
The Information-Seeking Behavior of Youth in the Digital Environment

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ABSTRACT

The theory of Radical Change, which is based on the digital age principles of interactivity, connectivity, and access, is suggested as a lens to reexamine existing research on youth information-seeking behavior in the digital environment. After a brief review of research meta-analyses, which often point to deficits in youth information-seeking behavior, questions that emerge from this research are suggested. Meta-analyses of gender and information behavior studies find that some recent research disputes former conclusions. Radical Change is applied to an examination of specific facets of contemporary research in order to demonstrate how new perspectives can be gained. This analysis addresses commonalities between information-seeking behavior related to the handheld book with hypertextual qualities and digital materials, the social nature of information seeking, and emerging issues of access. It is noted that the public library as a setting for research has rarely been used, even though its less structured nature might provide insights that do not surface in schools. A look at directions for youth information-seeking behavior research in the future proposes how brain research might shed further light on behavioral observations. Conclusions note existing research and summarize some new points of view and areas for investigation.

INTRODUCTION

An up-to-date overview of research conducted during the past decade related to youth information-seeking behavior in a digital environment reveals challenges and opportunities. A theoretical examination of some of

the studies provides new perspectives on research findings that have been overlooked and areas that are ripe for study.

Discussion of Terms

In this study, "information" refers to ideas or thoughts that individuals contribute, seek, or obtain from informal or formal discussion, investigation, or study. The whole of information behavior is a complex combination of factors. According to Wilson (1997), who is regarded as a founder of the study of information behavior, at least three facets must be considered. The focus will not be on the perceived need for information or on factors that affect the individual's response to this need but rather on the processes or actions, including information uses, involved in responding to the need.

The fully emerged digital age with a saturated digital environment did not occur until digital media (media with an embedded microchip) started to touch the lives of the general populace in the last decade of the twentieth century (Dresang, 1999b). In his book *Being Digital*, Nicholas Negroponte (1995) of the MIT Media Lab wrote, "Computing is not about computers any more. It is about living" (p. 8). Negroponte and Dresang purport that the impact of the microchip extends beyond direct contact with digital media to influence how one gives, receives, and creates information. The digital environment is ubiquitous; it permeates everyday life.

Young people in the early twenty-first century are "growing up digital," a term applied by Don Tapscott (1997) to those who were born after 1977 and who have experienced a life in which computers are commonplace. With the same Internet-generation youth in mind, Holloway and Valentine (2001) coined the word "cyberkids" to describe young people whose lives are inextricably bound up with an Internet-saturated setting. The information-seeking behavior of these cyberkids, growing up digital, has raised numerous questions among researchers and educators.

The Evolution and Application of Radical Change Theory

In the 1997 issue of *Library Trends, Children and the Digital Library*, Dresang (1997) introduced the theory of Radical Change for the first time in a scholarly publication. The thesis then—and now—is that the term "digital materials" refers not only to those media that incorporate the technology of the microchip but also to "handheld" materials that embody characteristics of the digital environment. In other words, the digital environment has influenced some nondigitized media to take on digital characteristics. Initially Dresang developed the Radical Change theory to explain the changes in handheld books for youth that reflect the interactivity, connectivity, and access of the digital world (Burnett & Dresang, 1999; Dresang, 1997, 1999b, 2003; Dresang & McClelland, 1999; Nodelman & Reimer, 2003). In the 1997 article, she applied Radical Change to explain this reflection of the digital environment in only one type of "change" in the handheld book, that is, forms and formats that reflect the hypertextual,

multilayered, and graphic interfaces of the computer. Subsequently she described two other types of changes that are observed in books influenced by the digital environment: perspectives that incorporate previously marginalized populations, including those of youth; and expanded boundaries that encompass new types of communities, characters, and subjects previously forbidden. These Radical Change books serve as one example that the influence of the digital environment extends far beyond the digital resources themselves.

But other developments have occurred in relation to the Radical Change theory since that 1997 article (Fisher, Erdelez, & McKenzie, 2005). Researchers in the fields of information studies and information science (Agosto, 2002; Dresang, 1999a) have noted that information seeking in a digital environment influenced by digital age principles may call for new perspectives. In the field of education, several researchers (Abele, 2003; Hammerberg, 2001; Pantaleo, 2002, 2004a, 2004b, 2004c) have applied the Radical Change principles to examine or explain not only books but also information behaviors. John Zbikowski (University of Wisconsin–Whitewater) used Radical Change to explicate “the relationship between information and communication technologies and literacy development in and out of schools” (personal communication, March 2, 2003), and Judith Ridge (University of Sydney) found Radical Change useful in exploring creative writing (personal communication, February 18, 2004).

Radical Change, then, is a theoretical concept that applies digital age principles to explain both some information resources and some information behaviors. These digital age principles are further described in the relevant sections below.

After an overview of the current state of research, the theory of Radical Change is applied to examine and explain selected areas of youth information seeking in a digital environment with the purpose of lending additional insights on which researchers and professionals might capitalize.

INFORMATION-SEEKING BEHAVIOR IN A DIGITAL ENVIRONMENT: META-ANALYSES

Enough studies have been conducted during the past decade to warrant meta-analyses of youth information-seeking behavior in a digital environment. Research has focused on attitudes and preferences, search processes, modes and skills, and perceived relevance of results; it has been carried out with specific age groups and disaggregated by gender. Schools have been the most common setting for this research, with few studies in public library settings. Research on youth and digital media, which first focused on Online Public Access Catalogs (OPACs) and CD-ROMs, more recently has turned to the Web as the medium.

General Studies

Bilal's (2004) examination of research focuses first on children's tasks—self-generated (see Gross, 1999), fact, or research—when approaching the Web. She analyzes their success and their strategies (or lack thereof), referring to her own seminal research on children's use of the Yahoo!igans! Web search engine (Bilal, 2000, 2001, 2002). What little is known about children's experience and domain knowledge as relevant to success (Marchionini, 1989) is covered. She concludes that more research is needed on measures of children's success; on the effect of the structure of tasks; on children's prior abilities related to results; on the influence of cognitive styles and mental models; and on children as designers of interfaces. A complementary meta-analysis piece (Large, 2004) focuses exclusively on elementary age children's Web searching.

Todd's (2003) meta-analysis of adolescents' information seeking and use scholarship provides a theoretical approach with an international point of view to three aspects of the topic, one of which is "searching or surfing the World Wide Web" (pp. 38–39). Another meta-analysis (Shenton & Dixon, 2004) focuses on commonalities of information-seeking behavior, regardless of the source, although specific issues related to digital resources are incorporated.

Taken as a whole, the bottom line of these general meta-analyses of information-seeking behavior related to children's *use* of digital media might be that young people are missing much of the richness of an environment saturated with information because of poorly developed information-seeking skills or a propensity to take the easiest path possible. Some researchers, for example, Bilal (2004), offer ample, plausible, youth-related explanations for these tendencies. One implication for practice surely is the one made by Todd (2003), who noted that "a consistent theme emerging from all these studies is the need to develop learners' information and critical illiteracies" (p. 38).

As Bilal points out, a study that she and Kirby (2002) conducted documents that children have "cognitive developmental abilities, problem solving skills and information needs that vary from those of adult users" (Bilal, 2004, pp. 271–272). So, to focus solely on behaviors that need improvement is to forget these differences. On the other hand, it is also important to note some similarities with adults' information seeking. Poole (1985) found that the Principle of Least Effort was the strongest result found in his review of a dozen information-seeking studies. Specifically, "least effort" does not just mean that people choose the lazy route. Rather, they minimize the overall work associated with something, both now and anticipated in the future. Gigerenzer (1999) adds to this concept, noting that human behavior wisely follows simple principles.

To view youth information-seeking behavior as generally lacking is to overlook the new behaviors nurtured and facilitated by the digital environment and to miss the golden nuggets embedded in these studies. For example, Shenton and Dixon note that "several untaught, expedient information-seeking methods were applied" in their study (2004, p. 195). What are these methods? What can be learned from them? Children consistently have more successful results on self-generated tasks, followed by imposed research tasks, with the least success on finding specific factual information (Bilal, 2004). What does this tell us about teaching and learning? Multiple research studies find students almost universally choose browsing over planned or systematically guided searching (Large, 2004). This is generally regarded as "less desirable," but is it? Or is there somewhere in between overly structured and completely unstructured searching? And what about measures of success? Adult "experts" determine the level of success of children's searches, but how often are children involved in defining the criteria for this success (Dresang, 1999a; Bilal, 2004)? What could be learned if they were? Perhaps a new model of youth information seeking in a digital environment should be developed, incorporating these somewhat overlooked factors.

Gender Studies

A large body of recent research focuses specifically on gender in relation to information seeking and media in the digital environment. Many of the studies examine male and female behavior in relation to video games, since game playing is a top activity for youth computer use (Agosto, 2004b; Casell & Jenkins, 1998). In a recent meta-analysis of gender and educational technologies, Agosto (2004a) concludes that gender as a sole determining factor is too simplistic a way to look at information-seeking behavior. Studies consistently used to find males were more interested and involved with technology than females; this is often no longer the case (Miller, Schwein-gruber, & Brandenburg, 2001; North & Noyes, 2002). Confirming this conclusion is a research project funded by the Institute for Museum and Library Services and conducted by Dresang, Gross, and Holt in the Saint Louis Public Library. Children's Access to and Use of Computers Evaluation (Project CATE), which appears to be the only such study set in a public library with the data disaggregated by gender. Analyzing data from 200 surveys, focus groups involving thirty-seven youth, and three week-long observations of several hundred youth in six public library locations, Dresang, Gross, and Holt (2004) found that girls and boys, ages nine to thirteen, were equally positive about computers and their ability to use them. The result of a close examination of these recent studies is a caution to avoid generic statements about gender and to realize that in the digital environment previous assumptions are not always accurate.

Radical Change and the Meta-Analyses

A trend observed about these meta-analyses is that many “research-driven assumptions” may need close reexamination in the interactivity, connectivity, and access of the digital environment. In the reconsideration of the studies focused on use in these meta-analyses, considering how the principles of interactivity, connectivity, and access could bring a new perspective to the research might increase understanding and suggest new directions for further investigations. In the sections below, Radical Change is applied to specific research findings, demonstrating how this can happen. It is obvious, of course, that the Radical Change principles of interactivity, connectivity, and access cannot be applied or examined in a mutually exclusive way, so research is discussed under the principle where it seems most fitting.

INFORMATION-SEEKING BEHAVIOR AND INTERACTIVITY

“Interactivity” refers to dynamic, user-controlled, nonlinear, nonsequential, complex information behavior and representation. The observations and examples below refer to the interactivity built into resources and the interactivity of the information-seeking behavior of youth as they access these resources.

Two terms, coined by Dresang (1999b) to apply to handheld, two-dimensional books, must be defined. “Handheld hypertext” refers to books that reflect the nonlinear, nonsequential characteristics of digital media, with text alone or text and graphics. “Digital design,” a subset of handheld hypertext, describes the presentation of pictures and text in a juxtaposition that requires, or at least promotes, a hypertextual approach to thinking and reading.

Children’s Affinity for Digitally Designed, Hypertextual Resources

In an early digital media study, Marchionini (1989) found that students’ strategies in an electronic textual environment tended to be interactive and particularly well suited to digital resources. Similar findings come from research on children’s use of the Web. In her overview of children’s information seeking on the Web, Bilal states that “overall, children did not explore text-only sites often; preferred sites with high visual content and short, simple textual content, and liked to see more animation and interactivity on the Internet” (Bilal, 2004, p. 278).

In a study of elementary school children’s use of a CD-ROM product, Large, Beheshti, and Breuleux (1998) demonstrated the children’s affinity for nonlinearly presented information and their “ability to extract selectively information and to evaluate sources in terms of usefulness as well as enjoyment and ease of use” (p. 343). The authors comment that “Dresang (1997, p. 649) may well be correct in saying that ‘children have demonstrated their comfort level with far more complexity than adults previously thought possible or appropriate’” (p. 369).

But until recently, no one had formally studied whether these same qualities interest children when they appear in handheld books. Several twenty-first-century studies find that handheld hypertext is as appealing to children as that in digital resources. Moreover, some of these studies conclude that the digitally designed resources promote higher-level thinking among young children rather than confusion because of their complexity.

Pantaleo (2002) has conducted research with first-grade children using digitally designed books identified by the Radical Change theory. The books she selected were nonlinear and nonsequential in organization and had interactive formats with multiple visual and verbal perspectives. From her study of children's reactions to David Wiesner's *The Three Little Pigs* (2001), in which the little pigs visually break out of their original story, Pantaleo concludes that "the Radical Change characteristics . . . described in this paper require readers to have heightened involvement in the creation of meaning" (2002, p. 81). She continues, "some individuals may think that . . . Radical Change characteristics are too difficult for children" (p. 81). However, she finds that children can handle quite sophisticated visual and narrative design. In another study Pantaleo (2004a) explores further how young children "read" nonlinear, multiple-layered texts; this time she focuses on David Macaulay's *Shortcut* (1995). Here she states that "Radical Change texts with metafictional devices can provide the kinds of reading experiences that develop readers' abilities to critically analyze, construct, and deconstruct an array of texts and representational forms that incorporate a range of linguistic, discursive, and semiotic systems" (2004a, p. 17). In her discussion of this study, she takes her findings a step further to the overlap between handheld hypertext and digital media: "Further, one can connect the kinds of skills required by web literacy with reading books with metafictional devices. . . . Web literacy . . . demands different navigational and reading strategies than traditional printed texts, and indeed, there are some similarities between the strategies and skills required for web literacy and those required for reading metafiction" (p. 17). She corroborates these findings in a third study (2004c) that uses Anthony Browne's nonlinear, multilayered picture book, *Voices in the Park* (Browne, 1998).

Hammerberg (2001) studied the reading and writing of early elementary school age children and concluded that their natural way of approaching both functions is "hypertextually." She studied texts identified by Radical Change to propose a reform of the teaching of writing. The purpose of her study was "to find the places where contemporary writing instruction can be updated to include elements of hypertextual reading, meaning beyond printed words, multiple perspectives, and complexities of plot" (p. 208). She proposes something she calls "shared and interactive writing."

While Pantaleo and Hammerberg ostensibly are studying how young children read and write, they are, in fact, observing the children's information-seeking behavior in relation to digitally designed text. Pantaleo details

how children make connections and fill in gaps to gain the “information” they seek, which is a story that makes sense to them. What Pantaleo and Hammerberg observe mirrors Cooper’s advice that “in order to best support children’s information-seeking needs, it is important to examine the manner in which children think about information” (2004, p. 189).

A previously unpublished pilot case study, too small to do more than tentatively suggest areas of investigation, conducted by Dresang and Chris Hart, a doctoral student at Florida State University, documented two sixth-grade students’ reactions to digitally designed books. Nonfiction books from the DK Publishing Company (Pearson), a pioneer in the sound bite presentation of information, were chosen for the study. The students were videotaped on two occasions of an hour each reading the books; they were asked to “think aloud” as they read. One of the researchers also commented aloud on the information behavior he observed, and the students were interviewed after the intervention. After these laboratory sessions, the students were given a book of their choice from those selected for the experiment to take home for a week to read, and they were interviewed again about their reading of the text. Although their information seeking differed in how they approached the materials (one followed research findings in her browsing behavior, while the other followed a planned, structured approach led by the systematic DK visual presentation), they were in agreement that the digitally designed format had become essential for them. One student expressed the sentiment of both: “I am so accustomed to making choices in the information I access and in the visual guides along with words, and with words that are not all buried in huge blocks of text, that I would not have pursued the information in another more traditional format” (personal communication, April 12, 2000). The children were attracted by the high degree of interactivity required by these books and the visual guides they provide.

Implications for Research and Practice

Interactivity as identified by Radical Change is reflected in information seeking related to both handheld and digital media. Researchers studying the information behavior of children related to reading and writing have recognized the similar “literacies” that need to be developed for hypertextual media in either environment. And they are capitalizing on these similarities. Knowing that children read naturally in a nonlinear manner might explain why some aspects of Web surfing are quite easy for youth. To date, researchers of specifically digital media have not recognized this common ground or what might be learned from it. Burnett and Dresang (1999) describe this instructive overlap in their discussion of rhizomorphic reading. The information literacy found lacking in online searching might be somewhat mitigated by studies of how children read similar handheld text.

Moreover, for practicing professionals, the recognition that the “divide” between handheld books and digital media is not the gulf that is sometimes portrayed will be useful in guiding youth to think or act in a more integrated, multisource manner in their information seeking. Using digital media and handheld books interchangeably to teach searching skills might yield rewards in approaching both. Recognizing the appeal of books that reflect digital media and the “why” of the appeal might help librarians and teachers with selecting books that motivate young people to read. Many benefits might come from recognition of this “overlap” between digital media and handheld hypertext for those who can think outside normal information structures.

INFORMATION-SEEKING BEHAVIOR AND CONNECTIVITY

“Connectivity” refers to the sense of community or construction of social worlds that emerge from changing perspectives and expanded associations in the real world or in resources. The media in a digital environment often serves as a catalyst for connections that in turn facilitate information seeking.

The Social Nature of Youth Information Seeking: Knowing Together

Children's collaborative information behavior has been studied in relation to digital media. Druin et al.'s (2003) analysis of children's use of interfaces for a digital library under two separate collaborative conditions produced no “black and white” conclusion about the extent to which collaboration facilitates children's information seeking. Much depends on expected outcomes for the activities. A meta-analysis (Lou, Abrami, & d'Apollonia, 2001) that examined 122 studies involving 11,317 student learners using technology found that overall small group achievement exceeded that of individuals working alone. Caveats to this finding exist: without proper structure and “coaching,” some individuals achieved better working independently.

Some adults have suggested that children's use of computers disassociates them from important social development (Healy, 1998). Project CATE provides an alternative view. A dominant theme that emerged from analysis of the statements made by youth in the study of their information-seeking behavior in the Saint Louis Public Library, with the assistance of NUD*IST content analysis software, was the preferred social, connected nature of information seeking (Dresang, Gross, & Thompson, 2002). Children reported both wanting to work together on the computer (despite the fact that many of them were doing different homework assignments) as well as desiring the opportunity to share information that they had found.

When asked what changes they would make in the library, many of both the boys and the girls mentioned that they would like to work at computers with one or more friends. In terms of wanting to share information, a fifth-grade boy explained, “I think they should have clubs where you

can get together and talk about . . . computer games that you like, and people can suggest good things . . . to hear ratings from other people your age” (Dresang, Gross, & Thompson, 2002, p. 23). A middle school boy articulated this sentiment: “We could share web sites with each other and different things on the computer” (Dresang, Gross, & Thompson, 2002, p. 23). Another aspect of this information-sharing behavior emerged from the desire of youth to teach others what they had learned. A fifth-grade girl suggested, “Little kids that are in kindergarten or in pre-school, they want to learn. . . You can teach them to go to those dot.coms on the computer” (Dresang, Gross, & Thompson, 2002, p. 22). The idea of “knowing together,” or a community of learners on or offline stimulated by or focusing on Internet sources and activities, emerged from this data when it was looked at holistically. Moreover, young people wanted this sharing to occur as they sought the information, not only with time delay. The message was so clear that the Saint Louis Public Library changed its policy of one child per computer and allowed small groups of children to seek information together; the library also established Club Tech, a formal opportunity for youth to share this kind of information.

Some previous research, for example, an earlier study of information search styles and gender (Burdick, 1996), has indicated that boys are less likely to enjoy working in socially connected environments than girls (Bilal, 2004, pp. 280–281). This finding was not corroborated in Project CATE, where both boys and girls wanted to interact in a similar manner. In another study a group of researchers (Anderson, Hilton, & Wouden-Miller, 2003) found that young children, videotaped at various activities, played more cooperatively at the computer center than any of the other three centers provided for them.

Serendipitous Social Information Seeking Online: An Example

Little information was gleaned from the Saint Louis Public Library study about online social worlds because at the time of the study the library did not encourage chatting online and emails. Much anecdotal evidence exists, however, that youth engage in online chat and build a wide variety of social worlds as they seek information.

An example of this type of connectivity comes from sixteen-year-old Celia McGinty in Moscow, Idaho, the daughter of a police officer at Washington State University and head of a cyber crime unit. One afternoon Celia logged on to a favorite music chat room and struck up a casual conversation with a seventeen-year-old from Detroit, who identified himself as Andrew Osantowski. The casual turned serious when Andrew revealed in specific detail his plans to take violent revenge on teachers, schoolmates, and a police liaison officer at Chippewa Valley High School with assault weapons he had accumulated and a homemade bomb. Celia instantly recognized danger and reported the incident to her father. The subsequent investiga-

tion resulted in the arrest of Andrew with a \$1 million bond and ten felony charges. Celia and her dad were invited to Detroit to be honored as cyber-heroes—and for Celia to talk to the teens there about the importance of detecting and reporting threats on the Internet (Officer's daughter, 2004). Celia's alert digital age information-seeking behavior required connectivity to both an online and an offline community that extended far beyond her geographic boundaries.

This is only one of numerous anecdotal instances of information-related connectivity that youth have discovered online, ranging from a gay young person in Texas finding people with whom he can freely discuss his issues and gain needed information (for the first time), to young activists in Brooklyn organizing a political demonstration, to students engaging in collaborative online projects such as *ThinkQuest* (2004), in which young people, separate geographically, produce sophisticated Web site projects with a great deal of information.

Implications for Research and Practice

The connectivity of the digital environment extends far beyond the electronic networking into the creation of communities on and offline. The social nature of information seeking that is occurring can be explained by the connectivity that permeates the digital environment, but little is known about it to date. Although researchers are examining the nature of online communities peopled largely by adults, little research seems to exist to determine what this type of connectivity does to facilitate information seeking for youth. Further research is needed to determine preferences and successes in collaborative activities using digital media, particularly when it is not "enforced," such as in public library settings, and to determine whether gender in these collaborations affects preference or success. Conditions under which collaborative learning on the computer yields greater success need to be identified. *ThinkQuest* (2004), which depends on collaborative learning, could provide a laboratory for the study of collaborative information-seeking behavior. Following the wisdom of the Saint Louis Public Library, which changed its policy in light of stated youth preference, librarians may examine how to capitalize on the social nature of knowing. Libraries should recognize different information-seeking styles just as other educators recognize different learning styles.

INFORMATION-SEEKING BEHAVIOR AND ACCESS

"Access" refers to the breaking of long-standing information barriers, bringing entrée to a wide diversity of opinion and opportunity. The digital environment may facilitate or inhibit access.

Previously Unheard Voices Emerge

One of the questions that has emerged in the past decade as crucial to understanding information access and digital media for children is "What

can we learn from children?" The posing of this question in and of itself provides additional access to youth. Interest in the idea of working with young information seekers in order to give them a role in achieving the access they want and need has become an increasingly accepted practice in the digital environment. In the past, children have been among the marginalized populations (and continue to be to some extent) whose voices were seldom heard in relation to decisions that affected their information-seeking behavior. Many different levels of this type of access for children exist in the digital environment, from asking about or observing their reactions after decisions have been made (possibly to incorporate them in future planning), to questioning them casually in ways that may or may not affect decisions, to soliciting their opinions formally on a one-time or occasional basis that will affect planning at a point in time, to long-term partnering that has a direct and ongoing impact on decisions.

Children as Part of the Design Process

The bulk of studies regarding child information behavior in a digital environment focus on the child as user of information. The most recent research (and practice) incorporates the child into at least part of the design process; slowly researchers and professionals are realizing that this is the optimal way to increase access to information (Nesset & Large, 2004). Druin (2002) categorizes children's roles in the design process as user, informant, tester, and design partner chronologically as they first appeared in the research literature. In her examination of existing research, she observes that, although the needs and resources of the individual project determine which role is set for the child, the potential for greatest positive impact resides with the children as design partner, which subsumes at least part of each of the roles that preceded it chronologically.

The Project CATE inquiry into children's use of technology in a public library setting was based on information solicited from the end user—youth—both at the beginning and throughout the project (Dresang, Gross, & Holt, 2003; Gross, Dresang, & Holt, 2004). These researchers developed an outcome-based model for planning and evaluating youth services (Dresang, Gross, & Holt, in press). It differs from other such outcome models by virtue of beginning with the young people and involving them throughout the process rather than only questioning them after their information seeking has taken place.

Throughout the project, and continuing after its completion, the technology staff of the Project CATE libraries reviewed the eleven technology outcomes that were developed from the survey and focus group data. From formative and summative interviews with staff members and youth, and from observations of the youth behaviors, it became clear that youth were gaining greater access to what they wanted and needed than prior to their involvement in the process. Focus on outcomes that were youth influenced

gave staff confidence in their services and encouraged youth receptiveness to what was provided.

The Increased Array of Information

Another access issue is the availability of an increased array of information on a wider diversity of topics. The Internet Archive, which attempts to archive all publicly accessible Web pages, currently contains approximately one petabyte of data, and it grows at a rate of twenty terabytes per month. This makes the collection already larger than the amount of text contained in the world's largest libraries, including the Library of Congress (*The Internet Archive*, 2004). Any study of youth information behavior has to take into account the explosion of information (data, knowledge) that has taken place in the digital environment. Coupled with close to universal access to computers at school, library, or home for most youth, the constantly growing stockpile of information is there for the taking.

With this increase in quantity has come access to topics that previously were forbidden to youth. Greater access to topics that have been considered too controversial or not "age appropriate" has happened in the handheld book as well as in the online environment. The attempt to hide information from youth or youth from information has become a more or less futile attempt.

Issues of Dissemination Versus Access

Nonetheless, it is important to recognize the barriers that lessen that access. The Internet Archive (and active Web pages) represents dissemination of information. Due to legislation and judicial actions, for example, the Children's Internet Protection Act (CIPA, 1999), schools, including school libraries, and public libraries must place filters, limited to visual images harmful to minors but in practice not applied solely to visual images, on all computers funded by the e-rate, Library Services and Technology Act, or Title III of the Elementary and Secondary Education Act ("No Child Left Behind"). At the moment, the focus on limitation of access to information for youth appears to be on the Internet; despite the increased "radical" nature of these limitations, censorship of books, as recorded by the American Library Association, has dropped 39.8 percent over the past decade, from 762 challenges in 1995 to 458 in 2003, the most recent year reported (ALA, n.d.)

Implications for Research and Practice

Access in the digital environment creates opportunities for previously unheard voices and taboo subjects. But dissemination and access are not the same. Research is underway regarding the role children can and do play in their own information fates, and this needs to receive increased emphasis. Little or nothing is known to date about how information policies limiting youth access, specifically to digital resources on the Internet, has affected information-seeking behavior. It is an area of research that would

provide immediate and useful insights for librarians. Likewise, has the drop in challenges to books, mostly books for youth, and the publication of books on previously taboo topics for youth had any impact on information seeking in libraries?

THE FUTURE: BRAIN RESEARCH AND INFORMATION SEEKING BEHAVIOR

Another question that emerged in the past few years is “What new technologies are being developed and how can these be used as building-blocks for future applications for children?” To date, what we know about information-seeking behavior of youth and digital media comes from informed observation of performance and from what young people can tell us. In 2005 we stand on the cusp of what could someday be a significant step forward in understanding the information seeking of youth based both on observed brain structure and measured brain activity. The current discoveries of neuroscientists will lead us at some time in the future beyond the point of the information-seeking theories extrapolated only from observations of human behavior. Some of our yet-to-be-developed information-seeking theories will be based on observations of the brain itself linked to simultaneous behavior.

Magnetic resonance imaging (MRI) and Positron Emission Tomography (PET) scans have given neuroscientists the opportunity to conduct longitudinal studies of physical brain development in healthy children and adolescents. A groundbreaking study conducted by a team of researchers at the University of California at Los Angeles, Harvard, McGill University, and the National Institutes of Health (NIH), reported in the scientific journal *Nature* (Thompson et al., 2000), resulted in a feature on National Public Radio two years later and a cover story in *Time* (Wallis, 2004) two years following that. The breakthrough finding of this project, which used MRI to take “brain snapshots” of 1,800 young people over 13 years, is that the brain is not through developing by around age twelve as previously thought. This was the theory put forth by Piaget and other “step” developmental psychologists, based on observations of children's behavior. Twelve or thirteen was the age of formal operations, thought to be the highest level of cognitive attainment in terms of brain development.

The brain, according to the new and more accurate research, in fact, may not be mature until its owner is around age twenty-five. With this “look inside,” scientists have observed that the last part of the brain to mature is the prefrontal cortex, home of functions such as planning, setting priorities, organizing thoughts, suppressing impulses, and problem solving (and possibly information seeking?). The cerebellum, the only part of the brain that continues growing well past the teens, supports more advanced learning activities such as mathematics, music, and more advanced social skills. It is easy to imagine how these findings may translate into a better

understanding of information-seeking behavior. Perhaps it could be the state of their brain development that affects what seems like less than stellar information-seeking behavior of youth.

But the scientists involved in this research give many caveats. One is that it is far too early to make any educational or policy decisions from the findings. Bruer (1999) and others warn that, as researchers discover more and more about the teenage brain, it is natural that parents, educators, and policy makers want to apply this new knowledge as quickly as possible in homes and classrooms. However, as an examination of the controversy over what has become known as the zero-to-three movement shows, there are potential pitfalls when advocacy groups and others prematurely attempt to apply science to public policy (Moughty, 2002). Issues that mitigate against this too-early application of findings include the lack of "system knowledge," that is, how all the parts of the brain work together, and an understanding that the brain and the mind are not the same (PBS Frontline, 2002).

Thus, mention of this research brings with it both a cautionary note (it is not time to make assumptions about information seeking yet) and an admonition (to keep a sharp eye on legitimate research in this field). It is possible that the scientific applications will give us more information about the "brain" in order to look at the behavior and get a firmer grasp on the "mind."

CONCLUSIONS

From this overview of meta-analyses followed by a theoretical look at some of the aspects of children's information-seeking behavior that can be explained by the Radical Change principles of interactivity, connectivity, and access, the following conclusions can be reached:

- An abundance of research exists on children's information-seeking behavior in the digital environment from which some overall trends can be discerned.
- Meta-analyses of the research on youth information-seeking behavior and use of digital materials tend to focus largely on the deficiencies and the need for improvement rather than ferreting out the potential of new and exciting ways of knowing in a digital age.
- New information is coming to light about specific factors, for example, gender and collaborative behavior, that may alter the interpretation and application of earlier research.
- Some important, and largely unexamined, commonalities exist between information seeking in relation to handheld hypertext and to digital materials, opening up a new arena for research and practice.
- Use of computer technology does not have to be a socially isolating activity and may, in fact, provide greater connectivity in a social environment.

- Most of the existing research focuses on children as users of digital materials, but a growing body of research highlights their roles as tester, informant, and designer, with each of these roles incorporating parts of the ones that came before it.
- Children's increased involvement in designing materials to meet their needs is relevant to their information-seeking behaviors as the outcome is accessed in ways that make sense to them.
- The digital environment has brought with it some government-mandated restrictions on children's access to digital materials in libraries, but in the balance the gain is far greater than the loss.
- Public libraries, despite legal and judicial restrictions, may provide opportunities for interactivity, connectivity, and access that are not as readily available in school or at home. In turn, researchers may learn about less-observed facets of information-seeking behavior in this currently relatively untapped setting.
- The future of brain research may be crucial in helping researchers understand the mind as it relates to information-seeking behavior.
- Looking at youth information-seeking behavior (both existing studies and new ones) with the Radical Change digital age principles of interactivity, connectivity, and access may bring new and perhaps more positive perspectives to both researchers and professionals.

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