

“Sometimes the Internet reads the question wrong”: children’s search strategies & difficulties

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ABSTRACT

When children search for information on a given topic, how do they go about searching for and retrieving information? What can their information seeking strategies tell us about the development of search interfaces for children's digital libraries, search engines and information repositories? We interviewed New Zealand (NZ) school children to seek insights into how they are conducting information searches during their education.

Keywords

Children, information behaviour, searching, browsing.

INTRODUCTION

Children are encountering information seeking opportunities both in formal educational settings and in their daily recreational activities. The breadth of information search tools and interactive communication technologies (ICT) available in the New Zealand classroom includes a variety of digital books on CD-ROMs, eBooks, and Internet resources, along with specific educational software on a range of desktop and mobile computing devices. Children in New Zealand classrooms have been observed to use this full range of technologies during their typical educational pursuits (Timpany & Vanderschantz, 2011; Vanderschantz, Hinze, & Cunningham, 2014).

Though this wide variety of technologies is being introduced into today’s classrooms, it is not clear how effective they are in facilitating information seeking for children, nor is it clear if children are able to use these systems effectively. Further research, including our own presented here, will offer clarification of the effectiveness of the use of these tools by children. There is still much to learn about children’s information needs and the impact of technology interventions in the classroom. New Zealand schools base their pedagogy on Constructivist and Socio-cultural theory with inquiry-based learning being a core value of the New Zealand Curriculum. This paper specifically addresses children’s information search and use of information search tools within a New Zealand child’s

educational pursuits.

When developing a study with age and cognitive ability being influencing factors, a particular age range or developmental level must often be targeted for empirical study. A child’s problem-solving skills are known to develop throughout a child’s life. Jean Piaget asserts that this is an active process that develops in a *series of stages*. While Piaget’s specific stages with their hard boundaries are hotly debated in the literature, Siegler (2005) notes that Piaget’s “descriptions feel right” (p.27) and that though his stages have shortcomings they give “us a good feeling for how children think” (p. 62). Piaget’s two developmental stages of most relevance to our work are the *concrete-operational stage* (ages 7 to 11 or 12), and the *formal-operational stage* (ages 11 or 12 and beyond). Tuckett & Stoffle state that at the formal-operational stage children “have the ability to formulate, test, and discard the whole range of possible solutions to a problem until an appropriate solution is found” (1984, p. 62) and that this is essential to effective problem solving. Demetriou et al. (2011) describe milestones rather than stages, where these milestones have similar age correlations to Piaget’s stages. Demetriou’s *Logical Necessity* milestone begins around the ages of 7 to 8 years and encompasses understanding “the multiplicity of knowledge and that the nature and ‘quality’ of knowledge depends upon the methods or processes generating it” (2011, p. 633). The subsequent milestone *Suppositional Thought* begins around the ages of 13 to 14 years and encompasses grasping “the complementarity of methods and processes in knowledge production and revision” (2011, p. 633).

Taken together, these two theories suggests that children at 12 or 13 years old and older can be or can become effective problem solvers, and thus, younger children will require further assistance with problem solving. We hypothesize that there is a need for solutions to assist these younger information users. This study therefore focuses on children at the *concrete-operational stage* and early *formal-operation stage* (Piaget) or at the *Logical Necessity* phase (Demetriou et al., 2011) – children who are 9, 10 and 11 years old.

This paper examines children's strategies when searching for information. We highlight in the following section

(Related Work) the paucity of recent literature that reports how modern tools (hardware and software technologies) for children's information seeking can support effective information problem solving, information behaviour and information literacy. We conducted a series of semi-structured interviews with children in the Waikato School District of New Zealand (Study Method). Our analysis provides a working process of children's online searching for information in NZ classrooms (Results) from which we are able to identify ways to develop interventions for improved information seeking (Discussion, Conclusions).

RELATED WORK

The work related to our study encompasses information problem solving and seeking, information seeking and schools, and interfaces for children's information seeking.

Information problem solving and seeking

Marchionini describes information-seeking as a "special case" of problem solving, which "includes recognizing and interpreting the information problem, establishing a plan of search, conducting the search, evaluating the results, and if necessary, iterating through the process again" (1989, p. 54).

Moore (1995) and Brand-Gruwel et al. (2005) discuss children's and adult's need to be able to identify their information needs. People must be able to locate, identify, collate, and organise appropriate sources to be successful information problem solvers. Further, people must be able to extract and combine information from these sources into sound solutions to their identified needs. Brand-Gruwel et al. (2005) describe this as the definition of information literacy or information problem solving.

Wilson uses the term *information-seeking behaviour* to describe the variety of methods people employ to discover, and gain access to information: "activities a person may engage in when identifying his or her own needs for information, searching for such information in any way, and using or transferring that information", (1999, p. 249). Many models of information search behaviour exist (see for example Wilson, 1999). We adopt Kuhlthau's *Information Search Process* (ISP) model. Kuhlthau's model is appropriate because of its simplicity and focus on specific information activities and information needs. Kuhlthau's model (2004) is comprised of six stages: initiation (the presence of an information need), selection (choosing a topic of investigation and a process for investigation), exploration (early search for information, typically progressing from general to specific), formulation (development of a focus that provides direction to the information collection and relevance decisions), collection (selecting information pertinent to a task and taking detailed notes) and presentation (organising information for giving to others).

Information seeking and schools

It is often argued in the literature that there is a need for teaching and training for information literacy, since

children often lack experience or practice in information seeking (see for example Bilal & Kirby, 2002; Bilal, 2002). De Vries et al. (2008) argue that web searching must be embedded in a learning task so that learners will develop personally relevant questions, so they might learn to search the web reflectively. Moore's (1995) work indicates that project exercises used in early school years, which are intended to develop students understanding of the use of information, may not currently meet children's needs. She suggests that students at this young age often require suitable intervention by an adult or expert-information-user. Druin et al. (2009) state that even though children in their study may have been exposed to computers for most of their lives, difficulties with spelling, typing, query formulation, and analysis of search results may still prevent children from finding or using information.

Should children not learn sound information literacy skills, there may be a negative flow-on effect to later education and employment. Moore points to a number of investigations (for example Rudduck & Hopkins, 1984; Tuckett & Stoffle, 1984) which show that school leavers often have limited abilities to find or use information successfully.

Interfaces for children's information seeking

Generating an appropriate set of keywords is often difficult for children; they tend to use keywords that were used in initial discussion of a project or that a teacher gave to them in the beginning of a project. Children are rarely able to develop synonyms or alternate words when their initial attempt fails (Bilal & Kirby, 2002; De Vries et al., 2008). Many studies have proposed browsing interfaces for children's information seeking (Bilal & Kirby, 2002; Bilal, 2002; Large, 2005). Often search interfaces for children target very young children, and studies investigate search engines targeted at children (Bilal, 2000; Druin et al., 2003; Gossen, Nitsche, & Nürnberger, 2012). Many of these search engines specifically targeted for children, such as Yahoo!igans!, are now no longer available. Jochmann-Mannak (2010) compared children's search performance on four interfaces designed for children, with their performance on Google and found that the children did not perform better on these interfaces than on Google.

STUDY METHOD

We conducted a series of semi-structured interviews with children at two primary schools in the Waikato School District of New Zealand. These interviews explored how children perform a search task, what issues children perceive they have with searching, what sorts of information they are looking for, who is setting these search tasks, and how children are prepared for these search tasks.

Each of the interviews took approximately 20 minutes to complete. Interviews took place in the classroom with the teacher present in the room. The interviews were audio recorded and handwritten notes taken. However, audio recordings were not always reliable or able to be

completely transcribed due to the boisterous atmosphere common in modern NZ classrooms.

Interview questions

After gathering demographic information, the researcher prefaced the interview by saying: “My questions relate to the most recent task that your teacher set where you searched for information on a topic.” The interview questions and their probes are shown in Figure 1.

- 1) What topic did you investigate?
- 2) Did your teacher set the topic of investigation or did you choose the topic to investigate?
- 3) Where did you investigate this topic?
- 4) Did the teacher or librarian teach you about how to investigate this topic?
What?
- 5) What resources did the teacher or librarian tell you to use?
- 6) What resources did you use?
- 7a) What was hard when *searching* for digital information?
- 7b) What was easy when *searching* for digital information?
- 8a) What was hard when *using* digital information?
- 8b) What was easy when *using* digital information?
- 9a) What was hard when *searching* for printed books?
- 9b) What was easy when *searching* for printed books?
- 10a) What was hard when *using* printed books?
- 10b) What was easy when *using* printed books?
- 11) Can you describe your process when searching using computers or iPads etc?
What did you do next?
How did you do that?
What did you type?
How did you choose from the result list?
What do you do when you visit a page?
What if you can't find information?
How do you change your search terms?
- 12) Can you describe your process when searching using printed material or books etc?
What did you do next?
How did you do that?
What if you can't find information?
- 13) Do you prefer printed information or information on computers?
- 14) How did you submit a result for this task?

Figure 1. Interview Questions

Participants

Participants in our study included boys and girls from two New Zealand primary schools. A primary school in New Zealand typically includes Year 0 through 6, and children typically start school on their 5th birthday.

Two principals in the Waikato School District gave their permission to have their school take part. We will refer to the schools as Schools A and B, which are rated as Decile 4 and 5, respectively. The NZ Decile rating (Ministry of Education, n.d.) is a measure of socio-economic status used in allocating governmental funding, with a range from 1 (a high proportion of students from low-socio-economic communities) to 10 (a low proportion of such students). Thus the two schools targeted in this study fall into the middle of the Decile spectrum.

Each principal identified four Year 5 or 6 teachers who subsequently agreed to take part in the study, and student participants were drawn from these teachers' classes. Our goal was to identify a sample of male and female children being taught by a range of teachers at more than one school within the given year levels of Year 5 and 6. The classes at both schools have a typical range of 24 to 27 students per class. Thus 4 students from each class would have given us an approximate sample size of 15% of each class (we obtained a sample size of approximately 12.5% of our potential population). We gained permission to interview 12 students at School A and 10 students at School B,

distributed across 8 classes over the two schools (4 classes from each school). These 22 students comprised 8 Year 5 (3 male & 5 female; 9 & 10 years old) and 14 Year 6 (6 male & 8 female; 10 & 11 years old). Throughout this paper we refer to individual students by an identifier indicating gender, age, and a unique letter identifier (i.e., M10E is a 10 year old male).

RESULTS

We report here the results of our interviews.

A snapshot of information seeking in NZ classrooms

Questions 1 to 6 and question 14 were designed to give an overview of information seeking in these classrooms.

What types of tasks are children undertaking?

12 of 22 students interviewed stated that they selected their own search topic for investigation from a larger topic area or “big idea”. In half as many cases (6 of 22) the teacher initiated the investigation that the student discussed. In only four cases did a student discuss a topic that they themselves had initiated. The types of topics that students described when answering this question were: my culture, kitchen chemistry, historical events, celebrities, and human rights. Children presented the results of their investigations in a range of ways, including speeches (6), essays (4), slideshows or PowerPoint presentations (4), posters (3), dioramas (2), written in homework books (1) and as a student-constructed book (1).

Where are students undertaking these tasks?

Students reported that the majority of their information seeking was conducted at home (18) and/or at school (15 in the classroom and 5 in the school library). 14 of the children searched both at home and at school. One student reported using the public library.

What resources are children using?

9 students recalled being advised by their teacher to use specific resources. This is not to suggest that the teachers only recommended resources in 9 instances, simply that 13 of the children did not recall any recommendations. However, students did state that when they approached the teacher with questions or for guidance that the teacher was able to offer feedback and guidance to assist them with their searches when required.

When comparing recommendation and use of digital and print sources and tools, we find that Google and Wikipedia were most frequently used. Digital information sources were described by the students in twice as many instances as print sources were. Very little use of digital books or a digital dictionary and no use of digital (commercial) encyclopaedias was reported. The public library, a public library catalogue and a card catalogue were three further resources (recommended 4 times, used 9 times). Printed books and school library books constitute the most used print resources reported by the children. No child used a children's search engine.

What senses of difficulty or ease exist for children?

We asked the children what was “hard” and what was “easy” when searching using computers and using books.

What children find “hard” when searching using computers

The children described four distinct difficulties in searching for information on computers: creating search queries (13), selecting an appropriate website from a search list (8), spelling search terms correctly (6), and understanding the language used in search results (1).

Creating search queries: Over half of the students (13 of 22) reported difficulties in identifying appropriate search terms, or knowing how to construct a query. M11A offered: “[it’s] hard to find the right thing to type in.”

Identifying a potentially relevant website from a search result list: Children found it difficult to judge relevance from the site summaries presented by Google; for example, “some don’t give the answer you are looking for. They tell you something different, something related [but tangential] and lead you in the wrong direction” [F11C]. If the child doesn’t spot a relevant site then she or he may conclude that the information can’t be found online: “sometimes there are no websites so [I] have to go to books. It says website not found or people don’t have an interest in it so didn’t make a website for it” [M11B].

Spelling: The difficulty of knowing how to spell a search term was also a common complaint; “I can’t spell well so that can get in the way. I am a bit of a slow typer” [M11C].

Language level: The language level of websites and the language used in the descriptions and website titles presented in search result lists was discussed by one student. F10E stated that she sometimes struggled to read the content of some websites and therefore she chooses a reading level setting of “Basic” or “Intermediate” using Google’s “Advanced Search” filters.

What children find “hard” when searching using books

Nearly half of the children (10 of 22) noted difficulties identifying and locating a relevant book in the library. Children cited a range of issues, including problems in understanding of the library geography and the library catalogue (Dewey Decimal) conventions [M11B], in using the catalogue [F10C] and in identifying catalogue cues on spines of books [M11B]. Language level was mentioned by two students as particularly difficult when reading and finding information in printed books. M9A simply stated that books have “heaps of words”, while F11B stated that “reading the adult text [is hard].” Only one student [F10E] described the language level of websites and digital content as proving difficult for her at times. No child described having language level or reading issues with both digital and printed sources.

Children seemed to believe that books might not have the information they needed; M10E stated that there is only a “limited number of books,” while F10E suggested that “sometimes [I] can’t find the right books – library [might]

not have [it] or someone else has it” and M11C stated “if [you are] looking for something quite specific it can be hard ‘cause they might not have the books,” and finally M11B concluded “sometimes there are no books on a topic.” F10C stated “books don’t always have what you are looking for.”

Children also noted that searching shelves can be hard; M10C complained that there “can be too many books in a big library, but there can be lots of good information in lots of books” and F9B stated that “[books with the] same title but different authors is confusing. Not having a book I am looking for [likely because it is on loan]. Fiction vs non-fiction is confusing and knowing which area of the library is which is confusing.” Using the spine of the book on the shelf can also be an issue; M11B stated that “non-fiction numbers can be hard to remember and hard to find on the spine,” while F10D noted “if lots of books [it can be hard]. So you have to search on the research computer and it gives a number or letter. It’s easier looking for letters than numbers.”

The physical library appeared to the children to offer less support in determining relevance than is available online. Specifically, children identified a lack of synopses in library catalogues “[I] have to really look to find the books that will have my information” [M9A]. They found it more difficult to spot a relevant book on a physical shelf than to identify a relevant website in search results: “looking at the shelves—are the books relevant? Catalogue does not give a synopsis” [F11D].

What children find “easy” when searching using computers

Approximately two-thirds of the children interviewed (15 of 22) were able to describe aspects of searching for digital information that they found easy. Paramount was the seeming simplicity of asking a question and getting an answer; “sometimes the answer you want comes straight up” [M10D] and “I get an answer straight away – starting out is easier, getting specific information is hard” [M10C]. How to use a search engine (where to type a query, what to click to open a search result etc.) is well understood by these 9-11 year olds. F10A stated “typing in the question” was easy, while M9A said “searching the information using the search box and clicking the links” is easy.

Children also noted the wealth of information available online: “it’s easy when lots comes up” [M11B] and compared to working with print material, online searching is “fast, not needing to read or look at the chapters of a book. [Websites] usually give[s] the answer to my question” [F11A].

What children find “easy” when searching using books

10 children were able to identify an aspect of using the library or searching for and using printed books that they found easy. However, 3 children stated specifically that there was nothing easy in the library or they did not use the library while 9 children could not identify something easy. The catalogue was described as easy; “the catalogue [returns] more relevant search results [than Google]. Only

gives books with [my keyword] in the title, no irrelevant search results" [F11D]. F10D stated that for her, "searching in the library is easy if the librarian is there to help." M10C described his ease of use of the library because he was able to "find the section with all the animal books, then you have to find the book you need." One student appreciated the relative stability of print in comparison to digital sources, stating, "a print book is always there—I don't need to find the website again" [F10C].

Some of the features of information search in print that children identified are slightly mistaken and would likely result in search issues for these children. For example, M9A stated that he would "look around the library for the letter that the topic starts with 'H' for Halloween." The school's library uses the Dewey Decimal system and it seems that the child was confused about how books are arranged and the meaning of the book identifiers. Similarly F10C described using the catalogue as easy because she can "type title or author or keyword." Of course this will not work when searching for unknown books or authors, such as typical in nonfiction searches similar to those described during these interviews.

Comparison of ease and difficulty using books and computer
Although we didn't ask the question "what is easier, print or computer?" we are able to infer from student comments some perceived strengths of computers compared to printed information sources. One 10 year old girl stated "the computer is easier because you know what to type in and what you want to find out. But in books you can't type it in and not all books will have the information you want" [F10C]. M10B described that in the library "you have to find the letter [of the Dewey Decimal system]. The answer might not be on the first page [of the book]," while F11B described "searching the library [can be hard] – not all libraries have a computer." Three children listed the accessibility of digital information as being of advantage compared to printed information. For example M11A stated "the computer is easier to find information because I have access to it. I don't usually have easy access to printed information books." F11C also prefers the computer: "You have to go through heaps of books to find one answer that you are looking for. Mainly two things on the computer to get the same information."

Even when our question asked what was easy, we received negative comments about physical book collections from two students; F11C stated "I don't think it is easy to find printed books", she continued, in answer to the question of what is hard when using books "on a computer heaps of things [pause thinking] you can understand, but in a book it's harder to understand." F10A stated when asked about the ease of searching for books "I don't look for books in the library for information. The public library and school library don't really have information on kings and queens for my speech."

Preference

Question 13 asked the children if they had a preference for print or digital information. Children interpreted this question as inquiring about finding or using information. Six children described searching for information using computers as being easier, while only three children preferred searching books for information. The reasons for preferring computers included "the computer has the latest stuff. The computer is easier for looking for and finding information" [F9A] and the Internet has "more information than the library" [M10E]. The reasons for preferring books included "it's easier to find information in a book. You can use the Table of Contents in a book, too." [F10D]. One of these three children who had stated a preference for finding information in a book saw the positives in both media, and also the shortcomings of her (preferred) books; "Books are easier. Books are factual, but not all websites are factual" followed by, "but, the Internet has everything, I don't have books about particular things" [F11B].

While more children preferred searching for information on computers than print, a further 6 children expressed a preference for reading in books rather than reading on a computer screen; the reasons given included "it's harder to read on screen. It's more natural to read a book" [F11D]; "It's easier to read in print. The computer has weird fonts" [F11A]; and "I prefer books 'cause I enjoy reading. I do a lot of reading for fun" [M11C]. One of these 6 children [F10A] stated she preferred "reading for a while in a printed book because the computer hurts my eyes" but "I prefer to search for information using the internet because it is easy, quick and fast."

The remaining nine children could not give a preference, often stating so explicitly. Only two of the thirteen children who responded to this question were male. In future interviews we would instead ask specifically about search preferences (on screen compared to in print) and seek insight into this aspect of information behaviour.

Information search behaviour

We asked children about their search processes. In having these processes explained to us, we discovered a fairly consistent explanation of the search processes when children are searching for books or digital documents. We model these two search processes in Figures 2 and 3.

A model of children's computer search behaviour

From the interviews we were able to identify four processes (indicated as 1 to 4) that children engage in and three decisions (indicated as A, B, C) that are central in their search tasks when using computers (see Figure 2).

Searching for information on computers begins with a new search in Google by entering either a question, a full sentence describing the information need, or a set of keywords (1). From here children described the need to make a decision regarding identifying a page to visit (A). The children then described selecting a search result in one of five ways (2). Once the children have clicked through to

a page the task then requires location of information (or an answer) on the page visited. Children described three ways in which they sought information on a page within a website (3). Once the child deemed that they had completed the use of that page a decision was necessary as to if the page answered their question or not (B). If the child felt they had answered the question they next needed to decide if they had confirmed the answer with multiple sources (C). If they had confirmed with a suitable number of sources, the search would likely be considered finished. If the child required further confirmation they would conduct a new search or select from their previously generated search result list a new page to visit. If a child had not answered their information search on the page they had chosen they would either conduct a new search or adjust their search terms. Children described using new keywords or a new sentence to adjust their search terms if this was required (4).

Starting. Children tended to describe using a hardware system to find information rather than a software tool; e.g., one student suggested that “the first thing I do is I go to my book and I write about the title of the topic, and then I go to a computer, or iPad or NetBook and I get some information” [F11A]. It became evident that when children described using a computer they were in fact describing using a Web browser and search engine. Children only referred to using a digital library catalogue to perform a search when they were specifically asked about finding books. None of the children mentioned using eBooks (or CD-Rom encyclopaedias) or software (other than a web browser) for finding information on a computer. Children

seemed to consider Google as synonymous with a web browser. For example, when specifically asked “what do you type in and where do you type it in?” an 11 year old girl replied “at my house I type it into Safari, and at school I type it into Google” [F11A]. Further, when asked, “what is Safari?” she responded with, “it’s a thing for Apple computers and it’s just another way to find the, um, to search up” [F11A]. When further asked, “do you type it into the box in the middle of Safari or the little box right up the top of Safari?” she responded “I use the box right at the top.” We are aware that the first screen that a student sees when opening a web browser at F11A’s school is www.google.com. We thus assume that when she searches “Google” at school she uses the Google search in the web page rather than the browser plugin for the Google search engine such as she describes as “Safari at home”.

Query construction. Process 1 in Figure 2 illustrates the three ways children described using Google searches. 17 children stated they would use verbose searches, a full sentence (8) or full question (9) within Google, while 11 children search using keywords.

All 22 children stated that they searched using Google, even if they were, in fact, looking for a known website (3 children searched Google for a known website such as BBC Kids, while 7 searched Google looking for the Wikipedia entry for their search). When asked to give examples of the types of search entries they used, 9 children provided questions, 8 provided sentences and 11 provided keyword strings.

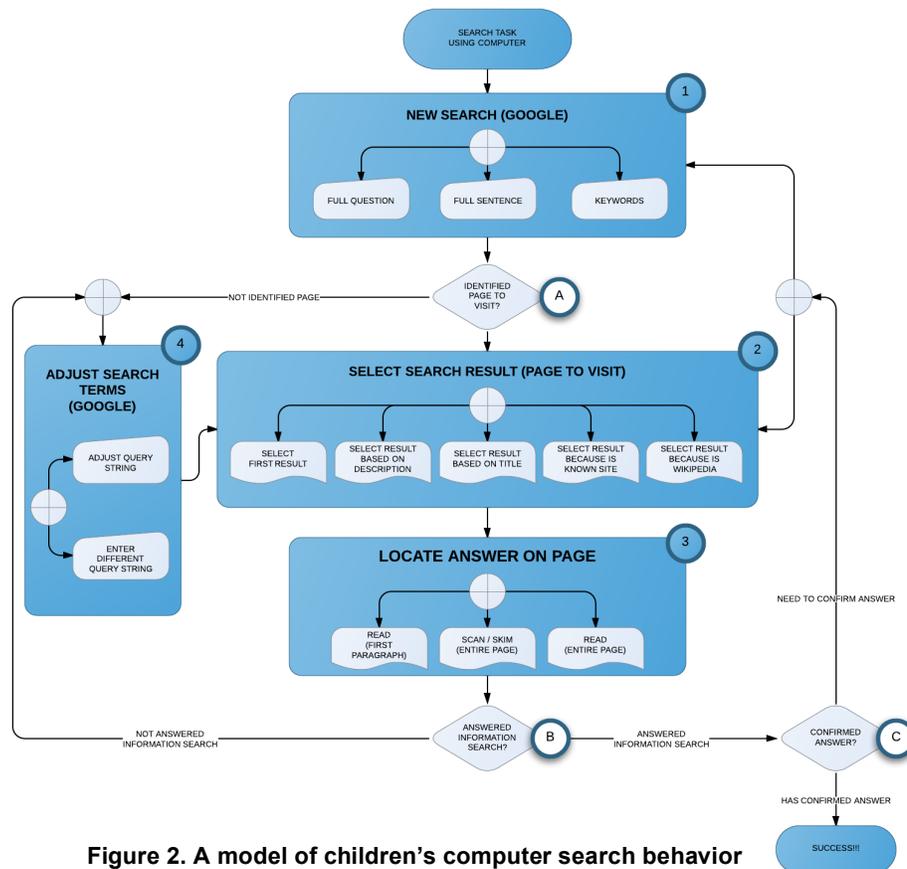


Figure 2. A model of children’s computer search behavior

Search result list triage. Process 2 (Figure 2) illustrates how children described choosing from the search result list they were presented with after an initial search. They described five methods for selecting from a result list. 8 chose the very first in the list, and 11 made a decision based on the description text below the link name, while 5 used the name of the link to make a choice. Seemingly 10 children were not triaging at all, because they were using a Google search to locate a predefined website. Three children searched Google for a known website such as BBC Kids, while 7 searched Google looking for the Wikipedia entry for their search.

In-page triage. Process 3 in Figure 2 summarizes how children described locating an answer or finding information within a page. When searching a page for information, 6 children stated they read only the first paragraph, 8 children read from the top to the bottom of the page or until they found what they wanted, and 4 children scanned or skim read the page. 4 children did not discuss their habits when using a web page to answer an information need.

Adjusting Search Terms. Process 4 in Figure 2 illustrates how children described adjusting search terms. When children described adjusting a query string they stated that they changed their search “terms” or shortened sentences to keywords (3), adjusted a sentence or changed to using a sentence as the query string (3), or adjusted the question or entered a question instead of a sentence (2).

The children struggled with describing strategies for refining searches. It was very difficult for children at this age to describe what they do when a search was not providing the answer to them. For example, one 11 year old boy stated, "you may have a couple of options, like you could look up one thing and then you ... you, I don't know, type in a different thing, you have to start again and go back and then put in something else that may have something to do with the search ... you just kind of, um, go on and see what happens" [M11A]. When asked how they modify their search terms, many of the remaining 14 students were only able to respond with “I don't know”. These responses clearly point to a need for education and support in effective query refinement.

A model of children's book search behaviour

Children seemed less able to clearly articulate their process with searching for printed information; their search processes for finding books, and finding information in books, was often described in far less detail than given when asked about searching on a computer. One student stated, "I don't look for books in the library for information" [F10A], indicating that she used books in the library for reading for pleasure but not for searching for information to answer a question.

From the interviews we were able to identify two processes that children engage in and two decisions that are central in their search tasks when searching for information in books

(Figure 3). All children described searching for a book as beginning with a new search in either a school or public library. The children described one of two methods (Figure 3, Process 1) for locating books in a library.

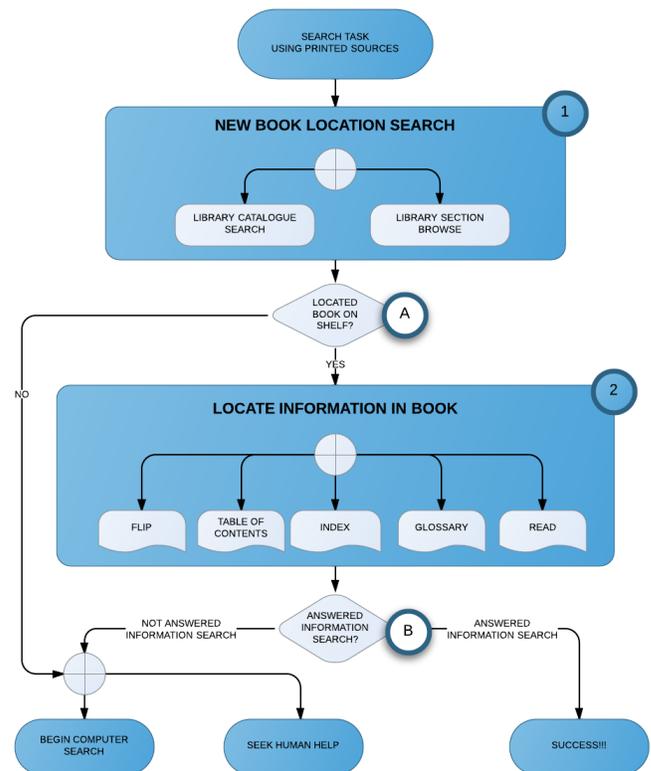


Figure 3. A model of children's book search behaviour

From here children described the need to make a decision whether a book exists that serves further investigation (Figure 3, Decision A). The children then described locating information in a book in one of five ways (Figure 3, Process 2). Once the children have analysed the content of the book(s) often at the shelves the final decision was to consider if the children had answered their information search (Figure 3, Decision B). Differing from the information search on computer, there was no discussion of a need to confirm sources when using printed material. Additionally children did not seem to have mechanisms to adjust a book search should they reach the conclusion that they could not locate a book to further the search or should they conclude they were unable to answer their question with the books they did identify as potentially relevant. Should the children conclude they could not answer their search tasks using printed books they were likely to seek assistance from a parent, librarian, or teacher, or seek information on the Internet.

DISCUSSION

Loss of structured search strategies for print material

Children conducted open-ended investigations using a range of information sources which is in line with a Socio-cultural theory or Constructivist focused classroom (typical in New Zealand). Students defined sub research questions

within a topic area set by the teacher which is similar to the types of projects that Penny Moore (1995) described in her research with NZ children almost 20 years ago. According to our interviews, children used both computer and printed information sources, while Moore's work only included children searching for printed information. Moore concluded that students had a simple rule for finding information; "think of a question, identify its keywords, look up the subject index for a Dewey number, go to the shelves and find the answer in the exact form it is wanted" (1995, p. 28). We find that our interviewed students, in turn, did not have such a structured approach to finding information in print suggesting that, 20 years on, children do a worse job searching *in print*.

Structured search strategies for online information

The children described in great detail their strategies when searching for information using a computer (Figure 2), which was more detailed and structured than that for print material. Similar to Moore's simple rule for finding print information, our interviewed children seemed to follow a process for finding digital information: think of a question, identify an appropriate search query, enter this into Google, assess the results list for the answer in the exact form that it is wanted and proceed to the Web page that contains the information in the exact form that it is wanted. As we will discuss in more detail below, the process that the children followed in searching for digital information aligns fairly closely to Kuhlthau's Information Search Process model.

However, while the children do follow a structured process, separate elements within the process need improvement for some students. When the children select a search result from a Google results list, most of them analysed the presented list for information to make a decision, but many just selected the first entry of the list. Such lack of selection strategies may result in slow search or selection of lower-quality results. Similarly when locating an answer on a webpage, several children described reading only the first paragraph, while others skimmed or read the entire page. If the answer to the student's question is not in the first paragraph, they are likely to dismiss the page altogether and therefore miss valuable content during their search.

Two process models for children's information seeking

From our interviews, we developed two flow diagrams, describing the children's search strategies when working with digital (Figure 2) and print (Figure 3) documents. Our models align with Kuhlthau's (2004) ISP model, in which she identifies *initiation*, *selection*, *exploration*, *formulation*, *collection* and *presentation* as the six phases of an information search. Our interviews did not aim to elicit insight about the *initiation* and *selection* stages of Kuhlthau's model. We do know that in New Zealand Year 5 & 6 classes there is some self-selection of topics to investigate by children and some freedom for children to explore their information search inside and outside the classroom. Children tended to begin the selection process by using the computer rather than book searching.

The interviewed children described difficulties in the *exploration* stage with constructing search queries at the outset of an information seeking problem. M9A discussed this need to explore a topic "the more I know about a topic the easier a search box is. I have to describe the item [topic] well." Children explored the search space to assist themselves in developing search terms. *Formulation* was described by the children when they detailed browsing, skimming, and reading search result lists and Web pages. It was during the exploratory and formulation phases that children were developing and refining their queries—and finding these stages difficult. The children understood the importance of relevance checking in the *collection* stage; specifically, they discussed the need to check sources and confirm answers using more than one website. The *presentation* mode of the information was dictated by the assignment. The majority of the issues raised by students in our interviews and much of what our process models describe fall within Kuhlthau's *exploratory* and *formulation* stages. Further research of these middle two phases of information seeking by children is required so that we might best support query construction and refinement as well as selection from search result lists and document triage. This additional research will assist to prove our own models and explore further Kuhlthau's model used with younger children. Even though the ISP model of information seekers focussed originally on adults and high school students, we found it also applies to younger children such as the primary school students interviewed in our study.

Recommendations for children's search interfaces

For the children interviewed, it seemed that digital search was often understood to be synonymous with searching the Internet (in particular, using Google). These interviews clearly indicate significant use of Google and no use of dedicated children's search engines, digital libraries or digital encyclopaedias. We have no data for why these children did not use such child-centred tools. However, it remains questionable if these tools would have changed the overall results, as Jochmann-Mannak (2010) found that children did *not* perform better when using search tools specifically designed for children. We therefore argue that, rather than developing dedicated children's search tools, an enhanced Google search user interface may better serve children's needs. The children in our study identified the three problems of constructing searches, identifying relevant information in search result lists, and finding the information contained in Web pages. We believe that enhancing the way Google displays search results may address these difficulties.

Constructing searches. Children stated that they struggled with knowing what would make a good search query for their needs and how to identify ways to improve search queries that they had tried. Research has shown that adults conduct few query reformulations or subsequent searches (Spink & Jansen, 2004), while older children appear to

reformulate search queries regularly (Bilal & Kirby, 2002; Bilal, 1998). Solutions for query formulation and reformulation are not broadly implemented for children or adults in current search engines or digital libraries.

Given the number of children who reported using full sentences or questions, the affordance of natural language queries supported by Google is clear. Further assisting children to recognize when natural language is an effective query process and what to do when natural language searching fails may be necessary. Research is needed into interfaces that assist with formulating appropriate natural language and keyword queries, as well as support for finding synonyms or alternate query terms and query strings when an initial search attempt fails.

Correct spelling of search queries was again found to be difficult for children (cf. Druin et al., 2009). We did not gain information about if and how the children used Google's spelling suggestions. Druin et al. (2009) suggest that the reason that Google's semantic search suggestions do not assist children presently is because children are looking at the keyboard when typing and therefore do not see the query suggestions. Solutions that solve this disconnect will assist here also.

Identifying relevant information in result lists. Children stated that they selected Web pages from a search result list based on the location of the item (i.e., selecting first in the list), the item being a known website, or the title or description containing search terms from their search query. More clearly highlighting search terms within the result list or the resulting Web page (such as seen in Google books) might benefit children when they triage search result lists. Children also reported seeking answers on Wikipedia by conducting a search in Google and scanning the result list for the Wikipedia entry. Perhaps the simplest solution here would be additional education in search practices, including the use of Search Operators, Advanced Search functions or the inclusion of such features into the Google interface.

Finding information contained in Web pages. Children described reading an entire Web page, skimming Web pages or only reading the first paragraph of a Web page in hopes of finding answers to their information needs. Surprisingly, no children reported searching within Web sites using either browser search functions or site search engines. Highlighting of search terms within the result pages would help in identifying the target information.

Browsing or searching

Some researchers suggest to support children's information need by browsing rather than search (for example Bilal & Kirby, 2002; Bilal, 1998; Large, 2005). Only four of the 22 interviewed children described browsing for information in print books. They particularly liked the consistent location of books in the library and their ability to go directly to a known shelf or library section to find books that might answer their questions. Browsing interfaces for children's digital information seeking might particularly support the

students who preferred browsing for print books. When asked for ease of search in print and digital media, only six students described using the library catalogue for finding print books, while 15 students named the ease or efficiency of Google for searching. Our findings support those from Spink et al. (2010), who reported the importance of query-based search. Therefore, we argue that browsing interfaces for digital content would best be coupled with a query-based interface, and not stand alone.

Online vs paper reading

Even though our study did not focus on reading but rather on search strategies, children indicated a preference for reading on paper vs reading on screen. Hinze et al. (2012) observed a similar preference in visitors to tertiary academic libraries. In both studies, similar arguments were used to describe limitations of access, quality of information and comfort of reading.

Limitations and Future Work

Our models at this early stage in our research are indicative and reflective. These models must be considered with reference to our small number of participants and the interviews with children that rely on children's recollections of their search strategies. We propose future work to test these models that includes contextual inquiries during children's information search as well as log analysis of children's information searches. We will also explore the use of these models to predict the search strategies of further groups of children.

CONCLUSIONS

Searching for information really is hard for children. Problems arise in creating initial queries and in query refinement, and the causes of these difficulties are unclear to the child. Indeed, in some cases it is not clear whether the problem can be rectified by the child, or whether the issue is external (a predicament beautifully summed up by one child's statement that, "sometimes the Internet reads the question wrong" [F10E]). If a search is unsuccessful, the children are uncertain as to whether they are simply not looking hard enough, or whether the material (or perhaps, the material written at their level) simply doesn't exist ("if you are looking for something very specific it can be difficult because there may not be a book about it" [M11B]). As we have shown in this paper, perhaps not only does the Internet "read the question wrong," but so, too, does a library catalogue. Perhaps even books don't know exactly what we are looking for. These difficulties are compounded by the fact that children are still learning to make relevance decisions and to construct searches effectively. We believe our findings demonstrate a need for a system that supports the development of a self-reliant information user. We foresee that systems supporting self-reliance during information use for young people will complement the work of educators and parents who introduce children to digital information search skills and information/digital literacy.

Though these children also search for print material, they were not able to articulate their strategies as well as with digital search. The children clearly have less insight into the organization of print collections than of digital information (though the latter is itself subject to misunderstandings). While there are some insights from children's interactions with print material that can suggest improved interfaces to children's digital collections (e.g. Cunningham, 2011), it appears that more substantial gains to the children themselves will come from research targeted at improving the digital information seeking experience rather than targeting better support for search in print collections.

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