efficacy throughout. This, in turn, influenced her interactions and strategies, leaving her unsure of where she was or how to proceed, and unable to move beyond basic search strategies.

### Research Question Four: Does system knowledge affect the strategies employed?

System knowledge also affects the strategies used in a hypermedia information system. Participants with low system knowledge engaged in more basic search strategies than those with higher system knowledge.

The level of system knowledge had a stronger influence on strategies used than subject knowledge. This is consistent with Park and Hannafin's (1992) conclusion that the lack of a functional mental model of the multimedia system tends to minimize the value of domain knowledge. While Alyssa possessed some domain knowledge, she had no prior system knowledge. The absence of a functional mental model, as well as an inability to establish one, resulted in very limited success in working with the system and an inability to move beyond basic search strategies. While increased system knowledge may not directly lead to success, system understanding is critical to selecting terms and knowing how to interact. Increased system knowledge can also reduce disorientation and frustration.

Closely related to a subject being searched is the intent behind what is sought in the system. The way that World Wide Web technologies are currently designed makes the environment one of "at your own risk." Anyone can place any kind of information on the Web. In addition, there is minimal structure to the documents. This leaves the user in a position where their intent may not match that of the document retrieved. A "best" solution for this issue remains unresolved.

The ability to use the system influenced the strategies the participants engaged. All participants entered the search task with no prior system knowledge directly related to Netscape®. While Mick reported using other hypertext systems, none had used Netscape® prior to its introduction in class. The two participants who built a functional model for the system, Bill and Mick, were also successful in their tasks and moved beyond basic search strategies.

Bill and Mick were also the only participants able to describe and depict their mental model of the system. Mayer's (1989) work on conceptual models provides an interesting interpretative background. Mayer found that in studies where conceptual models were provided, learners were able to make significant strides in problem solving and understanding. While participants in this study were not provided with a model prior to the search task, those who generated their own conceptual models engaged in strategies at a problem-solving level and increased their understanding.

Consistent with previous research, increased system experience and system knowledge seems to affect the strategies used in the system (Weil, Rosen, & Wugalter, 1990). The participants reinforced this observation through their interactions, and in the stimulated post-search interviews. All stated that, given more time and experience, they were confident that they would be better able to use the system.

### Research Question Five: Does subject knowledge affect the strategies employed?

The level of subject knowledge affected the strategies used in the hypermedia information system. While the participants used a variety of strategies independent of their prior subject knowledge, those with lower subject knowledge engaged in more primary search strategies. These results assist in confirming what other researchers have found: learners with extensive context-related prior knowledge out-perform their cohorts with limited prior knowledge (Langer & Nicolish, 1981; Recht & Leslie, 1988). Osman's (1992) conclusion that the availability of content-related prior knowledge as a powerful determinant of retrieved information was also supported in this study.

The level of prior subject knowledge also affects the ability to integrate and retain new information (Ausubel, 1963). Bill, who possessed a higher level of subject knowledge, refined his search based on terms he previously tried. Marsha, who possessed little prior subject knowledge, refined her search little, using few terms to seek information. While the number of terms used during the search process was not a strong indicator of failure, it could be an indication of the inability to monitor and judge relevance in relation to information sought. According to Ausubel, the ability to integrate and transform information is a crucial component to performance. The lack of integration of the information



the user receives while searching for information in Netscape® would cause conflict in relation to performance and search success.

## RECOMMENDATIONS AND IMPLICATIONS

The implications for creating productive and successful OELEs are compelling. Several studies have been conducted indicating the promise of these systems (see, for example, Harmon, 1992). However, much work is needed to realize the potential of OELEs for learning.

One area that was a significant influence on the learner's successful use of the system was a feeling of insecurity or discomfort. Hannafin, Hall, Land and Hill (1994) discussed this as a significant issue affecting the use of OELEs. In the present study, the second most influential factor inhibiting use of the hypermedia information system was disorientation, which led to discomfort and confusion. The methods for overcoming disorientation and discomfort, as well as for assisting and supporting learners in their use of the systems, remains unresolved.

Another issue arising from this study relates to the design and development of OELEs. While computer and information scientists have developed design models for creating information systems, and instructional designers and psychologists have created design models for the development of learning systems, none seem to satisfactorily support the design and development of OELEs. It is an area rich with significant, but unfulfilled, promise.

The need for guidelines, both in terms of supporting the learner and in developing the systems, is also apparent. Guidelines for placing information on the Web and Internet, as well as indexing and providing pointers to this information, are not standardized. This lack of standardization makes the development of these systems challenging for the designer, and also presents significant challenges to users of the systems as they attempt to create a functional model (Norman, 1983) of the information system. While the researcher agrees with Jones (1993) that "hard and fast" rules are neither feasible nor desirable for these environments, guidelines are necessary if we hope to see the continued growth and utility of these environments.

A final implication relates to how individuals think. A fundamental problem underlying the lack of understanding associated with OELEs is the manner in which "compliant" thinking is shaped by conventional school activities (McCaslin & Good, 1992). Traditionally, education has been a lock-step, highly directed experience (Hannafin, Hall, Land, & Hill, 1994). This engenders learners who lack the orientation, mental models, and strategies (or capabilities for creating them) for these environments (Hill, Lebow, Driscoll, & Rowley, 1994), where divergent thinking, multiple perspectives, and independent thinking are critical.

While educational history was not gathered in the current study, there is evidence to suggest that those learners who developed an orientation and functional mental model of the system proved more successful in their task. These learners used two primary techniques associated with OELEs: divergent and independent thinking. Adjusting the ways we teach to foster divergent thinking and multiple perspectives may assist learners in using these environments effectively and with minimal disorientation.

As open-ended hypermedia information systems continue to grow, both in their capabilities and affordances, the need to understand how to support learners in their use of the systems becomes critical. The promise of hypermedia and OELEs has been widely heralded (see, for example, Bransford et al., 1986; Grabowski & Small, 1991; Marchionini, 1988; Hannafin, Hall, Land & Hill, 1994). Continued research in this area will enable the realization this promise.

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