

How do I find blue books about dogs? The errors and frustrations of young digital library users

*Hilary Hutchinson¹, Allison Druin², Benjamin B. Bederson¹,
Kara Reuter², Anne Rose, Ann Carlson Weeks²*

Human-Computer Interaction Lab

¹Department of Computer Science, ²College of Information Studies
University of Maryland, College Park, MD 20742
hilary@cs.umd.edu

Abstract

Children are among the fastest growing groups of users of the Internet, so it is important to design searching and browsing interfaces, such as those found in digital libraries, to support them. However, many interfaces geared toward elementary-age children suffer from at least one of two common problems. First, many assume that young users can spell, type, read, navigate, compose queries, and/or select small objects. Second, many assume that children search for books using the same criteria as adults. In fact, children have difficulty using and understanding traditional interface tools, and often employ different searching and browsing strategies from adults. A number of researchers have created digital libraries that better support young children. Our lab has also focused on this goal, most recently with the International Children's Digital Library (ICDL) project. This paper elaborates on the reasons why children require different searching and browsing tools and how interfaces that fail to recognize this lead to frustrating experiences. It describes how the ICDL addresses these issues and a study designed to investigate them further.

1 Motivation

One of the fastest growing groups of Internet users is young children. In the U.S., households with children are more likely to have Internet access than those without children, and nearly 20% of children as young as 3 and 4 now use the Internet (NTIA, 2004). One of the most common ways children use the Internet is for schoolwork, and search engines and digital libraries are popular ways that children can search and browse for information for their assignments. Websites such as Yahoooligans! (yahooligans.yahoo.com) and Ask Jeeves Kids (www.ajkids.com/) are examples of portals that children can use to find age-appropriate content for school projects or consumer purchases. Project Gutenberg (www.promo.net/pg/) and the Rosetta Project (www.childrensbooksonline.org/) are examples of digital libraries that provide access to scans of out-of-copyright children's books from around the world.

However, these websites are geared towards users who can spell, type, read, navigate, compose queries, and/or select small icons and links, all skills that many young children do not have (Solomon, 1993; Borgman et al., 1995; Hourcade et al., 2003). Many digital library websites also assume that children select books using typical adult library organizations. In fact, children often use different criteria, such as number of illustrations, preferred genres, and recommendations, that are not supported by most digital libraries (Kuhlthau, 1988; Fleener et al, 1997; Cooper, 2002). The ability to select content such as reading material on their own is a powerful motivator for children (Kragler & Nolley, 1996), and these websites make it difficult for children to do so.

2 Why children get frustrated

2.1 Differences in information processing and motor skills

Young children process information more slowly than adults, and this affects their motor skills, which rely on rapid processing of perceptual input to respond. Kail (1991) studied results from more than 70 experiments and found that information processing speed increases exponentially with age. Thomas (1980) noted that this has a direct effect on motor skills, because the slower speed with which children can process information affects how quickly they can adjust their movements. For motor skills that involve moving a computer mouse, the total time is governed by Fitts Law, which says that the time to move the mouse is directly proportional to the distance to the target and inversely proportional to the size of the target (Fitts, 1954).

For children, this means that larger target sizes (e.g. buttons and other widgets) allow them to make selections more quickly while small targets slow them down and can lead to frustration. Hourcade et al. (2003a) studied 4- and 5-year-old children and found that 64 pixel targets offered significant advantages over 32 and 16 pixel targets for both accuracy and avoiding target reentry once the target was already acquired. Certain interaction styles and mouse types can also frustrate children. Strommen (1994) found that children have difficulty holding down a mouse button for extended periods of time and coordinating dragging and clicking. Inkpen (2001) showed that children perform better and prefer interfaces with point-and-click interaction to those with drag-and-drop style interaction. Children also struggle with double clicking and multi-button mice (Bederson et al., 1996), and with differentiating left and right buttons (Hourcade et al., 2003).

Children, like adults, can also become frustrated with interfaces that fail to take advantage of human perceptual abilities. Relying on the recognition ability of the perceptual system through direct manipulation of objects on the screen is faster than recalling and typing information (Shneiderman, 1983). Ahlberg et al. (1992) expanded this idea to searching with dynamic queries, allowing users to control graphical widgets rather than typing queries. Doan et al. (1996) introduced query previews to avoid getting too many results or none at all by presenting summary information about search results. Ahlberg & Shneiderman (1994) introduced tight coupling, where dynamic query controls and results are presented together on the same screen, and both are rapidly updated to reflect the current state of the query. Shneider (1996) notes that such techniques can have additional benefits for children given their smaller memories and shorter attention spans, provided the interface is not overwhelmed with too many objects, colors, or motions.

2.2 Differences in searching and browsing skills

2.2.1 *Keyword searching vs. category browsing*

In digital libraries and other searching and browsing environments, two interfaces are commonly supported: keyword entry and selection of pre-defined categories. Many studies have shown that children are capable of using both techniques, but generally prefer and are more successful with category browsing (e.g. Borgman et al., 1995, Cooper, 2002). Borgman et al. (1995) explain this result as a combination of childrens' "natural tendency to explore" and the ease of recognition of categories rather than recall or formulation of keywords. Researchers have also noted that young children tend not to plan out their searches, and simply react to the results they receive (Marchionini, 1989; Solomon, 1993). This result is consistent with young childrens' behavior in other activities. Vygotsky (1978) noted that young children solving problems talk themselves

through the task as it takes place. As a result, children tend to perform better in browsing situations with open-ended tasks, and equally or better with keyword searches in directed tasks where the plan is provided for them (Borgman et al., 1995; Schacter et al., 1998; Hirsh, 1999).

The reasons for childrens' preference for and better performance with browsing interfaces are related to their physical and cognitive development. While spelling and typing keywords are difficult for young children (Solomon, 1993; Borgman et al., 1995), before they can get to this stage, they face two other obstacles. First, they must have sufficient domain knowledge to come up with useful keywords (Moore & St. George, 1991). At this point, many children, not knowing how a keyword system works, will simply enter a full natural language query (Marchionini, 1989; Solomon, 1993; Schacter et al., 1998). For children who know they need to use keywords, the second step is to extract keywords from their query. Cognitively, this can be a difficult task for young children who don't yet think abstractly (Spavold, 1990). Even for those children who do extract appropriate keywords, the search engine or digital library may use different indexing terminology, resulting in no hits. Finally, in systems where Boolean searches are allowed, children are often confused between the meaning of AND and OR (Marchionini, 1989).

2.2.2 Category hierarchies vs. simultaneous menus

Hierarchies are often used to organize large numbers of items. In computer interfaces, the different levels of a hierarchy are presented so that users can navigate up and down levels to search and browse. The arrangement of the hierarchy requires tradeoffs between the depth of the hierarchy – how many levels it has – and the breadth – how many items per level. Many studies have confirmed that broad, shallow hierarchies are better than deep, narrow hierarchies (Miller, 1981; Larson & Czerwinski, 1998). The extreme case of presenting all the items in a hierarchy on a single level is known as simultaneous menus. The simultaneous menu design is efficient because it prevents users from having to navigate and backtrack between different levels, at the cost of the increased visual and cognitive complexity of having more choices on the same screen. Hochheiser et al. (1999) compared a category hierarchy to simultaneous menus in a web environment. They found that for simple tasks that did not require backtracking, users were faster with the hierarchy, but for more complex tasks, they were faster with simultaneous menus.

Children are capable of using category hierarchies provided they have adequate domain knowledge (Borgman, 1995), but do have some problems with them. Marchionini & Teague (1987) observed children using an online encyclopedia and noted that the children often returned to the top of a hierarchy and drilled back down to get to intermediate levels, rather than taking the more efficient path of moving up one level at a time. To date, no studies have evaluated the use of hierarchies vs. simultaneous menus with children. The latest version of the ICDL category browser uses simultaneous menus, and we are currently studying whether or not this provides an improvement over the hierarchical category browser.

2.2.3 Boolean search

It has long been known that people have difficulty with Boolean logic, the use of the connectives AND, OR, and NOT to determine whether statements are true or false (Tversky & Kahneman, 1975). In digital libraries, people frequently misuse Boolean logic or don't use it at all to retrieve matching bibliographic records (Borgman, 1986). Children also have difficulty with Boolean logic, though they are still capable of using it (Snow & Rabinovitch, 1969; Neimark et al., 1970; Bloom et al., 1980). Many attempts have been made to simplify Boolean queries in adult interfaces to digital libraries. For children, the first example of a graphical interface that allowed Boolean searching was the QueryKids interface (Druin et al., 2001). In this interface, children

could search for animals with a hierarchical category browser. Boolean searches were created automatically with conjunctions between selected categories and disjunctions within them. Revelle et al. (2002) conducted a study with QueryKids and found that children were able to successfully construct both simple and Boolean queries when asked 85% of the time.

The Enhanced version of the ICDL was built based on the QueryKids interface and allowed children to combine categories about book metadata in a similar way (Druin et al., 2003). However, Reuter & Druin (2004) found that when asked to look for a book on their own, the children did not use the Boolean feature. We speculate that this is because doing so required backtracking in the category hierarchy to select another category. The latest ICDL category browser uses simultaneous menus with the goal of better supporting children in selecting more than one category. We are currently conducting a study to compare this simultaneous interface to a similar hierarchical interface to see if this design is more effective.

2.3 Differences in book selection criteria

While adults have become accustomed to searching for books using information such as title or author, elementary age children use different methods. Pre-school and early elementary children choose based on the appearance of the cover and illustrations (Moore & St. George, 1991; Kragler & Nolley, 1996; Fleener et al., 1997). Older children focus on textual summary information in jackets, covers, and indices (Wendelin & Zinck, 1983). Younger children tend not to make a distinction between fiction and non-fiction books, and prefer books about genres like fantasy to fiction or learning books (Kuhlthau, 1988; Fleener et al, 1997; Cooper, 2002). Older children focus on particular genres that interest them, such as sports and animals (Wendelin & Zinck, 1983; Kuhlthau, 1988). Young children tend to search and browse for books in the physical library by returning to shelves where they have been before (Borgman et al., 1995). Children of all ages enjoy rereading books, and older children like reading books by the same authors (Wendelin & Zinck, 1983; Fleener et al. 1997). Finally, recommendations by peers and teachers also influence children's book selections (Kragler & Nolley, 1996; Fleener et al., 1997). Most of these criteria do not fit into physical library organizations, or the adult digital library interfaces that are built based on them, making finding books a frustrating experience for children (Edmonds et al., 1990).

Later studies of digital libraries reflect the same general patterns found in physical libraries. Reuter & Druin (2004) found that when using the ICDL, younger elementary children tended to open books more frequently than older children so they could see illustrations before deciding to read the book, whereas older children relied on textual summary information in the book summary. Younger children like to search by physical attributes such as color (Busey & Dorr, 1993), while older children search using genres such as animals (Reuter & Druin, 2004). In the areas of repetition and recommendation, the digital also reflects the physical. In both search engines and digital libraries, children return to previous searches rather than running new ones (Bilal, 2002; Reuter & Druin, 2004). The top 5 books in the ICDL accounted for 20% of all book selections (Reuter & Druin, 2004), and the 100 most frequently used search terms accounted for 51% of all search terms used in Solomon's study of an online catalog (Solomon, 1990).

3 Solutions from Past and Present Children's Digital Libraries

Based on these findings, a number of researchers have built digital libraries to address children's skills and needs. Pejtersen (1989) created the BookHouse interface with category icons for different facets of the book classification scheme and tools to find previously read books or books

that were classified similarly. Borgman et al. (1995) used a book shelf metaphor with category icons in the Dewey Decimal hierarchy for the Science Library Catalog. Busey & Doerr (1993) worked with children to create the Kids Catalog, which provided multiple modes of access. Both Borgman et al. and Busey & Doerr found that the Dewey system didn't capture the search needs of children well. Both renamed the categories with more child-appropriate terminology, and Busey & Doerr added categories like animals and fairy tales that were missing. Külper et al. (1997) designed Bucherschatz with a category hierarchy and designed the interaction to avoid getting no hits. Druin et al. (2001) designed the QueryKids interface for finding information about animals with iconic categories and a built-in Boolean search capability.

While all of these systems provided improvements over adult-oriented libraries, none was a publicly accessible library containing scans of entire books. Some provided access to bibliographic records, and others were small collections of specialized media. In 2002, this changed with the launch of the ICDL, which provides free access via the Internet to scans of more than 500 children's books from all over the world using interfaces designed for and with children (Druin et al., 2003). The ICDL now provides the largest collection of children's books with an age-appropriate interface. Project Gutenberg (<http://www.promo.net/pg/>) and the Rosetta Project (<http://www.childrensbooksonline.org/>) both provide access to scans of out-of-copyright books from around the world, but both have text-only interfaces. Stories from the Web (<http://www.storiesfromtheweb.org>) contains children's books and book excerpts organized into child-appropriate categories, but requires reading and clicking of small text links. The Fairrosa Cyber Library of Children's Literature (<http://www.fairrosa.info>) provides links to digitized books around the web and to lists of recommended books for children, but in a text-oriented interface. Children's Books Online (<http://www.magickeys.com/books/>) provides access to about 30 English books created specifically for the web environment and published only online by their authors.

4 The International Children's Digital Library

4.1 Background

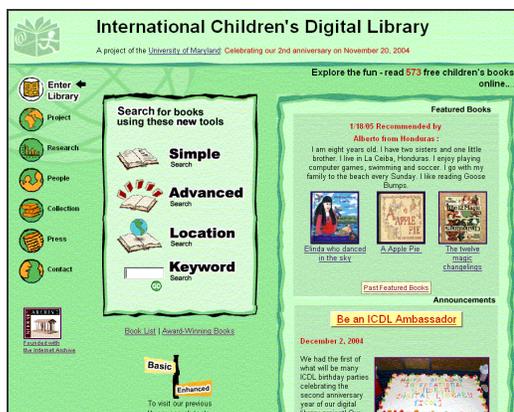


Figure 1: The ICDL home page



Figure 2: The ICDL Simple Search

The ICDL (www.icdlbooks.org) was initiated in 2002 with funding by the National Science Foundation and the Institute for Museum and Library Services (Figure 1). The University of

Maryland runs the library and the Internet Archive was a founding partner. The goals of the project include creating a collection of 10,000 children's books in 100 languages, collaborating with children to develop new interfaces for searching, browsing, reading, and sharing books, and evaluating the impact of access to multicultural materials on children, schools, and libraries. The project has two main audiences: children ages 3-13 and adults such as teachers and librarians who work with them, as well as international scholars who study children's literature. The project draws together an interdisciplinary team of researchers from computer science, library and information science, education, and art backgrounds. The research team is also intergenerational, including team members ages 7-11, who work with the adult members of the team to design the software for the ICDL. The original ICDL consisted of two interfaces for accessing the current collection of roughly 500 books in 30 languages: a Java application that could be run over the Internet using a plugin and a broadband connection and an HTML interface that ran on a 56K modem. The Java interface is being phased out due to its advanced technology requirements.

4.2 Handling frustrations

4.2.1 Information processing and motor skills

The ICDL interface draws heavily from previous research about children's perceptual skills and adeptness at handling a mouse. Important interface tools are implemented with pictorial icons to accommodate children who cannot yet read. The icons are at least 64 pixels in diameter to allow for easy selection and are accompanied by descriptive text for those users who can read. All functions are executed using direct manipulation of these buttons via a single point-and-click action and require the use of only a single mouse button. In the category browser interface, a simple form of query preview is created by enabling category buttons that have matching results in the current search and disabling buttons that don't. This method allows users to see the extent of category coverage in their search and prevents the creation of no-hit queries. The latest category browser is also tightly coupled with matching search results, which are presented on the same page and updated as the search is refined.

4.2.2 Searching and browsing skills

To accommodate the skills and needs of both children and adults who use the library, the ICDL supports a number of different tools for searching and browsing in an easily accessible HTML interface. The Keyword search allows adults and older children to type in keywords that match different types of book metadata (e.g. title, author, category, plot summary). The Location search consists of a globe that users can spin to select books from, about, or set in a particular continent. In the first version of the ICDL, a hierarchical category browser allowed children to navigate and select child-appropriate category icons to find books. Our research indicated that young children preferred the simplicity and concreteness of spinning the globe in the world interface, while older children preferred the category interface (Reuter & Druin, 2004).

In the original version of the ICDL, the category browser in the Java implementation allowed users to create Boolean searches by selecting more than one category in the hierarchy. However, Reuter & Druin (2004) found that while elementary-age children were able to navigate this hierarchy, they did not make use of the Boolean capability. As a result, we decided to redesign the category browser for the HTML implementation using simultaneous menus. We created a Simple version for children (Figure 2) and an Advanced version for adults. For children, the hierarchy was flattened so that leaf-level category icons are presented as buttons arranged around the perimeter of a box showing matching books. The selected categories are only joined conjunctively because children have an easier time with conjunction than with disjunction (Neimark et al., 1970; Bloom

et al., 1980). In addition, unlike disjunction, conjunction facilitates narrowing down the results so that children can easily select from a few books.

4.2.3 Book selection criteria

To facilitate easy selection of books in the ICDL, the team spent a great deal of time researching, organizing, and designing the categories for the category browser. The team looked at previous research on how children search for books in physical libraries (Pejtersen, 1989; Busey & Doerr, 1993; Kragler & Nolley, 1996; Fleener et al., 1997), visited physical libraries to observe children looking for books, sketched icons, and sorted them into a hierarchy. The final hierarchy included some traditional library categories, such as genre and subject, plus several more child-oriented categories, such as color, shape, and feeling. When the category browser was redesigned, we analyzed a years' worth of web log data and researched the most popular categories for younger children to select a smaller, more manageable subset of categories to include in the simultaneous menu design.

4.3 Future work

With the redesign of the category browser, our next research study seeks to investigate the tradeoffs between the additional navigation required in the hierarchical category browser and the large, potentially overwhelming, number of icons available in the simultaneous menu browser. We will conduct a study in local elementary schools to learn how children of different ages use these interfaces to conduct both simple and Boolean queries. There have been many studies of adults using hierarchical interfaces, indicating that broad, shallow hierarchies are preferable to deep ones, and that simultaneous menus have some advantages over hierarchies. Similarly, many studies have established that Boolean search is hard for both adults and children, and may be made easier by means of graphical rather than textual interfaces. However, no studies have looked systematically at how children of different ages are able to use hierarchies, simultaneous menus, and Boolean logic in computer interfaces designed to support their abilities. It is the aim of our research to develop a better understanding of these issues, which will inform the design of the ICDL and provide guidelines for designers of future interfaces for children of various ages.

5 Conclusion

As children continue to use the Internet in growing numbers, at younger ages, and for a greater variety of activities, it is imperative that interfaces be designed to support their skills and needs. Just like their adult user counterparts, children become frustrated when they can't use a computer interface, and may be turned off from the experience as a result. Digital libraries can provide vast quantities of information for children that may not be available to them in their local physical library, but only if they are able to access it. Fortunately, there is a sizable body of existing research on how children search for physical books, and a growing body of research about how children search for books using computers that designers can use to avoid creating frustrating interfaces. The ICDL is one example of a digital library that has taken advantage of this information and continues to build on it with an ongoing research program exploring the skills and needs of elementary-age children. While our focus is on creating interfaces for children, we also believe that much of this information may be relevant to interfaces for adults as well.

6 References

- Ahlberg, C. & Shneiderman, B. (1994). Visual information seeking: tight coupling of dynamic query filters with starfield displays. *Proc. of human factors in computing*, 313-317.
- Ahlberg, C., Williamson, C., & Shneiderman, B. (1992). Dynamic queries for information exploration: an implementation and evaluation. *Proc. of human factors in computing*, 619-626.
- Bederson, B., Hollan, J., Druin, A., et al. (1996). Local tools: an alternative to tool palettes. *Proc. of user interface software and technology*, 169-170.
- Borgman, C. (1986). The user's mental model of an information retrieval system: an experiment on a prototype online catalog. *International journal of man-machine studies*, 24, 47-64.
- Borgman, C., Hirsh, S., Walter, A., & Gallagher, A. (1995). Children's searching behavior on browsing and keyword online catalogs: the science library catalog project. *Journal of the American society for information science and technology*, 46 (9), 663-684.
- Bilal, D. (2002). Children's use of the Yahoo!igans! web search engine. III. cognitive and physical behaviors on fully self-generated tasks. *Journal of the American society for information science and technology*, 53 (2), 1170-1183.
- Bloom, L., Lahey, M., Hood, L., et al. (1980). Complex sentences: acquisition of syntactic connectives and the semantic relations they encode. *Journal of child language*, 7, 235-261.
- Borgman, C., Hirsh, S., Walter, A., & Gallagher, A. (1995). Children's searching behavior on browsing and keyword online catalogs: the science library catalog project. *Journal of the American society for information science and technology*, 46 (9), 663-684.
- Busey, P. & Doerr, T. (1993). Kid's catalog: an information retrieval system for children. *Youth services in libraries*, 7 (1), 77-84.
- Cooper, L. (2002). Methodology for a project examining cognitive categories for library information in young children. *Journal of the American society for information science and technology*, 53 (14), 1223-1231.
- Doan, K., Plaisant, C. & Shneiderman, B. (1996). Query previews in networked information systems. *Proc. of research and technology advances in digital libraries*, 120-129.
- Druin, A., Bederson, B., Hourcade, J., et al. (2001). Designing a digital library for young children: an intergenerational partnership. *Proc. of the joint conference on digital libraries*, 398-405.
- Druin, A., Bederson, B., Weeks, A., et al. (2003). The international children's digital library: description and analysis of first use. *First Monday*, 8 (5). Retrieved January 5, 2005 from http://firstmonday.org/issues/issue8_5/.
- Edmonds, L., Moore, P., & Balcom, K. (1990). The effectiveness of an online catalog. *School Library Journal*, 36 (10), 28-33.

- English, J., Hearst, M., Sinha, R. et al. (2002). Hierarchical faceted metadata in site search interfaces. *Extended abstracts of human factors in computing*, 628-629.
- Fitts, P.M. (1954). The information capacity of the human motor system in controlling the amplitude of movement. *Journal of experimental psychology*, 47, 381-391
- Fleener, C., Morrison, S., Linek, W., & Rasinski, T. (1997). Recreational reading choices: how do children select books? In W. Linek & E. Sturtevant (Eds.), *Exploring literacy: The 19th annual yearbook of the college reading association (75-84)*. Platteville: University of Wisconsin.
- Hirsh, S. (1999). Children's relevance criteria and information seeking on electronic resources. *Journal of the American society for information science and technology*, 50 (14), 1265-1283.
- Hochheiser, H. & Shneiderman, B. (2000). Performance benefits of simultaneous over sequential menus as task complexity increases. *International journal of human-computer interaction*, 12(2), 173-192.
- Hourcade, J., Bederson, B., Druin, A. & Guimbretiere, F. (2003). Accuracy, target reentry and Fitts' law performance of preschool children using mice. *University of Maryland technical report, HCIL-2003-16*.
- Inkpen, K. (2001). Drag-and-drop versus point-and-click mouse interaction styles for children. *ACM transactions on computer-human interactions*, 8 (1), 1-33.
- Kail, R. (1991). Developmental change in speed of processing during childhood and adolescence. *Psychological bulletin*, 109 (3), 490-501.
- Kragler, S. & Nolley, C. (1996). Student choices: book selection strategies of fourth graders. *Reading horizons*, 36 (4), 354-365.
- Kuhlthau, C. (1988). Meeting the information needs of children and young adults: basing library media programs on developmental states. *Journal of youth services in libraries*, Fall 1988, 51-57.
- Külper, U., Schulz, U., & Will, G. (1997). Bücherschatz – a prototype of a children's OPAC. *Information services and use*, (17), 201-214.
- Larson, K. & Czerwinski, M. (1998). Web page design: implications of memory, structure and scent for information retrieval. *Proc. of human factors in computing*, 25-32.
- 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. & Teague, J. (1987). Elementary students' use of electronic information services: an exploratory study. *Journal of research on computing in education* 20(2), 139-155.
- Miller, D. (1981). The depth/breadth tradeoff in hierarchical computer menus. *Proceedings of the human factors society*, 296-300.
- Moore, P. & St. George, A. (1991). Children as information seekers: the cognitive demands of books and library systems. *School library media quarterly*, 19, 161-168.

National Telecommunications and Information Administration (NTIA) (2004). A nation online: entering the broadband age. Retrieved January 5, 2005 from <http://www.ntia.doc.gov/reports/anol/index.html>.

Neimark, E. & Slotnick, N. (1970). Development of the understanding of logical connectives. *Journal of educational psychology*, 61 (6), 451-460.

Pejtersen, A. (1989). A library system for information retrieval based on a cognitive task analysis and supported by an icon-based interface. *ACM conference on information retrieval*, 40-47.

Reuter, K., & Druin, A. (2004). Bringing together children and books: An initial descriptive study of children's book searching and selection behavior in a digital library. *Proceedings of the 67th Annual Meeting of the American Society for Information Science and Technology*, 339-348.

Revelle, G., Druin, A., Platner, M., et al. (2002). A visual search tool for early elementary science students. *Journal of science education and technology*, 11(1), 49-57.

Schacter, J., Chung, G., & Dorr, A. (1998). Children's Internet searching on complex problems: performance and process analysis. *Journal of the American society for information science*, 49, 840-849.

Schneider, K. (1996). Children and information visualization technologies. *Interactions*, September-October 1996, 68-74.

Shneiderman, B. (1983). Direct manipulation: a step beyond programming languages. *IEEE Computer*, 16 (8), 57-68.

Snow, C. & Rabinovitch, M. (1969). Conjunctive and disjunctive thinking in children. *Journal of experimental child psychology*, 7, 1-9.

Solomon, P. (1993). Children's information retrieval behavior: a case analysis of an OPAC. *Journal of the American society for information science and technology*, 44 (5), 245-264.

Spavold, J. (1990). The child as naïve user: a study of database use with young children. *International journal of man-machine studies*, 32, 603-625.

Strommen, E. (1994). Children's use of mouse-based interfaces to control virtual travel. *Proc. of human factors in computing*, 405-410.

Thomas, J. (1980). Acquisition of motor skills: information processing differences between children and adults. *Research quarterly for exercise and sport*, 51 (1), 158-173.

Tversky, A. & Kahneman, D. (1974). Judgements under uncertainty: heuristics and biases. *Science*, 185, 1124-1131.

Vygotsky, L.S. (1978). *Mind and society: the development of higher mental processes*. Cambridge, MA: Harvard University Press.

Wendelin, K. & Zinck, R. (1983). How students make book choices. *Reading horizons*, 23, 84-88.