Children's Use of the Yahooligans! Web Search Engine: II. Cognitive and Physical Behaviors on Research Tasks

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This study reports the results of Part II of a research project that investigated the cognitive and physical behaviors of middle school students in using Yahooligans! Seventeen students in the seventh grade searched Yahooligans! to locate relevant information for an assigned research task. Sixty-nine percent partially succeeded, while 31% failed. Children had difficulty completing the task mainly because they lacked adequate level of research skills and approached the task by seeking specific answers. Children's cognitive and physical behaviors varied by success levels. Similarities and differences in children's cognitive and physical behaviors were found between the research task and the fact-based task they performed in the previous study. The present study considers the impact of prior experience in using the Web, domain knowledge, topic knowledge, and reading ability on children's success. It reports the overall patterns of children's behaviors, including searching and browsing moves, backtracking and looping moves, and navigational styles, as well as the time taken to complete the research task. Children expressed their information needs and provided recommendations for improving the interface design of Yahooligans! Implications for formal Web training and system design improvements are discussed.

Introduction

As many children become "Web savvy," there is a need for understanding how young people use the Web to find information about specific tasks. While the Web offers ease of use through "point and click" navigation, supports searching and browsing through search engines, it "is likely to exacerbate users' feelings of being lost in hypertext, and cause them difficulties in navigating WWW subspaces" (Cockburn & Jones, 1996, p. 108). Unlike on-line catalogs, CD-ROM multimedia encyclopedias, and traditional print resources, the Web is dynamic, heterogeneous, lacks structure, and has unique navigational properties. Although children are motivated to use the Web (Bilal, 1998, 2000; Bilal & Watson, 1998; Watson, 1998), many may lack cognitive skills to navigate Web space effectively and efficiently. There is little evidence of how children use the Web to find information for different types of search tasks.

This study examined the information-seeking behavior of seventh-grade science children in using the Yahooligans! Web search engine/directory to find relevant information for an assigned research task. It constitutes the second part of a research project that investigated children's cognitive and physical behaviors in using the engine.

Understanding how children use a search engine, such as Yahooligans!, that is specifically designed to support their information seeking offers guidance for Web training and system design improvements.

Relevant Literature

Research on children's use of various types of information retrieval systems reveals that, in general, they lack adequate understanding of the information seeking process, have problems formulating search strategies, and do not have a conceptual understanding of the system used (Bilal, 1998, 2000; Borgman et al., 1995; Marchionini, 1989; Solomon, 1993; Wallace & Kupperman, 1997). Three main bodies of literature support the theory of children's information-seeking behavior and provide guidance in the conduct of this study: on-line public access catalogs (OPACs), multimedia encyclopedias, and the World Wide Web.

OPACs

Studies of children's use of OPACs have revealed that success rates in finding information vary from 10% with a touch-screen on-line interface (Edmonds, Moore, and Balcom, 1990) to 66% on standard OPACs (Solomon, 1993), to 80% in some versions of the Science Library Catalog (Borgman et al., 1995; Hirsh, 1997). Few studies have investigated the effect of domain knowledge on children's success in OPACs. Borgman et al. (1995) examined the success and searching behavior of 32 children, aged 9 through 12, as they used four different versions of The Science Library

Catalog (SLC) that implemented a Dewey Decimal-based hierarchical browsing. The study results show that children searched effectively in the four versions of the Catalog. Overall, children had little difficulty navigating the hierarchical structure of the SLC. The latter was most effective in its simpler form (i.e., versions 1 and 2), because it had a small database and four levels of hierarchies. Children had more difficulty with searching version 3, with its more complex navigational features, and with version 4 when both the size of the database and the depth of the hierarchies were increased. Children's success rates across all versions appear to be related strongly to search topics. Differences were found in children's success rates between searching science and technology topics. These differences were influenced by children's domain knowledge (science vs. technology), spelling, and vocabulary problems. In another study of the SLC, Hirsh (1997) examined the effects of task complexity and domain knowledge on children's success in using the Catalog. Sixty-four fifth-grade science children used the SLC to find information on two types of tasks: simple and complex. Simple-browsing tasks were defined as those that matched the terminology of the bookshelf headings in the SLC. Complex-browsing tasks were characterized by not containing match words to the bookshelf topic headings. Children were more successful in finding information on simple-browsing tasks than on complex-browsing tasks. Children's domain knowledge had a significant effect on their success, regardless of the complexity of the search task or its domain (i.e., science vs. technology). Those with high domain knowledge were more successful on all types of searches than those with low domain knowledge.

Research on children's use of standard on-line catalogs show that the approach children take in using an on-line catalog influence their success in locating information. Solomon (1993), for example, examined the search moves of children in grades 1–6 in using an OPAC. The study results reveal that the approach children took varied by grade level. In most cases, children in grades 4–6 who used complex search moves that included abstract concepts were less successful in locating information than children who employed simple moves that contained concrete concepts. Children's failure was mainly due to use of terminology that did not match the controlled vocabulary employed in the OPAC database. Although children had difficulty formulating search strategies and revising search queries, they became increasingly proficient in using the OPAC as they gained experience in maneuvering more effectively within the on-line environment. This study suggests that cognitive abilities and developmental level influence the search moves children make. In a follow-up study, Solomon (1994) examined the connection between students' proficiency in using an OPAC and the types of assignments they received. He found that students who had assignments that were "challenging" and that required use of their content knowledge creatively were more able to recognize and respond to system breakdowns than children who were given assignments about "simple" topics of little interest. This finding suggests that the type of tasks children are given should stimulate and encourage intellectual curiosity, information seeking, and exploration behaviors (Small, 1999).

Multimedia Encyclopedias

Marchionini (1989) studied the searching behavior of 28 third and fourth graders and 24 sixth graders in using the Grolier's Electronic Encyclopedia on CD-ROM. Students were assigned two tasks: one closed (fact finding) and one open ended (research). Success on the closed task was judged by finding the correct fact (i.e., the year in which the speed skating event was introduced into the modern Olympics). Children's success on the research task was judged by using two measures: (a) gathering facts about at least one of three females who were space travelers, and (b) listing the number of relevant articles on search worksheets. The study results show that, in general, children were able to use a full-text, electronic encyclopedia with minimal prior training. Although children identified the key facets of the search tasks, they had difficulty formulating effective search requests. Many children, especially younger ones, used sentences as queries. Older children (sixth graders) were more successful on both tasks than younger ones (third and fourth graders). They made fewer moves, found more relevant information, and took less time to complete the open task. Children's success rates in finding the desired information varied by the type of search task. Overall, they were more successful on the open task than the closed task. Children who failed the closed task were unable to extract the required fact from the relevant text found. In sum, the results of this study indicate that three main factors influenced children's searching behavior and success: the structure of the tasks, cognitive abilities, and level of conceptual understanding of how to use a multimedia encyclopedia.

In a study of middle school students' use of three CD-ROM multimedia encyclopedias, Large, Beheshti, and Breuleux (1998) found that the students were able to cope effectively with the physical manipulation of three CD-ROM interfaces although they found certain interfaces easier to use than others. Students had greater difficulty using the encyclopedia *Exploring Castles* than C*astle Explorer* and *Encarta*, mainly because its hierarchical design was confusing and lacked consistency. Although children were able to handle the sophisticated interfaces in the three encyclopedias, they had difficulties constructing effective queries. In a prior study, Large et al. (1994) examined how elementary school children used a print encyclopedia and its CD-ROM equivalent. Using tasks that varied in complexity, the authors found that 50% of the students were successful in finding texts for complex queries in both sources. Complexity was defined by the number of search terms the queries contained, from one word to four words. The time children took to locate information varied significantly by query complexity. Retrieval time was seven times longer on queries that contained four terms as opposed to those that

had one term. There was no evidence to indicate that the retrieval time was shorter in using the CD-ROM than its print equivalent. This finding suggests that children's information seeking is more significantly influenced by the type of search task (simple vs. complex) than the type of the source used (i.e., print vs. CD-ROM).

World Wide Web

Children's information seeking on the Web is an area of research that has recently emerged. In a previous study, Bilal (2000) reported the results of part one of a research project that investigated the cognitive, affective, and physical behaviors of seventh-grade science students in using the Yahooligans! Web search engine/directory to find information for an assigned fact-based task. The key findings of this study are summarized below.

Key Findings from Bilal's (2000) Study

Twenty-two children from three seventh-grade science classes at a middle school located in East Tennessee used Yahooligans! to find the correct answer for an assigned fact-based task about the "age of alligators in the wild and captivity." Children's success rates were judged by extracting the correct facts from the relevant home page found. Both quantitative and qualitative inquiry methods were used to collect data. The quantitative method employed Lotus ScreenCam, a software package that captures on-line activities in Web browsers, such as Netscape, to capture children's Web activities. These activities were recorded, saved, replayed, coded and analyzed. The qualitative method generated data through use of questionnaires and exit interviews. The study results reveal that 50% of the children found the correct answer for the task. Overall, children's cognitive behavior reflected an understanding of the search task, term relationships, concept selection, and search formulation. Their selection of appropriate subject hierarchies and Web sites indicated adequate knowledge of both the domain of the task (science) and the topic of the task (alligators). Children's information-seeking behavior varied by success levels. Successful children used incorrect search syntax less frequently, looped searches (reactivated previously executed searches) and hyperlinks (reactivated previously visited hyperlinks) less often, and took less time to complete the task (11.89 minutes vs. 19.69 minutes, respectively). Successful children also appeared to be more focused on the task, deviated from the target hyperlink rarely, and were more systematic in their navigation than unsuccessful children.

Children's effectiveness and efficiency in using Yahooligans! and the quality of Web moves they made were based on the "Web Traversal Measure" the author developed for the study. Traversal, in this measure, is defined as searching, browsing, screen scrolling, backtracking, and looping. Effectiveness is evaluated in terms of the *amount of effort* a user makes to locate a target hyperlink/page. Efficiency is assessed based on the *weight* (i.e., 1 = relevant, 0.5 = semi-relevant, 0 = irrelevant) of the *relevant actions* a user makes out of the total traversal actions. The quality moves are computed by quantifying the *percentage of relevant or meaningful moves* a user makes out of the total traversal moves (i.e., quantity vs. quality). The measure shows that children's "weighted" effectiveness, efficiency, and quality moves varied by success levels. Successful children had a higher effectiveness score than unsuccessful children (31.14 vs. 12.42%, respectively). This means that the former group put approximately 70% of their traversal efforts to find the target hyperlink and the latter group put nearly 88%. Successful children's efficiency score was slightly higher than unsuccessful children's score (26.28 vs. 22.14%, respectively). The quality moves scores also varied slightly between the two groups (32.14 vs. 28.85%, respectively). In sum, this measure reveals that children made lots of "effort" to locate the target hyperlink (effectiveness); nearly 25% of the moves they made were either relevant or semi-relevant (efficiency); and out of all the moves they made, nearly 30% of their effort were "quality" moves.

In a prior study, Bilal (1998) examined the success and searching behavior of 22 middle school children in using Yahooligans! to find information for a research task about "diet." The study findings reveal that children had difficulty locating relevant information about the topic. They used incorrect search syntax, utilized either broad or very specific concepts, and examined the hits returned minimally. Backtracking (i.e., use of Netscape *Back* command), search looping (i.e., reactivation of previously executed search requests), and hyperlink looping (i.e., reactivation of previously visited Web sites) occupied the largest segment of children's navigation. Children use of Netscape *Back* button as the primary means of navigation among Web pages reflected naive knowledge of navigating the Web. Their frequent search and hyperlink looping suggested lack of focus on the task, possibly, due to disorientation in navigating Web space. Overall, children had difficulty formulating effective search queries and possessed inadequate knowledge of how to use Yahooligans! The design of Yahooligans! influenced children's information seeking. Its misleading titles of hyperlinks, poor indexing and abstracting of Web sites, lack of spell-checking techniques, and inadequate guidance under its on-line help surfaced as major problems in children's use of the engine.

Other Web Literature

Two studies examined children's Web searching on self-selected topics for class-related research projects. Large, Beheshti, and Moukad (1999) studied the behavior of 53 sixth graders (12 and 13 years old) in finding information for a research task about "Winter Olympics." This study did not measure children's success in using the Web. It analyzed the Web activities children made to complete the research tasks. The study findings reveal that children were inefficient in using the Web, and possessed inadequate

knowledge of navigating Web space. Their use of Netscape *Back* command accounted for 90% of their total Web moves. Conversely, the on-line help was used the least (only once). Children browsed more than searched by keyword to locate the desired information.

Wallace and Kupperman (1997) investigated how eight students in sixth grade used the Web to locate relevant information about specific aspects of ecology that interested them. Children had limited success in locating relevant information for their topics. They spent 76% of their time searching by keyword, made repetitive searches using identical keywords, queried search engines using natural language, placed commas in between the concepts they used, and employed Boolean logic incorrectly. In addition, students did not use feedback from search engines to improve returned results, hardly examined the hit lists returned, and rarely went more than a few links away from a search page. Children approached the tasks by seeking specific answers. They submitted searches one after another until they had a very small number of hits and, on several occasions, they reduced the results to finding a single page they believed to contain the answer. Children also used the *Back* command exclusively to navigate among the Web pages they retrieved.

Schacter, Chung, and Dorr (1998) examined the performance and searching behaviors of 32 students in fifth and sixth grades in using the Web for two assigned tasks: one closed (i.e., fact driven) and one open ended (i.e., research). Both tasks were about crimes in California. Children's performance/success was measured on a five-point relevance scale of the documents they bookmarked. The study results show that children were significantly more successful on the open task than the closed task. Thirty out of 32 children found relevant information on the former, as opposed to two out of 32 children who located relevant information on the latter. Most children queried search engines using natural language. Children browsed significantly more than searched by keyword on both tasks. They employed significantly more analytic search strategies on the closed task as opposed to the open task. This study did not indicate the search engines children used to locate information. In addition, it did not report on the type of moves children made to navigate among Web pages (e.g., Back, Forward, Home, etc.). The findings of this study indicate that the structure of the task had a significant effect on children's performance.

Kafai and Bates (1997) investigated elementary school students' interaction with the Internet at five different elementary classrooms that participated in the SNAPdragon Project. Children evaluated Web sites and created an annotated directory for use by other children. The study findings show that children were reluctant to read or scan the results returned. Younger children (grades 1–4) had more difficulty evaluating Web sites and writing annotations than older children (grades 5–6), and needed more instruction and assistance at different stages of their search process. Like the research findings of children's use of certain OPACs and multimedia encyclopedias (Marchionini, 1989; Solomon, 1993), the results of this study indicate that children's developmental level and cognitive abilities have a strong influence on their information seeking.

Bilal (1999) evaluated the retrieval performance of three search engines designed for children: Yahooligans!, Super Snooper™, and Ask Jeeves for Kids™ on queries submitted by a group of middle-school children. The retrieval performance criteria used were: retrieval output, relevance, overlap in search results, and redundancy. The study results reveal that Yahooligans! was more effective on keyword searches with one single concept than with multiple concepts. Super Snooper™ returned the highest number of hits but with zero relevance on all types of searches (single concept, multiple concepts, and natural language). Ask Jeeves for Kids™ offered students success only on one search request containing one single concept and failed searches with multiple concepts and natural language. The study identified weaknesses in the design of these engines that may impact children's information seeking. In regard to Yahooligans!, weaknesses include: absence of a spell-checking technique, inadequate guidance under on-line help, absence of search instructions and search examples from the search and retrieval interfaces, poor indexing of Web pages, inadequate abstracting of hyperlinks returned, misleading titles of hyperlinks, and absence of an alphabetical listing of terms contained in the database.

In summary, current research reveal that children grades 1–7 use different types of information retrieval systems (IRs), such as OPACs, multimedia encyclopedias, and the Web. However, they have difficulty formulating search strategies and possess inadequate knowledge of how to use these systems effectively and efficiently. The interface design and search features employed in these systems affect children's searching behavior. Children's success in these IRs are influenced by domain knowledge, topic knowledge, prior experience, cognitive abilities, developmental level, type of search task (i.e., fact-based vs. research), as well as task complexity and how this complexity is characterized.

Research in educational psychology and information science has shown that children's cognitive abilities (Siegler, 1991), developmental level (Piaget & Inhelder, 1969) and information needs (Bilal & Kirby, in progress; Walter, 1994) differ from those of adults. With the exception of research by Bilal (1998, 1999, 2000; Bilal & Watson, 1998), to date, research on children's use of the Internet/Web has focused exclusively on search engines designed for adults. No attention has been paid on how children seek information in search engines that are specifically designed to support their information seeking. If "adults have a difficult time constructing a meaningful mental model of the Internet" (Jacobsen, 1995, p. 71), one can imagine that children who already experience difficulty using well-structured information systems, such as OPACs and CD-ROM multimedia encyclopedias, possess an inadequate mental model of using these systems, and lack adequate research skills may search the Web in vain and with great frustration. Although

there are few search engines designed for use by young children (e.g., Yahooligans!, Super Snooper™, Ask Jeeves for Kids™, KidsClick!), little is known about how children seek information in these engines. This study examined how seventh-grade students in science classes used Yahooligans! to locate relevant information for an assigned research task.

Results gained from this study will provide a better understanding of how children use a Web search engine/directory specifically designed for them. These results will also be used to build a framework for formal Web training and to provide guidance for system design improvements.

Research Questions

This study examined the cognitive and physical behaviors of seventh-grade science students in using Yahooligans!

The cognitive behavior relates to "behavioral acts such as knowledge, comprehension, problem solving, and critical interpretation. The physical behavior concerns behavioral acts that are externally observable, such as visual perception, speaking, and navigating" (Nahl, 1997, pp. 13–14). In this study, the cognitive behavior was examined in terms of children's search and browse moves in Yahooligans! The physical behavior was observed in terms of backtracking (i.e., use of Netscape *Back* button), total number of Web moves made, time taken to complete the research task, exploratory moves (e.g., use of Netscape *Bookmarks*, *Search*), and navigational styles.

This study sought answers to these research questions:

(1) How successful are children in finding relevant information for the research task in Yahooligans!? (a) Does children's success in using Yahooligans! vary with the type of search task (i.e., research vs. fact based)?
(2) What cognitive behavior do children demonstrate to find relevant information for the research task in Yahooligans!? (a) Is there a difference in the cognitive behavior between children who succeed in finding relevant information for the research task and those who do not? (b) Does children's cognitive behavior in using Yahooligans! vary with the type of search task (i.e., research vs. fact based)?
(3) What physical behavior do children demonstrate to find relevant information for the research task in Yahooligans!? (a) Is there a difference in the physical behavior between children who succeed in finding relevant information for the research task and those who do not? (b) Does children's physical behavior in using Yahooligans! vary with the type of search task (i.e., research vs. fact based)?
(4) What influence do these factors have on children's success in finding relevant information for the research task in Yahooligans!? (a) Prior experience in using the Internet/Web and knowledge of Yahooligans! interface; (b) domain knowledge (i.e., science); (c) topic knowledge (i.e., ozone layer); (d) reading ability.

Method

This study employed both quantitative and qualitative inquiry methods. The quantitative method provided empirical data about children's cognitive and physical behaviors in using Yahooligans! These behaviors were captured by using Lotus ScreenCam (http://www.lotus.com), a Windows-based software package that records, saves, and replays activities in Web browsers, such as Netscape. The qualitative method generated data from questionnaires and interviews. The researcher developed and used four instruments to collect qualitative data: (a) a questionnaire that generated information about children's prior experience in using the Internet/Web, (b) an Internet/Web Quiz that provided data about children's prior knowledge of using Yahooligans!, (c) an Exit Interview that captured children's experience in using Yahooligans, and (d) a Teacher Assessment of Student Characteristics that elicited the science teacher's rating of children's domain knowledge of the task (i.e., science), topic knowledge of the task (i.e., ozone layer), and reading ability.

The Setting

The study took place at a Middle School (named Middle School for confidentiality purposes) located in East Tennessee. The School was mainly selected for its pioneering efforts in integrating the use of technology into the classroom curriculum. Other selection criteria included: the science teacher's involvement in using technology in the science curriculum, availability of an Internet connection in the School library, the cooperation of the School librarian, the willingness of the School administration, and the volunteering efforts of the seventh-grade science children.

At the time of the research experiment, the school library had two computer stations with an Internet connection. For purposes of the study, three computers were added, networked, and connected to the Internet to accommodate use of five computers at a time. Lotus ScreenCam version 2.0 was installed on each computer. Software and hardware were pretested to ensure proper operation. Yahooligans! was set up as the default home page in Netscape browser.

Population and Sample

The population for this study consisted of students in three science classes (90 students) taught by one teacher at a Middle School located in East Tennessee. Due to the school's Internet Use Policy, children's parental consent to use the Internet was sought. Out of 90 invitations for participation, 30 consent forms were received. Of these, 25 children were willing to take part in this project. Three were involved in pilot testing, leaving 22 children for the final study. Due to absences, 17 children completed the research task.

The Task

Children performed the following assigned research task in Yahooligans!: *Environmentalists are concerned that the*

ozone layer is being depleted. Search Yahooligans! to learn how the lack of ozone in the earth's atmosphere is affecting our forests. The science teacher selected the subject matter for the task and, at her request, the researcher formulated the task in collaboration with the School librarian. The teacher's motive in participation in this research was to provide children with the opportunity to gain some skills in using the Web. Thus, the students' results were not assigned a grade. The researcher and the school librarian searched Yahooligans! in advance and found that the engine contained relevant information about the topic. They also judged that the amount of information the engine had was suitable (12 relevant pages of short text) for the purpose of this non class-related Web activity.

The research task was more complex than the fact-based task the children performed in the previous study (Bilal, 2000). That is, the topic of the task had multiple facets (i.e., depletion of the ozone layer, lack of ozone in the earth's atmosphere, and impact of lack of ozone on forests), and did not offer a target answer. This task required that the children use their critical thinking skills to construct "meaning" from the relevant information found. That is, to understand the link between "lack of ozone and its impact on forests." As Schacter, Chung, and Dorr (1998) maintain, tasks that require research "entail a struggle to find information that is potentially very difficult to define" (p. 842). Based on the differences between the research and fact-based tasks, the author believed children's success and information seeking behavior in using Yahooligans! on the research task might vary from the success and the behavior they demonstrated on the fact-based task.

Success Measure

Children performed the research task using Yahooligans! only. Although the engine had one relevant Web site about the environment, it linked to five topics relating to various aspects of the environment. These included: *Climate Change*, *Energy*, *Forests and Biodiversity*, *Ozone Depletion*, and *Resource Use*. Each of these topics contained 10 to 12 pages of text. Under *Ozone Depletion*, 12 pages of short text discussed different aspects about the ozone layer. Specifically, pages 1, 4, 7, and 12 provide information that can be used as an introduction to the topic. Page 1, for example, describes that the ozone layer is in jeopardy; page 4 describes where ozone resides; page 7 discusses the impact of ozone depletion on life on the planet; and page 12 describes the effect of ozone depletion on living tissue of plants and animals. Because this task required that students construct "meaning" from the relevant information found, children were judged to be fully successful if they printed and submitted either the whole text (12 pages) found under *Ozone Depletion* or pages 1, 4, 7, and 12 combined. They were judged to be partially successful if they printed and submitted one of the four relevant pages (i.e., 1, 4, 7, or 12). They were judged to be unsuccessful if they printed and submitted text that was irrelevant to the topic of the task (e.g., Forests and Biodiversity). Two middle-school teachers and one expert in environmental science evaluated the search results children submitted.

Limitations of the Study

This study involved 17 children aged 12 and 13 years old. They were selected from three seventh-grade science classes in one Middle School located in East Tennessee. Due to confidentiality, individual students' grade levels or general school success were not secured. The children who participated in this study may not represent all middle-school students in Tennessee, nor may they represent the general population of seventh-grade science students.

The small sample size (17) may impact the external validity of the results and their generalization to the whole population of seventh-grade children.

Yahooligans!

Yahooligans! is a search engine and directory designed for children ages 7 to 12. At the time of the study, the engine provided both keyword searching and browsing by subject hierarchies. Retrieval from Yahooligans! included the number of categories and the number of sites within each category. It indexed titles of homepages, Uniform Resource Locators (URLs), and descriptions from homepages. The database was built through automated search robots that crawled new sites at various locations, and through user recommendations of specific sites. At the time of the study, Yahooligans! did not employ advanced search syntax, such as Boolean logic, proximity, nesting, or natural language. It lacked a spell-checking technique, had limited guidance under the online help about how to use the engine, and did not provide search instructions or search examples from its interface (Yahooligans!, 1994–1998, 1994–2000).

Procedure

The research experiment began in April 1998. Both the science teacher and the researcher described the nature of the project to the children. As they volunteered to participate, children were escorted five at a time to the School library, signed a consent form, and were each given a folder labeled "My Web Searches." The folder material described the research task in writing. After reading the task and expressing understanding of its content, each child was seated at a computer station that had Yahooligans! as the default Web page in the Netscape browser.

The research experiment was conducted over the course of 1 week and occupied 3 days. Children completed the fact-based task (Bilal, 2000) on the first day of the week, the self-selected task (Bilal, in progress) on the third day, and the research task on the fifth day. Children were instructed to (a) perform the task in Yahooligans!, (b) limit search time to 30 minutes, (c) print the relevant information found, (d) highlight the relevant information with a marker, (e) place

the information found in the Web folder, and (f) announce the completion of the task to the researcher and/or the school librarian. Children were not given specific instructions as to how to approach the task (i.e., search or browse), nor were they given prior instruction or training about how to use the search engine. The intent was to examine how, as novices, children used Yahooligans! that is specifically designed to support their information seeking. Children were encouraged to ask questions as needed. When technical problems occurred, they were given additional time to complete the task. Each student's Web session was captured on-line and saved on the computer used when completed. The Web sessions saved were transferred electronically to the researcher's computer station. Each session was replayed, analyzed, transcribed, and coded by both the researcher and a trained research assistant.

Domain Knowledge, Topic Knowledge, and Reading Ability

The science teacher rated children's domain knowledge (i.e., science), topic knowledge (i.e., ozone), and reading ability on a 10-point scale instrument (1 = low, 10 = high) developed by the author. The purpose was to examine whether any of these variables had an effect on children's success. Only one child received a low rating on domain knowledge, topic knowledge, and reading ability (2, 2, and 3, respectively). One child received a moderate rating on these variables (6, 5, and 7, respectively); two children were rated moderately high on these variables (8, 7, 8, respectively); one child received a score of 8 on each variable; and eight children received a high rating on each variable (9 or 10). Overall, children's mean scores were: 8.9 on domain knowledge, 8.4 on topic knowledge, and 8.9 on reading ability. The distribution of these scores varied by success level. Successful children's mean scores were 7.9, 7.7, and 8.2, respectively, and unsuccessful children's mean scores were 9.5, 9, and 9.5, respectively.

Prior Experience in Using the Web

Children indicated their level of experience in using the Internet/Web on a questionnaire that listed five categories of experience that ranged from no experience to over 1 year of experience. Due to the low number of children who marked each of the five categories, the answers were condensed into three categories: no experience, less than 1 month of experience, and experience ranging from 6 to over 12 months. Only one child never used the Internet/Web, two children had less than 1 month of experience, and 10 children had experience ranging from 6 to over 12 months.

Children were also asked to place a check mark next to the name of the search engine(s) they were familiar with. Eleven children mentioned one of these engines: WebCrawler, Yahoo, Excite, and Alta Vista. One child indicated Yahooligans! and two children named Netscape. Evidently, the children who named Netscape did not recognize the difference between a search engine and a Web browser.

Results

The results are reported within the context of the four research questions and subquestions posed. Seventeen children completed the research task. Four Web sessions failed to replay fully and were, therefore, dropped from data analysis. The results are based on 13 full sessions of children's Web activities. Descriptive statistics are used in reporting rather than statistical significance.

How Successful Are Children in Finding Relevant Information for the Research Task in Yahooligans!, and Does Children's Success Vary with the Type of Task (i.e., Research vs. Fact Based)?

Most children (69%) located the Web page that contained the relevant information for the research task, but printed and submitted one page of relevant text (three to four lines) about *ozone depletion* as the information that completed the task. Based on the success measure used, these children were considered partially successful. Four children (31%) printed and gave one page of irrelevant text (three to four lines) that discussed *Forests and Biodiversity*. These children were judged to be unsuccessful. Surprisingly, these children failed despite the fact that they had higher mean scores on domain knowledge, topic knowledge, and reading ability (mean = 9.75, mean = 9.25, and mean = 9.75, respectively) than the nine children who partially succeeded (mean = 8.5, mean = 8, mean = 8.5, respectively). It is noteworthy that these scores were not tested for statistical significance. If these children were highly knowledgeable about the topic, why did they fail? There are two possible explanations: When children read the task, they may have recalled the word *forests*, because it was stated last in the phrasing of the task and, subsequently, focused their search on the concept of *forests* rather than *ozone* or *ozone layer*. Second, some children did not link the two main facets included in the task: *ozone layer* and *forests* and only focused on one facet.

The search results that partially successful children submitted varied. Three printed and gave text from the first page (1 of 12) about *Ozone Depletion* and stopped their search process; and six scanned the 12 pages but submitted text only from the last page (12 of 12). Regardless of success, all children seemed to seek specific answers to the task. Evidence of this approach was seen in the search results they submitted. They marked specific keywords and sentence fragments as the "answer." One child, for example, highlighted the concept *ozone layer* and the following sentence fragments: *placed the ozone layer in jeopardy*; *threaten to eat away the life-protecting shield surrounding the world*. Children did not attempt to develop an overall understanding of the topic or construct "meaning" from the relevant information they found. This may be due to chil-

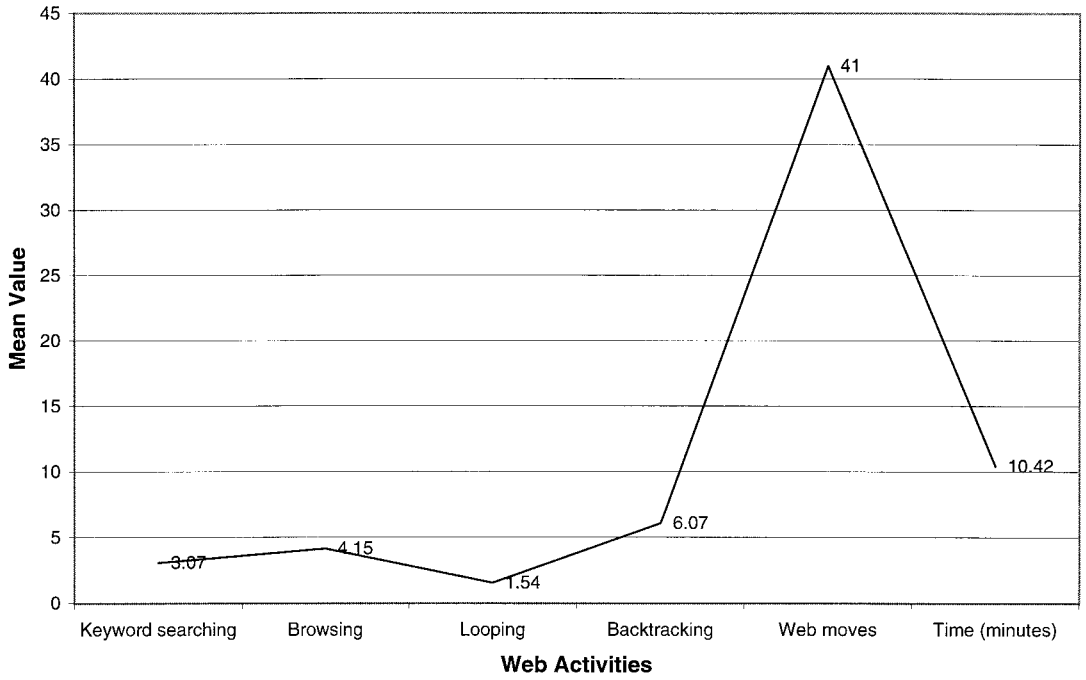


FIG. 1. Children's Web activities on the research task.

dren's inadequate level of research skills and misunderstanding of how to complete the task successfully.

Children's success levels varied between the research and fact-based tasks. Sixty-nine percent partially succeeded in finding relevant information for the research task, while 31% failed. In the previous study, on the fact-based task (Bilal, 2000), 50% succeeded and 50% failed. Overall, children had more difficulty with the research task than with the fact-based task. The research task dealt with a complex topic that required use of prior domain and topic knowledge in order to construct "meaning" of the relevant information found. Although all children received high ratings on the domain and topic knowledge of the task, they did not use that knowledge fully to complete the task successfully. In addition, the phrasing of the research task did not specify the *amount of information* needed. It is possible that children were unsure as to how much information was needed to complete the task successfully. Further studies should specify the amount of information children need to locate so that they have good understanding of how to satisfy task requirements.

What Cognitive Behavior Do Children Demonstrate to Find Relevant Information for the Research Task in Yahooligans!?

Search Formulation Strategy

Search formulation strategy reflects how a user expresses his/her information need in an information retrieval system (Bilal, 2000). In Yahooligans! an information need may be expressed by either performing a keyword search or by browsing subject hierarchies. Of the 69% of the children who searched by keyword in their initial moves, 61% used the multiple concept *ozone layer* and 8% entered the single concept *ozone*. In subsequent moves, 39% of the children employed the concrete term *ozone* and 23% used other concrete concepts (*atmosphere*, *forests*, *environments*, and *environmentalists*). Only one child searched by natural language (*ozone affecting forests; lack of ozone in earth's atmosphere*), and two children searched by keyword within subject categories. Overall, children negotiated different strategies (single concept, multiple concepts, and natural language). In two cases, children composed queries with abstract concepts (e.g., resources, environmental issues) when concrete ones did not yield relevant hits. Despite the fact that children had the task written in front of them during searching, two children committed misspelling errors, one typed *o-zone* but corrected the spelling in a subsequent move; and another typed *forrests*, but instead of correcting the spelling, the child initiated a new search under *environmentalists*.

Browsing Strategy

"Browsing is a process of skimming over information and selecting choices" (Borgman et al., 1995, p. 666). From the 31% of the children who browsed by subject hierarchies in their initial moves, 23% activated the appropriate category, *Science and Oddities* (currently *Science and Nature*), and 8% chose the inappropriate category *Around the World*. In subsequent moves, children shifted back and forth between keyword searching and browsing. Overall, the mean number of subject categories and Web sites the children browsed was 4.15. The fact that browsing requires less cognitive load than keyword searching (Marchionini, 1995),

TABLE 1. Children's search formulation on the research task by success.

Group	Single concept	Search frequency	Multiple concepts	Search frequency	Natural language	Search frequency
Successful	Ozone	7	Ozone layer	8	N/A	N/A
	Earths	1	Earths atmosphere	2		
Unsuccessful	Forests	5	Ozone layer	4	Ozone affecting forests	1
	Atmosphere	3	Affected forests	1		
	Ozone	2	Environmental issues	1	Lack of ozone in earth's atmosphere	1
	Environment	2				
	Environmentalists	1				
	Resources	1				

and the fact that many of the keyword searches children performed failed, may have influenced the amount of browsing. As Figure 1 shows, children browsed more than searched by keyword (mean = 4.15 vs. Mean = 3.07, respectively).

Is There a Difference in the Cognitive Behavior between Children Who Succeed in Finding Relevant Information for the Research Task and Those Who Do Not, and Does This Behavior Vary with the Type of Task (Research vs. Fact Based)?

Children's cognitive behavior varied by success levels. Table 1 shows partially successful children's search formulation in Yahooligans! They used the concrete concepts *ozone* and *ozone layer* most frequently (seven and eight times, respectively) in their search statements. Unsuccessful children (31%) utilized the concrete concept *forests* most frequently (five times) and the concepts *ozone* and *ozone layer* less often (two and four times, respectively). They also made two searches using abstract concepts, *resources* and *environmental issues*, and queried the engine in natural language (*ozone affecting forests; lack of ozone in earth's atmosphere*). Partially successful children made fewer but more relevant keyword searches than did unsuccessful children, as was evident in the mean number of these searches (mean = 2.4 vs. mean = 8, respectively) (Figure 2).

The amount of children's browsing also varied by success levels. Table 2 shows the subject categories and Web sites partially successful children browsed. They browsed three subject categories, of which two were appropriate to the task (appropriateness ratio = 66%). They also browsed four Web sites, of which two were appropriate (appropriateness ratio = 50%). Conversely, unsuccessful children browsed eight subject categories, of which only one was appropriate (appropriateness ratio = 12.5%) and visited 14 Web sites, of which only two were appropriate (appropriateness ratio = 14%) (Table 3). These children browsed a higher number of subject categories and visited more Web sites than did partially successful children (mean = 8.75 vs. mean = 3.28, respectively). These differences may be due to the increased difficulty that unsuccessful children had with the task.

The amount of children's search and hyperlink looping also varied by success levels. Search looping relates to reactivation of previously executed searches. Hyperlink looping concerns reactivation of previously visited hyperlinks. As Figure 2 shows, partially successful children looped searches and hyperlinks less frequently than unsuccessful ones (mean = 0.2 vs. mean = 3.75, respectively). This finding suggests that partially successful children were more focused on the task and had better recall knowledge of the searches they had made and the sites they had visited.

All children used a combination of keyword searching and browsing methods in subsequent moves. Children's cognitive behavior showed similarities and differences between the research and fact-based tasks. The initial moves the children made in Yahooligans! were similar on both tasks: 69% searched by keyword and 31% browsed by subject hierarchies on the research task, as opposed to 64 and 35%, respectively, who did so on the fact-based task. Figure 3 shows differences in children's behavior between the two tasks. The mean frequencies on keyword searching,

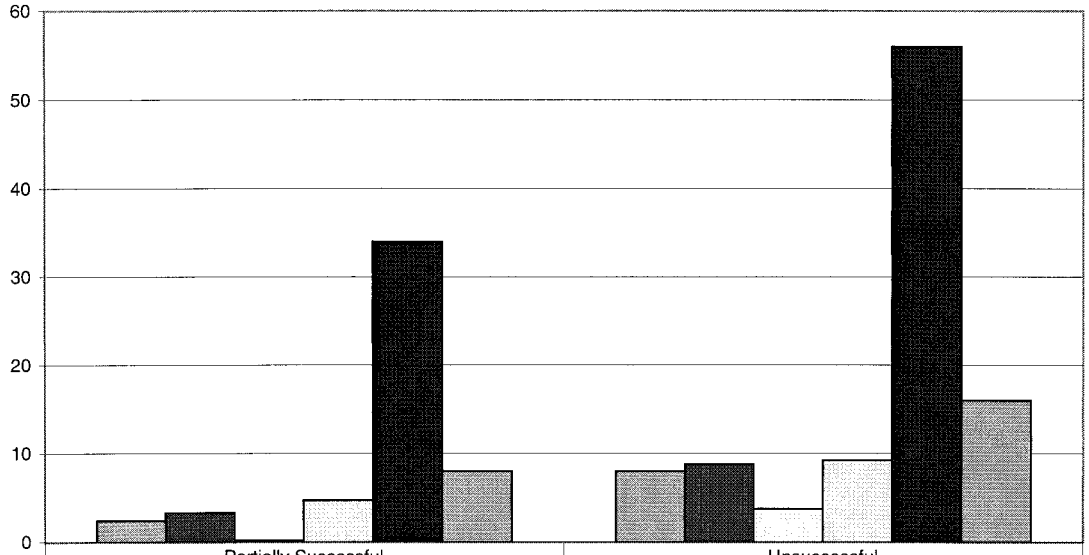
TABLE 2. Subject categories and Web sites partially successful children browsed on the research task.

Subject categories browsed	Browsing frequency	Web sites browsed	Browsing frequency
• Environment	2	• Environment on-line	8
• Science and Oddities: Environment: Earth Day	2	• Forests and Biodiversity	4
• Science and oddities: Environment	1	• Ozone depletion	2
		• TOC	2

TABLE 3. Subject categories and Web sites unsuccessful children browsed on the research task.

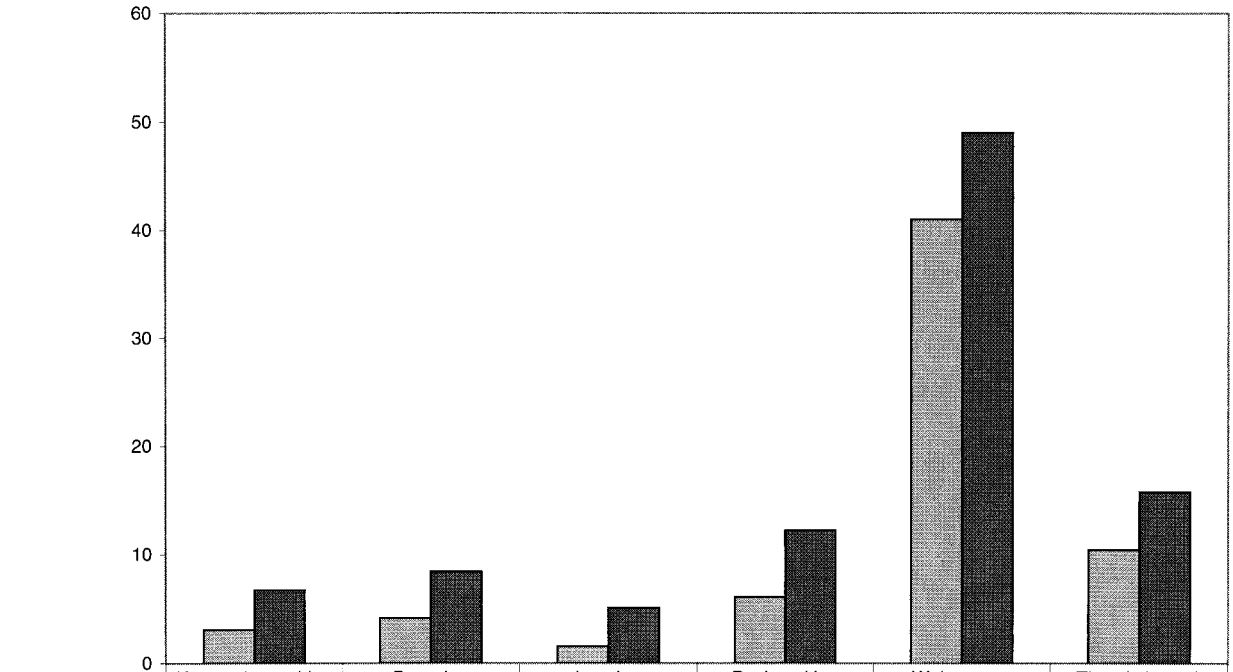
Subject categories selected	Browsing frequency	Web sites selected	Browsing frequency
• The scoop: current events: past current Events: weather and disasters: Indonesian rainforest fires	2	• Educational resources	2
		• Planetary fact sheet	2
		• Environment on-line	2
• Science and oddities: geography: rainforests: Rainforest action network	1	• Forests and biodiversity	2
		• Rainforest action network	1
• Science and oddities: space: NASA	1	• Ozone depletion	1
• Science and oddities: environment	1	• Earth fact sheet	1
• Weather	1	• Wilderness society	1
• Past current event	1	• Quest of the ring leader	1
• Current events	1	• Intergovernmental oceanographic Commission	1
• Geography	1	• Natural resources defense Council	1
		• Rainforest information	1
		• Mitsubishi pit mine in B.C.	1

browsing, and looping were lower on the research task (mean = 3.07, mean = 4.15, and mean = 1.54, respectively) as opposed to the fact-based task (mean = 6.7, mean = 8.4, mean = 5.1, respectively). In addition, the number of keyword searches within subject categories that children made varied by task. There were three searches of this type on the research task as opposed to 16 on the fact-based one. Moreover, only 8% of the children searched by natural language on the research task, as opposed to 35% who did so on the fact-based task. The decline in use of incorrect search syntax (i.e., natural language) and in search and hyperlink looping is encouraging, as it shows gain in children's skills in how to use Yahooligans! by the time they performed the research task. It is believed that the "learning effect" had a stronger impact on these skills than the nature of the task; that is, the amount of learning they gained by trial and error about how to use the engine and navigate its Web space over the span of the research experiment. Children performed the research task on the fifth day of the experiment and after they had made two other searches—one for the fact-based task and another for the self-selected task. This gain in skills indicates that children had adapted to the search and browse mechanisms of Yahooligans! and Netscape browser without prior training. With formal Web



	Partially Successful	Unsuccessful
Keyword searching	2.4	8
Browsing	3.28	8.75
Looping	0.2	3.75
Backtracking	4.7	9.25
Web Moves	34	56
Time (minutes)	8	16

FIG. 2. Children's mean scores on the research task by success.



	Keyword searching	Browsing	Looping	Backtracking	Web moves	Time (minutes)
Research task	3.07	4.15	1.54	6.07	41	10.42
Fact-based task	6.7	8.4	5.1	12.2	49	15.78

FIG. 3. Children's mean scores on the research and fact-based tasks.

training, one can assume that these same children could acquire sophisticated skills in using the engine and navigating its Web space.

What Physical Behavior Do Children Demonstrate to Find Relevant Information for the Research Task in Yahooligans!, and Does This Behavior Vary by Success and with the Type of Task?

The physical behavior included the actions the children made other than searching and browsing. These were backtracking (i.e., use of Netscape *Back* command), total number of Web moves, search time, exploratory moves (e.g., use of Netscape *Bookmarks*), and navigational styles.

Backtracking

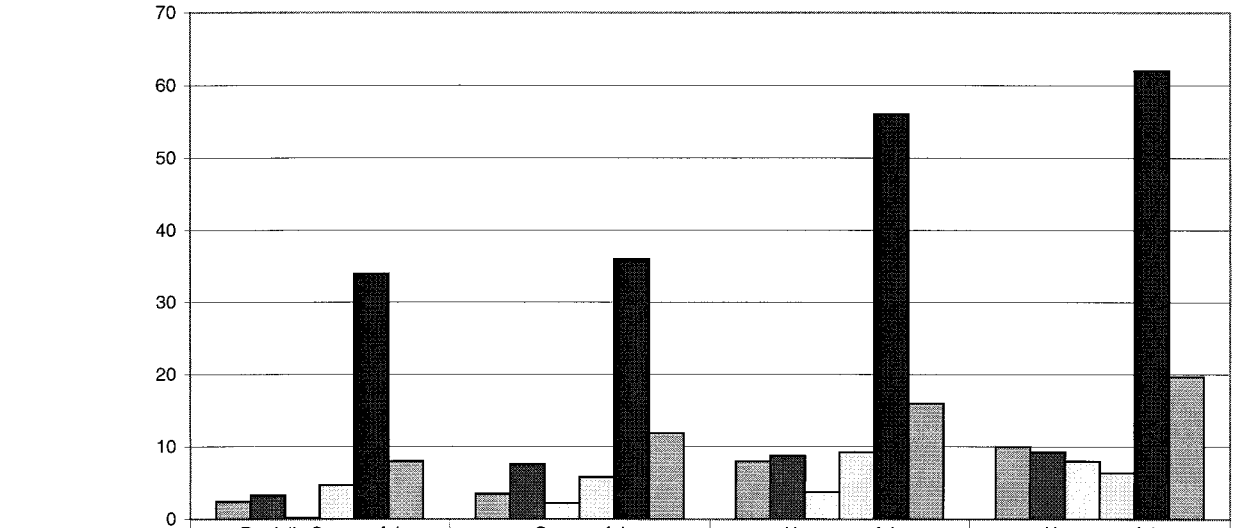
Figure 3 shows a great difference in backtracking between the research and the fact-based tasks. Children backtracked less frequently on the research task as opposed to the fact-based task (mean = 6.07 vs. mean = 12.2, respectively). Use of the *Back* command varied by success levels on the research task. Six out of nine children that partially succeeded (66%) and three out of four children that failed (75%) used this command to navigate among the Web pages they had retrieved. Partially successful children backtracked less frequently than unsuccessful ones, as was evident in the mean number of backtracks they made (mean = 4.7 vs. mean = 9.25, respectively). This behavior varied by task and success levels. As Figure 4 illustrates, children who partially succeeded on the research task and fully succeeded on the fact-based one backtracked slightly less on the research task than they did on the fact-based one (mean = 4.7, mean = 5.8, respectively). On the contrary, unsuccessful children backtracked more often on the research task than they did on the fact-based task (mean = 9.25 vs. mean = 6.4, respectively).

Web Moves

The number of Web moves children made to complete the task varied by task and success. The mean number of moves taken on the research task was 41 as opposed to 49 on the fact-based task (Figure 3). As seen in Figure 4, the mean number of moves taken varied greatly by success levels. Partially successful children took fewer moves to complete the research task (mean = 34) than did unsuccessful children (mean = 56). Within the successful group, the mean number of moves taken was similar to the mean number on the fact-based task (mean = 34 and mean = 36, respectively). Within the unsuccessful group, the mean number of moves taken varied slightly. It was (mean = 56) on the research task and (mean = 62) on the fact-based task.

Search Time

The time taken to complete the research task varied by success levels. As Figure 4 shows, partially successful children took half the time (mean = 8 minutes) of unsuccessful



	Partially Successful Research	Successful Fact-based	Unsuccessful Research	Unsuccessful Fact-based
Keyword searching	2.4	3.49	8	10
Browsing	3.28	7.58	8.75	9.29
Looping	0.2	2.2	3.75	8
Backtracking	4.7	5.8	9.25	6.4
Web moves	34	36	56	62
Time (minutes)	8	11.89	16	19.69

FIG. 4. Children's mean scores on the research and fact-based tasks by success.

children (mean = 16 minutes). This findings was not surprising because unsuccessful searchers are usually more persistent in their quest than successful ones (Borgman et al., 1995).

Children took less time to complete the research task than the fact-based task. The mean time taken on the research task was 10.42 minutes as opposed to 15.78 minutes on the fact-based task (Table 4). This finding was surprising, especially because prior studies of children's searching behavior showed that children spent more time locating information for the research task than the fact-based task (Borgman et al., 1995; Marchionini, 1989). There are two possible explanations for this finding: first, children sought "specific answers" to the topic of the task and, subsequently, they did not read the content of the relevant 12 pages of short text. They stopped their search process after locating one page of text that they believed contained the "answer."

TABLE 4. Children's cognitive and physical behaviors on research and fact-based tasks by mean.

Behavior	Research task (n = 13)	Fact-based task (n = 14)
Keyword searching	3.07	6.7
Browsing	4.15	8.4
Looping	1.54	5.1
Use of Back command	6.07	12.2
No. of web moves	41	49
Time to complete task	10.42min	15.78min

Second, children performed the research task on the fifth day of the experiment and after they had used Yahooligans! to find information for two other tasks (factual and self-selected). As was reported in the previous study (Bilal, 2000), backtracking occupied the largest segment of children's Web activities on the fact-based task (Table 4). In addition, the frequent use of incorrect search syntax (i.e., natural language) in search requests that resulted in zero retrieval hits increased children's search time. On the research task, children queried Yahooligans! using natural language only two times. They backtracked and looped both searches and hyperlinks less frequently than they did on the fact-based task. It believed that the "learning effect" and the nature of the task mainly influenced the decline in these Web moves.

Exploratory Moves

Only three children explored two command features in Netscape browser. They activated *Search* and *Bookmarks*, but did not perform a search within the browser's Search box or select a bookmark from the Bookmarks list. It seems that they were familiarizing themselves with these features. Surprisingly, none of the children activated the on-line help in Yahooligans! even when their search results returned zero hits. This may be due to either their lack of attention to its presence or incognizance to its value.

Navigational Styles

Children"s navigational styles were observed from point of arrival at the relevant Web site, relevant hyperlink, and

relevant home page to determine their "logical progression" in locating the relevant information. Overall, 69% of the children deviated from the relevant home page after viewing the text, backtracked to the relevant site, activated other hyperlinks, shifted back and forth between various links, and returned to the initial relevant home page. These children showed a "nonlinear" navigational style. That is, a style that reflects shifting back and forth between various links before selecting the relevant information. This style suggests that children were "uncertain" about the relevance of the information they found in their initial navigational moves. Thus, they explored other choices before they made a final relevance judgment.

Thirty-one percent of the children did not deviate from either the relevant site or relevant hyperlink or relevant home page after locating them. They maintained a "linear" style that was sequential, and did not include backtracking or shifting back and forth between links. This style reflects that these children were "certain" and "confident" about the actions they made and the choices they selected.

In sum, children's cognitive and physical behaviors varied greatly between the research task and the fact-based task. Children used incorrect search syntax (natural language) rarely, looped searches and hyperlinks less often, and backtracked less frequently on the research task as opposed to the fact-based task. Successful children differed on both tasks. Children who partially succeeded on the research task and fully succeeded on the fact-based task made fewer but more appropriate search moves, browsed fewer but more relevant subject categories and Web sites, looped searches and hyperlinks less frequently, backtracked less often, and took less time to complete both tasks than did unsuccessful children. In addition, children showed two navigational styles on the research task: linear and nonlinear, whereas as they showed one additional style (i.e., looped) in performing the fact-based task. A "looped" style is characterized by navigating between links and shifting back and forth between Web pages that result in a futile quest in locating relevant sites, hyperlinks, or pages for a specific task.

Overall, children had more difficulty completing the research task as opposed to the fact-based task. This is mainly because they possessed inadequate levels of research skills and sought specific answers to the task rather than constructed "meaning" from the relevant information found. The complexity of the research task has also contributed to its difficulty. It had multiple facets to the relevant information, and did not have prescribed responses or preset solutions as was the case for the fact-based task.

What Influence Do These Factors Have on Children's Success in Finding Relevant Information for the Research Task in Yahooligans!?

Prior Experience

Children's prior experience in using the Web was captured via a questionnaire they completed prior to using Yahooligans! Only one child had never used the Internet/Web; two children had less than 1 month of experience, and 10 children had experience ranging from 6 to 12 months. Prior experience in using the Web did not have a significant effect on children's success. It is believed that this finding was mainly due to unequal distribution in the number of children who had a high level of prior experience and those that had a low level of experience. However, the skills the children gained by the time they completed the research task showed a positive effect on their performance. Therefore, future studies should consider not only the effect prior experience has on the children's success, but also the amount of experience/learning they gain in performing various tasks over the course a research experiment.

Domain Knowledge, Topic Knowledge, and Reading Ability

Children's domain knowledge (i.e., science), topic knowledge (i.e., ozone), and reading ability were gathered via an instrument the science teacher completed. None of the variables had a significant effect on children's success. This finding was mainly due to the unequal distribution in the number of children who had high ratings on these variables and those who had low ratings. Surprisingly, unsuccessful children had higher mean scores on domain knowledge (9.75), topic knowledge (9.25), and reading ability (9.75) than partially successful children (8.5, 8, 8.5, respectively). However, the fact that 69% of the children who partially succeeded chose appropriate links to browse and extracted text from a relevant home page (*ozone depletion*) suggest that their success, although partial, was influenced by their adequate domain and topic knowledge. Further studies should consider these variables when measuring success, especially since prior research reveal that these two variables have a significant effect on children's success in using IRs, such as online catalogs (Borgman et al., 1995; Hirsh, 1997).

Discussion

This study reports the results of part two of a research project that investigated the cognitive and physical behaviors of middle-school students in using Yahooligans! to find relevant information for an assigned research task. It compared children's success and behaviors on this task to the success and behaviors they demonstrated on the fact-based task that they completed in the previous study (Bilal, 2000).

Children performed the research task on the last day of the research experiment (day five) and after they had used Yahooligans! for two other tasks (fact-based and self-selected). Although children had more difficulty with the research task than with the fact-based task, their performance showed some skills gain in using the engine and navigating its Web space. Children gained experience in using the search engine by trial and error, and adapted to its search and browse mechanisms without prior training.

The findings are discussed within the context of the four research questions and subquestions addressed in this study.

How Successful Are Children in Finding Relevant Information for the Research Task in Yahooligans!, and Does This Success Vary with the Type of Search Task (i.e., Research vs. Fact Based)?

Children were asked to locate relevant information for this assigned research task: *Environmentalists are concerned that the ozone layer is being depleted. Search Yahooligans! to learn how the lack of ozone in the earth's atmosphere is affecting our forests*. Children expressed their understanding of the task prior to searching Yahooligans! They also had the task written in front of them throughout searching. All children approached the research task by seeking "specific answers." Based on the success measure used, 69% of the children were partially successful in locating relevant information for the task and 31% failed. Partially successful children were unable to extract the required relevant information for the research task. In fact, "extraction of relevant information demands that students continually assess the state of their topic knowledge and remember the purpose for which they were gathering information" (Moore, 1995, p. 18). Although children had high topic knowledge, they did not use this knowledge fully when they encountered the relevant information. Conversely, unsuccessful children did not use their high topic knowledge at all as they printed and submitted information that was irrelevant to the topic of the task. The fact that 38% of the children (including those that partially succeeded and those that failed) chose text from the first page they encountered (1 of 12), did not scan or read the rest of the text, and stopped their search process after they printed the page suggest that they possessed inadequate knowledge of how to gather information. Kuhlthau (1993) describes the step at which users stop their information-gathering process. She notes that stopping a search is an action that relates to the concept of *enough* and "enough relates to seeking meaning in a quantity of information by determining what one needs to know and by formulating a perspective on which to build" (p. 165). Children did not seem to seek "meaning" from which to build a perspective about the topic.

This study revealed that all children sought specific answers to the research task. This finding is consistent with the research results by Wallace and Kupperman (1997). They found that middle school students who used the Web to locate information for class-related research projects performed multiple keyword searches until they reduced the number of hits to a single page that they believed contained the answers. In a traditional library setting, Moore (1995) observed that in using a card catalog, sixth graders approached research tasks with the expectation of finding the exact answer to their questions in the exact format required. Thus, the approach children take to solve research tasks is similar regardless of the type of library setting (card catalog vs. Web) or age. This approach is most likely influenced by children's level of adequate research skills (Kuhlthau, 1996; Moore, 1995; Pitts, 1995; Stripling, 1995). Such skills were not examined in the study reported here. Therefore, further research should examine the nature of these skills and determine how they influence the approach children take in locating information.

Another factor that may have influenced this behavior is lack of incentive (i.e., a grade). Children maximized their interest in using the Web as an end in itself rather than completing the task successfully. Research by Wallace and Kupperman (1997) has shown that most middle-school children who used the Web for class-related research projects were unsuccessful in locating relevant information. Further studies are needed to determine how use of the Web for class- and non class-related activities impact children's success and information-seeking behavior.

Children's success levels varied by task. Sixty-nine percent partially succeeded in locating relevant information for the research task, as opposed to 50% who fully succeeded in finding the correct answer to the fact-based task. Children who failed the research task (31%) printed and submitted irrelevant information, while those who failed the fact-based task (50%) submitted either incorrect answers or did not find the answer. Surprisingly, children's failure on both tasks was not associated with domain knowledge, topic knowledge, or reading ability. What may generally explain this failure is a lack of "engagement" on the part of the children. This may be due to lack of interest in the assigned topics, absence of incentive in performing the tasks, such as a grade, and inability to process the information encountered. Further research is needed to explain this "disengagement" and determine its nature. Watson (in press) suggests that children be given assignments that interest them mainly because they "need to show and practice expertise in their personal pursuits and their necessity to communicate and socialize with each other" (p. 14). Moore (1995) notes that self-selected assignments give children a sense of control and challenge in completing them. Hirsh (1999) also supports this view. However, the Web literature has little evidence of how assigned and self-selected influence children's information seeking behavior. This is an area of research that bears further study.

What Cognitive Behavior Do Children Demonstrate to Find Relevant Information for the Research Task in Yahooligans!, and Does This Behavior Vary by Success and with the Type of Task (Research vs. Fact Based)?

Children were not given instruction as how to approach the research task in Yahooligans! (search or browse), nor were they provided with prior training in using the engine and navigating its Web space. The intent was to examine whether, as novices, children were able to use a search engine that was specifically designed to support their information seeking. Most children searched by keyword rather than browsed by subject hierarchies in their initial moves. In subsequent moves, children shifted back and forth between

browsing and searching by keyword. Overall, children demonstrated good skills in formulating search strategies. They selected appropriate, concrete concepts from the search task and, in few instances, they employed abstract concepts when concrete ones did not yield results. Children also exhibited creativity in rotating search terms. No child used Boolean logic in formulating search strategies. Although the search engine did not provide this search feature, the fact that none of the children attempted this search method indicates their unfamiliarity with this type of searching.

Children browsed more than searched by keyword on the research task (mean = 4.15 vs. mean = 3.07, respectively). This finding was in line with prior research of children's use of the Web (Large, Beheshti, & Moukad, 1999; Schacter, Chung, & Dorr, 1998), on-line catalogs (Borgman et al., 1995), and multimedia encyclopedias (Large, Beheshti, & Breuleux, 1998; Large et al., 1994; Marchionini, 1989). The amount of browsing the children made in this study may have been influenced by search requests that failed. Children tried many concepts that were relevant but failed mainly because of Yahooligans! poor indexing. To alleviate the zero hit *problem, designers of Yahooligans! should provide an alphabetical listing of search terms indexed in the database and/or a thesaurus of such terms. The fact that Yahooligans! is a directory and maintains a hierarchy of subject categories facilitated children's browsing and, hence, compensated for their search failure.*

Only one child queried the engine using natural language. Surprisingly, two children committed misspelling errors on this task, although they had the task written and placed in front of them during searching. One child typed o-zone *but corrected the error in a subsequent move, and another typed* forrests *but initiated a new search instead of correcting the spelling. This finding indicates that regardless of age, users tend to make misspelling errors either because of inability to spell correctly or because of lack of attention to the error made. Designers of Yahooligans! should implement an effective spell-checking technique to assist children to recover from misspelling errors. This feature is essential, especially because Yahooligans! is specifically designed to support the information seeking of children with varied ages (7–12).*

The fact that children's cognitive behavior on the research task varied by success levels deserves some explanation. Partially successful children exhibited better performance than unsuccessful ones. They made fewer but more relevant searches by keyword, browsed fewer but more appropriate subject hierarchies and Web sites, and looped both searches and hyperlinks less often. One may suspect that these differences may be due to domain knowledge of the task, topic knowledge of the task, or reading ability. In fact, most children received high ratings by their science teacher on these variables. Based on partially successful children's mean score of search and hyperlink looping (mean = 0.2), it appears that they were more focused on completing the task than were unsuccessful children (mean = 3.75).

Overall, children's cognitive and physical behaviors on the research task varied from their behaviors on the fact-based task. They made fewer searches by keyword, browsed subject hierarchies and Web sites less often, and looped both searches and hyperlinks less frequently on the research task (mean = 3.07, mean = 4.15, and mean = 1.54, respectively) as opposed to the fact-based task (mean = 6.7, mean = 8.4, and mean = 5.1, respectively) (Fig. 3). This finding indicates that the children in this study browsed and searched by keyword less frequently on the research task as opposed to how they searched and browsed on the fact-based task. This may be explained by the fact that children performed the research task on the last day of the experiment (day 5) and after they had used Yahooligans! for two other search tasks (fact-based and self-selected). By the time the children performed this task, they had acquired some skills in using the search engine and navigating its Web space. These skills are mainly seen in the infrequent use of incorrect search syntax (i.e., natural language) and decrease in search and hyperlink looping. Search looping relates to reactivation of previously executed searches, whereas hyperlink looping concerns reactivation of previously visited hyperlinks. Search looping resulted from activating the Next Search *button that displayed a previously executed search in the engine's retrieval interface every time a search was made. Clicking on this button would reexecute an identical search. Evidently, children recognized the purpose of this button and, subsequently, activated it less often on the research task. Thus, the behavior children showed on the research task is attributed to both the nature of the task and the "learning effect."*

What Physical Behavior Do Children Demonstrate to Find Relevant Information for the Research Task in Yahooligans!, and Does This Behavior Vary by Success and with the Type of Task (Research vs. Fact Based)?

Children's physical behavior on the research task was observed in terms of the actions they made other than searching and browsing. These included use of Netscape *Back* command, total number of Web moves made, session time, exploratory moves (e.g., use of Netscape Bookmarks), and navigational styles. Nine out of 13 children (69%) who performed this task clicked on the *Back* button. The mean frequency for activating this command was 6.07. In fact, backtracking is common among Web users regardless of age. In a study of middle school children's use of the Web, Large, Beheshti, and Moukad (1999) found that children's backtracking accounted for 90% of the Web activities they made. Fidel et. al. (1999) found that high school students made frequent use of the *Back* button to return to familiar grounds they called "landmarks." At the university level, Catledge and Pitkow's (1995) study revealed that 41% of the browsing patterns of faculty, staff, and students at the Georgia Institute of Technology included activating the *Back* button, and was the second preferred method of

browsing after opening URLs. In a similar study, Tauscher and Greenberg (1997) showed that while half of user navigation actions were open URL addresses, 30% included the *Back* command. Wang, Hawk, and Tenopir's (2000) study of graduate students' interaction with the Web revealed similar results. Consequently, backtracking by the children in this study is considered typical of Web users' behavior. However, this behavior raises the issue of efficiency in using the Web. This is especially true in cases when a user needs to navigate among several pages to return to a specific page. The greater the number of Web pages retrieved, the longer it will take a user to navigate among the pages by using the *Back* command. When a user needs to retrace previous moves or revisit previously retrieved results, use of the *Go* list or the *History* list may become more efficient. The *History* list provides a comprehensive listing of a user's Web activities, including the name of the Web sites visited, the URL addresses, and the time these sites were visited. This list can also be searched by keyword. The *Go* list is organized in a "stack," meaning that it keeps the last 10 to 15 Web sites visited. When the number of Web sites visited exceeds the size of the stack, the sites displayed on the top of the list are replaced with new ones. In this study, only two children explored Netscape features, such as *Bookmarks* and *Search*, but none activated the *Go* list or the *History* list, indicating their unfamiliarity with these features. To assist children in navigating Web space efficiently, information professionals should incorporate use of these two features in information literacy/Web training programs.

Overall, children's physical behavior varied between the research and fact-based tasks. They made fewer actions and took less time to complete the research task than they did on the fact-based task. Children's behavior varied by success levels on the research task. Partially successful children backtracked less often than unsuccessful ones (mean = 4.7 vs. mean = 9.25, respectively), made fewer Web moves (mean = 34 vs. mean = 56, respectively), and completed the task s faster (mean = 8 minutes vs. mean = 16 minutes, respectively) (Table 4). These differences appeared to be influenced by the difficulty unsuccessful children experienced with this task. They made several searches by keyword that failed, browsed several subject categories and Web sites that were inappropriate and, subsequently, spent more time to complete the task.

Although prior studies of children's searching behavior show that children generally spend more time on open tasks than they do on closed tasks (Borgman et al., 1995; Marchionini, 1989), this study found the opposite. It is believed that the amount of time children took to complete the research task was mainly influenced by the approach they adopted to complete the task (seeking specific answers) and the skills they had gained in using Yahooligans! prior to performing the task.

What Influence Do These Factors Have on Children's Success in Finding Relevant Information for the Research Task in Yahooligans! Prior Experience, Domain Knowledge, Topic Knowledge, and Reading Ability?

This study did not reveal a significant relationship between children's success and prior experience in using the Web, domain knowledge, topic knowledge, and reading ability. It is believed that this finding was influenced by the unequal distribution in the number of children who had high ratings on these variables and those who had low ratings. Regardless of success, however, the skills the children showed on the research task suggest that the experience they had gained in using Yahooligans! prior to performing this task had a positive influence on their performance. Further research should consider the effect children's prior experience in using the Web have on success as well as the experience children gain when they perform multiple tasks over the course of a research experiment.

Implications

This study revealed that children sought specific answers to the research task, gained some skills in how to use Yahooligans! by trial and error, and possessed naïve Web navigational skills. It also showed that the design of Yahooligans! impacted children's information seeking behavior. The findings of this study have implications for formal Web training and search engine design improvements.

Web Training

This study found that children were unable to construct "meaning" from the relevant information they encountered. The approach they took indicates that they had inadequate level of research skills. Children must be taught how to locate, use, analyze, and evaluate information effectively and efficiently. The "Nine Information Literacy Standards for Student Learning" described in *Information Power* (AASL & AECT, 1998) emphasize K-12 students' effective and efficient use of information and ideas for becoming lifelong information literate. The Standards also call for collaborative efforts between school librarians and teachers to equip K-12 students with adequate research skills. Information professionals and teachers should take a leading role in teaching children how to apply a systematic approach to solve information problems. Adoption of the Big6 Skills© model developed by Eisenberg and Berkowitz (1990), for example, would provide children with the critical thinking skills they need to solve any information problem.

Due to exposure to Yahooligans! to complete two search tasks (fact-based and self-selected) prior to performing the research task, children showed some skills gain in using Yahooligans! and in navigating its Web space. Although this learning by trial and error is encouraging, it raises questions about Web use. Children must be taught effective and efficient use of the Web through formal instruction so that they develop sophisticated information seeking skills

and good "habits" in navigating the Web. As Fidel et al. note: "Without such training, the introduction of the Internet into schools will not help improve learning and may even help some students to develop unproductive learning habits" (1999, p. 34).

The children who participated in this study were seventh graders at one middle school. As Watson (1999) notes: "The intermediate and middle school grades offer a powerful, developmentally appropriate period in which to teach initial skills of information seeking and assessment because of personal interest and collegiate openness" (p. 16). Integration of use of the Web into a school's curriculum requires the collaborative efforts of both school librarians and teachers. These two mediators should ensure that children learn adequate research skills and know how to discriminate between different types of tasks (i.e., fact-based and research), regardless of the IR system they use. "Delaying the teaching of initial research skills and information literacy until high school may, by default, become more prescriptive than dynamic and motivational" (Watson, 1999, p. 16).

Yahooligans! Design

Children commented on their use of Yahooligans! during the exit interviews that were conducted at the conclusion of the research experiment. They articulated their likes and dislikes about Yahooligans! and made recommendations for improving it. Most children liked using Yahooligans! mainly because it provided keyword searching, had colorful graphics, was easy and fun to use, and was part of searching the Web. However, they did not like its slow response time, lack of relevant information, zero hits return, and its "confusing and a bad screen display." Children made five recommendations for improving the design of Yahooligans!: (1) add more sites, (2) add more categories, (3) add more keywords, (4) improve screen display, and (5) make response time faster.

The first recommendation (a*dd more sites*) denotes that the database needs enhancement. The second one (*add more categories*) implies that the content of the subject categories should be better represented. The third recommendation (*add more keywords*) indicates that database indexing should be enriched. The fourth one (improve screen display) implies the hierarchial structure of subject categories. Although this hierarchical structure facilitates browsing, its retrieval interface of subject categories and sites within categories can be confusing to many children. Broad subject categories, for example, have multilevel hierarchical menus that many children may find difficult to navigate. Prior research of children's use of the Science Library Catalog that employed a hierarchical structure reveal that the deeper the hierarchies were, the more difficulty children had in locating information (Borgman et al., 1995). Designers of Yahooligans! should improve its hierarchical subject structure and provide screen displays that encourage children's browsing and searching. Combined with faster response time, these recommendations would certainly provide better support of children's information seeking in Yahooligans! This is especially important because the engine is specifically designed for children ages 7–12 (Yahooligans!, 1994–2000).

Based on the findings of this study, system designers should also consider these improvements to facilitate children's use of the engine: (a) develop an alphabetical listing of terms contained in the database and/or a thesaurus of terms used; (b) give better guidance on-line about how to use the engine; (c) provide a context-sensitive online help; (d) incorporate effective error recovery methods, especially when zero hits are returned; (e) redesign the subject hierarchies to decrease the levels of hierarchical menus for broad topics; (f) eliminate redundancy in search results; and (g) provide a spell-checking technique.

This study found that children looped searches and hyperlinks frequently. The Web imposes a cognitive overload and "is likely to exacerbate users' feelings of being lost in hypertext, and cause them difficulties in navigating WWW subspaces" (Cockburn & Jones, 1996, p. 108). Due their limited cognitive abilities, children are more apt to get lost in cyberspace than adults. Because Yahooligans! is specifically designed to support the information seeking of children, and because children's level of recall knowledge varies with age level (Siegler, 1991), Yahooligans!' designers should implement some type of mechanisms that capitalize on children's recall and recognition skills.

Conclusions

This study presented the findings of Part II of a research project that investigated the cognitive and physical behaviors of seventh-grade science students in using Yahooligans! search engine/directory to locate relevant information for an assigned research task about the "ozone layer." Children's behaviors and success on this task were compared to their behaviors and success on the fact-based task they did in the previous study (Bilal, 2000).

Most children (69%) were partially successful on the research task, while 31% failed. Children's limited success in completing the task is attributed to the complexity of the task, their inadequate level of research skills, seeking specific answers, inadequate knowledge of how to use Yahooligans!, naive Web navigational skills, as well as Yahooligans!' inadequate design. Although information seeking and navigational problems can be remedied through formal Web training, the redesign of Yahooligans! should be addressed by system designers. Yahooligans! does not build on children's developmental level and cognitive abilities, nor does it model children's information-seeking behavior. A prior study of Yahooligans!' retrieval performance on queries submitted by a group of children showed many shortcomings that affected their success in locating desired information (Bilal, 1999). System designers should address these shortcomings so that they provide interfaces that facilitate children's information seeking and, subsequently, contribute to their learning.

This study found that 31% of the children failed the research task, although they possessed high levels of domain knowledge, topic knowledge, and reading ability. Children's failure seemed to be influenced by lack of "engagement" in performing the task. What may generally explain this failure is lack of interest in the assigned topic, absence of incentive in performing the tasks (e.g., a grade), and inability to process the information encountered. Garland (1995) notes that when children are given choices in selecting their research topics they develop a sense of control and tend to be more positive about embarking on a research project than if they had used an assigned topic. This suggests that assigned tasks may have a negative effect on children's performance (Gross, 1997) as it reduces their motivational level and challenge (Small, 1999; Solomon, 1994). Additional work is needed to develop a better understanding of how assigned and self-selected topics may impact children's success and information seeking on the Web.

Overall, children had more difficulty with the research task than with the fact-based task. This finding should not entirely confirm, however, that fact-based tasks are better suited for Web use than research tasks. This study reveals that children browsed less on the research task as opposed to the fact-based task. The fact that this finding was not in line with prior research of children's Web searching behavior (Schacter, Chung, & Dorr, 1998) suggests the need for further studies of how children of varied grade levels use the Web.

Children expressed design features that would support their information seeking in Yahooligans!. Designers of search engines should capitalize on the recommendations children make to improve the interface design of search engines and, subsequently, provide interfaces that build on children's cognitive abilities and developmental levels.

More research in children's use of the Web is needed to gain better understanding of the type of processes they adopt and approaches they take to solve various types of information problems on the Web. Some questions that bear study include: How do children use search engines designed for them as opposed to engines designed for adults to locate information for various types of tasks? To what extent does the design of Web browsers influence children's navigational behavior? How does the design of search engines influence children's success and information seeking behaviors on the Web? Are children more successful in using the Web for class-related activities as opposed to non class-related activities? To what extent do assigned tasks influence children's success as opposed to self-selected tasks? What influence do prior research skills have on children's success in locating information on the Web?

Much remains to be learned about children's information seeking behavior on the Web. Unlike on-line catalogs, online databases, and multimedia encyclopedias, the Web is an associative, nonlinear hypermedia system that lacks structure and imposes cognitive load and disorientation on users. Not only children, but also "adults have a difficult time constructing a meaningful mental model of the Internet" (Jacobson, 1995, p. 71). Therefore, in examining how children seek information on the Web, researchers should consider using search engines that are specifically designed for children, such as Yahooligans!, Super Snooper, KidsClick, and Ask Jeeves for Kids rather than only search engines that are designed for adult users. Results gained from these studies will be used to build a framework for improving the design interfaces of these search engines. We need to learn as much as possible about children's information seeking on the Web so that we can develop appropriate information literacy skills programs to educate and train children in using the Web effectively and efficiently.

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