Designing Information Retrieval Interfaces for Children's Use

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The “child-friendly” search engine, Kiddle, which is powered by Google’s safe search but is not affiliated with Google, made headlines in the winter of 2016 (Griffiths, 2016; Kleinman, 2016; Wheatstone, 2016). Parents, teachers, and librarians expressed excitement for a search engine aimed at children’s use that takes advantage of users’ familiarity with Google, while others criticized the service for deliberately excluding search terms such as “menstruation,” “gay,” “lesbian,” and “transgender,” returning results that say “Oops, looks like your query contained some bad words. Please try again!” (Kleinman, 2016). On its “About” page, Kiddle explains that it is designed specifically for kids, as evidenced by the fact that it uses safe search, large image thumbnails, a large font, and doesn’t collect any personally identifiable information (“About Kiddle,” 2016). The site provides no information about its ownership or details about why these design choices were determined as the best way to meet childrens’ search needs.

The excitement over and disappointment in Kiddle reflect a truism long-acknowledged in the information and library science literature: children have unique information needs and modes of interacting with information related to their developmental characteristics (Kuhlthau, 1988). Information retrieval interfaces should be designed for children’s use with these developmental characteristics in mind (Bilal, 2007). A rich body of literature investigates children’s information behaviors and how information retrieval systems can best be designed to address their unique cognitive capabilities (Gossen & Nürnberger, 2013). This literature review explores this literature, focusing on the interaction between child development and interface design for children. First, it introduces stages of child development and children’s unique information behaviors and the challenges these present for information retrieval. Then, it describes evaluations of several existing IR interfaces for children. Finally, it reviews systems created to address specific IR challenges that children face.

Child Development and Information Retrieval

In their state-of-the-art survey examining the literature on children and information retrieval, Gossen and Nürnberger (2013) identify a number of aspects of child development that may influence their information retrieval experiences. First, children’s cognitive development proceeds in a series of gradual stages (Kuhlthau, 1988; Piaget, 1953). These stages are the sensorimotor (age 0–2), pre-operational (age 2–7), concrete operational (age 7–11) and formal operational (age 11–adulthood) stages. In the sensorimotor stage, children are able to recognize cause and effect, but are not able to consider objects that are not directly in front of them. In the pre-operational stage, children tend to be self-centered. They are beginning to use language, but do not have strong reading skills. In the concrete operational stage, children learn to read and can consider concrete objects, but are not yet ready to deal with abstract concepts. By the formal operational stage, children can read well and consider abstract concepts.

Related to cognitive development, children’s information processing capabilities are different from those of adults (Gossen & Nürnberger, 2013). Information is processed in sensory memory, where sensory inputs are briefly stored, then placed into either working memory or long-term memory (Kail, 2011). Working memory can hold a limited amount of information, and this is where children tend to process information as they engage in information retrieval tasks. Young children, having less experience and less information stored in long-term memory than older children and adults, require more of their working memory for IR tasks, whereas older

children and adults may have internalized some of the processes involved in IR and transferred them to long-term memory.

The final aspect of child development that Gossen and Nürnberger (2013) mention is emotional development. They cite Erikson (1963), noting that children ages 6 – 12 are in the “industry vs. inferiority” stage of their development, and require “emotional support and a feeling of success and increasing confidence” (Gossen & Nürnberger, 2013, p. 743). Children want to be productive; if they experience failure, they may develop feelings of incompetence and inferiority.

These three aspects of child development have important implications for information retrieval interface design (Gossen & Nürnberger, 2013). Children in the early stages of cognitive development are not readers or abstract thinkers yet, and as such, will have difficulty using text-based interfaces and creating successful keyword queries. With limited information processing capability and working memory, children may have difficulty navigating interfaces that are inconsistent or remembering the steps they have already taken in the search process. Finally, children experiencing repeated failure in information retrieval may develop feelings of incompetence and refuse to continue their search for information.

Children’s Information Behaviors

Child development theories provide some insight into how information retrieval interfaces for children should be designed; studies of children’s actual information behaviors enhance our understanding of how children use IR interfaces and the challenges users and designers face (Gossen & Nürnberger, 2013). While a thorough review of such studies is outside the scope of this literature review, a brief overview of their findings will inform the discussion of existing systems and prototypes.

Children tend to enter short, natural language queries, rather than using keywords or Boolean operators (Bilal & Kirby, 2002; Duarte Torres & Weber, 2011; Gossen, Low, & Nürnberger, 2011; Kammerer & Bohnacker, 2012; Marchionini, 1989; Solomon, 1993). Older studies indicated that children preferred browsing to keyword searching (Borgman, Hirsh, Walter, & Gallagher, 1995), but more recently, children have expressed a preference for keyword searching (Jochmann-Mannak, Huibers, Lentz, & Sanders, 2010); this may be because children are exposed to Google at a young age now. Children tend to have a “loopy” browsing style, backtracking often to earlier results pages or the search homepage (Bilal & Kirby, 2002; Gossen et al., 2011). They have difficulty judging the relevance of retrieved documents (Jochmann-Mannak et al., 2010; Large & Beheshti, 2000).

Evaluations of Existing Systems

A number of information retrieval systems have been studied with respect to children’s use. These include systems designed for a general audience, such as library Online Public Access Catalogs (OPACs) and the Google search engine, as well as systems designed explicitly for children’s use, such as the Science Library Catalog and the Yahoooligans! search engine.

Solomon (1993, 1994) studied elementary school children’s use of their school library’s Online Public Access Catalog (OPAC). He performed a case study over the course of the 1989-90 school year at an elementary school in Fairfax, Virginia; of the 872 students in preschool through sixth grade, only the 679 in grades one through six used the OPAC. He observed 902

information retrieval transactions initiated by about 500 students using the OPAC, asked them questions about their experiences, and engaged 20 of them in a think-aloud protocol.

The OPAC interface operated primarily through a keyword search, instructing students, "Type in what you are looking for" and offering text input boxes for subject, title, and author. The OPAC relied on Library of Congress Subject Headings for its subject database. It offered three possible responses to users' input: a TERM NOT FOUND message, a QUERY ERROR message, or a list of items retrieved.

This minimal interface worked well for students who knew what information they were seeking. Because it did not offer many options, it directed focus to the development of keyword queries. Its lack of a browsing option presented a problem for students who did not know the exact subject heading for the topic of their interest. The simple keyword search often led to the inclusion of irrelevant results; for example, a student looking for "Virginia" would also find items with the subject "West Virginia." The system did not offer spelling correction or use a thesaurus that mapped natural language terms to Library of Congress Subject Headings, so it did not offer scaffolds or supports for users whose initial searches failed. Solomon soundly criticizes the OPAC for its lack of these supports, stating, "...there is no reason for an OPAC or any other information retrieval system to issue TERM NOT FOUND or zero hits messages. Whatever the structure of interaction, the interface should help people learn to control the system" (Solomon, 1994, p. 18).

While the OPAC Solomon studied was part of an integrated library management system and not designed explicitly for children's use, the Science Library Catalog was designed with child users in mind (Borgman et al., 1995; Hirsh, 1996, 1997; Walter, Borgman, & Hirsh, 1996). The Science Library Catalog originally used a hierarchical, browsing-oriented interface based on science categories in the Dewey Decimal System. Its interface was presented as a bookshelf metaphor; children used a mouse to point and click on bookshelves to browse through the hierarchy. A "bookworm" character was available on all screens to offer help with the use of the catalog. Borgman, Hirsh, and Walter conducted a variety of studies in both school and public libraries, observing children's behavior on a number of search tasks with varying complexity. Software tracked mouse-click sequences and timestamps; the authors used both one-on-one and focus group interviews with child users, and also had experts in the domains of child development, education, instructional technology, and interface design review the software. They also sought critiques of the Science Library Catalog from school and children's librarians and science teachers. In their studies, they compared children's use of the Science Library Catalog to their use of two different keyword search OPACs. They found that children had an average 80% success rate using the Science Library Catalog across all search tasks, but that success varied according to the characteristics of task (Hirsh, 1997). The vocabulary used within the system sometimes was more complex than the vocabulary children used for searching; children were more successful when searching for topics about which they already had a high level of domain knowledge; most children were most successful when they used a combination of browse and keyword search methods. The few children who only used keyword search were 100% successful, but most children were not confident enough in their understanding of the topic of the search task to use this method.

Bilal (2000, 2001, 2002) studied children's use of the Yahoooligans!, a web search engine designed for users aged 7 to 12. She worked with twenty-two seventh graders, having their teacher assign them a search task or having them generate their own search task. She collected data on children's cognitive, physical, and affective behaviors as they searched, using screen

recording software and interviews. She found that the design of the search engine influenced children's search behaviors. She identified the following obstacles to children's use of the search engine: the lack of instructions, help that is not context-sensitive, a hierarchical interface, and abstract vocabulary in both link text and descriptions. Like Solomon (1994), Bilal suggests that a search interface for children should not merely provide results or connect user queries to a database, but should instead be a tool for learning; it should include instructions and examples, work well with natural language queries, provide context-sensitive help, check spelling, and offer feedback on searches. As children interact with the interface, they should become better searchers.

Gossen, Hempel, and Nürnberger (2012) evaluated the usability of search engines designed for children to determine if they were appropriate for the cognitive and motor skills of children. They selected seven English search engines and five German search engines, all designed for children, and compared them with Google, designed for a more general audience. They found that most search engines designed for children required several mouse-clicks on small areas of the screen and a great deal of scrolling, essentially making them no more appropriate for the motor skills of children than Google. Only a few of the search engines conformed with the cognitive skills of children; most presented results less effectively than Google. They tended to present ten or more results on the results page, which might be too large a number for children. They used small font sizes and failed to incorporate multimedia. Only half of the search engines offered browsing in addition to keyword search. They rarely featured a clearly visible home button.

Most of the existing systems evaluated for children's use, whether designed for children or for a more general audience, do not take into account children's developmental level and capabilities. Obstacles included mismatch between children's vocabulary and the vocabulary used by the system (Borgman et al., 1995; Hirsh, 1996, 1997; Solomon, 1993, 1994; Walter et al., 1996) and the need for a high level of domain knowledge to formulate successful search queries (Hirsh, 1997; Solomon, 1993, 1994). A number of researchers, however, have designed systems intended to mitigate or overcome these obstacles.

Systems Designed to Address Children's Specific Information Retrieval Challenges

Several researchers have designed systems or models of information retrieval to address the problems a variety of challenges that children face when using information retrieval systems. These include both systems that provide suitable results for children and systems that mitigate the challenge of entering keyword queries and reading results.

Suitability

While Gossen and Nürnberger (2013) don't address suitability in their review of the literature addressing information retrieval for children, one of the features Kiddle prides itself on is filtering of content so that children see content that is "appropriate" for them ("About Kiddle," 2016). While the Kiddle website does not indicate that its methods for filtering content are grounded in empirical research, researchers are developing filtering systems that are based in both child development and information behavior research. It is worth noting that none of the studies mentioned below define "suitability" or "appropriateness." They seem to tiptoe around the question, referring to both topicality (topics of interest to children that should be included;

topics from which adults might want children to be protected, such as “erotic material”) and cognitive suitability such as text features, presentation, and navigation (Eickhoff, Serdyukov, & de Vries, 2010).

Eickhoff, Serdyukov, and de Vries (2010) point out that children are using the web at younger and younger ages with less and less supervision. They further point out that search engines designed for adults, such as Google and Yahoo!, state that their safe search tools are not intended to filter results for children. They propose that manually-filtered web directories are less flexible and have less coverage than an automatically filtered search engine would. They designed a system that automatically filters results, showing only those that are “suitable” for children.

Eickhoff, Serdyukov, and de Vries describe suitability as relying on both topical and non-topical features; it involves more than just topical concerns such as “filtering out erotic material” (p. 1) and must also take into consideration text complexity and developmentally-appropriate web design. Eickhoff and colleagues identify two dimensions of suitability: child-friendliness and focus towards child audiences. Child-friendliness includes textual complexity, site presentation, and site navigation. Focus towards children could be identified based on the language used in the website, the frequency of words such as “kids” and “children” and whether those instances were talking about children (adult-oriented sites) or to children (child-oriented sites), and URL features (children have an easier time remembering shorter URLs).

Eickhoff, Serdyukov, and de Vries trained a state of the art classifier using web sites identified by the Open Directory Project as being either for kids (up to age 12) or general audiences (over 18). The training corpus included 20,778 English-language web pages (6,225 for children and 14,553 for general audiences). Having trained the classifier, they tested it using a set of 1800 web sites (900 for children, 900 for adults). Using crowdsourcing, they asked 5 human users to annotate the pages for purposes of comparison with the machine classification. They found that “a topical approach augmented by non-topical features is able to reliably predict web page suitability” (p.4), out-performing a topical approach and approximating human performance.

Eickhoff and de Vries (2010) extended this work beyond search engines to video sharing, observing that larger numbers of children are viewing YouTube and other video sharing web sites beginning at earlier ages. They suggest that the following features of videos might provide information that could be used to automatically determine video suitability: video content and related metadata (title, tags, full text description, genre, play time), author information (name and linked user profile), meta information (publication date and number of views), and community-created information (user ratings, video responses, comments). Several of these features might be used in conjunction with language modeling to determine video suitability; in addition, video length and user age might provide valuable information about whether a video fits children's attention span or was created by a child user. Finally, Eickhoff and de Vries propose using sentiment analysis to analyze comments for positive or negative responses to videos; “[children's] content is in general expected to cause positive affection rather than negative sentiments” (p. 3).

Eickhoff and de Vries collected a research corpus of 12,673 YouTube videos in January 2010, using 20 queries deemed typical of either children's queries or non-children's queries, including the top 3 videos for each of these queries and then crawling related videos. A domain expert in childcare and education rated a sample of 1000 of these videos for their child-friendliness. Eickhoff and de Vries extracted the information described earlier (video content and

metadata, author information, meta information, and community-created information) from these videos. They used 90% of the videos as a stratified training set and 10% as a test set, training state of the art machine learning classifiers to classify the videos as suitable for children or not suitable for children. They focused on high precision (showing as few unsuitable videos as possible) over high recall (retrieving all suitable videos).

The machine learning classifiers were able to automatically identify child-friendly videos using exclusively non-audio-visual information. Community-created information was the strongest category predictor of suitability for children, but number of views was the strongest single feature predictor of suitability. Suitable videos tended to have fewer views. Play time was not a significant predictor of suitability.

Gyllstrom and Moens (2010) created “AgeRank, a link-based approach to label pages by the likelihood that those pages are appropriate for children” (p. 1). This algorithm operates similarly to Google's PageRank. Their goal in creating the algorithm was not to limit children's exposure to inappropriate pages, but rather to increase their exposure to suitable pages.

Gyllstrom and Moens ran AgeRank on a set of 11,594,120 pages identified from the Open Directory Project, comparing its results with actual user ratings, investigating its relationship with PageRank, examining how well it works with simulated child-generated queries including both coverage and relevance order. Based on their findings, they make the following claims:

AgeRank effectively captures the age-appropriateness of a page, and is necessary because PageRank alone cannot effectively do so; the usefulness of both directions and polarities of linking, in this context, present a potential advantage over single-direction, single-topic approaches such as topical PageRank. The coverage of the automatically labeled pages is high, including many important pages, and results for many queries. AgeRank can potentially improve children's search, as for child-oriented queries, currently the number of pages assessed to be child-appropriate that appear in the best positions is low, and reordering by AgeRank concentrates more relevance to the top pages than reordering by reverse AgeRank, and very likely concentrates more age-appropriateness as well. Beyond individual pages, AgeRank can also be used to predict the child-appropriateness of queries. Finally, evidence suggests that our approach to generating children's queries is reasonable, which both helps justify findings pertaining to search results, and can be used by others wishing to execute similar studies on children's IR. (p. 10)

Taken together, these three studies suggest that it is possible to automatically filter and rank search results according to how suitable they are for children, though none of them provide a clear definition of what “suitable” means.

Reading Challenges: Queries, Results, and Relevance Judgment

Young children are not accomplished readers yet (Kuhlthau, 1988; Piaget, 1953) and might have difficulty formulating keyword queries, preferring instead to enter natural language queries (Marchionini, 1989). They also benefit from results that include not just text, but images. Several information retrieval prototypes address these capabilities.

The Science Library Catalog was designed for children to use without having to face the usual OPAC challenges of formulating keyword queries, spelling them correctly, or using Boolean logic (Borgman et al., 1995). Children were able to search it without prior training and

tended to use it with more success than the two comparison OPACs (Orion and LePac). Younger children tended to prefer the Science Library Catalog's hierarchical browsing structure, while older children were equally comfortable with the Science Library Catalog and the keyword search OPACs. Based on these results, the Science Library Catalog was modified to include both the hierarchical browsing interface and a keyword search interface (Hirsh, 1997).

Hirsh (1997) conducted a study to evaluate the addition of the keyword search interface. She found that children "who used the keyword method exclusively were 100 percent successful... but only six children fell in this category" (p. 11). The keyword search interface included tools to help users in the ways that Solomon (1994) suggested, such as spelling correction, relevance ranking, and subject context displaying the results within the browsing hierarchy. In spite of these supports, however, children still encountered some difficulty with keyword search. Some of them used natural language queries rather than keyword queries. Children who used the browsing method exclusively were successful when they understood the bookshelf topic headings, but had more difficulty when they encountered unfamiliar topics. If a specific topic they were seeking was located on a level below an unfamiliar heading, they sometimes did not find it. Children who used a combination of both methods were sometimes very successful, but other times moved back and forth between the two options because neither of them provided exactly what they were seeking.

Revelle, Druin, Platner, Bederson, Hourcade, and Sherman (2002) designed a visual search interface called "SearchKids" to help children find animals within a visual hierarchical structure. The search area "displayed four icons representing the four main branches in the hierarchy: *Animals*, *Where They Live*, *How They Move*, and *What They Eat*" (p. 51-52, emphasis in original). Each icon consisted of both an image and text. At each level of the hierarchy, new icons appeared; clicking these icons would add them as search parameters. As parameters were added to the search, a preview of query results, also represented by icons, would appear in a small box next to an illustration of two children. The user could click on this box to zoom in and review the results.

Revelle and colleagues (2002) tested the "SearchKids" prototype with 50 elementary school students in second and third grade. Children were very successful at constructing queries using the system, with an 85% success rate. Revelle and colleagues suggest that scaffolding tools built into the system may have contributed to this success rate. These include a visually concrete interface, physical manipulation of the search elements, display of "in-progress" results as the query was constructed, and the fact that the system handled any Boolean construction of search queries automatically based on the organization of the hierarchy. Revelle and colleagues express hope that future IR systems for children will be designed to teach them gradually how to use Boolean logic.

Hutchinson and colleagues (2005; 2006; 2007) designed the International Children's Digital Library search interface to address both information processing and searching and browsing challenges. The interface includes pictorial icons for users who can't read and a query results preview in which category buttons with no results are disabled. Searches can be conducted using keywords and a globe-based visual location search; browsing hierarchical categories is also an option. Hutchinson and colleagues conducted multiple user studies with elementary school students and also included children on their design team. They found that younger children require more time and more scaffolding to complete a search task than older children regardless of the interface they use; they recommend the following design guidelines for interfaces intended for elementary children's use:

1. Both flat, simultaneous and hierarchical, sequential designs are useful for single-item searches.
2. Flat, simultaneous designs support better conjunctive Boolean searching and browsing.
3. Boolean search must be implemented with care.
4. Navigation tools must be large and prominent. (p. 1628)

In response to concerns over children's difficulty formulating queries and identifying relevant documents, Elliot, Glassey, Polajnar, and Azzopardi (2010; Glassey, Elliott, Polajnar, & Azzopardi, 2010) designed an interaction-based information filtering system for children's use, calling it PuppyIR. The system is populated with a variety of manually-selected syndication feeds. Users select from a default set of topics; the relevance of a document is indicated by the amount of space it takes up on the screen. As users interact with documents, the system adapts to their interests, eventually inferring which topics will be of interest to a user. The use of topics minimizes the need for users to enter queries; a large font size and list of results that only includes document titles, not description, reduces the reading difficulty of the results set. As of this writing, they have not published the results of any user studies.

Jansen, Bos, van der Vet, Huibers, and Hiemstra (2010) designed a tangible user interface (TUI) called TeddIR that allows children to use tangible objects rather than a keyboard to enter queries into a library catalog. The design includes a green box with a happy face on it, a red box with a sad face on it, a computer display, and tangible objects: figurines and books. The children search by placing items they would like matched in the green box and items they would like excluded in the red box. When children insert or remove a tangible object in one of the boxes, the display immediately updates with a set of results, showing the twelve most relevant books to the search and displaying images representing the items in the two boxes on the lower corners of the screen. Figurines represent concepts, either concrete or abstract; for example, a dog figurine leads to results of books about dogs, whereas a spider figurine leads to a set of results featuring scary books. When a book is placed in one of the boxes, similar books are either included in or excluded from the results. The tangibles are equipped with RFID chips, while each box is equipped with a hidden RFID reader.

Jansen and colleagues conducted a usability study at a Dutch primary school to evaluate the system. Seventeen students in third and fourth grade, all between the ages of 6 and 8, participated in the study. They used the methods of Co-Discovery and Active Intervention to collect data, prompting children to answer questions as they used the system. They also captured data using video and system logs. Children were asked to find books about soccer, then to find books that were about dogs but were not about soccer. Children reported that using the system was fun. They understood the relationship between the physical boxes and their representations on the screen. They understood the abstract symbolism of some of the tangibles and were able to instruct others in how to use the system. Children had more trouble understanding the logic behind the red, sad face box, which essentially operated like the NOT operator in Boolean logic. In spite of this, Jansen and colleagues concluded that tangible user interfaces are a promising avenue of development to overcome the challenges children face when interacting with IR systems. In particular, they noted that while children might not be able to verbalize abstractions, they can still work with them in tangible form, and this might provide an area where TUIs have a distinct advantage over more traditional keyboard-and-mouse or touch-screen based user interfaces.

The results of user studies of systems designed to overcome specific IR challenges children face suggest that, when systems are designed not merely “for kids,” but with children’s specific cognitive capabilities and obstacles to IR in mind, systems can help children be successful in their searches. As many studies suggest, there is an opportunity for IR designers to create systems that not only overcome common obstacles children face, but scaffold their searches and even serve as instructional tools, teaching them how to be better searchers. This is a promising avenue for future IR research.

Conclusion

The buzz about Kiddle confirms that parents and teachers are aware of the need for search interfaces that take into consideration children’s developing capabilities. These capabilities, such as limited reading ability and difficulty with abstract thought, make traditional information retrieval interfaces difficult for young children to use. Existing interfaces, even those designed for children, often fail to take these capabilities into account. A number of researchers, however, have designed prototypes that are designed specifically to mitigate children’s difficulties with formulating search queries and navigating results. The best of these not only make it easier for children to search, but teach them to become more efficient searchers over time through the use of scaffolding and hints. As Gossen and Nürnberger (2013) point out, however, the tools we use shape our abilities, and children who use interfaces like Google from an early age may be more comfortable with keyword searches and detailed results than the children in early studies of IR for children may have been. Continued research in this area is necessary to ensure that interfaces are designed to work with the capabilities of the children using them today, rather than the children who might have used them twenty years ago, as well as to design systems that teach children to be better searchers.

References

- About Kiddle. (2016). Retrieved March 3, 2016, from <http://www.kiddle.co/about.php>
- Bilal, D. (2000). Children's use of the Yahoooligans! Web search engine: I. Cognitive, physical, and affective behaviors on fact-based search tasks. *Journal of the American Society for Information Science*, 51(7), 646–665. [http://doi.org/10.1002/\(SICI\)1097-4571\(2000\)51:7<646::AID-ASI7>3.0.CO;2-A](http://doi.org/10.1002/(SICI)1097-4571(2000)51:7<646::AID-ASI7>3.0.CO;2-A)
- Bilal, D. (2001). Children's use of the Yahoooligans! Web search engine: II. Cognitive and physical behaviors on research tasks. *Journal of the American Society for Information Science and Technology*, 52(2), 118–136. [http://doi.org/10.1002/1097-4571\(2000\)9999:9999<::AID-ASI1038>3.0.CO;2-R](http://doi.org/10.1002/1097-4571(2000)9999:9999<::AID-ASI1038>3.0.CO;2-R)
- Bilal, D. (2002). Children's use of the Yahoooligans! Web search engine. III. Cognitive and physical behaviors on fully self-generated search tasks. *Journal of the American Society for Information Science and Technology*, 53(13), 1170–1183. <http://doi.org/10.1002/asi.10145>
- Bilal, D. (2007). Grounding children's information behavior and system design in child development theories. In D. Nahl & D. Bilal (Eds.), *Information and emotion : the emergent affective paradigm in information behavior research and theory* (pp. 39–50). Medford, N.J.: Information Today.
- Bilal, D., & Kirby, J. (2002). Differences and similarities in information seeking: children and adults as Web users. *Information Processing & Management*, 38(5), 649–670. [http://doi.org/10.1016/S0306-4573\(01\)00057-7](http://doi.org/10.1016/S0306-4573(01)00057-7)
- Borgman, C. L., Hirsh, S. G., Walter, V. A., & Gallagher, A. L. (1995). Children's searching behavior on browsing and keyword online catalogs: The Science Library Catalog project.

Journal of the American Society for Information Science, 46(9), 663–684.

[http://doi.org/10.1002/\(SICI\)1097-4571\(199510\)46:9<663::AID-ASI4>3.0.CO;2-2](http://doi.org/10.1002/(SICI)1097-4571(199510)46:9<663::AID-ASI4>3.0.CO;2-2)

Duarte Torres, S., & Weber, I. (2011). What and How Children Search on the Web. In

Proceedings of the 20th ACM International Conference on Information and Knowledge Management (pp. 393–402). New York, NY, USA: ACM.

<http://doi.org/10.1145/2063576.2063638>

Eickhoff, C., & de Vries, A. P. (2010). Identifying suitable YouTube videos for children. *3rd*

Networked and Electronic Media Summit (NEM). Retrieved from

<http://mediamatica.ewi.tudelft.nl/sites/default/files/nem2010.pdf>

Eickhoff, C., Serdyukov, P., & de Vries, A. P. (2010). Web Page Classification on Child

Suitability. In *Proceedings of the 19th ACM International Conference on Information and Knowledge Management* (pp. 1425–1428). New York, NY, USA: ACM.

<http://doi.org/10.1145/1871437.1871638>

Elliot, D., Glassey, R., Polajnar, T., & Azzopardi, L. (2010). Finding and Filtering Information

for Children. In *Proceedings of the 33rd International ACM SIGIR Conference on*

Research and Development in Information Retrieval (pp. 702–702). New York, NY,

USA: ACM. <http://doi.org/10.1145/1835449.1835569>

Erikson, E. (1963). *Childhood and society* (2d ed., rev. and enl.). New York: Norton.

Glassey, R., Elliott, D., Polajnar, T., & Azzopardi, L. (2010). Interaction-based Information

Filtering for Children. In *Proceedings of the Third Symposium on Information Interaction in Context* (pp. 329–334). New York, NY, USA: ACM.

<http://doi.org/10.1145/1840784.1840834>

- Gossen, T., Hempel, J., & Nürnberger, A. (2012). Find it if you can: usability case study of search engines for young users. *Personal and Ubiquitous Computing*, 17(8), 1593–1603.
<http://doi.org/10.1007/s00779-012-0523-4>
- Gossen, T., Low, T., & Nürnberger, A. (2011). What are the real differences of children's and adults' web search. In *Proceedings of the 34th international ACM SIGIR conference on Research and development in Information Retrieval* (pp. 1115–1116). ACM. Retrieved from <http://dl.acm.org/citation.cfm?id=2010076>
- Gossen, T., & Nürnberger, A. (2013). Specifics of information retrieval for young users: A survey. *Information Processing & Management*, 49(4), 739–756.
<http://doi.org/10.1016/j.ipm.2012.12.006>
- Griffiths, S. (2016, February 9). Search engine for children called Kiddle launches. Retrieved March 3, 2016, from <http://www.dailymail.co.uk/sciencetech/article-3469244/Just-Kiddle-Child-friendly-search-engine-uses-humans-weed-adult-content-not-racy-images-blocked.html>
- Gyllstrom, K., & Moens, M.-F. (2010). Wisdom of the Ages: Toward Delivering the Children's Web with the Link-based Agerank Algorithm. In *Proceedings of the 19th ACM International Conference on Information and Knowledge Management* (pp. 159–168). New York, NY, USA: ACM. <http://doi.org/10.1145/1871437.1871462>
- Hirsh, S. G. (1996). Complexity of Search Tasks and Children's Information Retrieval. *Proceedings of the ASIS Annual Meeting*, 33, 47–51.
- Hirsh, S. G. (1997). How do children find information on different types of tasks? Children's use of the science... *Library Trends*, 45(4), 725.

- Hutchinson, H., Bederson, B. B., & Druin, A. (2006). The evolution of the international children's digital library searching and browsing interface. In *Proceedings of the 2006 conference on Interaction design and children* (pp. 105–112). ACM. Retrieved from <http://dl.acm.org/citation.cfm?id=1139101>
- Hutchinson, H., Druin, A., & Bederson, B. B. (2007). Supporting elementary-age children's searching and browsing: Design and evaluation using the international children's digital library. *Journal of the American Society for Information Science and Technology*, 58(11), 1618–1630. <http://doi.org/10.1002/asi.20646>
- Hutchinson, H., Druin, A., Bederson, B., Reuter, K., Rose, A., & Weeks, A. (2005). How do I find blue books about dogs? The errors and frustrations of young digital library users. In *Proceedings of the 11th International Conference on Human- Computer Interaction (HCI 2005)*. Mahwah, NJ: Lawrence Erlbaum Associates. Retrieved from <http://hcil.cs.umd.edu/trs/2005-27/2005-27.htm?sOpenLinkIn=Same>
- Jansen, M., Bos, W., van der Vet, P., Huibers, T., & Hiemstra, D. (2010). TeddIR: Tangible Information Retrieval for Children. In *Proceedings of the 9th International Conference on Interaction Design and Children* (pp. 282–285). New York, NY, USA: ACM. <http://doi.org/10.1145/1810543.1810592>
- Jochmann-Mannak, H. E., Huibers, T. W. C., Lentz, L. R., & Sanders, T. J. M. (2010). Children searching information on the Internet: Performance on children's interfaces compared to Google. Retrieved from <http://eprints.eemcs.utwente.nl/18231/>
- Kail, R. V. (2011). *Children and Their Development*. Pearson Education.
- Kammerer, Y., & Bohnacker, M. (2012). Children's Web Search with Google: The Effectiveness of Natural Language Queries. In *Proceedings of the 11th International Conference on*

- Interaction Design and Children* (pp. 184–187). New York, NY, USA: ACM.
- <http://doi.org/10.1145/2307096.2307121>
- Kleinman, Z. (2016, March 1). Kiddle search engine for children causes controversy. Retrieved March 3, 2016, from <http://www.bbc.com/news/technology-35694883>
- Kuhlthau, C. C. (1988). Meeting the Information Needs of Children and Young Adults: Basing Library Media Programs on Developmental States. *Journal of Youth Services in Libraries*, 2(1), 51–57.
- Large, A., & Beheshti, J. (2000). The Web as a Classroom Resource: Reactions from the Users. *Journal of the American Society for Information Science*, 51(12), 1069.
- 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.
- Piaget, J. (1953). *The origin of intelligence in the child*. Routledge & Paul.
- Revelle, G., Druin, A., Platner, M., Bederson, B., Hourcade, J. P., & Sherman, L. (2002). A Visual Search Tool for Early Elementary Science Students. *Journal of Science Education and Technology*, 11(1), 49–57. <http://doi.org/10.1023/A:1013947430933>
- Solomon, P. (1993). Children's Information Retrieval Behavior: A Case Analysis of an OPAC. *Journal of the American Society for Information Science (1986-1998)*, 44(5), 245.
- Solomon, P. (1994). Children, Technology, and Instruction: A Case Study of Elementary School Children Using an Online Public Access Catalog (OPAC). *School Library Media Quarterly*, 23(1).
- Walter, V. A., Borgman, C. L., & Hirsh, S. G. (1996). The Science Library Catalog: A Springboard for Information Literacy. *School Library Media Quarterly*, 24(2), 105–12.

Wheatstone, R. (2016, February 28). What is Kiddle? The “child-friendly” search engine with some worrying results. Retrieved March 3, 2016, from

<http://www.mirror.co.uk/news/world-news/what-kiddle-child-friendly-search-7460351>