How Do Children Find Information on Different Types of Tasks? Children's Use of the Science Library Catalog

SANDRA G. HIRSH

ABSTRACT

CHILDREN ARE INCREASINGLY GAINING access to digitized information through many media—online catalogs, CD-ROMs, online services, and the Internet. Using these tools to find the desired information can be challenging, as research has shown with adult searchers of online catalogs and online databases. Searching these electronic information sources requires a different set of search strategies and skills than searching print sources and appears to be related to the type of information that is desired. This article examines some of the issues related to how elementary schoolchildren find information on different types of search tasks on information retrieval systems, focusing on their use of the Science Library Catalog. The study found that task complexity and the amount of knowledge children have about the topic influence their success in locating information in the Science Library Catalog.

INTRODUCTION

Children are increasingly gaining access to digitized information made available to them in their schools, homes, and libraries. While electronic information retrieval tools such as online catalogs, electronic encyclopedias, and the World Wide Web allow children to search for information in ways that are not available in print resources, they require increasingly sophisticated skill levels and knowledge of search systems. In addition, most electronic information retrieval systems have been designed for adult users with little or no consideration of how young users

Sandra G. Hirsh, School of Information Resources and Library Science, 1515 E. First Street, University of Arizona, Tucson, AZ 85719
LIBRARY TRENDS, Vol. 45, No. 4, Spring 1997, pp. 725-745

search and retrieve information. Children are usually expected to search the same information retrieval systems designed for adults, but research has shown that children's information needs (Walter, 1994), research approaches (Kuhlthau, 1991), cognitive abilities (Siegler, 1991), developmental levels (Piaget & Inhelder, 1969), and skills (Vandergrift, 1989) differ from those of adults. Studies performed on children's use of online catalogs, which were designed for adults, have found that children usually like using them, but often have difficulty locating specific information related to their information needs. This article explores how children find different types of information on an information retrieval system called the Science Library Catalog designed specifically for elementary schoolchildren.

The Science Library Catalog Project

The Science Library Catalog Project began in 1989 as an outgrowth of the larger Project SEED (Science for Early Educational Development). The Science Library Catalog Project's goals were to design an interface for an automated library catalog that was appropriate for elementary schoolchildren and that could be used to increase understanding of children's information retrieval behavior. The Science Library Catalog, built in HyperCard on Macintosh computers, provided access to bibliographic records on science topics through a graphical interface and utilized a bookshelf metaphor to correspond to children's mental models of a library catalog. The Science Library Catalog was designed to minimize the known difficulties children have with existing online catalogs (e.g., spelling, typing/keyboarding, alphabetizing, Boolean logic) and to build on their skills and abilities (e.g., browsing, recognizing relevant topics, navigating hierarchical displays, using a mouse). Since the project began, six experiments were performed in several elementary school libraries and public libraries to test, evaluate, and improve the Science Library Catalog interface (e.g., Borgman et al., 1995; Hirsh, 1996a; Hirsh & Borgman, 1995).

The Browse Interface

The first four versions of the Science Library Catalog interface provided children with a single subject search method—a hierarchical browsing approach to searching for science materials. Using the Dewey Decimal Classification as a subject hierarchy, the browse interface presented children with a "bookcase" containing ten bookshelves; each bookshelf corresponded to a Dewey classification with only the science and technology shelves available as search options. This structure enabled children to navigate through successive levels of the science and technology hierarchies (the Dewey 500s and 600s) by clicking on bookshelves with a

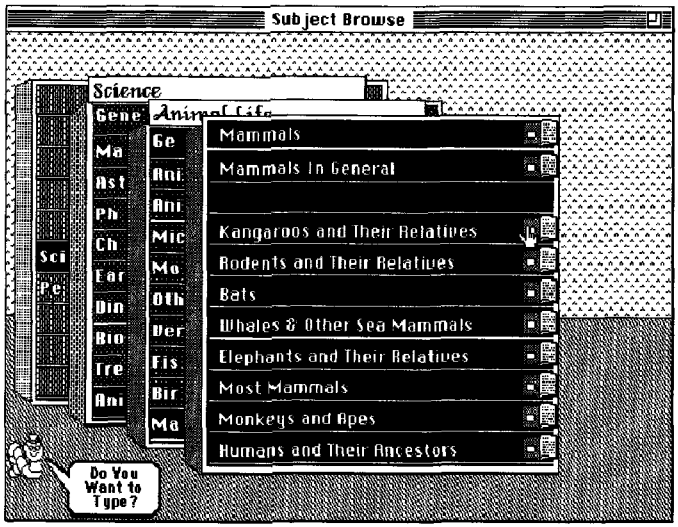

Figure 1. Browsing in the Science Library Catalog

mouse. Figure 1 shows a sample browse method search. The system had several features that were particularly beneficial for children: first, children were able to initiate a search without generating specific search terms; second, there were no error messages in the browse mode of the Science Library Catalog; third, the Science Library Catalog provided children with a map of the library and indicated where the book was located in the library they were using; and, fourth, the system could be used with little or no prior training. Results from the series of experiments involving the four versions of the browsing only interface are summarized in Borgman, Hirsh, Walter, and Gallagher (1995).

The Browse/Keyword Interface

The latest version of the Science Library Catalog interface combined the hierarchical browsing search method with a keyword search method. The keyword method was added because prior research indicated that some children, particularly the older elementary schoolchildren, preferred to type in their searches rather than navigating through multiple levels in the science/technology hierarchy (Borgman et al., 1991). Children initiated a keyword search by clicking on a bookworm which was located in the lower left-hand corner of every screen and which asked "Do you want to type?" After children typed in their search query, the system automatically ran each search request through spelling correction and stemming programs. The keyword search method matched children's search terms against the subject-rich portions of the bibliographic record (i.e., the title, subject headings, and notes fields). The

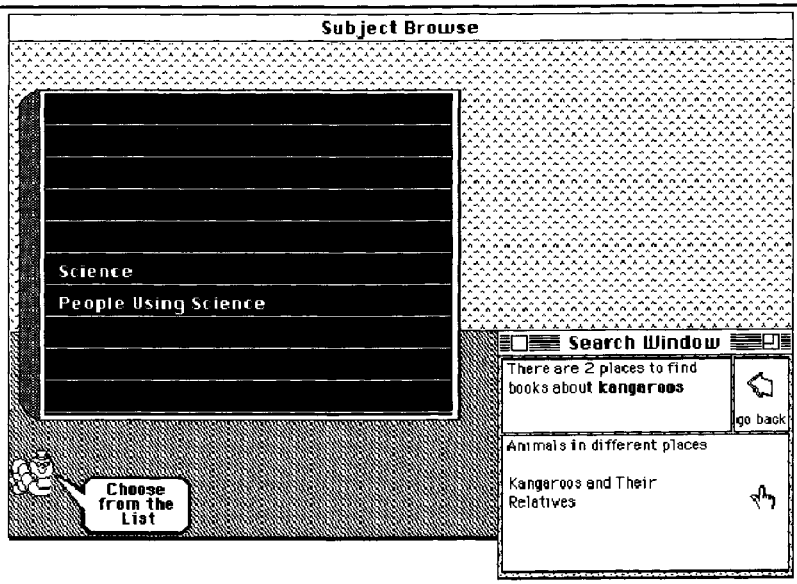

Figure 2. Keyword Searching in the Science Library Catalog for Information on "Kangaroos"

search results were presented as a rank-ordered list of shelf topic headings which contained book records matching the search request, as seen in a sample keyword search for books on "kangaroos" in Figure 2. By selecting one of these shelf topic headings, the mouse pointer was automatically placed at the selected bookshelf heading in the browsing structure. The keyword search method was embedded within the browsing structure in order to allow children to move easily between the browse and keyword search methods at any point during the search process and to provide children with context for their search topic. Children were able to make the transition between browse and keyword search methods without leaving their current search.

Prior Research

Research on children's search behavior on electronic information retrieval tools has found that children generally like to search online catalogs and electronic encyclopedias, often better than their print counterparts (Armstrong & Costa, 1983; Alberta Department of Education, 1983). While children tend to be enthusiastic in their use of electronic retrieval tools, they often have difficulty locating specific information when they use them (Vandergrift, 1989). One of the most complex processes is to express an information need in the form of a search request that is appropriate for a search system. Belkin (1980) describes this process in cognitive terms as Anomalous States of Knowledge (ASK). ASK describes the cognitive state involved in choosing the right vocabulary to describe

an information need that may not be fully formulated yet.

Children's vocabularies are less extensive than an adult's vocabulary, complicating this process further. Most keyword systems require children to express their information need in the form of a search query to initiate the search. Many children find it difficult to select search terms and then generate alternate search terms when their first attempt was unsuccessful, as found in the study conducted by Moore and St. George (1991) with sixth- and seventh-grade children working on an assigned research project on birds. Not only is it difficult to select search terms, but many print and electronic information retrieval systems require users to match their search terms to a controlled vocabulary or classification system. Brown (1995) found that third- , seventh- , eleventh- , and college-level students failed to generate subject search terms matching expected subject headings in 60 to 70 percent of their trials. It is unreasonable to expect that children would be able to match adult-oriented subject headings since Moll (1975) found that only 32.1 percent of the subject headings assigned to the sixth-grade books in her study were at children's reading levels.

Given these difficulties with selecting search terms and matching standardized vocabularies, how successful are children in retrieving information? Studies have found that success rates on online catalogs vary from 10 percent on a touch screen online catalog (Edmonds et al., 1990) to 66 percent on a standard online catalog (Solomon, 1993) to 80 percent in some of the Science Library Catalog experiments (Borgman et al., 1995). However, success rates and the search strategies employed on these systems have varied by the nature of the search task, such as the purpose (e.g., to collect information for a research paper, to find a specific fact, to find a book for recreational reading), subject focus, how much the searcher already knows about the topic, and complexity (e.g., relative ease of locating information on the topic).

Marchionini (1989) examined the information-seeking strategies used by third- , fourth- , and sixth-graders to find two assigned tasks on a menu-driven electronic encyclopedia: (1) a closed task, to find a specific fact (i.e., the date speed skating was introduced into the Olympics); and (2) an open task, to find information about a topic which had many possible answers (i.e., information on women space travelers). While the study found that children were equally successful on the open and closed task, the open task took more time to complete and required more moves than the closed task. These findings suggest that search behavior can vary depending on the amount of information needed and the purpose of the information retrieval experience.

Children's familiarity with the topic of the search has been found to influence search outcomes in several of the Science Library Catalog experiments with browse-only versions of the interface (Borgman et al.,

1995). Science topics appeared to be easier to find than technology topics since children generally study more science in school than technology and thus have greater domain knowledge in science. Less familiar topics, such as technology topics, were harder to find in the browsing structure of the Science Library Catalog. These findings suggest that the amount of domain knowledge children possess on the topic may influence the results, as has been found with adult searchers of information retrieval systems (e.g., Hsieh-Yee, 1993; Marchionini et al., 1990). In addition, the technology area in the Dewey Decimal Classification appears to be less structured than the science area, making some topics particularly difficult to find in the browsing interface of the Science Library Catalog. For example, the most difficult topic to locate in the browsing structure of the Science Library Catalog has consistently been "fire trucks" and "fire fighting" since these concepts were classified under Technology and then Engineering and then Building for City Services. Search topics that are more difficult to spell, such as "tyrannosaurus" and "vegetarians," appeared to be more difficult to find in standard online catalogs.

Search tasks can also vary by their level of complexity (i.e., how hard it is to find information on the topic). In a study examining how well children's choice of vocabulary terms matched a standardized vocabulary, Brown (1995) defined complexity in terms of the number of concepts represented by the vocabulary term. Studies with children and students have used other measures of search task complexity. Solomon (1993) performed an extensive qualitative study of elementary schoolchildren's use of an online catalog over an entire school year. In his study, success rates appeared to vary by how concrete or abstract the search concepts were. He observed that higher success rates resulted when children used simple concrete search terms (e.g., "cats" and "dogs") that matched subject descriptors in the catalog and used alternate search strategies when their first strategy was not successful. Older children, in grades four through six, had more complex information needs (e.g., topics like "ancient numerals") which required more complex search moves. However, searches involving more abstract concepts proved to be difficult and often resulted in high failure rates (56 percent) since the search terms selected frequently did not match the vocabulary of the catalog.

Matching the vocabulary of the system was found to be problematic in an earlier study by Egan et al. (1989). In this study, university student performance using a statistics text presented in print form was compared to a text browser called SuperBook. The results found that the phrasing of a search task affects success. Searchers performed information retrieval tasks more successfully when they were given the keywords in the phrasing of the search task that matched records, index terms, or free text terms in the search system.

This research suggests that the nature of the search task and the way

it is expressed does influence the search process in terms of success and strategies used. This article explores the effect of search task characteristics on search success and search behavior on an automated library catalog that was designed for elementary schoolchildren and provided children with two subject search options (i.e., browse and keyword) on the same search system.

Research Questions

The research questions presented here represent a subset of the issues discussed in Hirsh (1996b), which examined the factors that influence children's search success, search behavior, and learning when searching for information on the Science Library Catalog. The research questions presented in this article investigated the ways children find information on different topics and types of tasks on an automated library catalog and will contribute to our understanding of children's information seeking in digital environments.

- Does the topic of the search task influence information retrieval results on an automated library catalog?
- Does the complexity of the search task influence information retrieval results on an automated library catalog?
- Does the amount of prior knowledge children have about the topic influence information retrieval results on an automated library catalog?
- Does success on search tasks vary by search options?

Research Method

This study employed one-on-one interviews, online monitoring techniques, observations, and card sorting tasks to understand children's search behavior on the Science Library Catalog.

Participants

Sixty-four fifth grade children participated in the study. The sample was balanced by sex, level of domain knowledge in science (high, low), and school (school with library, school with computers). Behavioral data were collected from two public elementary schools in the Pasadena Unified School District. These schools differed in terms of library and computer resources. The "school with library" provided children with a school library, but no computer resources were available at the school at the time the study was conducted. The "school with computers" provided extensive computer facilities in a computer lab and in each classroom but no school library.

Measures: Independent Variables

This study examined the influence of user and task characteristics on search success and search behavior as children searched for science ma-

terials on the Science Library Catalog. User characteristics varied by sex, domain knowledge, and computer experience. Children were placed into high and low science domain knowledge groups based on their science grades averaged over two quarters and based on teacher recommendations.

Children were administered eight search tasks over two interview sessions that varied by topic, browsing task complexity, and keyword task complexity. Tasks were balanced for browsing task complexity and topic but not for keyword task complexity and topic. These task characteristics are described in more detail below. Table 1 lists the eight assigned topics; the exact phrasing of the search tasks can be found in the Appendix.

Science and Technology Topics. Children were assigned an equal number of science topics (drawn from the Dewey 500s) and technology topics (drawn from the Dewey 600s). The "Technology" category was named "People Using Science" in the Science Library Catalog to be more easily understood by elementary schoolchildren.

Browsing Task Complexity. Browsing task complexity refers to the difficulty of matching search terms to standardized vocabularies like the Dewey Decimal Classification. Simple-browsing tasks were those in which the

Table 1. Search Task Topics

Topics of Search Tasks	*Science/Technology Topics*	*Browsing Task Complexity*	*Keyword Task Complexity*
Electricity	Science	Simple	Simple
Garden Crops	Technology	Simple	Complex
Saturn	Science	Complex	Simple
Endangered Animals	Technology	Complex	Complex
Jellyfish	Science	Simple	Simple
Building Homes	Technology	Simple	Complex
Desert Environment	Science	Complex	Complex
Astronauts	Technology	Complex	Simple

task phrasing contained match words to the bookshelf or Dewey topic headings. For example, "building homes" was considered a simple-browsing task because the search terms given in the task phrasing matched the terminology of the bookshelf headings in the catalog. Complex-browsing tasks were those in which the task phrasing did not contain match words to the bookshelf topic headings. The four complex-browse topics assigned to children and their corresponding bookshelf headings were:

- "Saturn" was located under the bookshelf heading "Planets."
- "Desert Environment" was located under the bookshelf heading "Ecology."

- "Endangered Animals" was located under the bookshelf heading "Nature Conservation."
- "Astronauts" was located under the bookshelf heading "Space Travel."

Keyword Task Complexity. This measure was added during the data analysis phase to reflect complexity contributed by the keyword search method. Search tasks were recategorized as simple-keyword and complex-keyword tasks based on the number of topic headings appearing in the search window after a keyword search. Searches that yielded lengthy results sets (i.e., greater than ten headings) were considered complex-keyword topics. For example, the search for "endangered animals" was considered a complex-keyword task because it resulted in a display of fifty-nine categories. Searches that yielded ten or fewer headings were considered simple keyword topics. For example, the search for "jellyfish" resulted in a search window display of only two categories and was considered a simple-keyword task.

Dependent Variables

The independent variables were measured in terms of success and consistency behavior search method.

Success. Success in finding book records in the Science Library Catalog was defined as any book children identified as matching the assigned task. Children who were unable to find book records abandoned their search. This measure reflects children's interpretation of the assigned search task and the corresponding materials they would use to support their research. This was the same measure that was used in all prior Science Library Catalog experiments.

Search Method Consistency Behavior. Search behavior was evaluated with children as the unit of analysis and relied on monitoring log data collected from the built-in monitoring facility. The monitoring data were reduced into search strategy states to reflect the search methods children used on each search task. A consistent use of search methods was demonstrated when children used the same search method (i.e., browse only, keyword only) to complete all eight search tasks performed over both sessions. An inconsistent use of search methods was indicated by children who used a combination of browse and keyword search methods to complete the search tasks–i.e., mixed methods.

Procedure

Children were drawn individually from their classes twice for one-on-one search interviews each lasting between forty-five to sixty minutes; each interview was separated by approximately one week. The Science Library Catalog was loaded on a Macintosh Powerbook 160 and was used with an attached mouse. Given the differences in research sites, the same

database of science records (1,500 MARC records) was used at each school. No map of the library was included in this version of the interface.

All of the participants began their first interview session by viewing a brief automated tutorial on how to search the Science Library Catalog. When they were ready, children were asked to find book records on four tasks that were phrased as story questions that were intended to be similar to school research assignments. Search topics were selected from topics covered in the fifth-grade science curriculum and based on discussions with the teachers to determine science topics of interest to children at this age. Each search task was both read aloud and handed to children on an individual sheet of paper so that they could read the question. Children received identical search tasks in one of four different orders to control for systematic variance due to the task sequence. The ordering varied by which question set children received first and by the order of the tasks within each question set. Children were instructed to tell the interviewer when they found the book(s) they would need to write a school paper on the topic. In addition, they were told they could abandon the search if they were unable to find a book on a topic. Children were allowed to search for the topics using any search method they wanted and for as long as they wanted. During the search interviews, monitoring data were automatically collected on the Science Library Catalog; the online monitoring program automatically collected time stamps of each user and system action during the search interview.

The second interview session began by asking children to find book records on a different set of four search tasks than previously given. When they completed the search tasks, children were asked to explain their use of search methods (e.g., browse, keyword, or a combination of search methods). At the conclusion of the second session, children were asked several questions about the type and extent of their experience with computers, video games, and online catalogs.

Results

The results of the study are discussed in terms of the dependent variables: success and search method consistency behavior.

Search Success by Task Characteristics

A descriptive analysis shows that children's success rates varied by individual search task as shown in Table 2. Children were most successful in finding materials on the simple-browsing task, "Growing Garden Crops"; all but two children were successful in locating a book on this task. The complex-browsing topic, "Desert Environment," proved to be the most difficult task as only 62.5 percent of the children were successful in identifying books on this topic. Children also achieved lower success scores on two other complex-browsing topics with three-quarters of the children successfully completing their searches for "Astronauts" and "Endan-

gered Animals." The easiest complex-browsing topic for children to find information on was "Saturn" with a success rate similar to those rates found on simple-browsing tasks. This topic may have been less difficult since "Saturn" is one of the planets that most children learn about early in their elementary school program. In addition, the relationship between the assigned topic and corresponding bookshelf topic heading was more direct and hierarchical than the other complex browsing topics.

This descriptive analysis suggests that success rates varied by browsing task complexity. To examine the effect of browsing task complexity on search success, tasks were grouped by browsing task complexity (simple-browsing and complex-browsing). Browsing task complexity was treated as the repeated factor in a repeated measures ANOVA; domain knowledge and gender were treated as between group factors. The results for this analysis show a significant main effect for domain knowledge (F=4.25; df=1,60; p=.044). Children with high domain knowledge were more successful in finding book records than children with low domain knowledge regardless of the complexity of the search task. This analysis found a second main effect for the repeated factor of browsing task complexity (F=12.63; df=1,60; p=.001). Children were more successful in identifying book records when they performed simple-browsing tasks (mean=3.5 of 4 tasks) than when they performed complex-browsing tasks (mean=3.0 of

Table 2. Frequency of Success by Search Task

Task	Frequency	Percentage
Electricity	56	87.5%
Jellyfish	54	84.4%
Growing Garden Crops	62	96.9%
Building Homes	53	82.8%
Saturn	55	85.9%
Desert Environment	40	62.5%
Endangered Animals	47	73.4%
Astronauts	48	75.0%

Note: Sixty-four children searched each task. Percentages are based on the success rates for 64 children.

Search Topics (SimB = Simple-Browsing, ComB = Complex-Browsing; SimK = Simple-Keyword, ComK = Complex-Keyword; Sci = Science; Tech = Technology)

Electricity:	SimB -SimK - Sci
Jellyfish:	SimB -SimK - Sci
Growing Garden Crops:	SimB - ComK -Tech
Building Homes:	SimB - ComK -Tech
Saturn:	ComB -SimK -Sci
Desert Environment	ComB - ComK -Sci
Endangered Animals:	ComB - ComK -Tech
Astronauts:	ComB - SimK -Tech

4 tasks). There were no significant interaction effects.

A similar analysis was performed to examine whether children were more successful in identifying book records on science topics (Dewey 500s) than on technology topics (Dewey 600s) and to determine the effect of domain knowledge by topic. Tasks were grouped by topic (science and technology) and a repeated measures ANOVA was used to investigate this question. The topic was treated as the repeated factor; domain knowledge and gender were the between groups factors. The results for this analysis found a significant interaction effect for topic by gender (F=4.56; df=1,60; p=.037). Post hoc tests of simple effects for the interaction of gender and type of topic revealed that the only significant difference resulted from a paired + - test between the means for boys on the repeated factor topic (t = 2.028; df = 61; p = .047); boys were more successful on technology topics (mean = 3.4 of 4 tasks) than on scientific topics (mean = 3.1 of 4 tasks). In addition, a significant main effect for the between groups factor of domain knowledge was found (F=4.25; df=1,60; p=.044); children with high domain knowledge performed more successfully than children with low domain knowledge on both science and technology topics.

Since the keyword task complexity measure was not balanced for science and technology topics, only descriptive statistics are reported. Children's mean success scores on simple-keyword and complex-keyword tasks by level of domain knowledge followed the earlier task analysis patterns. Children with high domain knowledge had higher mean success rates on both simple-keyword (mean = 3.6 of 4 tasks) and complex-keyword tasks (mean=3.3 of 4 tasks) than children with low domain knowledge (mean = 3.1 of 4 tasks, mean = 3.0 of 4 tasks, respectively).

Search Method Consistency Behavior

Children were treated as the unit of analysis, so the task analyses were performed in terms of children's success on various tasks when they consistently used the same search method. Looking at search behavior and search tasks, the results show that children's success using the browse and keyword search methods varied by the individual search task. Table 3 shows the success rates of children who displayed search method consistency behavior by individual task topic.

Table 3 indicates that the six children who used the keyword only method to complete all of their search tasks were successful on all tasks. Given the limited number of children who used this method exclusively to complete all tasks, it is not possible to generalize about these findings. However, the results do suggest that all keyword only searchers were always successful in identifying book records they considered relevant to the search topic.

The success rates for the fourteen children who used browse only to

complete their search tasks ranged from 43 percent on Topic 8 (Astronauts) to 100 percent on Topic 3 (Growing Garden Crops). To find book records on "Astronauts" using the browse method, children needed to navigate through the hierarchical structure by looking first under People Using Science, then under Engineering, then under Other Branches of Engineering, and finally under Space Flight. Children may not have understood what Engineering meant or thought to look under the category, Other Branches of Engineering. Books on "Growing Garden Crops" appeared to be easy for these children to find, probably because the bookshelf heading corresponded well with the assigned task. These books were located under People Using Science, then under Raising Plants and Animals, then under Garden Crops, and finally again under Garden Crops.

Success rates for the majority of the children (n=44) who used a combination of browse and keyword search methods or mixed methods displayed a similar range of scores. Children who used mixed methods were least successful (52 percent success rate) in finding books on Topic 6 (Desert Environment) and were most successful (95 percent success rate) on Topic 3 (Growing Garden Crops).

Table 3. Success Rates on Individual Tasks by Search Method Consistency Behavior

Search Method	*n*	*Topic 1*	*Topic 2*	*Topic 3*	*Topic 4*	*Topic 5*	*Topic 6*	*Topic 7*	*Topic 8*
Browse Only	14	71%	71%	100%	93%	93%	79%	79%	43%
Keyword Only	6	100%	100%	100%	100%	100%	100%	100%	100%
Mixed	44	91%	86%	95%	77%	82%	52%	68%	82%

Search Topics
Topic 1 = Electricity
Topic 2 = Jellyfish
Topic 3 = Growing Garden Crops
Topic 4 = Building Homes
Topic 5 = Saturn
Topic 6 = Desert Environment
Topic 7 = Endangered Animals
Topic 8 = Astronauts

In order to understand the relationship between the search methods used and the success rate on specific categories of tasks, children's success in using the browse-only method to search for simple-browsing and complex-browsing tasks was examined. Children who used the browse-only method consistently to complete all tasks (n=14) performed better

on the simple-browsing tasks (mean = 3.36) than on the complex-browsing tasks (mean=2.93). It was not possible to compare children's success on simple-keyword and complex-keyword tasks when the keyword-only search method was used to complete all of the tasks since there was no variability in the data.

Discussion

While children overall experienced success rates averaging 80 percent across all of the tasks on the advanced version of the Science Library Catalog, the results show that success varied by task characteristics. The discussion interprets the findings by the research questions posed earlier in this article.

1. *Does the topic of the search task influence information retrieval results on an automated library catalog?*

Children were equally successful in finding materials on science topics (Dewey 500s) and technology topics (Dewey 600s) on the advanced version of the Science Library Catalog. These findings differ from some of the prior studies on the Science Library Catalog browse-only interface which found that children performed more successfully on science topics than on technology topics (Borgman et al., 1995). However, these earlier studies also found that children performed equally well on science and technology topics when the topics were searched on keyword-based online catalogs. This suggests that the availability of both keyword and browse search methods on the same information retrieval system minimized these science/technology topic differences.

An interaction effect for topic and gender was found, with boys performing more successfully on technology topics than on science topics. While several research studies have found sex differences in levels of computer experience and attitudes toward computers, with boys usually having more experience on computers and more positive attitudes toward computers (e.g., Fasick, 1995; Harvey & Wilson, 1985), no other sex differences were found in the present study. Thus, this interaction effect may be an anomalous finding.

2. *Does the complexity of the search task influence information retrieval results on an automated library catalog?*

In this study, two measures of task complexity (i.e., browsing task complexity, keyword task complexity) were employed to examine their influence on information retrieval behavior. The browsing task complexity measure investigated the effect of search terminology that did not match the catalog's vocabulary, a common occurrence in information retrieval with adults and children (Egan et al., 1989; Moll, 1975; Solomon, 1993). Simple-browsing tasks provided children with match words to the catalog's

bookshelf topic headings in the phrasing of the search task, while complex-browsing tasks did not. The results showed that children achieved lower success rates on complex-browsing tasks than on simple-browsing tasks. Children experienced the most difficulty locating books on the complex-browsing topic, "Desert Environment."

Observations of children's performance on complex-browsing topics, such as "Desert Environment," suggested that many children had difficulty understanding the vocabulary on some of the bookshelf topic headings. The Science Library Catalog used a modified version of the Dewey Decimal Classification to structure the database, replacing some of the difficult and more scientific terminology with terminology thought to be more understandable to elementary schoolchildren; this modified terminology was drawn from the vocabulary in the bibliographic records, such as the title and the notes field. Even with these modifications to the vocabulary in the Dewey Decimal Classification, some of the cataloging vocabulary used in the system may still have been beyond children's reading levels. Some of the children participating in this study were not at the reading level for their grade in school, which made some of these tasks even more challenging. Given the difficulties children have understanding the vocabularies in subject classifications, children are likely to have even greater difficulty in utilizing adult-oriented systems effectively.

The keyword task complexity measure investigated how the size of the results sets from a keyword search affected information retrieval behavior. However, no evidence was found to suggest that size of results sets on the Science Library Catalog influenced children's success in finding information. Since the results sets displayed bookshelf topic headings rather than individual book titles (as implemented in most information retrieval systems), the size of the results sets was probably smaller than those typically resulting from searches on standard keyword information retrieval systems. Research with adult searchers on online catalogs has found that people generally prefer to scan relatively small results sets, averaging thirty items (Wiberley & Daugherty, 1988). It is likely that a larger keyword task complexity effect would be seen if this measure were applied to children searching other information retrieval systems, such as the Internet, which produces extremely large results sets.

3. *Does the amount of prior knowledge children have about the topic influence information retrieval results on an automated library catalog?*

The results found that domain knowledge influenced search success on all types of tasks. The task analyses found that children with high domain knowledge, regardless of the complexity of the task or the science/technology topic, performed better on information retrieval tasks than children with low domain knowledge. These findings support prior research on the influence of domain knowledge on information retrieval with adult

searchers (Allen, 1991; Hollands & Merikle, 1987; Hsieh-Yee, 1993; Marchionini et al., 1990, 1991, 1993) and the findings from the expert-novice literature in other fields (e.g., education and psychology), which found that children who are domain experts performed better on problem-solving and memory tasks than domain novices (Ceci, 1989; Chi et al., 1989; Gobbo & Chi, 1986). Children with high domain knowledge had well-defined and developed knowledge bases that enabled them to perform information retrieval tasks more successfully. Similar to Marchionini, Dwiggins, Katz, and Lin's (1993) findings regarding adult subject experts, children with high domain knowledge were better able to make relevance judgments and to evaluate whether the retrieved information actually answered the search questions. These findings on the effect of domain knowledge on children's information retrieval must be interpreted cautiously. Given that science grades were used to measure children's science domain knowledge, variations in search success and search behavior by level of domain knowledge may also be influenced by children's attitudes toward the subject of science and motivation for learning about science, elements not measured in the study.

4. *Does success on search tasks vary by search options?*

The search behavior data suggested that children's success rates varied on search tasks depending on the search methods employed. This discussion evaluates performance in terms of each of the search behaviors: keyword, browse, and mixed.

Children who used the keyword method exclusively were 100 percent successful on every task, but only six children fell into this category. The implementation of the keyword search method, with its spelling correction program, ranked output, relatively short results displays and additional subject context given by placing the keyword searches in the browsing hierarchy, appeared to allow these children to be highly successful in finding bibliographic information. Even with these enhancements, query formulation for search options requiring children to type in their search queries remains problematic. For example, some children typed in natural language queries, such as "how much sunlight and water does a plant need" to search for books on "growing garden crops." While this query successfully resulted in book records on the topic of growing garden crops, natural language queries may not be supported in other information retrieval systems.

Children who used the browse method exclusively appeared to be most successful when they had a good understanding of the bookshelf headings encountered during the search, such as those for the simple-browsing tasks "growing garden crops" and "building homes." Conversely, this group of children appeared to be least successful when the bookshelf headings involved less familiar topic areas. For example, this group of

children had extreme difficulty finding books on "astronauts," which was located under the bookshelf heading Engineering and further buried under the Other Branches of Engineering category; it would be impossible to know what was included under this bookshelf heading without clicking on it first. Similarly, to find books on the simple-browsing task "jellyfish," children must select the bookshelf heading Microscopic Animals in order to reach the lowest bookshelf heading Jellyfish and Their Relatives. Selecting the bookshelf heading Fish, which many children chose, led them to books about fish in general or to lakes but not to books on jellyfish. Thus, while the browse searchers did not encounter problems with query formulation, several children had difficulty navigating their way to the desired book records since some topics were located under bookshelf topic headings that were not obvious or easily understood by elementary schoolchildren.

Children appeared to benefit from having more than one subject search option, with 69 percent of the children using both the keyword and browse search methods to complete some of their tasks. The mixed category included both children who made extensive use of both browse and keyword methods and those who used primarily one search method. Children in this group had a very difficult time finding materials on the topic "desert environment," with half of the children eventually abandoning their search on this topic. From reviewing the monitoring logs, many of the children switched back and forth between the browse and keyword search methods while searching for book records on this topic, suggesting that its location under the heading Ecology was difficult for some children using both browse and keyword search methods. In other cases, having the ability to use both keyword and browse search options led to more successful results. Whereas only 43 percent of the children using the browse method exclusively were successful in finding materials on "astronauts," 82 percent of the children who applied mixed methods consistently were successful. These analyses show that the success of the information retrieval interaction involved not only the nature of the search task but also the types of search options available.

Conclusion

Children were able to successfully find information in the Science Library Catalog with a success rate averaging 80 percent across all search tasks. However, considerable variation was found in success rates on individual search tasks. These variations were due, in part, to the complexity of the tasks, the amount of domain knowledge children possessed, and the search methods used. Children achieved higher success rates when the search terms they used matched the vocabulary that the system used. This finding supports earlier research indicating that children were successful when they used concrete search terms matching the catalog's ter-

minology on an online catalog designed for adults (Solomon, 1993). The present study concludes that matching children's vocabulary to classifications is still problematic, even when children searched a system that was designed for elementary schoolchildren and replaced some of the most difficult terminology with easier to understand concepts. Some children would benefit from more help and instruction in formulating and articulating search queries that are appropriate for search systems. In addition, the results indicate that children who knew more about the subject area they were searching had higher success rates in finding bibliographic information, regardless of the task characteristic. Thus, domain knowledge appears to be a critical factor influencing children's search success on information retrieval systems and requires further study to determine the generalizability of this finding.

The findings from this study suggest that children are highly successful in finding bibliographic information when they had several subject search options. Most of the children made use of both search options at some point during their search. While, in some cases, the use of more than one search option indicated that children were having problems locating the desired information, in other cases the ability to use more than one approach to locate information resulted in successfully finding information on the topic. Unlike the findings from children's use of keyword systems designed for adult users, children who searched exclusively with the keyword search option were successful on all of the search tasks. The keyword search option in the Science Library Catalog, which was designed to minimize many of the known difficulties children typically have with this method, appeared to yield productive results. Children who searched exclusively with the browse search option appeared to be more successful when the bookshelf headings they encountered involved terminology that was more familiar to them and easy to understand.

In conclusion, as children prepare to work and learn in an increasingly information-oriented society that uses technology to distribute and provide access to information, children need the search skills and the search tools that will enable them to find the information they need. In general, the Science Library Catalog provided children with an appropriate interface for finding bibliographic information. However, more information retrieval tools designed specifically for children are necessarily in order to facilitate children's information-seeking in digital environments.

Appendix
Exact Wording of Search Tasks

Electricity

Electricity is necessary for turning on light switches and for using electric

sockets. Electricity allows household appliances, such as your refrigerator, to run. Your task is to look for books about electricity for writing a school paper.

Garden Crops

Growing plants, such as vegetables and flowers, requires knowledge about many things. For example, people with gardens need to know how much water and sunlight to give their plants. Your task is to look for books about growing garden crops for writing a school paper.

Saturn

When it is dark, you can see stars, moons, and other objects in the nighttime sky. One of the objects in the nighttime sky is Saturn. Your task is to look for books about Saturn for writing a school paper.

Endangered Animals

The increasing size of the human population has led to the near extinction of several animals, including whooping cranes, bald eagles, and whales. There are people now who try to save and protect these rare and endangered animals from extinction. Your task is to look for books about endangered animals for writing a school paper.

Jellyfish

There is an entire world of living creatures that inhabit the ocean. One of the most fascinating creatures is the translucent jellyfish. Your task is to look for books about jellyfish for writing a school paper.

Building Homes

The process of building a home is complex. It requires many steps, including designing architectural blueprints, surveying the land, and building the frame. Your task is to look for books about building homes for writing a school paper.

Desert Environment

One of California's most famous deserts is the Mojave Desert. The desert environment provides a home to unique plants, such as cacti, and animals; these plants and animals have adapted to living in the harsh desert climate. Your task is to look for books about the desert environment for writing a school paper.

Astronauts

Travel in space is for real. First animals were sent into space to orbit the earth. Now humans pilot spacecraft in our universe. Your task is to look for books about astronauts for writing a school paper.

REFERENCES

Alberta Department of Education, Edmonton. (1983). *Utilization of a microcomputer in an elementary school learning resource centre.* Edmonton, Alberta: Planning Services Branch. (ERIC Document Reproduction Service No. ED 239 601)

Allen, B. (1991). Topic knowledge and online catalog search formulation. *Library Quarterly, 61*(April), 188-213.

Armstrong, M., & Costa, B. (1983). Computer Cat(tm) at Mountain View Elementary School. *Library Hi Tech, 1*(3), 47-52.

Belkin, N. J. (1980). Anomalous states of knowledge as the basis for information retrieval. *Canadian Journal of Information Science, 5*, 133-143.

Borgman, C. L.; Gallagher, A. L.; Walter, V. A.; & Rosenberg, J. B. (1991). The Science Library Catalog Project: Comparison of children's searching behavior in a direct manipulation and a keyword search system. In J.-M. Griffiths (Ed.), *Proceedings of the 54th Annual Meeting of the American Society for Information Science* (vol. 28, pp. 162-169). Medford, NJ: Learned Information, Inc.

Borgman, C. L.; Hirsh, S. G.; Walter, V. A.; & Gallagher, A. L. (1995). Children's search behavior on browsing and keyword online catalogs: The Science Library Catalog Project. *Journal of the American Society for Information Science, 46*(9), 663-684.

Brown, M. E. (1995). By any other name: Accounting for failure in the naming of subject categories. *Library and Information Science Research, 17*(4), 347-385.

Ceci, S. J. (1989). On domain specificity...more or less general and specific constraints on cognitive development. *Merrill-Palmer Quarterly, 35*, 131-142.

Chi, M. T. H.; Hutchinson, J. E.; & Robin, A. F. (1989). How inferences about novel domain-related concepts can be constrained by structured knowledge. *Merrill-Palmer Quarterly, 35*, 27-62.

Edmonds, L.; Moore, P.; & Balcom, K. M. (1990). The effectiveness of an online catalog. *School Library Journal, 36*(10), 28-32.

Egan, D. E.; Remde, J. R.; Gomez, L. M.; Landauer, T. K.; Eberhardt, J.; & Lochbaum, C. C. (1989). Formative design-evaluation of SuperBook. *ACM Transactions on Information Systems, 7*(1), 30-57.

Fasick, A. (1995). Children's use of information technology. *Encyclopedia of Library and Information Science, 55*, 51-69.

Gobbo, C., & Chi, M. (1986). How knowledge is structured and used by expert and novice children. *Cognitive Development, 1*, 221-237.

Harvey, T. J., & Wilson, B. (1985). Gender differences in attitudes towards microcomputers shown by primary and secondary school pupils. *British Journal of Educational Technology, 16*, 183-187.

Hirsh, S. G. (1996a). Complexity of search tasks and children's information retrieval. In S. Hardin (Ed.), *Proceedings of the 59th American Society for Information Science Annual Meeting* (October 19-24, 1996, Baltimore, MD) (pp. 47-51). Medford, NJ: Information Today, Inc.

Hirsh, S. G. (1996b). *The effect of domain knowledge on elementary school children, information retrieval behavior on an automated library catalog.* Unpublished doctoral dissertation, Department of Library and Information Science, University of California, Los Angeles.

Hollands, J. G., & Merikle, P. M. (1987). Menu organization and user expertise in information search tasks. *Human Factors, 29*(3), 577-586.

Hsieh-Yee, I. (1993). Effects of search experience and subject knowledge on the search tactics of novice and experienced searchers. *Journal of the American Society for Information Science, 44*(5), 161-174.

Kuhlthau, C. C. (1991). Inside the search process: Information seeking from the user's perspective. *Journal of the American Society for Information Science, 42*, 361-371.

Marchionini, G. (1989). Information-seeking strategies of novices using a full-text electronic encyclopedia. *Journal of the American Society for Information Science, 40*(1), 54-66.

Marchionini, G.; Dwiggins, S.; Katz, A.; & Lin, X. (1993). Information seeking in full-text end-user-oriented search systems: The roles of domain and search expertise. *Library and Information Science Research, 15*(1), 35-69.

Marchionini, G.; Lin, X.; & Dwiggins, S. (1990). Effects of search and subject expertise on information seeking in a hypertext environment. In D. Henderson (Ed.), *Proceedings of the 53rd American Society for Information Science Annual Meeting* (pp. 129-137). Medford, NJ: Learned Information, Inc.

Marchionini, G.; Meadow, C.; Dwiggins, S.; Lin, X.; Wang, J.; & Yuan, W. (1991). A study of user interaction with information retrieval interfaces: Progress report. *Canadian Journal of Information Science, 16*(4), 42-59.

Moll, J. K. (1975). *Children's access to information in print: An analysis of the vocabulary (reading) levels of subject headings and their application to children's books.* Unpublished doctoral dissertation, Rutgers University.

Moore, P. A., & St. George, A. (1991). Children as information seekers: The cognitive demands of books and library systems. *School Library Media Quarterly, 19*, 161-168.

Piaget, J., & Inhelder, B. (1969). *The psychology of the child.* New York: Basic Books.
Siegler, R. S. (1991). *Children's thinking,* 2d ed. Englewood Cliffs, NJ: Prentice Hall.
Solomon, P. (1993). Children's information retrieval behavior: A case analysis of an OPAC. *Journal of the American Society for Information Science, 44*(5), 245-264.
Vandergrift, K. E. (1989). Are children and teenagers second-class users? *Library Resources & Technical Services, 33*(4), 393-399.
Walter, V. A. (1994). The information needs of children. *Advances in Librarianship, 18,* 111-129.
Wiberley, S. E., & Daugherty, R. A. (1988). Users' persistence in scanning lists of references. *College & Research Libraries, 49*(2), 149-156.

[6] Sandra G. Hirsh, How Do Children Find Information on Different Types of Tasks, Children's Use of the Science Library Catalog. Library Trends 45(4): (1997) [7] Carsten Eickhoff et.al, A combined topical/non-topical approach to identifying web sites for children, WSDM '11 Proceedings of the fourth ACM international conference on Web search and data mining Pages , 2011 [8] Carsten Eickhoff Et.al, Web page classification child suitability, CIKM '10 Proceedings of the 19th ACM international conference on Information.Â This manual provides information on using the 3M Cloud Library patron reading application(app), which include apps for ios and Android devices, PCs and MACs. What you can do with the 3M Cloud Library app. More information. Special Libraries- Special libraries are libraries that are not the traditional type of library. Sometimes, a special library will be a part of a larger library. You will see this typically in university settings. Special libraries can really be any type of collection that has a narrow focus or has a different purpose than a public or academic library. For example, many engineering companies have a library and staff it with a librarian to help with research, finding information, and other tasks to are specific to that company. Another example is a library that focuses on one narrow topic. Keen...Â Teaching, the academics mostly teach classes to students on how to use the library. Government materials, such as federal, state or international documents. Childrenâ€™s. use of the Science Library Catalog. Library Trends, 45 (4), 725-745. Official Abstract: â€œChildren are increasingly gaining access to digitized information through many media -- online catalogs, CD-ROMs, online services, and the Internet.Â This article examines some of the issues related to how elementary schoolchildren find information on different types of search tasks on information retrieval systems, focusing on their use of the Science Library Catalog. The study found that task complexity and the amount of knowledge children have about the topic influence their success in locating information in the Science Library Catalog.â€ Database: Library Literature & Information Science Full Text.