A Visit to the Information Mall: Web Searching Behavior of High School Students

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This article analyzes Web searching behavior for homework assignments of high school students through field observations in class and at the terminal with students thinking aloud, and through interviews with various participants, including the teacher and librarian. Students performed focused searching and progressed through a search swiftly and flexibly. They used landmarks and assumed that one can always start a new search and ask for help. They were satisfied with their searches and the results, but impatient with slow response. The students enjoyed searching the Web because it had a variety of formats, it showed pictures, it covered a multitude of subjects and it provided easy access to information. Difficulties and problems students encountered emphasize the need for training to all involved, and for a system design that is based on user seeking and searching behavior.

Introduction

Searching the World Wide Web is like visiting a shopping mall the size of Seattle: Innumerable types of information, in a large variety of containers and in many different locations, are all available in one place. To begin explorations about human searching behavior in this information mall, we examined the searching behavior of a group of high school students who visited the Web in order to retrieve information they needed for class assignments.

Although computer-based information systems have been used in school libraries for a while in the form of online catalogs and CD-ROM systems, the Internet is a novelty in many school libraries and is still absent from many more. Nevertheless, studies about students' searching behavior that were carried out with other systems are relevant to the study of Web searching behavior. Research in this area, however, is rather limited. In 1993, a study of trends in school library media research showed that only 22% of the research carried out during 1987–1991 investigated users, their needs, and searching behavior (Grover &

Fowler, 1993). In 1997, Bruce and Leander still point out that there is a need for more and better accounts of what happens when the technology of the future digital libraries is actually used.

To date, only a few studies have attempted to identify typical attributes of online searching behavior of children and young adults. Summarizing the findings of these studies is not an easy task because each study examined users of a certain age, ability, and socioeconomic level. These factors are likely to affect searching behavior and therefore prevent a comparison among the studies. In addition, not all studies describe the tasks the students were performing, yet these tasks are likely to affect searching behavior (Marchionini, 1989).

Studies of elementary-school children revealed that they can use online catalogs (e.g., Solomon, 1993; Hirsh, 1997) as well as the Web (Kafai & Bates, 1997). Yet, they all have difficulties in finding search terms and in spelling. In addition, they preferred sites with pictures when searching the Web. Small and Ferreira (1994) studied middle-school students comparing their searching behavior when using print and multimedia sources. They found that while students searching multimedia resources spent more time and effort browsing and exploring than their counterparts using print resources, their perception of the value added by their resource was higher.

The few studies that examined searching behavior of high-school students arrived at the same conclusion (e.g., Neuman, 1993; Nahl & Harada, 1996). These studies also indicated that in addition to language skills, students lacked information-seeking skills. In her study of the use of an online catalog, however, Chen (1993) found that despite these shortcomings many students found the needed information.

Of special interest here is the use of the Web by high-school students. Based on the librarian's reflections, students' assignments, and the librarian's comments on them, and on other written documents such as e-mail correspondence and essays written for class, Jacobson and Ignacio

(1997) evaluated the Web information-seeking behavior of high-school students of high ability. Among their findings, the authors revealed that in contrast to elementary-school children (Kafai & Bates, 1997) their students employed very clear criteria to distinguish between "good" and "bad" Web pages. In addition, despite their critical view of the Web and their low expectations of its resources in comparison to other library resources, they considered the Web very highly.

None of these studies, however, investigated how students navigated the Web. A related study, which was done in a physical space rather than a conceptual one, may suggest an observation that is relevant to Web navigation. Eaton (1991) examined, in an experimental setting, how children and young adults would navigate in shelf searches. Her strongest finding was that most successful were students who "decentered" themselves, detaching from unsuccessful strategies and continuing in a different way.

Most of the studies in searching behavior were aimed at guiding the school librarian in training and supporting students' searching (e.g., Kuhlthau, 1994). The research project reported here had a different purpose. It analyzed searching behavior of high-school students when they searched the Web for homework assignments. The purpose of the project was to describe the students' searching behavior and to suggest changes in the design of the Web that may improve the students' learning experience.

Research Method

To study the searching behavior of high-school students, a research team carried out a field study at West Seattle High School, Seattle, WA, using observation and interviews. The research project was part of a course about the analysis of searching behavior offered by the Graduate School of Library and Information Science at the University of Washington. The participants in the course, seven graduate students and the instructor, became a research team.

Field activities began after the team members had received training in qualitative and field research methods and after the initial communication with the librarian and the teacher at the high school had promised enthusiastic cooperation. Field activities included: Observation in class and at the terminal with students thinking aloud, interviews with various participants, and team discussions.

Plans were developed for the team to observe three searching sessions. As part of the preparation, the team visited the school and met with the librarian, the teacher, and the students enrolled in a horticulture class. During this first meeting with the class, the team introduced itself and explained the purpose and nature of the study.

The teacher then invited students to participate in the study. The team asked for eight participants so that each team member could observe one student, but only six came forward at first, all males. The teacher then encouraged two female students to volunteer as well.

The following week, the research team reported to the horticulture class and began the first formal observation of the eight student volunteers. The second and third observations occurred during the successive weeks. Each week, the teacher explained the weekly assignment to the students in the classroom. The students then went to the library, and the research team accompanied them. The study participants used computers in a separate computer room located in the library where the rest of the class used the computers or other resources in the library. Each team member sat beside the student she or he was observing throughout the project and audiotaped the student's narration of the search process.

At the beginning of each session at the terminal, each team member asked the participating student two questions: What do you plan to do? and What do you think you will find? At the end, students responded to three questions: Did you find what you were looking for? Is it what you expected to find? How do you feel about the search? Other comments were kept to a minimum and were as non-directive and non-judgmental as possible to avoid influencing searching behavior. Because not all students were present during the three weeks of observation, some performed only two searches in the team's presence. In total, the team observed 21 search sessions.

At the end of the observation period, each team member interviewed the student to obtain background information, insights into that student's searching behavior, and to uncover the student's perceptions about Web searching. The team as a whole developed the script for the interview, but individual members could ask additional questions. The team also interviewed the librarian, the teacher, and the school's principal. All verbal protocols, think aloud as well as interviews, were audiotaped and then transcribed.

The study employed the case-study method with controlled comparison (Fidel, 1984). After the first search, each team member wrote a description of the search he or she had observed based on the transcribed verbal protocols, notes taken during and after the search, and on available paper documents, such as printouts of Web pages the student had used or a copy of the notes the student took during the search. After the second search, each member wrote a report that described the searching pattern of the student as it appeared from observing two searches. At the end of the observation period, and after the interview with the student, each team member wrote a case report describing the searching behavior of the participating student.

Before the completion of the project, each student received a copy of the case report describing her searching behavior. Team members asked the students to make any comments they wished, but most importantly, to determine how valid was the description of their searching. All students were happy with the reports, and all claimed that the reports described them accurately. The teacher and the librarian received a copy of the final report.

The case reports, the transcriptions of the interviews with the eight students, the librarian, the principal, and the

teacher are the basis for the description of the students' searching behavior presented here.

The Setting

The study took place at West Seattle High School. The school has a diverse population of students. About half are students of color, and the majority were born in the United States. Many students are the first in their families to finish high school. In the past, about 60% of the students at West Seattle High School continued in two or four-year colleges after graduation.

The school had four computer labs and a team of students who were technologically proficient. Although the school had no money from its district for computer technology, its connection to the Internet was supported by gifts and donations from organizations outside the school system. Through the project Libraries Online!, which is funded by Microsoft®, the school received a T-1 line, Internet connection, and ten computers with Microsoft's Internet Explorer® browser. The project was managed by Technical Resource Institute (TRI), which provided the initial installation and continued technical support. The librarian felt that the school was extremely fortunate because it was highly unlikely that it, like any other public school, would have been able to purchase a T-1 line from its budget.

When installing the network, TRI personnel involved students from the Computer Club and trained them to become experts in computer technology. These students were a local resource for the library. The librarian depended on them and claimed that when these students graduated, and if no other students are trained to replace them, it would severely affect the library's ability to manage its technology. Both the network and the computers were available for community use on evenings when the school was ordinarily closed.

Students as well as teachers had shown great interest in the Internet, and the librarian encouraged and supported both. Indeed, it was used for many classes. In addition, since the Internet had been installed in the library, circulation of library material almost tripled. The librarian explained, however, that the situation could be improved with additional clerical help in the library, which would increase her involvement in training and planning, and with a separate budget for the operation of the computers. At the time of the study, she noted, she had to decide: "Do I buy five reams of paper [for printouts], or do I get books?"

The librarian had received some training in the use of the Internet, but she believed in hands-on learning: "The more time you have your hands on it," she explained, "the more it makes sense." She thought students did not receive enough training, and she did her best to guide and train them on the spot. Often she personally trained students on a one-on-one basis. The pace usually became hectic, however, when many students needed help. Commenting on President Clinton's inaugural promise that every 12 year old would be able to log into the Internet she said "Logging onto the Internet is not the deal; it's finding information on the Internet." Therefore, she promoted library and Internet use among teachers as well as advocating training for students.

The librarian explained that students' knowledge of searching depended on how much the teacher who assigned work on the Web introduced them to searching. Indeed, the team found out that none of the students who participated in the study had ever received formal training in Web searching. Half of them had taken a computer applications class, but only one student recalled learning something about the Internet. Similarly, half had computers at home, but only one had Internet access. Most of the other students had access to computers in the public library or in friends' or relatives' homes. Generally, all the participating students had experience with using computers in other classes, and all but one had searched the Internet for assignments.

The teacher believed that Web searching was very useful for the horticulture class because of the limited resources available at the school's library. His experience showed that students could find the information on the Web for the assignments, and that they became better at it as the course progressed. His purpose in the assignments was three-fold: to help students find information that might not be available in other sources, to show them that the Web had information about science in general and about horticulture in particular, and to help them practice Web searching.

In preparation for the class, the librarian gave a short hands-on introduction to Web searching, explaining how to log in and out. In addition, she often participated in class sessions, pointing to useful clues for the assignment of the day. The teacher was also available to help students when they were doing their assignments in the library. He believed, however, that formal training in a classroom setting would have been highly beneficial. Unfortunately, no resources were available to carry out such training. He himself had very minimal experience in searching, and he wished he could have had time built into his day to learn and practice more.

The first assignment the team observed asked the students to identify a specific plant which grew in the Pacific Northwest, to provide a picture or a sketch of the plant, and to answer questions about that plant such as its genus/species name, common names, origin, uses, and historical significance. The second assignment included a list of three Universal Resource Locators (URLs) for horticultural sources. Students were asked to describe five sources by recording the name of the source, briefly describing the layout of the source and the information it offered, and explaining how they might use the source in relation to the horticulture class. The third assignment was identical to the first one, but this time students were asked to select a state flower. During the time students were working on the third assignment, they were also engaged in another assignment: Looking for pictures of five specific plants.

The Participants

The eight students who participated in the study were typical of the students in the school. The librarian noted that most would come to the library only for a class assignment. Five of them were in the 12th grade, and three were in the 11th. The six boys and two girls were from varied ethnic backgrounds, and half said they planned to go to college, three to the trades, and one to the army. Some of the participants had more experience with computers than others. Some were expert surfers and others surfed only occasionally or had no experience in surfing. Although all had used the Web for class assignments before, they had very little experience in information retrieval and had no knowledge about the subject area. Most did not like school most of the time.

When asked how the Web works, two students simply declared that they did not know. Among the remaining six, four thought that a central body deposits the information on the Web for the rest of us to search, and only two suggested that users can be authors as well. As one of them explained: "There's like a master program or something and everyone just puts information in, and it can be sent out to all the computer systems that hook up to it." The other emphasized the existence of a central place to which all individual contributions were delivered and which then sent the information to all users' computers.

Given that Microsoft donated the computers the students used, and that they were searching with Microsoft's Internet Explorer®, it was not completely surprising to discover that half of the participating students believed that Microsoft was responsible for the information on the Internet. Four students assumed that Microsoft collected or generated the information, and stored it on its computer, but their opinions varied about the level of control exercised by the company. While two saw Microsoft involvement on the technical level only, the other two suggested that the office of Bill Gates selected the information on the Internet and directly monitored its use.

Several participating students had experience with surfing and chatting on the Web. The task the research team observed all students carrying out was very different: Finding information for a class assignment. In other words, the team observed teenagers who had spent much time window shopping and hanging out in the information mall. Now their task was to get particular items for their teacher, items about which they had heard for the first time.

Preparation for a Search

Unless students were otherwise occupied, they went to the computer room in the library immediately when the teacher released them. A few times they were already sitting at the computer and searching when team members arrived with their tape recorders. One of the great advantages of the Web, the students explained, was the ease and speed of use: One could just type in the words and then click; no thorough preparation was necessary.

In fact, one of the reasons students preferred the Internet over the school's library, they claimed, was just that: Immediate access to information. One student summarized this approach: "It's easier on the Web, especially if you're lazy. It's easier because . . . it's just sit and click, . . . and just see what you get." Another elaborated: "[In the library] first you have to find out what you're looking for. Like, maybe I want a book on baseball. Got to go through the card files, find the baseball, go through all the aisles, look for the book. . . It's boring! With the Web, just type 'baseball' and it just gives you a whole bunch of information about baseball."

The interactive nature of the Web supported the students' belief that there was no need to plan ahead because the progression of a search would be largely determined by what they saw on the screen. This principle was clearly reflected in their searching behavior, which was highly reactive. Yet, even though they claimed to have no plans, and most explained that they did not prepare for a search at all, they all had some idea how they would start to search.

All searches began with clicking on the *search* button after entering a string of characters, either keywords, or a URL, most without selecting a search engine. No student had started a search by clicking on a subject category. To some students, the easiest search was a URL search, when the class assignment designated which sites to visit. Such assignments required no preparation at all, one had only to type in the address. A subject search, however, required some preparation. When no URL had been given, some students prepared themselves by thinking about the subject. One student explained: "I don't write anything down on paper; I'm thinking in my head, in my mind, 'Okay, this is what I need to look for, so as soon as I get on there, I am going to search for blah blah blah, and see what I get.'"

For three students, subject searches meant a bit more planning. One claimed that he always liked to get a couple of ideas in his head about what he was looking for and just try to type in the topic, and if that one didn't work, he would try the other idea. Another student explained that he would start with a name, and if it didn't work, he would make the search more specific by adding words in the *search* box. The third believed in the opposite approach. He first used the most specific combination of terms. He appeared to plan the search while typing and before clicking, assuming that the more specific the statement in the *search* box was, the more likely he was to find good sites.

In addition to strategies for actual searching, most students had strategies for starting a search.

Follow Past Experience

Several students assumed that a previously successful search should guide them in a new search. They relied on their past experience to determine the best way to start a new search. Some would usually begin a search with a URL and others with keywords. Frequently they entered a URL to a site they had visited before, or keywords that had worked well in a previous search. One student, for example, started

a subject search with a URL that was given in the previous assignment, even though the URL was for a local daily newspaper and the new assignment asked students to find horticultural information about a plant. Another entered several keywords he had used in the previous search, even though the new assignment provided URLs and asked students to evaluate their sites.

Follow Others' Experience

Most students were glad to be told where to start searching, that is, the best words to type in the *search* box. At times, they asked classmates for suggestions or volunteered information themselves. A few students would not begin to search before they asked the teacher, librarian, or their classmates where to start. This strategy, they assumed, would support efficient searching.

The Search Process

For the participating students, searching was both a social and an academic event. They conversed with one another while searching, asking questions and giving advice. This mutual assistance was encouraged by the teacher. Their interchanges covered many aspects relating to searching, ranging from technical pointers to tips about searching to interpretations of the questions in the assignment, and all intertwined with social intercommunications, mostly verbal, typical of students their age. These interactions made the computer room a lively and busy place.

With no formal training in Web searching, most students had no information about the various search engines. Two exceptions stood out. One student always started a search with selecting the Webcrawler because this was the engine she had learned in the computer applications class. She also changed search engines to speed up a search, a move which seemed to work, but she did not know what the other search engines were, nor their characteristics. Another student had very definite ideas about search engines and their attributes. He explained that Yahoo!, for example, is for entertainment and Magellan or InfoSeek are for more scientific material. When searching, he mentioned a couple of times that he could choose another engine, but in reality he always used the *search* button without selecting a search engine.

Although each search had its unique characteristics, we discovered several common patterns in the students' searching behavior.

Focused Searching

Regardless of their beginning strategy, all searches, from initiation to completion, were highly focused. Their purpose was to find lines on the screen that would answer the questions in the assignment. In other words, students looked for information to fill in the assignment's "blanks" and did not deviate from this task.

This assignment-centered approach was manifested in a variety of ways. All searches were guided by the assignment sheets, and students constantly referred to them. Students kept exploration to a minimum, and resorted to this path only when they assumed it to be useful for finding missing information. Similarly, they ignored entertaining diversions on the screen, such as moving images or scrolling news reports, because these usually did not contribute information relevant to the assignments.

In hope of finding an efficient route to the answers, some students took a conservative approach and consistently followed the teacher's instructions for the first search strategy, whether or not it coincided with what they would have done on their own. One student, for example, started a search with the school library's URL, saying "I think that's where they want us at," even though he regularly started a search with keyword searching. Another, closely followed what the teacher wrote on the blackboard and entered "Ash (Oregon)" in the *search* box even though he did not think the Web would have it the same way.

In some searches students took somewhat drastic measures to stay within the bounds of the assignment. For instance, they changed the topic of a search if they could not find the needed answers easily. This was clearly manifested in the two assignments in which the students were asked to choose a plant and then look for information about it. During the search, it was not unusual for them to change their minds about the selected plant if they thought they could not find the required information about the chosen one. In fact, some students tried several plants, one after the other, before they completed their assignment. The most important task was to find the information requested; the specific plant was a secondary issue.

Similarly, students recorded information of any type as long as it could answer the assignment's questions. Many sites retrieved for the plant assignments were commercial in nature and were geared to the gardener rather than to the student in a science class. Nevertheless, these sites often included information that was relevant to the assignments.[1] For example, in response to a question about the growing specifics of mistletoe, one student wrote: "Grows by vibrating in coastal breeze." Another recorded on his assignment sheet that the blueberry bush "makes a nice hedge" as an answer to a question about the uses of the plant.

Students also used the assignment requirements as filtering criteria. One student, for example, would not view any page that did not have graphics if the assignment required a picture of a plant. Content was not the only consideration; she was looking for a Web page which would best help her complete the assignment.

For an efficient completion of the assignments, students most often copied the relevant lines from the screen directly to their assignment sheets or their note paper (which was

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[1] In fact, students perceived the diversity in the Web sites as one of the Web's strongest advantages, as explained later.

used at times as the final version of the assignment to hand in). On very few occasions did they print out text, and usually not before they read the text carefully on the screen to make sure it included all the information they needed for the assignment. They printed out pictures only when the assignment asked for a picture of a plant.[2]

Swift and Flexible Searching

Dedicated to their aim of completing the assignments, almost all students made quick decisions about where to click next, and whether or not a site was relevant. Most scanned sites quickly before they clicked to move. If there were too many sites to visit, or if there was lengthy text on a page, most students usually skimmed quickly through each site and then moved on. Situations in which many sites had been retrieved, but none of those visited first were helpful, were frustrating. Students did not have much tolerance for long lists on the *results* page and moved to another place. As one of them explicated: "They are just giving me the run around."

Thus, searching for information involved much clicking and moving swiftly from one site to another. To keep up the pace, some students usually determined the relevance of a site by what appeared on the first screen of a site. They rarely scrolled to the bottom of a Web page.

To uncover the clues they used to help them scan the information on the screen so quickly, the team asked the students to explain how they determined the usefulness of the information on the screen. Although a couple of students had difficulties articulating their criteria, others were able to describe specific methods they used to assess the potential value of the information on the screen quickly.

Most students used the graphics on a page as a clue to relevance and quality. As one of them explained: "If it looks like a good picture, I'll read it." While it was difficult to define the meaning of "good" in this context, one student claimed that pictures can give hints of what the page is about. Another student provided an example: "It depends on what you're looking for. Like, if I wanted to look up music, I would type in 'rock music.' And [if] the home page was a bunch of guys with guitars and the drums, and I like rock music, that's going to interest me to go to the next page and see what it is. But if I say 'rock music' and all I see is an album cover, I'm hesitant to keep going."

In addition to the graphics clues, some students used the amount of information in the site as a measurement of quality. They wanted a site to include all the information they needed. They did not want to spend time on sites that were only one paragraph, or that gave only basic information but no details. The horticulture teacher had a similar approach. He said that he evaluated a Web site by whether

or not it included the information he had expected it to include, and by the graphics.

Landmarks: "If You Get Lost, Go Back a Couple of Times, Go Home."

With the Web's vast territory to cover, students boldly forged ahead, clicking on new links and looking for new sites. Yet the *back* button was used most frequently in almost all the searches we observed, because students spent a considerable amount of their searching time going back to safe and familiar sites.

The progression of a search was rarely linear, with each site leading to one new site. A typical search progressed around a home base, or a landmark, to which a student would return to continue the search. Arriving at a landmark, students started excursions in search of information. When they got lost, they returned to the landmark, using the *back* button, to start a new excursion. Students explained that when they got lost, they clicked back to find "home," their "comfort zone," or their "starting point." One student said she would click the *home* button if she thought she was too far away from the landmark, rather than going back step by step clicking the *back* button. Another explained: "I click back or click home . . . until I can find out where I am."

A landmark could be changed during a search, and one search might have more than one active landmark. Some students used the same landmark for all their searches, such as the *results* page. For others it was different for every search. They might select, for example, the last site that was useful or a site with a *search* box. But students always used a landmark the same way: As a home base to which they could go to get their bearings and start anew.

Several students used the *results* page as their landmark for most searches. Some clicked back to it, and others just started a new search with the same keywords, expecting to see the same *results* page as before. The latter approach usually did not work because search engines were selected randomly for each search, leading students to different *results* pages, with their landmarks never to be found. Such situations generated anxiety and frustration even among the students who understood why they did not land on the same page.

Although students did not always articulate their feelings, it seemed that having landmarks in a search was an important safeguard. One student explained: "I have a thing with like traveling everywhere, and then I will just forget where I was before, and then I can't find my way back, and that's the hardest thing." The fact that most students began their searches with either keywords or a URL they had used before can also be interpreted as evidence of the students' strong need for a familiar home base.

Students frequently identified their landmarks through graphical clues. One student, for example, was clicking back to "the one with the moving feet." Another student frequently selected as landmarks sites that included a graphical *search* box, that is, a window and a button next to it. Yet

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he let sites with "Keyword Search" links pass by. In one search a student spent considerable time exploring unproductively a "wrong" site because it had similar graphical features as the landmark and was also linked to it.

One Can Always Start a New Search

When all landmarks had been exhausted with no satisfactory results, and usually before, students went back to the initial page to start a new search. This approach was supported by the teacher whenever students asked him to help. He explained: "I've found, if they have a window that's not giving them very much information or not even in the right place, I just go right back to *start.* I say, 'Let's back all the way out of this and start over.' Because I feel, for myself, that's my comfort zone. . . Let's go back to word search and try it again." A new search required new search terms, and students were very resourceful in finding such terms, given the limited knowledge they had in both the subject matter and the search system. This was probably the most challenging and frustrating part of a search, and one that required most help.

At times students made attempts to express the same concept in different ways, and at others they started a new search with a new topic. Some students always entered the search terms that were given in class and would not think about new terms. They would rather change the topic—for example, look for another plant—than try to express the concept in different words. For those, a new search was always about a new topic.

Students who attempted to keep to a topic used two tactics: They entered more terms or different ones, and they typed in spelling and orthographic variants. Entering additional words usually resulted in a more specific search, but students rarely searched for topics more specific than their original ones. When a search for "onion" was unsuccessful, for example, a student entered "origin of the onion," which reflected one of the questions on the assignment sheet. Not all multiword search statements were more specific, however. For instance, in the same search for information about the onion, the student also tried "fruits of the Northwest"—a concept intended to be broader than onion. Whether narrower or broader terms, all were within the topic of the assignment.

When students entered different terms altogether, they were either more specific or more general, but they were always within the confines of the assignment. After a search for "Northwest plants" was unsuccessful, for example, a student entered "Idaho plants"—a search that could still find a Northwest plant because Idaho is part of the Northwest. Finding such new terms presented a challenge to most students. In a search about the Oregon ash, for instance, a student wanted to enter a broader term such as "Oregon trees," "Oregon bushes," or "Oregon flower," but did not know what kind of a plant would be correct in the ash case.

With such limited knowledge, a student might be ready for radical actions. Indeed, one student changed his whole search strategy because of a fruitless search. In the search about a Northwest plant, after repeatedly using the same strategy "[state name] plants" and coming up empty-handed, he decided to step back and try to obtain the information from a different angle. He decided to use the simple term "plants," find a plant, figure out from what state it was, and then go from there. Most students, however, tried a new search with spelling and orthographic variations. They changed the order of words in an expression, switched upper case letters to lower ones, or changed the spelling of a word.

Students were very aware that spelling, in a URL or in a search term, could make or break a search, and they frequently checked their own spelling. Yet, difficulties with spelling prevented more than half the students from pursuing a desired path at least once during the observed searches. Most encountered difficulties in spelling URLs, some of which were long and included both letters and numbers as well as unfamiliar strings of symbols. Several times students gave up trying to go to a promising site because of these difficulties. In addition, there were instances in which students did not type in a term full of promise because they did not know how to spell it.

To add to the students' frustration, the search system and some sources had obscure rules that interfered with searching without any explanation. For example, a search for "ash" produced an "error" message because the source did not accept search terms with fewer than four letters (as the team discovered later). The same horticultural source had no matches to "water lily," a term which the student entered with several orthographic and spelling variations. Another barrier was the categories used in certain sites, which did not correspond to the assignments' questions. This was especially apparent when some sources were designed for gardeners looking for seeds or gardening ideas and suggesting links such as "flower color" or "bloom season." Such links were obviously not helpful when students looked for academic information about flowers of the Northwest.

It should be noted that Neuman (1993, 1995) identified similar problems in her studies about high-school students searching bibliographic databases.

Always Ask for Help

With all these obstacles to searching, it is not surprising that the students actively and constantly asked for help from the teacher, the librarian, and their classmates.

During the observed searches, the librarian and the teacher made themselves available to students. The librarian was busy all the time, circulating among students and helping them. When looking for assistance, students most often asked whomever was closest to them, frequently another classmate. In reality, there was only one librarian but plenty of classmates around who might have the answers. The students explained, however, that their first choice for help was the librarian.

It seems they believed that the librarian knew all the answers. In addition to questions about how to find information, students asked her questions about the assignment and about the topics they investigated: "Does this sentence talk about the uses of a tulip?" "What is the difference between yellow lily and water lily?" "Did I do enough to finish the assignment?"

Most frequent, however, were questions about how to find the information needed for the assignment. When students asked for help, most often they wanted to step back and let someone else direct their action. Some also believed that the librarian knew exactly where the information was and could lead them directly to it. Students, therefore, asked questions such as: "Where do I go from here?" "What do I type here?" "Where am I supposed to go, what page?" "Which URL should I try?" "Where should I start?" or "What do I need to do to get the information I need?" They also believed that the librarian knew what were the best sites for them. One student remembered in the interview: "When I was looking up flowers, I'd go in the flower place. But . . . [the librarian] suggested something better that you could probably find more information. She suggested to me to go in the Virtual Garden, and there was more information there, so I thought that was helpful."

Almost all students wanted to receive most directional and specific help. However, one explained that she would have preferred to be guided so that she would do the search herself, and two clarified that by observing how the librarian solved their problems they could learn new strategies that would help them in future searching.

Ending a Search

About half of the assignments were completed in one session. For the rest, students needed to look for some more answers. Some explained they would perform another Web session later on, but most turned to books for unfinished assignments. As the course progressed, students became aware of useful print sources that were recommended either by the teacher or by their classmates. They knew which print sources in the library included the information they needed for the assignment and had an idea of what type of information each source had. Some decided to switch to these printed sources instead of searching the Web, and others wanted to complement Web searching with information from print sources.

Regardless of what portion of the assignment was completed during a session, students were always satisfied with their searches and the results. While they could point to general problems with Web searching, they never felt that they could have done better searches. In fact, when asked in the interview if they would like to learn how to search the Web better, most students thought they already knew what they needed to know, at least for that time. Some mentioned that maybe in the future they would be interested in learning more about Web searching.

Students' Opinions about the Web

After searching the Web for the horticulture class, as well as for other activities, the students had definite attitudes towards searching the Web. They willingly explained what they found frustrating about the Web, what they saw as its advantages, what types of searches were the most satisfying, and how the Web could be improved.

Sources of Frustration

One of the most appealing qualities of the Web to the students was the speed in which they could find information. It is no wonder, therefore, that their greatest frustration was caused when the Web failed to produce results quickly. This happened when response time was too long or when they could not find the information, even though in their opinion it was there.

All students understood that searching the Web required patience. Yet all were highly impatient with slow response. "This is making me mad!" or "I don't like to use the Internet because it's slow; I hate it!" were typical and immediate answers to our question about problems with searching the Web. It was not uncommon for a student to abandon a search and begin a new one if a response did not appear in a reasonable time.

Similarly, students were frustrated, and at times impatient, when a search was not successful after what they thought was a reasonable time. "It is frustrating when you cannot find something that you're looking for," explained one student, and another mentioned that it was particularly difficult when one knew the information was there but had to search and search and search. A testimony to this difficulty surfaced during the searches we observed when one of the most challenging tasks was to find a picture of a certain plant. Students arrived at various sites with pictures but often could not find the specific picture they needed. Because they saw pictures of other plants, they assumed that a picture of their plant must be on the Web.

Some students became highly irritated when a click on a link brought them to a site under construction or to one that had been moved, or when a browser could not open a site. "I hate it when they have something up there and it ain't there," asserted one of the students after he patiently waited for a slow response which led to a dead end. "If they don't have it, they should take it off!" he declared. An additional hurdle to fast searching is the public nature of the computers at school. Although West Seattle High School was relatively well endowed with computers, students at times had to look for free computers or wait until other students were finished. With strong feelings about the lack of immediate access, one student protested: "There are too many people in there and you gotta wait forever just to get in or you just can't get into it. That's foul."

Another hardship for some students was the URLs. Some were difficult to type, and a few that were given to them were simply wrong. While these might appear as minor

technical problems that could easily be corrected, they were a major source of frustration because they brought a feeling of helplessness. There was no way for the students to work around or reason through problems such as these.

One student, who is an active Web surfer and a participant in various chat rooms, mentioned that one of his difficulties was his limited access to the Internet. To participate in contests or in other rewarding activities, he explained, one had to have an e-mail account, or to subscribe in other ways that were not open to him.

The Joy of Web Searching

In spite of the frustration that can be brought by Web searching, the students who participated in the study enjoyed searching the Web for several reasons.

Students mentioned that they liked the Web because of the diversity in formats and levels of specificity on the Web. In their searches for the horticulture class, for example, they found scientific as well as popular and commercial sources and appreciated being exposed to this variety. They believed that the Web had all types of information. They liked the way the Web gave details of things one found and the interesting little sites at which they could look.

Some students liked the Web because it showed pictures, and others liked it because of the multitude of subjects it covers. "It has everything about everything," they said. A couple of students enjoyed the Web because they believed it enabled them to go around the world and look for anything, and then to get to see things and learn about things about which they never knew.

We asked students to compare library and Web searching, and to explain where they would look for information for their next assignments. All the students who participated in the study said they would use the Web for their next assignment. About one-half said they would go to books as well, either after they finished extracting the information from the Web, or because they already knew certain books that could provide the needed information.

The main advantage of the Web over the library was the ease of accessing information. Following the law of least effort, students explained that one might need to look in several books to find information about a topic, whereas all the information was in one place on the Web. This one-stop-shopping convenience of the Web was extremely appealing to most students. But Web searching can also save physical efforts. First, to find a book on the shelf requires effort. Second, if one closes a book, one needs to look through the index or table of contents and then turn pages to find the desired page. On the Web, one can just click and get back to that page.

One student observed that "harder" questions are easier to search on the Web than "easier" ones. His experience in the class taught him that if the assignment was about a well-defined and specific topic, such as a Latin name or the growth area for a certain plant, it was difficult to answer with information from the Web. However, if the topic required a search for information about more general concepts, such as how an information source was laid out, or about concepts for which they could use their own decisions and judgments, finding useful information on the Web was easier. In other words, it was difficult to find information on the Web if one knew what one wanted, but if one were not completely sure, finding information was easier because one could decide what is relevant based on what one could retrieve.

Students also believed that information on the Web was more up-to-date than information in books. This made sense, they reasoned, because it was easier to update information on the Web than to publish a new book. This argument, if not new, has played a central role in advocating the use of the Internet for students' homework because most school libraries are underfunded and are likely to have books with out-of-date information.

One student claimed that whether to use the Web or a book depended on the nature of the question. He explained that if he needed to find some information about, for example, Martin Luther King, the library would have a book, and it would take him two seconds to find specific information about him, such as his birth date. But to find the same information on the Internet would take several trials and much clicking. Another student proclaimed the end of the book era. He preferred to use the Web exclusively because "It's the tech age and that's what everyone does. There's nothing wrong with books but ... that's more the old school. Now with the computers ... you're going to see a lot more people forgetting about the books and the Encyclopedia Britannicas, the big book shelves and everything. Because the computer is just easier to use and people don't like to struggle. They like to be able to get what they want and get it fast."

This student happened to be an avid reader of books. Another classmate of his mentioned that she was devoted to the library because it was a place for reading. Among all the praise for the Web, one student suggested that it was easier to find pictures in books. He mentioned that if one used an encyclopedia, for example, one would most often find the picture needed, which was not the case with the Web.

Several of the participating students also had experience in surfing the Web. They all agreed it was much more fun when they were not there to look for a specific thing. They definitely preferred to have the free time to go there to just surf and not to have to concentrate on one thing, like an assignment for a teacher.

How to Improve the Web

Most students could not see how the Web could be improved, except for working faster and having shorter URLs. This is not surprising for a group of people who had received no formal training in searching and who had a limited understanding of the way the Web works.

Three students, however, could articulate how improved Web design could help their searching. Two of them sug-

gested improvements in navigation, so they could go directly to where they needed to be. One even declared that she did not like to browse. Although both were unfamiliar with concepts or terms associated with navigational structures, one suggested a hierarchical structure using an example, and the other asked for clustering within lists of results.

A third student lamented the large amount of useless information on the Web. He felt that some central authority should develop standards or guidelines by which all Web pages would be evaluated and approved before publication online.

Advice about Searching the Web

To elicit advice from students about how to search the Web, the team asked them how they would explain Web searching to a grade-school student. One student thought that she would not be able to help a novice searcher because she herself was "still kind of lost in the Internet." Another said that it was hard to explain and he would basically just show the novice what he himself already knew.

Another student also maintained that he would teach by actually showing how to search, but he added a general principle. Being concerned that a grade-school student might be afraid of the computer, as he himself had been, he repeatedly emphasized the importance of assuring the novice that the search is simple and keeping it so. His recommendation: "Just go with the flow; just click on something."

The remaining five students were a bit more specific in their instructions. Four of them explained that a search would begin with typing in a word or a topic. One of those students suggested preceding the topic search with the selection of a search engine. The fifth student suggested that it is best to type in an address because then one can go directly to a site. His advice was to be aware of the addresses of sites while searching, possibly writing them down, because one might want to go back to a site. The same student also observed that, when searching by topic, one should start with the most specific terms possible. The next step, they all explained, was to click in the results list on the title that best fitted what one was looking for.

Generally, students had difficulties describing search strategies. Only one student addressed the dynamics of the search process: "If you want to go back, press the button up here and you go back a couple of times, go home. Maybe you want to look at a different [site]."

Discussion

The participating students were "average" youth. They were not a selected group of high ability or college-bound students, but a representation of a social cross section. Some will go to college and others to a trade school or the army. Nevertheless, the description presented here cannot be generalized beyond the searching behavior of the eight student volunteers. Even with this limitation, the description still raises several issues of general implications.

The main goal of the study was to understand and describe the students' searching behavior, and, based on that understanding, to recommend changes in the design of the Web that may improve a student's learning experience. During the study, however, the team observed that several steps can be taken now to help students to search productively, and to have a positive learning experience, with the current Web system. These steps are discussed first.

The Need for Training

The participating students had a very difficult task to perform. They were to find information about completely new topics and at the same time to learn how to find information and how to explore, that is, to learn how to search the Web. These two tasks were very different in nature. Exploring a new topic was a conceptual endeavor, and learning how to search the Web had strong technical components. The students could concentrate on one aspect only when they felt stable in the other, and they rarely concentrated on both in a search. They tried new ways to search a topic only when they felt confident in the technical aspects, and when they encountered technical difficulties, the conceptual aspect became a minor issue. Similar observation was made by Pitts (1995). She found that when students encountered problems in assignments, they tended to try skills from the domain, or "learning strand," in which they had most prior knowledge.

It seems, therefore, that learning both new academic material and how to search the Web is not likely to be optimal if performed simultaneously. Although no student articulated this problem, the teacher pointed out a difficulty he himself encountered when helping students: ". . .It left me feeling kind of frantic sometimes because I'm trying to go back and forth from very technical to [helping with the content of the assignments]."

Knowledge of one aspect can be extremely helpful even if the other aspect is new. For example, when a student received no retrievals for "Oregon ash," it would have helped her to have some basic information about the plant. Knowing that it was a blooming tree, for instance, she could have entered the broader formulation "Oregon trees" or followed a link such as "blooming trees" without dealing with technical issues. Familiarity with searching the Web could have helped her to explore this new concept as well. If she knew how search engines worked and whether or not they were case sensitive, she would not have tried to use different combinations of upper- and lower-case strings, or rotating word order. In addition, she could have focused on a collection of Web resources that directly related to horticulture and thus increased her chances of retrieving information about the tree without knowing much about it.

In addition, students who taught themselves Web searching did so by looking for information about various sports and entertainment fields in which they were interested. One student, for example, found out that if one cannot retrieve anything about a topic, one should try a related topic and the

retrieved pages may include information about the original topic. He discovered this searching "trick" when looking for information about baseball players. Another developed some basic strategies when looking for sites about rock music.

This finding shows that being somewhat knowledgeable of the topic being searched is necessary for learning how to search the Web, and that being somewhat knowledgeable about Web searching is necessary for exploring new topics. Because many school assignments involve exploring new concepts and topics, it is obvious that training students in Web searching is necessary for optimal learning of new topics. The study Neuman (1993) carried out of students searching bibliographic databases online and on CD-ROMs arrived at a similar conclusion.

The research team had the opportunity to observe first-hand the waste, inefficiency, and frustration that were generated when the participating students tried to collect information on new topics with no formal training in Web searching. The standard the students adopted was the bare minimum—just find something to fill in the assignment's blanks—but they put much energy and creativity into fulfilling this basic task. As a result of this experience, the team's first and strongest recommendation is to provide teachers and students with formal training in Web searching. The team believes that without such training, the introduction of the Internet into schools will not help to improve learning and may even help some students to develop unproductive learning habits.

The need to integrate information-seeking skills into the curriculum is not new. Based on her studies, Neuman (1995, 1997) analyzed a wide range of issues and recommendations related to the design and use of electronic information resources with high-school students. For example, she found that the most important problems students encountered in retrieving information were (a) finding search terms and (b) designing effective strategies. She then suggested topics that could be covered by the curriculum to address these problems, and instructional strategies to deliver these topics. Earlier, Eisenberg and Berkowitz (1990) developed a systematic information–problem-solving process that can be integrated and linked to the curriculum. Our investigation of Web searching clearly points to the need for training beyond the technical competencies required for Web searching, and thus emphasizes the importance of integrating information-seeking skills into the curriculum.

Training would help teachers and librarians to think of new ways in which students should view information. It is likely that most students with no training would view information on the Web simply as a means for completing an assignment. In this case, they would view the Internet as simply another textbook: Look up the correct topic in the index, find the right page, and copy down the necessary information. With training, teachers could think of ways to use the possibilities of the Internet to challenge students to learn, not just to retrieve bits of information for assignments.

Training would also help both teachers and students to prepare for Web searching. Teachers would be able to discover what types of assignments warrant a Web search, and what types are better answered by other sources. Students could be proactive and plan their searches before they go online, rather than being reactive and be guided only by computer responses.

The importance of training is not a new issue, and although most participating students did not think they needed to learn more about searching, both the librarian and the teacher as well as the school's principal, pointed out that their students needed formal Web training. A major obstacle to Web training is the lack of funds. While both Federal and state money, as well as private funds, are being invested in upgrading technologies in school libraries, very little resources are allocated for training students in the effective use of this technology. The research team believes that training should receive top priority in funding.

The Need for Support in Searching

Even if the participating students had received training, they could have benefited from various types of support which would have made their searches more productive for learning.

To help in the conceptual aspect of the search, the students could have used knowledge tools such as an encyclopedia and lexicographic aids. Consider the case of the student looking for a picture of the Oregon ash. After failing to retrieve any results with the name of the plant, she wanted to know what type of plant it was, so she could search for "Oregon trees" or "Oregon flowers." She could find no search strategy that would find this information on the Web. If she could have clicked on an "encyclopedia" button on the screen and be linked to the appropriate entry, she could have found information about the plant that would have helped her to find the picture she needed.

Easy and immediate access to an encyclopedia may also help at the beginning of a search. Before one explores new territories, it is useful to have some basic information. An encyclopedia can provide some facts before one embarks on finding detailed and specific information about a topic. When such a knowledge tool is in place, teachers can ask students to use it when planning a search. Without such a tool, it might be difficult to plan a search on a completely new topic. While such tools are available on CD-ROMs, the students in this study did not have direct links to such tools.

In addition to an encyclopedia, a synonym finder and a thesaurus would have helped students to find new terms when all the words they knew could not produce satisfactory results. Indeed, some search services already provide this type of help, such as LiveTopics with AltaVista. Currently, word associations are derived from the text that is stored on the Web, but future research should investigate the use of dictionaries, synonym finders, and thesauri that already exist in print or in machine-readable form. Most promising are thesauri that designate explicitly the type of

association between each two concepts. It would also help the participants of this study if these tools could be accessed by clicking rather than by typing (e.g., Johnson & Cochrane, 1995).

To help navigation, Web browsers could provide a space to "shelve" a landmark. The participating students employed the *back* button to go back to a landmark, or they clicked *home*, which usually took them to another place. While they seemed rather successful in finding their landmarks, they usually spent extra time on that task and at times could not find their landmarks. With current Web searching capabilities, the students could have created bookmarks for their landmarks. This, however, might not be a viable option. First, it was the team's impression that most of the students were not familiar with the concept of bookmarks. Second, since landmarks play a role for a relatively short time, for only a segment of a search, each search may generate several bookmarks. Imagine the number of bookmarks a publicly available search site, such as a high school or a library, would have if each user created even one bookmark per search. And how would a user find her or his own bookmarks next time around? It is quite clear, therefore, that creating a bookmark for each landmark is not an efficient way to return to a landmark.

It would have been of help to the participating students if they could have gone back to a landmark with one click. Their navigation would have been much better supported if they could "put" a landmark on a shelf and just click on it when they needed to go back. As Hearst (1997) demonstrates, this is possible to do, and, therefore, should be explored.

The students could have been helped with spelling and with screening out useless sites. Because of the difficulties that the students had with spelling, any program that could have improved their spelling, would have improved their searching. As mentioned earlier, students at times came up with promising words to enter but could not do so because they did not know how to spell them. As Neuman (1993) suggested, a spell-checker program would be helpful even to correct typographical errors. Another difficulty was typing in long and unfamiliar URLs. Because it is unlikely that URLs will become simpler, it would help users like the participating students if they could access sites using partial or incomplete URLs, or if they could browse through a URL list that is like a thesaurus or a telephone book and retrieve by point-and-click.

Filtering non-useful information could have helped the students as well. A great number of pages they retrieved were promotional or advertising material that included no information. Screening such pages out would have made it easier for them to focus on useful sites. A more helpful step would be to filter out non-useful sites and to assist in finding useful ones. Systems that do just that already exist. As Resnick and Varian (1997) explain, recommender systems may suggest particularly interesting pages as well as indicating those that should be filtered out. For assignments in any class, a teacher or a group of teachers, can employ such a system to indicate all the sites that are rich with information. Students may then decide if they want to use the recommending system. It might be possible for students themselves to recommend sites for their own use in later assignments and for their colleagues working on the same assignments, and to point to unproductive ones that would be better avoided.

A New Role for Graphics

In their searching, students often relied on information that was displayed in a graphic form. They examined the graphics of a site to determine its relevance and quality, and they used graphics clues to help them find landmarks. This dependence on graphics is not new. For instance, Pejtersen and Austin (1984) discovered that users of public libraries routinely examined the graphics on a book cover to help them determine if it was likely to be desirable. In addition, international standards have been developed for graphics to represent useful sites such as elevators, places with wheelchair accessibility, or restaurants.

With Web searching, however, this aspect has received much greater importance because most Web pages include both images and text, and therefore make searching in a multimedia environment a matter of course. Images are easy and fast to scan and are therefore likely to be used during Web searching as informative sources. Indeed, students in the study used graphics as if they were abstracts or even indexes to Web sites. They inferred from graphics what the sites were about and whether or not they were likely to be useful.

Moreover, the students often did not read beyond the first screen. This was found to be the case with other users as well. For instance, a study of graduate students in a library school revealed that none scrolled beyond the first page (Heffron, Dillon, & Mostafa, 1996). To help such users to find relevant information, therefore, the first screen should include as much pertinent information about the site as possible. Images are promising vehicles for providing information in a restricted space.

Because an information source such as the Web includes not only multimedia information but also diverse types of information sources, images can be created to express the "nature" of the text (and images) in a site, much as a shop window reflects the nature of the items being sold in the store. For example, a Web site with textbook type of information should not have moving cartoons on its home page because students who are looking for textbook information may reject it before they even read the name of the site. Even though we do not yet know how to express the topics and nature of a document in images, authors of Web sites may want to select graphics for their home pages that represent the nature of their sites, rather than those which might be attractive to the "average" user.

At the same time, research is needed to find out what attributes are essential to different user groups when they decide whether or not a Web site is useful and how users

employ images to decide whether or not a home page includes a certain attribute. Once these attributes are discovered, research in graphic design is needed to find ways to express these attributes in images that can be used on home pages. We may then understand, for example, how a home page that shows a rock band is different to the lover of rock music from one that shows the cover of an album. When more is known about graphical clues, and when authors of Web pages incorporate this knowledge into their graphic design, such clues could be used to support relevance and quality assessments.

Graphical clues have already been used for retrieval. For instance, using the BookHouse system, users can retrieve a list of books of fiction by clicking on an image that represents best what they would like the book to be about (Pejtersen & Austin, 1984). Retrieval of information on the Web, conversely, has been based only on textual clues. In a response to a search string, current search engines display a list of title-like phrases to represent Web pages, and some add a short summary to each title. While these textual descriptions are usually somewhat informative, the findings of this study suggest that adding graphical clues to the list of results might prove highly beneficial.

Most obvious is the fact that images can be browsed quickly. This feature would be particularly helpful when a user confronts a list of results that includes a large number of items. It is also clear that, when users can use both text and graphics to decide which Web site might be relevant, their decisions are likely to be more accurate and useful than when they use only textual clues. Further, if both types of clues are displayed, users who interact better with text can choose one type, and those who prefer images can choose the graphics. Finally, adding graphics to textual information would not add much time to browsing as it is practiced today because images are fast to scan.

Using graphical clues to support relevance judgment would create a new channel of communication between authors and users. This has been done in text-based retrieval systems to a certain degree. A lawyer in Seattle, for instance, attached a small image of the Statue of Liberty to the entry of his telephone number in the city's white pages. Spotting it, users looking for an immigration lawyer would immediately know they found one. Similarly, authors could "draw" summaries of their sites to help users decide if a site fits their needs. It might not be too soon for the designers of future search engines and of metadata templates to consider incorporating graphics clues in addition to the textual ones that are already in place.

Conclusions

The potential of the World Wide Web as a tool for information gathering and learning is enormous, and much of it has not been envisioned as yet. The study adds to many that show that this potential cannot be realized without user training and systems design that accommodates users' information seeking and searching behavior.

To be effective in school systems, both students and teachers, as well as librarians, require training. To turn Web searching into a productive and satisfying experience, all involved require training that explains how to search the Web and how to evaluate the search process and results; trainers need to spell out the limitations and strengths of the Web. While browsers and search engines can be improved, the inherent structure of the Web and of information retrieval are still obscure to most users. Moreover, the more users understand that structure, the more productive and satisfying their search for information will be.

At the same time, system designers could develop systems that help users better than the current ones. The searching behavior of the participants in the study illustrates that they would have greatly benefited from easy and immediate access to knowledge tools and those that support navigation. Further, correction of spelling and typographical errors, retrieval with partial or incomplete URLs, and filtering of non-useful sites would have increased the productivity of searching. In addition to these helping features, the participants' behavior suggests that the design of Web sites be adjusted to respond to the important role of visual clues in information retrieval.

Most of the findings of this study reinforce those of previous studies (e.g., Neuman, 1993; Kafai & Bates, 1997; Jacobson & Ignacio, 1997). This study demonstrates, however, that both Web design and the environment in which searching is performed can still be much improved. Moreover, the study provides additional evidence that analyzing users' seeking and searching behavior as it occurs in actual situations is a promising method for evaluating the effectiveness of this behavior and for suggesting improvements in system design and in search environments.

References

Bruce, B.C., & Leander, K.M. (1997). Searching for digital libraries in education: Why computers cannot tell the story. Library Trends, 45, 746–770.

Chen, S.H. (1993). A study of high school students' online catalog searching behavior. School Library Media Quarterly, 22, 33–39.

Eaton, G. (1991). Lost in the library: Are spatial skills important in shelf searches? Youth Services in Libraries, 5, 77–86.

Eisenberg, M.E., & Berkowitz, R.E. (1990). Information Problem Solving: The Big Six Skills Approach to Library and Information Skills Instruction. Norwood, NJ: Ablex.

Fidel, R. (1984). The case study method: A case study. Library and Information Science Research, 6, 273–288.

Grover, R., & Fowler, S.G. (1993). Recent trends in school library media research. School Library Media Quarterly, 21, 241–249.

Hearst, M.A. (1997). Interface for searching the Web. Scientific American, 276, 68–72.

Heffron, J.K., Dillon, A., & Mostafa, J. (1996). Landmarks in the World Wide Web: A preliminary study. In S. Hardin (Ed.), ASIS '96: Proceedings of the 59th ASIS Annual Meeting, Baltimore, MD, October 21–24, 1996 (pp.143–145). Medford, NJ: Information Today.

Hirsh, S.G. (1997). How do children find information on different types of tasks? Children's use of the science library catalog. Library Trends, 45, 725–745.

Jacobson, F.F., & Ignacio, E.N. (1997). Teaching reflection: Seeking and evaluation in a digital library environment. Library Trends, 45, 771–802.

Johnson, E. H., & Cochrane, P.A. (1995). A hypertextual interface for a searcher's thesaurus. http://csdl.tamu.edu./DL95/papers/johncoch/johncoch.html.

Kafai, Y., & Bates, M.J. (1997). Internet Web searching in the elementary classroom: Building a foundation for information literacy. School Library Media Quarterly, 25, 103–11.

Kuhlthau, C.C. (1994). Students and the information search process: Zones of intervention for librarians. In I.P. Godden (Ed.), Advances in Librarianship, 18, 57–72.

Marchionini, G. (1989). Information-seeking strategies of novices using full-text electronic encyclopedia. Journal of the American Society for Information Science, 40, 54–66.

Nahl, D., & Harada, V.H. (1996). Composing Boolean search statements: Self-confidence, content analysis, search logic, and errors. School Library Media Quarterly, 24, 199–207.

Neuman, D. (1993). Designing databases as tools for higher-level learning: Insights from instructional systems design. Educational Technology, Research and Development, 41, 25–46.

Neuman, D. (1995). High school students' use of databases: Results of a national Delphi study. Journal of the American Society for Information Science, 46, 284–298.

Neuman, D. (1997). Learning and the digital library. Library Trends, 45, 687–707.

Pejtersen, A.M., & Austin, J. (1984). Fiction retrieval: Experimental design and evaluation of search system based on users' value criteria (Part 2). Journal of Documentation, 40, 25–35.

Pitts, J.M. (1995). Mental models of information: The 1993-94 AASL/Highsmith Research Award study. School Library Media Quarterly, 23, 177–184.

Resnick, P., & Varian, H. (1997). Recommender systems. Communications of the ACM, 40, 56–58.

Small, R.V., & Ferreira, S.M. (1994). Multimedia technology and the changing nature of research in the school library. Reference Librarian, 44, 95–106.

Solomon, P. (1993). Children's information retrieval behavior: A case analysis of an OPAC. Journal of the American Society for Information Science, 44, 245–264.