The Evolution of the International Children's Digital Library Searching and Browsing Interface

Hilary Browne Hutchinson[1], Benjamin B. Bederson[1], Allison Druin[1,2]
Human-Computer Interaction Lab
Department of Computer Science[1] and College of Information Studies[2]
University of Maryland, College Park, USA
{hilary, bederson}@cs.umd.edu, allisond@umiacs.umd.edu

ABSTRACT
Elementary-age children (ages 6-11) are among the largest user groups of computers and the Internet, so it is important to design searching and browsing tools to support them. However, many such tools do not consider their skills and preferences. In this paper, we present the design rationale and process for creating the searching and browsing tool for the International Children's Digital Library (ICDL), the results from a user study evaluating it, and the challenges and possibilities it presents for other children's interfaces.

Keywords
Children, search, browse, category browser, digital library

ACM Classificaton Keywords
H.5.2 User Interfaces; H.3.3 Information Search and Retrieval; H.3.7 Digital Libraries

MOTIVATION
In both the E.U. and the U.S., households with children are more likely to have computers and Internet access than households without children [4,5]. In 2003, 42% of U.S. children age 5-9 and 67% of children age 10-13 used the Internet [19]. Around the world, children use the Internet for schoolwork, games, and communication [4, 15]. These activities often require searching and browsing, using interface tools such as search engines and digital libraries.

However, many searching and browsing tools for children suffer from 1 or more of 3 problems. First, they do not take into account the information processing and motor skills of children, specifically their difficulties using a mouse [10]. Second, they do not consider children's searching and browsing skills, specifically their difficulties with spelling, typing, navigating, and composing queries [2]. Third, they do not consider how children prefer to search, using criteria appropriate only for adults [3, 8, 18]. As more children rely on these tools to access ever-increasing amounts of information, it is crucial to address these problems.

IDC '06, June 7-9, 2006 Tampere, Finland

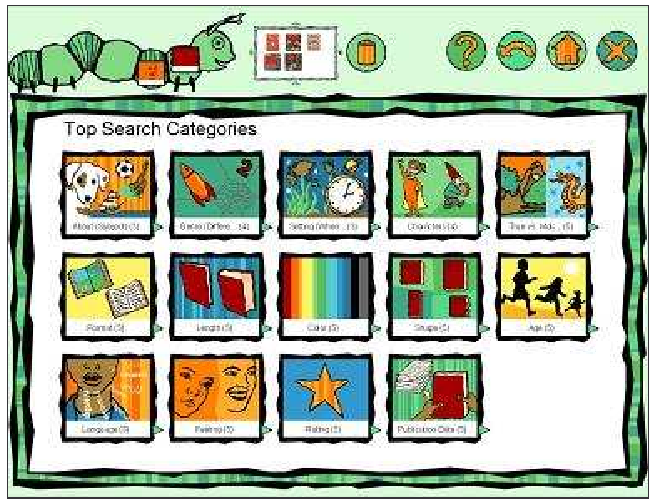

Figure 1. Original ICDL category browser

BACKGROUND
Recent work in our lab has focused on designing searching and browsing tools for digital libraries that support elementary-age children. QueryKids allowed children to find information about animals [8]. This tool used large, easily clickable icons; incremental and clearly visible results; and built-in Boolean search. Search categories were based on how children look for animals, and elementary-age children were able to use it to conduct single-category and Boolean, multiple-category searches [24].

Based on the success of QueryKids, we built the ICDL (*www.icdlbooks.org*) [7], a free collection of over 900 children's books from around the world used by roughly 25,000 users from 150 countries each month. The original ICDL design used an interface similar to QueryKids, with the addition of a hierarchical category browser (Figure 1).

The first version of the browser consisted of 14 top-level categories, such as age, color, and shape, each with several levels. Users could navigate down a category to select leaves for a search. Leaves with the same parent were combined disjunctively (OR), broadening the search, while leaves with different parents were combined conjunctively (AND), narrowing the search. This implicitly supported Boolean queries such as "(Red OR Orange) AND English". Books that matched the search were shown in a small box that could be zoomed in once the search was complete.

Reuter and Druin found that elementary-age children were able to navigate the hierarchy while browsing, but they did not use the Boolean capability [23]. As the size of the library grew, it became more important to support Boolean queries, particularly conjunctive Boolean queries. As the size of any information resource grows, conjunctive search is necessary to help users narrow down their results to a manageable size. Based on this study, we believed that the design of the browser discouraged children from creating conjunctive Boolean queries, and we decided to redesign it to address this problem.

This paper discusses the evolution of the design of the ICDL category browser as we responded to this and other challenges, and presents an evaluation of the current version of the software.

RELATED WORK

Our interface design decisions for the ICDL category browser were based on related work in three areas: information processing and motor skills; searching and browsing skills; and selection criteria.

First, young children process information more slowly than adults, and this affects their motor skills [28]. For motor skills that involve a mouse, children are slower to acquire a target than adults and require larger targets [10]. Children also have difficulty holding down a mouse button, dragging and clicking, double-clicking, and using multi-button mice [10]. As a result, single-clicking of large targets is a good choice in interfaces for children.

Second, children have difficulty with two common searching and browsing tools: keywords and hierarchies. While browsing emphasizes progressive filtering of results based on visual scanning and searching is a methodical activity with a specific goal [1], both tools support both tasks. Keyword tools are problematic because children have difficulty spelling, typing, and composing queries [18]. When browsing, children often do better with category browsers because they don't have to do these things [2]. However, category hierarchies are problematic because children do not always navigate them efficiently [16], may not think hierarchically [29], and may have difficulty understanding abstract, top-level categories [25].

Finally, children use different search criteria than adults. In physical libraries, young children choose books based on the appearance of the cover and illustrations, while older children focus on information in book jackets [13, 18]. Younger children tend not to make a distinction between fiction and non-fiction, and prefer books about certain genres like fantasy [3, 14]. Older children focus on different genres, such as sports and animals [3, 14, 30]. Recommendations by peers and teachers also have an important influence on selections [13]. Many of these trends are also true in digital libraries [23], making the choice of search criteria a crucial part of children's interface design.

Several previous digital library systems for children have attempted to address these issues [e.g. 2, 3, 21]. These systems included large, easily clickable buttons and child-appropriate categories, addressing the first and third concerns described above. However, they were generally based around a hierarchical category browser using the Dewey Decimal system, an improvement over keyword-based systems, but still a concern because of the hierarchy. The ICDL category browser also addressed the first and third concerns. It had a hierarchy with more child-appropriate terms than the Dewey system, but still suffered from the same challenges associated with hierarchies.

DESIGN CHALLENGES

We identified two major problems with the first version of the ICDL category browser, plus two smaller problems. First, the structure of the browser was a problem. The browser was created using faceted metadata [31], a collection of independent classifiers such as shape, color, and genre, each of which was hierarchical in structure. To select a leaf in a facet hierarchy, users had to rely on their knowledge of hierarchies and understanding of abstract, top-level facets, both of which can be difficult [25, 29].

Second, users could only explore one category at a time. This sequential presentation [9] meant that backtracking was required to explore multiple facets, something children don't always do efficiently [16]. Creating a Boolean search using categories from different facets required navigating to the leaves of one facet, backtracking to the top of the structure, and then navigating to the leaves of another facet.

In addition to these two problems, we observed that children often did not differentiate between the leaves and the interior nodes in the facet hierarchies because they were visually identical. This made it difficult to know whether clicking on a category would descend into the hierarchy or add the category to the search. Finally, the results of a search in the browser were isolated in a small box at the top of the screen, or on a different page entirely in a later version. In both cases, the results were separated from the focus of attention while searching and browsing, and we observed that children did not always find them.

DESIGN PROCESS

The ICDL project draws together an interdisciplinary team of researchers from computer science, information studies, education, and art. The research team is also intergenerational – team members include six to eight children age 6 to 11 who work with the adult members of the team twice a week during the school year and for two weeks in the summer on the ICDL and other research projects in our lab. Children and adults work together as design partners in a process of Cooperative Inquiry [6], observing one another using existing technologies, creating low-tech prototypes of new technologies, and evaluating high-tech prototypes of future technologies.

Figure 2. First revised interface

The children on our "kids team" played an integral role in developing the ICDL software. They visited libraries to interview other children, helped select, organize, and design the categories for the browser, and helped design and test the interfaces for finding and reading books [7]. When we decided to redesign the category browser, the kids team played an integral role in the iterative prototyping process. Our design process also involved children in two other contexts. We conducted usability tests with children from a local pre-school and with a group of elementary-age children we invited to our lab. In addition, we conducted formal user studies with a large group of children from local elementary schools, reported below.

FIRST REVISION

In the first prototype we developed to address these problems, we chose to focus on the presentation problem [11]. Rather than navigating facets sequentially, users could open multiple facets simultaneously (Figure 2). For adults, this type of simultaneous presentation was found to be faster when selecting multiple categories to create a Boolean query than a sequential presentation [9]. We thought the same might be true for children as well.

The interface consisted of six top-level categories, each of which had several levels below. Selecting a top-level category caused it to shrink and its children to radiate out from behind it in an animated way. When a leaf-level child was selected, it moved away from its parent to the top of the screen to a separate area showing currently selected categories. A link indicating the number of matching books took users to a new page with a list of the books.

This interface solved the presentation problem by allowing users to view multiple facets simultaneously, eliminating much of the navigation. However the structure was still hierarchical, requiring knowledge of high-level categories. The interior and leaf nodes were still difficult to tell apart because they were all rectangular, and there was not enough room on the screen for results. In addition, usability testing indicated that the animation was distracting.

SECOND REVISION

Based on the problems with the first revision, we designed a new interface, which consisted of a ring of category icons arranged around a collection of books (Figure 3). Over several months, together with our kids team, we critiqued initial sketches of this design, sketched low-tech prototypes of improvements, and iterated over several high-tech prototypes. After a usability-testing session with another group of elementary-age children, we replaced the original category browser with this design in October, 2004.

This new interface was designed to address all the design challenges we identified in the original browser. First, we flattened the hierarchies in the original category facets to a single layer, using the leaf-level categories rather than the abstract, top-level categories. Next, we identified a subset of the most popular of these categories and presented them simultaneously, avoiding much of the navigation required in the sequential presentation. By flattening the category structure, we also removed the distinction between interior and leaf level categories, avoiding potential confusion between them. Finally, we placed the search results in the middle of the screen to draw attention to the goal of the search: reading the books in the library.

Category Button Design

After flattening the hierarchy, we analyzed a years' worth of web log data from the old ICDL category browser to determine which leaf level categories to present. To make both the category and book icons large enough for children to click on, we could not use all the categories, nor could we even fit the subset we chose on a single screen. As a result, we had to introduce either paging or scrolling to accommodate them. We chose paging (between 2 pages) because it is believed to be superior to scrolling in many situations [17], and because we wanted the interface to fit on a single screen at 1024x768 pixel resolution. This resulted in 22 categories on the first page, plus two buttons labeled "More Choices" that linked to a second page with another 22 categories. More Choices buttons in the same location on the second page link back to the first page.

Figure 3. Second revised interface

Figure 4. Interface after selecting Rainbow and Fairy Tales.

For the design of the category icons, we used round rather than rectangular icons because we observed that children sometimes got confused about whether they were looking at categories or books. To accommodate all the categories, we needed to make them small enough so that many would fit on the page, but not so small that they were difficult to click. Icons with 64 pixel diameters are sufficient for children as young as 4 to click [10], so we chose this diameter. Like physical buttons, selected categories appear depressed, while unselected categories appear raised.

Category Button Function

Clicking a category button selects it and adds it to the search, and clicking it again unselects it. Categories are joined conjunctively: selecting multiple categories matches only books that belong to all of those categories. We chose to support only conjunctive searches for three reasons. First, children have an easier time with conjunction than disjunction [20]. Second, the goal of the interface is to narrow down the number of books so that children can easily select from a few. Finally, while the original browser used conjunction between categories and disjunction within category groups, we felt that this would be confusing when all the categories are on the same level.

When categories are selected, they are combined in an "equation" across the top of the results section to indicate that their combination adds up to the count of the results (Figure 4). This visual tool makes the effect of selecting multiple categories concrete, which is important for children learning to reason logically [26]. Categories that do not match any books in the current result set are grayed out to avoid the creation of no-hit searches (Figure 4).

In addition to selecting categories, users can refine their search by including keywords and limiting the results to a particular language. The keyword appears as part of the search equation. The language menu also appears in the equation and contains only languages that appear in the current result set, preventing no-hit searches. However, it is possible to create no-hit searches using keywords.

Results Section Design

We followed the advice of Plaisant et al. [22] to bring the "treasures" of the library to the surface by having books appear on the same page with the search tools. We chose to place the books in the middle of the page, rather than having categories on one side and result on the other, as is common in other interfaces, for two reasons. First, we felt that the books should be the main focus of the page. Even if a user doesn't understand the categories, it is clear that the books are the important part of the page. Second, the inspiration for this design, which we originally called Fisher-Price®, came from our observation of toys for young children, which often have a central feature with large buttons around the outside. We felt that using this familiar design might make children more comfortable.

Result Section Function

Frequent observation of children using software informed our choice to implement a progress bar in the results section. We observed that children are impatient if an interface does not respond immediately, and may click a button multiple times if they don't get immediate feedback. The progress bar lets children know that their action has worked. When no categories are selected, a group of 2 or 3 featured books appears. The results are incrementally updated whenever categories are added or removed. For instance, if a user selects Rainbow and Fairy Tales, the results show books that match both categories (Figure 4).

Design Tradeoffs

This new interface addressed the concerns we had with the original interface. Children can rely on perception rather than hierarchical knowledge to find categories because the hierarchy is flattened. Children need only select from concrete, leaf-level categories because the more abstract, top-level categories are removed. They do not have to navigate and backtrack because the categories are viewed simultaneously. They do not have to distinguish leaves from interior nodes, and they can easily find books because they are prominently displayed in the center of the page.

However, this design had three tradeoffs. First, the increased number of categories on the page could be visually overwhelming to young children [26]. Second, placing the categories around the perimeter results in an interface that requires a lot of visual scanning. More traditional interfaces of this type place categories on one side and results on the other side to reduce visual scanning. Finally, by using paging to accommodate all the categories, we ran the risk of children not finding the paging buttons and never reaching the second page of categories.

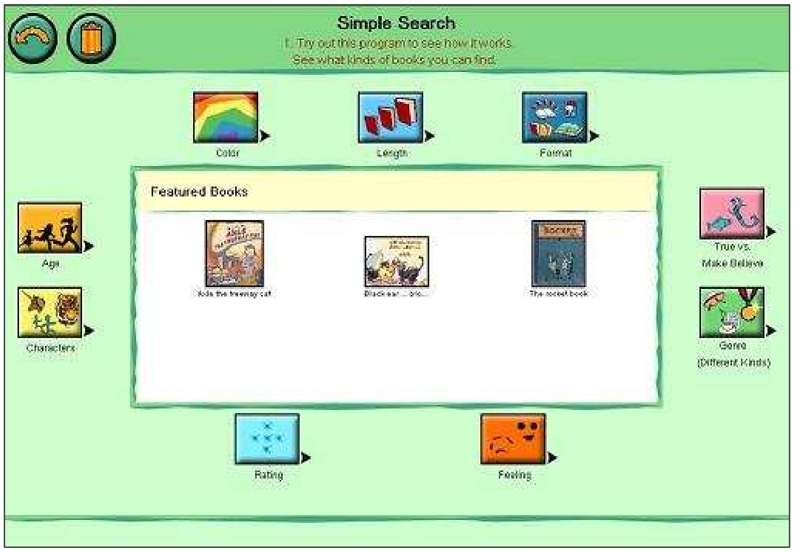

Figure 5. The top level of the hierarchical interface

EVALUATION

To explore these tradeoffs, we conducted a controlled user study. We believed the new interface would be faster, easier, more likeable, and preferred to the old interface while searching, and would better facilitate the creation of Boolean queries while browsing. We also thought it might better support comprehension of Boolean search.

We compared our new interface to a second interface similar to the old design, a hierarchical category structure. These designs both fixed the categories around the perimeter of the screen and placed the books in the middle, but varied the structure and presentation of the categories. Since one of our motivations was to better support the creation of Boolean queries, we had participants do searching and browsing tasks that involved selecting two categories. We varied interface and age, and measured speed, accuracy, comprehension, and preference.

Study Design

Participants

The participants were 12 first graders (age 6-7), 12 third graders (age 8-9) and 12 fifth graders (age 10-11), equally split between boys and girls. Children came from 4 suburban Maryland elementary schools. All were familiar with computers; none had previously used the ICDL.

Materials

Participants used a Dell laptop with a 12 inch display, 1024x768 screen resolution, an Intel Pentium 3 Mobile CPU, Windows XP, and a Kensington single-button mouse. The software was an adapted version of the ICDL running locally and instrumented to record each mouse click. Participants used the Microsoft Internet Explorer 6 browser in full screen mode with the task bars hidden.

Interfaces

We created two interfaces: *flat* and *hierarchical.* The flat interface was identical to the new interface, minus the keyword and language search options. The hierarchical interface used a two-level category structure (Figure 5). It organized the 44 leaves from the flat interface into 9 top-level facets, each with 2-12 leaves on a second level. To select leaves from different facets, users had to backtrack to the top level using a large "Up Arrow" button (Figure 6). In both interfaces, when no categories were selected, three featured books were shown in the results area.

Procedure

Each participant worked with a researcher one at a time. Participants completed tasks with one interface, then the other. Each participant used both interfaces, so we created two different but structurally and cognitively similar sets of tasks. For example, children might be asked to find "Red, Happy" books in one set and "Orange, Sad" books in the other. The buttons were located near each other in both interfaces and involved the same concepts. Interface order and task set were counter-balanced and search task order was randomized.

Tasks

The first task was a browsing task to observe how participants used an interface without instruction. After 2-3 minutes, the researcher demonstrated how the interface worked. This included instruction on how to select and unselect a category, start over, use the paging arrows, and use the More Choices or Up Arrow buttons. It did not include instruction on how to create a Boolean query.

Participants were then asked to select two category buttons and questioned about what kinds of books were found. This question was designed to elicit whether participants understood that they were creating a conjunctive Boolean query when they selected two category buttons.

Participants then completed 6 timed search tasks. Each task was a question of the form "How many X books are there?", where X was two categories from different facets. These tasks were designed to see which interface allowed the children to select categories from different facets faster. Performing a task in the hierarchical interface always required more clicks, but more visual scanning was required in the flat interface. Tasks were selected so that each facet in the hierarchical interface was used at least once. In the flat interface, half of these tasks required using the More Choices buttons to reach the second page (*two-page tasks*) and half did not (*one-page tasks*). In the hierarchical interface, there was no distinction between these tasks.

Next, participants were again asked to select two category buttons and questioned about what kinds of books were found. Participants then answered two questions about the difficulty and likeability of the interface and then repeated the same protocol with the second interface. Finally, participants were asked which interface they liked better.

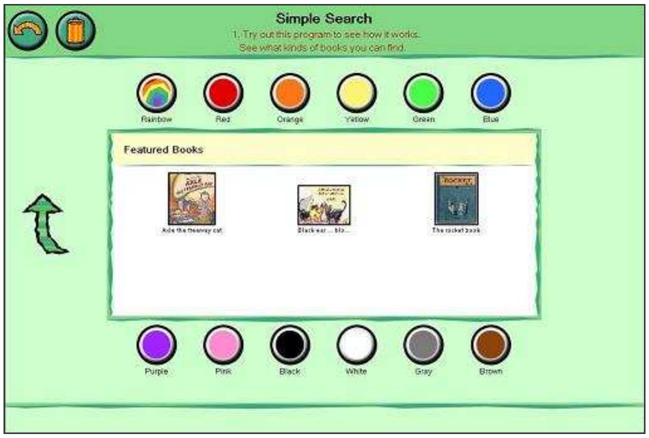

Figure 6. The color leaf level of the hierarchical interface

Hints

Our university human subjects rules required that the study take no more than 30 minutes per child, which pilot testing showed would require giving some children hints until they successfully completed a task, or enforcing time limits. We chose to give hints as verbal scaffolding to support children [27]. During pilot testing, common problems were identified and strict protocols were developed for giving hints to reduce the potential for bias. For each problem, several increasingly more helpful hints were developed and provided in order until a child was able to successfully complete a task. The same researcher worked with all participants to avoid inconsistency.

Results: Browsing

During the browsing task, we counted the number of Boolean queries created. A Boolean query was defined as having at least two leaf-level categories selected. Overall, children created a total of 224 Boolean queries in the flat interface and 104 in the hierarchical. The results of a Wilcoxon signed rank test were significant ($p<0.01$), indicating that more Boolean queries were created in the flat interface than the hierarchical. Significant differences were also found in fifth grade. These results suggest that when no prior instruction is given, the flat design better supports the creation of Boolean queries.

We also counted the number of children who found the navigation buttons on their own while browsing. In the flat interface, 12 children used the More Choices buttons, while 24 did not. The results of a binomial test were significant ($p<0.01$), indicating that more children did not find these button than did. In the hierarchical interface, 23 children used the Up Arrow and 13 did not. The results of a binomial test were significant ($p=0.05$), indicating that more children found this button than not. At the individual grade level, significant differences were found with first graders, who exhibited the same pattern, and fifth graders, who were more likely to find the Up Arrow than not. These results were interesting because they indicate that our paging design was a usability problem for children.

Results: Searching

For the 6 search tasks, average times were submitted to a 3 (grade) x 2 (interface) x 2 (task type) ANOVA. Results indicated significant differences by grade $F(2,33)=19.96$, $p<0.01$ and interface $F(1,33)=53.25$, $p<0.01$, and a significant interaction effect between interface and task type, $F(1,33)=18.71$, $p<0.01$. For the interface effect, the flat interface was significantly faster than the hierarchical, regardless of task type (Figure 7). The same was also true in each grade. Tukey post-hoc tests on grade indicated that differences between all grades were significant, with older children faster than younger children. These results suggest that performance with either interface is tied to age, but regardless of age, the flat interface is faster.

In the flat interface, children needed 116 total hints to complete the searching tasks, compared to 221 in the hierarchical. A Wilcoxon signed rank test was significant ($p<0.01$), indicating that significantly more hints were required in the hierarchical interface. The same was also true for first graders. Combining both interfaces and looking at the data by grade, first graders needed an average of 18.2 hints, third graders an average of 7.4, and fifth graders an average of 2.5. To analyze whether there was a difference in the number of hints by grade, we conducted a Kruskal Wallis test. This test was significant ($p<0.01$). These results suggest that as with speed, ease of use with either interface depends on age, but regardless of age, the flat interface is easier to use.

Results: Difficulty, Likeability, and Preference

For the difficulty and likeability questions, children were asked whether they thought an interface was hard, medium, or easy to use, and whether they liked using it not much, a little, or a lot. We assigned these choices values from 1 to 3 and conducted Wilcoxon signed rank tests. The results of both tests were significant, indicating that the flat interface was considered easier and better liked than the hierarchical overall. At the individual grade level, no significant differences were found in either difficulty or likeability. These results suggest that in addition to measured performance and ease of use, perceived performance and ease of use also favors the flat interface.

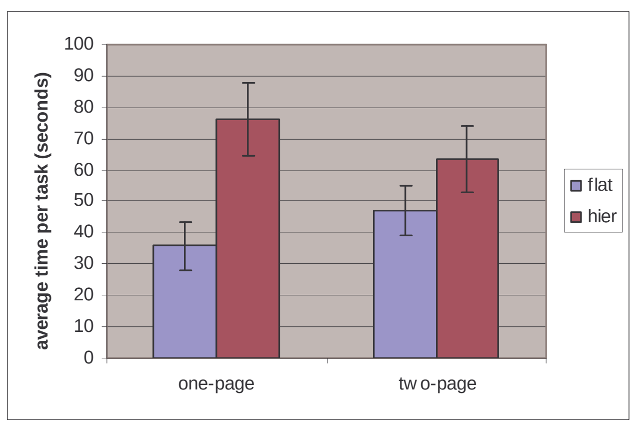

Figure 7. Average time per task by interface and task type

For overall interface preference, 19 children preferred the flat interface, 4 preferred the hierarchical interface, and 13 liked both equally. The results of a one-sample median test were significant ($p<0.01$), indicating that more children preferred the flat. At the individual grade level, only third graders had a significant preference, also favoring the flat.

Results: Comprehension

Children completed two tasks where they were asked to select two categories and then to explain what kinds of books they found. We analyzed the second of these tasks, asked after the children had completed the search tasks. We found that 22 children understood that they were creating conjunctive Boolean queries in the flat interface, compared with 14 who did not. The results of a binomial test were not significant, indicating that children were as likely to understand as not. In the hierarchical interface, only half the children understood what type of task they were doing.

To see if there was a difference in understanding by grade, we combined both interfaces and conducted a Fisher exact test. There were 10 instances of understanding in either interface in first grade, 7 in third grade, and 23 in fifth grade. The results were significant ($p<0.01$), indicating that fifth graders understood more often than first and third.

At the individual grade level, we found no significant differences in comprehension for either interface for first graders. For third graders, there was no significant difference in the flat interface, but significantly more children did not understand what they were doing in the hierarchical. In fifth grade, significantly more children understood than not in both interfaces.

These results were interesting because they indicate that neither interface supported Boolean comprehension very well, though the flat interface leaned more in that direction.

Discussion

The results indicate that younger children require more time and hints than older children to find two categories in different facets, regardless of the interface. However, the results revealed clear advantages for the flat interface. When browsing, children created significantly more Boolean queries using the flat interface. When searching, the flat interface was faster and required fewer hints. It was also liked more, easier to use, and preferred overall.

However, the flat interface had some challenges. Older children understood that they were creating a conjunctive Boolean query more often than younger children, and the flat interface was no more likely to support this understanding. Children were likely to find the Up Arrow in the hierarchical interface, but not likely to find the More Choices paging buttons in the flat interface.

Finally, while the combined statistics yielded significant results in favor of the flat interface, many of the statistics in the individual grades did not reach significance. However, with only 12 participants per grade, there may not have been enough power to detect differences within each grade.

CHALLENGES AND POSSIBILITIES

Our user study identified a number of challenges and possibilities for the new interface. For challenges, we were concerned about problems with visual overload, visual scanning, and paging. The first two concerns do not appear to be crucial, as the new interface had both performance and preference advantages despite these issues. However, paging was a problem. Without prior instruction, many children did not find the More Choices paging buttons. More research is needed to discover how to improve paging, and to study alternate approaches (e.g. scrolling). In addition, we were interested to see if the new interface improved user comprehension of Boolean queries, but we did not find that this was the case. More research is needed on interfaces that might improve comprehension.

Despite these challenges, the benefits we discovered for the new interface were noteworthy. The new design had both measured and perceived performance and preference benefits over the old design for children doing conjunctive Boolean searches. This design also facilitated the creation of more Boolean queries while browsing. We conducted another study, reported elsewhere [12], with a nearly identical protocol where children looked for a single category in each interface. The results of this study found no major differences in performance or preference between the two interfaces, suggesting that the new design is a reasonable choice for single category searches as well.

These benefits suggest that the new interface has possibilities for use in other digital libraries and search engines for elementary-age children. Any large collection of data will require conjunctive queries to narrow down the result set to a reasonable size. As children continue to gain access to growing bodies of information through both their schoolwork and recreational activities, our design appears to support this process better than previous designs.

CONCLUSIONS AND FUTURE WORK

We presented the design rationale, process, and evaluation of a searching and browsing interface for elementary-age children. Our rationale was based on problems identified in an existing interface used by children world-wide. Our design process involved children as design partners and usability testers and resulted in the creation of a new interface. Our evaluation involved a formal user study that identified both benefits and challenges for this new interface. The benefits suggest that our design may be useful for other searching and browsing environments, such as other digital libraries and search engines. The challenges present interesting opportunities for future work in improving the use of paging and in creating interfaces that better facilitate comprehension of Boolean queries.

ACKNOWLEDGMENTS

We would like to thank the ICDL team and the elementary schools who participated in our studies. This research was partially funded by the National Science Foundation and the Institute of Museum and Library Services.

REFERENCES

1. Ahlberg, C. and Shneiderman, B. (1994). Visual Information Seeking: Tight Coupling of Dynamic Query Filters with Starfield Displays. *Proc. of Human Factors in Computing*, 313-317.
2. Borgman, C., Hirsh, S., et al. (1995). Children's Searching Behavior on Browsing and Keyword Online Catalogs: The Science Library Catalog Project. *JASIST, 46 (9)*, 663-684.
3. Busey, P. and Doerr, T. (1993). Kid's Catalog: An Information Retrieval System for Children. *Youth Services in Libraries, 7 (1)*, 77-84.
4. Day, J., Janus, A., et al. (2005). Computer and Internet Use in the United States: 2003. U.S. Census Bureau, October 2005.
5. Demunter, C. (2005). The Digital Divide in Europe. Eurostat 38/2005, ISSN 1561-4840.
6. Druin, A. (1999). The Role of Children in the Design of New Technology. *Behaviour and Information Technology, 21 (1)*, 1-25.
7. Druin, A. (2005). What Children Can Teach Us: Developing Digital Libraries for Children. *Library Quarterly*, *75 (1)*, 20-41.
8. Druin, A., Bederson, B., et al. (2001). Designing a Digital Library for Young Children: An Intergenerational Partnership. *Proc. of JCDL*, 398-405.
9. Hochheiser, H. and Shneiderman, B. (2000). Performance Benefits of Simultaneous Over Sequential Menus as Task Complexity Increases. *Int'l Journal of Human-Computer Interaction*, 12(2), 173-192.
10. Hourcade, J., Bederson, B., et al. (2004). Differences in Pointing Task Performance between Preschool Children and Adults Using Mice. *ACM Transactions on Computer-Human Interaction*, *11 (4)*, 357-386.
11. Hutchinson, H. (2003). Children's Interface Design for Hierarchical Search and Browse. *ACM SIGCAPH* Newsletter, 11-12.
12. Hutchinson, H., Bederson, B., et al. (2005). Interface Design for Children's Searching and Browsing. *U. of MD HCIL Technical Report*, HCIL-2005-25, available at www.cs.umd.edu/hcil/pubs/tech-reports.shtml.
13. Kragler, S. and Nolley, C. (1996). Student Choices: Book Selection Strategies of Fourth Graders. *Reading Horizons, 36 (4)*, 354-365.
14. 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.
15. Livingstone, S. (2003). Children's Use of the Internet: Reflections on the Emerging Research Agenda. *New Media & Society, 5 (2)*, Sage Publications, 147-166.
16. Marchionini, G. and Teague, J. (1987). Elementary Students' Use of Electronic Information Services: An Exploratory Study. *Journal of Research on Computing in Education 20(2)*, 139-155.
17. Mills, C. and Weldon, L. (1987). Reading Text From Computer Screens. *ACM Computing Surveys*, *19 (4)*, 329-358.
18. Moore, P. and St. George, A. (1991). Children as Information Seekers: The Cognitive Demands of Books and Library Systems. *School Library Media Quarterly, 19*, 161-168.
19. National Telecommunications and Information Administration (NTIA) (2004). A Nation Online: Entering the Broadband Age. Retrieved June 28, 2005 from www.ntia.doc.gov/reports/anol/index.html
20. Neimark, E. and Slotnick, N. (1970). Development of the Understanding of Logical Connectives. *Journal of Educational Psychology, 61 (6*), 451-460.
21. 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.
22. Plaisant, C., Marchionini, G., et al. (1997). Bringing Treasures to the Surface: Iterative Design for the Library of Congress National Digital Library Program. *Proc. of Human Factors in Computing*, 518-525.
23. Reuter, K. and Druin, A. (2004). Bringing Together Children and Books: An Initial Descriptive Study of Children's Book Searching and Selection Behavior in a Digital Library. *Proc. of ASIS&T 200*,. 339-348.
24. Revelle, G., Druin, A., et al. (2002). A Visual Search Tool for Early Elementary Science Students. *Journal of Science Education and Technology, 11(1)*, 49-57.
25. Rosch, E., Mervis, C., et al. (1976). Basic Objects in Natural Categories. *Cognitive Psychology, 8*, 382-439.
26. Schneider, K. (1996). Children and Information Visualization Technologies. *Interactions, 3 (5)*, 68-74.
27. Soloway, E., Guzdial, M., et al. (1994). Learner-Centered Design: The Challenge for HCI in the 21st Century. *Interactions, April 1994*, 36-48.
28. Thomas, J. (1980). Acquisition of Motor Skills: Information Processing Differences Between Children and Adults. *Research Quarterly for Exercise and Sport, 51 (1)*, 158-173.
29. Tversky, B. (1985). Development of Taxonomic Organization of Named and Pictured Categories. *Developmental Psychology*, *21*(6), 1111-1119.
30. Wendelin, K. and Zinck, R. (1983). How Students Make Book Choices. *Reading Horizons*, *23*, 84-88.
31. Yee, K. et al. (2003). Faceted Metadata for Image Searching and Browsing. *Proc. of CHI '03*, 401-408.