CHAPTER

USER NEEDS AND SEARCH BEHAVIORS

8

TYPES OF USERS AND THEIR USE OF DIGITAL LIBRARIES

Users are the main stakeholders of digital libraries. In order to design digital libraries for diverse types of users, we must first understand their needs, their search behaviors, and associated factors. Users of digital libraries have not been evenly investigated. While most of the studies focus on the children and college students, less research has been done on other types of users such as elderly people and people with disabilities.

CHILDREN AND DIGITAL LIBRARIES

By studying children's information-searching behaviors, researchers have identified tactics that children apply and roles they assume in the digital library searching process. With respect to the steps involved with searching, Bilal et al., (2008) studied the information-seeking behaviors of Arabic-speaking children interacting with the International Children's Digital Library (ICDL). Children's information search tactics consist of seven modes: Start, Recognize (scanning and selecting), Browse (viewing, verifying, and examining), Differentiate (viewing and sweeping), Read (viewing and flipping), Explore (navigation and backtracking), and Finish (ending a task or stopping). Foss and Druin (Foss, 2014; Foss and Druin, 2014) conducted a longitudinal study of 50 children from 2008–13 focusing on the roles children play in their interactions with digital libraries. At the outset of the study in 2008, researchers identified seven types of roles exhibited by the children, which emerged from the data: Developing, Domain specific, Power, Nonmotivated, Distracted, Visual, and Rule bound. In 2013, follow-up analysis of the same 50 participants revealed that the major change in children as they aged was the occurrence of a new Social role. The developing role and the domain-specific role were the most frequently observed roles in both the beginning and end of the study, in 2008 and 2013, respectively. However, over the course of the study as time progressed, the greatest percentage of change was in children moving from domain-specific searchers to power searchers, the most skilled type of role. Another interesting finding is that the study participants embodied multiple roles over the course of the longitudinal study.

Unique characteristics of children influence the design of digital libraries. In particular, children's special cognitive and physical abilities are an essential consideration for digital library design. Based on a review of the literature regarding how children's cognitive states influence their interactions with digital interfaces, Martens (2012) identifies children's developmental restrictions, which include underdeveloped motor skills, difficulty with spelling, and difficulty in understanding hierarchies and metadata. Children's diversity in age, race, background, and developmental skills poses a challenge for the development of digital libraries for children. Theng et al. (2000) worked with children as design partners and testers for the development of a children's digital library. They found that children like a

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simple interface design with bright colors, graphics, and audio, and they enjoy having links to other relevant sources. In order to design digital libraries to satisfy children's needs, multilingual, multicultural, and multigenerational issues also need to be considered (Hutchinson et al., 2005). After comparing children's searching behaviors using different types of category browsers (tools for navigating categories) in the ICDL, Hutchinson et al., (2007) conclude that a flat interface is better than a hierarchically structured interface for children to perform both Boolean searching and casual browsing searches.

In addition to characteristics of children, the types of tasks that children perform also influence their interactions with digital libraries. After studying children's searching for entertainment-related information versus problem-solving information, Wu (2015) discovers that children prefer to use a digital library more for entertainment, rather than to satisfy a particular information need or solve a problem. Moreover, they are more comfortable with uncertainty and demonstrate greater user control of the discovery process when searching for entertainment information than problem-solving information. The results also indicate that a gamelike interface is a great tool for learning.

Of course, not all children exhibit the same information-searching behaviors in digital libraries. After investigating children's information-searching behaviors in the ICDL, Reuter and Druin (2004) conclude that first-grade children prefer browsing strategies while fifth-grade children apply more query searches. At the same time, girls love to search by colors while boys gravitate to character searching. In addition, older boys are more inclined to search by genre. In another study, Druin et al. (2010) point out that the developing searchers often need search tools with helpful features, such as auto-complete text or spelling correction, whereas children personifying the nonmotivated role usually do not ask for help when confronted with difficulties in searching information. The research of Druin et al. (2010) shows that factors, such as age, gender, and types of searcher, contribute to different information-searching behaviors in children.

International children have their own unique issues in searching digital libraries. After investigating the searching behavior of Arabic-speaking children using the ICDL, Bilal and Bachir (2007) notice that Arabic-speaking children do not recognize the representations embedded in the interfaces of the ICDL. This phenomenon was found to be mainly caused by three factors: lack of enough experience in using the Internet, lack of cognitive preparation, and lack of language ability. The researchers propose a simple visual interface with meaningful and noticeable icons along with an audio option to facilitate use among a variety of children representing culturally diverse groups. According to Jochmann-Mannak et al. (2008), most of the problems children experience with searching and browsing are caused by the interface design being designed by adults based on an understanding of adults' needs. Adults generally have not considered children's low motor skills nor their different approaches to searching and browsing. More research should investigate children's search behaviors, and prototypes of digital library interfaces need to be designed and tested with children.

COLLEGE STUDENTS AND DIGITAL LIBRARIES

Compared to children, college students have a different set of unique characteristics in using digital libraries. A large amount of money has been invested in online library resources, in particular digital libraries. However, college students do not frequently use these sources; instead, they choose less credible but easy to access Internet-based electronic resources (Booker et al., 2012; Gross and Latham, 2011). According to Booker et al. (2012), information literacy instruction is beneficial only at the early stages of students' digital library use; however, a positive outcome has also been found through continued

use of digital libraries after receiving information literacy instruction. In that case, the design of digital libraries needs to guide users, in particular expert users, to make good use of digital libraries.

Research has indicated that both undergraduate and graduate students use digital libraries because of ease of access, but interestingly, there is a difference among the two groups in the factors leading to not using digital libraries. Liu and Luo (2011) compared the digital library use of both undergraduate and graduate students. Research projects and papers are the main motivations for both groups to use digital libraries. For both groups, digital library use has saved considerable time in locating materials and resulted in reduced visits to physical libraries. They find that the factors affecting digital library use are similar between the two groups. Both groups consider "remote access," "24 h access," and "faster access" as the most important factors in deciding to use digital libraries. However, the factors influencing students who are not using digital libraries are quite different. While 52.0% of undergraduates selected "digital libraries are difficult to use" as the major factor, only 28.7% of graduate students chose the same reason. In contrast to undergraduate students, graduate students cited the lack of the availability of relevant materials and no access to archival and older publications as the main reasons for not opting to use digital libraries. After investigating the relationship between resistance to change and the perceived ease of use of a university digital library, Nov and Ye (2008) identify personalities that are resistant to change as a significant factor that determines the perceived ease of use, and further influences digital library use in a university setting.

Integrating different system acceptance models, Cheng (2014) proposes a model to explain users' intentions to continue to use a digital library based on questionnaires distributed in a Taiwan university. Among the factors, the most vital ones accounting for users' continuance intention for using digital libraries were found to be those of information relevance, system accessibility, and technical support. In another study, also based on questionnaires, Hu et al. (2014) analyze the factors affecting users' perceptions of university digital libraries in China. Within all the service factors, information-providing services, information-retrieval services, and individual services play direct roles in influencing users' perceptions of digital libraries, while the information-organizing services have an indirect role. In a qualitative study of undergraduate students' use of digital resources, Matusiak (2012) finds that user perceptions of usefulness and usability, especially perceived ease of use, play an important role in user intentions to adopt and use digital collections for academic learning and teaching. The limited use of digital libraries is related to the following perceptions: (1) Library systems are not viewed as user friendly, which in turn discourages potential users from trying digital libraries provided by academic libraries; (2) Academic libraries are perceived as places of primarily textual resources; perceptions of usefulness, especially in regard to relevance of content, coverage, and currency, seem to have a negative effect on user intention to use digital libraries, especially when searching for visual materials.

College students apply a variety of specific information search tactics and strategies in interacting with digital libraries. Joo (2013) investigated how college students exercised different types of search tactics and how digital libraries supported these tactics. Users performed a known-item search task, a specific information search task, and an exploratory search task. The findings indicate there are differences in terms of the frequency and time of search tactics applied for different types of search tasks. The shifts between a series of search tactics form search strategies, which arise in their interactions in digital libraries. The data uncover four types of search strategies: result evaluation strategy, browsing strategy, iterative browsing strategies, and iterative search results evaluation strategies. Students' perceptions of system support, difficulty, and satisfaction for each type of tactic were measured and were found to influence aspectual recall and users' satisfaction with search results. In addition, system support for

the evaluation of search results and the modification of search statements are considered less important than other types of tactics. With a different focus from Joo's tactic study, Huang (2014) focuses on how learning styles affect college students' help-seeking behaviors in digital libraries. This study explores how four dimensions—processing (active/reflective), input (visual/verbal), perceiving (sensing/intuitive), and understanding (sequential/global)—of learning styles affect users' help-seeking behaviors, as well as help feature uses in their digital library searching process. Qualitative data analysis presents eight types of help features that are used by users with different learning styles. Active learners preferred interactive help features while reflective learners chose reflective help features; visual learners used visual help features, and verbal learners made use of both verbal and exploring help features; sensitive learners selected scaffolding help features, and intuitive learners preferred channeling help features; sequential learners liked the help features that include the sequential order, and the global learners did not use specific help features. Quantitative data confirm that three dimensions of learning styles—processing, input, and perceiving—influence subjects' use of different types of help features when interacting with digital libraries.

Not all college students share the same search behaviors in digital libraries. Nicholas et al. (2009) compared students' information-seeking behaviors with that of other academic communities in a digital scholarly environment. The results reveal that among students and other academic communities, students are the biggest users in terms of sessions and pages viewed. Undergraduate students are more likely to use the search features in one system but use the alphabetical or subject menu in another system. Undergraduate students are more frustrated than graduate students by searches not yielding enough results and by an overwhelming number of results with not enough details (Dougan, 2012).

Researchers have also compared college students and other types of users in their usage and evaluation of digital libraries. Matusiak (2006) uncovers a substantial difference between college students' and community users' information-seeking behaviors in searching digital libraries. In their first encounter with the collections, most students performed keyword searches. Simple one-word or one-phrase queries were entered by most of the students. They rarely used Advanced Search features. In contrast, community users applied more browsing searches, explored more features, and were more successful in finding relevant results. The main reason for the difference lies in the different mental models that students and community users have. While students treat the collection as another dynamic searchable web site that they are used to searching, the community users consider the site as an online exhibit. They take advantage of visual cues and browse the digital collections. Interestingly, Górny et al. (2015) observe that even though students and academics are not different from nonacademic users in their evaluation of digital libraries, nonacademic users rate the quantity of resources, reliability of digital library, and information searching higher than students and academics. On the other hand, expectations of nonacademic users are lower than the students and academics, who expect full-text searching, mainly because they are unexperienced users.

In summary, college students are an important demographic group for digital libraries. Nonetheless, it is a challenge to attract the Google generation of college students. Digital libraries must consider the unique characteristics and search behaviors of this group in order to attract these users and facilitate the effective use of digital libraries for them.

ELDERLY PEOPLE, PEOPLE WITH DISABILITIES, AND DIGITAL LIBRARIES

Elderly people have special needs as part of the natural aging process. Although no research has been conducted specifically on elderly people's interaction with digital libraries, it is beneficial for us to

review some of the relevant research on elderly people's information searching. Fiske et al. (2009) specify the changes that aging brings to elderly people, including sensation (color, vision, auditory), perception (awareness of the environment), cognition (reasoning and memory), and movement (control to coordination). Older people have more difficulty accomplishing different computer tasks, which could lead to frustration (Decker, 2010; Smith et al., 1999). Elderly people in general have low self-efficacy and higher anxiety in using computers (Czaja et al., 2006). They have a tendency not to look for information beyond their comfort and ability level (Martyn and Gallant, 2012). Butcher and Street (2009) suggest that keeping instructions simple helps elderly users. On the contrary, Nasmith and Parkinson (2008) present different findings based on their study on senior blind users' use of a digital talking book player in New Zealand. They find that seniors do have a positive attitude to change and are not afraid of technology if they are well supported.

In terms of using IR systems, compared to younger adults, older users, and in particular the ones who do not have computer experience, do not understand the search features and operations, and are not able to complete all the tasks and show more errors (Mead et al., 2000). Moreover, Stronge et al. (2006) notice that elderly people do not effectively apply search strategies. It is a challenge for some elderly people to understand IR systems and features (Mates, 2004). New technologies, such as mobile devices, bring both opportunity and challenge to elderly people. E-books and other digital materials are becoming more prevalent online. According to Kapusiak (2015), most of the Baby Boomers are unaware that public libraries offer e-books and other digital materials. Few were found to have accessed their public library web site from their mobile devices. Kapusiak further developed the Baby Boomer Mobile Device Searching Model based on her research findings that incorporated Predisposing, Intermediary, and Transactional Factors, which affected their use of mobile devices and their interactions with the mobile system. These factors include the perceptions of the user; knowledge infrastructures; digital literacy skills; self-efficacy/confidence; comfort level/uncertainty; physical ability; the information need and search task; mobile device; environmental, social, and cultural context consisting of the stability of the Internet connection; and social ageism. These interrelated factors influence the Baby Boomers' tendency to initiate and perform a search on a mobile device. Not surprisingly, nonmobile device usage is still important and is still utilizied on a regular basis by most of the Baby Boomer participants.

While universal accessibility is a goal for digital libraries, few studies concentrated on people with disabilities. Bell and Peters (2005) report on four representative examples for using digital information technology to improve the accessibility and usability of digital libraries for all users: *Online Programming for All Libraries (OPAL), Mid-Illinois Digital Talking Book (MI-DTB), Project: Audible E-Books, OverDrive: Unabridged Digital Audio Books,* and *InfoEyes* (a virtual reference service for the visually impaired). Zhang et al. (2012) illustrate that accessibility technologies applied in the China Digital Library for the Visual Impairment web site can be beneficial. These technologies include accessibility of web site design, content presentation accessibility, and accessibility of auxiliary technology compatibility. Bertot et al. (2006) highlight accessibility as an important factor in digital library evaluation in addition to the functionality and usability. Accessibility refers to the ability for users with disabilities to access a digital library and focuses on the issues related to alternative forms of content, color independent, clear navigation mechanisms, and table transformation.

As one of the few researchers who have investigated blind users' interaction with digital libraries, Xie et al. (2014, 2015) conducted a study with blind users to explore types of help-seeking situations that occurred in their search processes. Three tasks representing typical search activities were selected for blind

participants to perform in the Library of Congress Digital Collections: (1) a known-item search (find the letter written by Alexander Graham Bell to Helen Keller dated Mar. 23, 1907); (2) a specific information search (find when and how Presidents Lincoln and Garfield were assassinated); and (3) an exploratory search (identify some US immigration policy issues using multiple sources). A laptop with Internet Explorer 10, JAWS 12, and Morae 3.1 was used for this study. Multiple data collection methods were employed: prequestionnaires, presearch interviews, think-aloud protocols, transaction logs, and postsearch interviews. The main contribution of this study is the identification of nine types of unique help-seeking situations at the physical level and eight types of help-seeking situations at the cognitive level.

Help-seeking situations at the physical level are mainly related to the difficulty in accessing information, difficulty in identifying current status and paths, and difficulty in efficiently evaluating information. In particular, there are nine types of help-seeking situations: (1) difficulty in identifying the format of an item, (2) difficulty in finding the alternative text for an image, (3) difficulty in recognizing preexisting text in the input box, (4) difficulty in identifying the current location, (5) difficulty in returning to home, (6) difficulty in recognizing the page-loading status, (7) difficulty in finding a specific word or phrase in the digital library pages, (8) difficulty in finding heading information, and (9) difficulty in efficiently evaluating information (Xie et al., 2015).

Simultaneously, help-seeking situations at the cognitive level can be characterized as confusion about multiple programs and structures, difficulty in understanding information, difficulty in understanding and using digital library features, and avoidance of a specific type of format or approach. In particular, there are eight types of help-seeking situations that arise: (1) confusion about multiple programs, (2) confusion about digital library structure, (3) difficulty in recognizing a label, (4) difficulty in understanding help information, (5) difficulty in understanding how to use a specific function, (6) difficulty in making sense of organizational criteria, (7) avoidance of visual items, and (8) avoidance of the browsing approach (Xie et al., 2015).

Marcus (2003) introduces the universal design movement, which started in the United States. This movement presents a challenge for user-centered design for the disabled and elderly. Universal design anticipates diversity of ability and needs, thereby facilitating the development of sensible, useful, and doable designs. While the movement began over a decade ago, there is still a long way to go to create universal design for different user groups with diverse needs. Higgins and King (2013) point out that universal access to digital libraries is still in its infancy. It will take time and effort for the creation of digital libraries for the "disadvantaged," which not only covers traditional minorities, such as African Americans, Hispanics, and Native Americans, but also persons with lower income and education, those living in rural areas, the physically disabled, as well as those in developing countries. Different challenges exist for different types of groups. These challenges include the tension among low-income users, publishers, and public libraries; varying standards for people with disabilities; cost issues; and technology infrastructure for people living in rural and developing countries.

For a related discussion of people with disabilities and digital libraries, see Chapter 7.

CHARACTERISTICS OF INFORMATION SEARCH BEHAVIORS

Convenience is identified as one of the key characteristics of information search behavior in a digital library environment. Convenience consists of users' preference for information sources, satisfaction with the sources, and their ease of use, as well as their time spent in the information search process.

Research has shown that convenience is one of the main criterion used in the information search process. Users may sacrifice content for convenience (Connaway et al., 2011). The convenience principles affect how users learn and use digital libraries. Information search behaviors are characterized by information search tactics and information search strategies. They are the foci of user studies.

INFORMATION SEARCH TACTICS

Search tactics and moves are the elements of information search strategies. Researchers have applied different definitions of tactics and moves in their papers. In some cases, tactics and moves are used interchangeably. Incorporating Bates' (1979, 1990, 1992) and Marchionini's (1995) definitions, Xie and Joo (2010) further define the meaning of the terms moves and search tactics. According to them, moves are basic thoughts or actions in the information search process, while search tactics refer to a series of moves, including search choices and actions, that users apply to advance their searches in the information search process.

Tactic research has focused on query formulation and reformulation. Fidel's (1985) operational moves are characterized by reducing or enlarging the size of search results, and conceptual moves are exemplified by intersecting, narrowing, or expanding the meaning of queries. Other researchers discovered the following tactics: broadening, narrowing, searching for an author, term checks, changing topics, error, and repeat (Shute and Smith, 1993; Vakkari et al., 2003; Wildemuth, 2004).

In addition to query formulation and reformulation tactics, tactics have been identified for different aspects of the search process. Bates (1979) organizes 29 tactics into monitoring (e.g., check, correct, etc.), file structure (e.g., select survey, etc.), search formulation (specify, exhaust, etc.), and term tactics (e.g., super, related, etc.). Extending Bates' work on the Internet, Smith (2012) incorporates new dimensions—evaluation tactics and new tactics, such as context evaluating, crosschecking, etc. Search tactics are further analyzed with respect to the search process. Yue et al. (2012) associate the search tactics Query, View, Save, Workspace, Topic, and Chat with a search process, such as defining a problem, selection of sources, and examining results. Children's information search tactics in digital environments are classified into seven modes: Start, Recognize (scanning and selecting), Browse (viewing, verifying, and examining), Differentiate (viewing and sweeping), Read (viewing and flipping), Explore (navigation and backtracking), and Finish (ending a task or stopping) (Bilal et al., 2008).

Previous research on moves and tactics sets up a foundation for researchers to further investigate patterns of search tactics in the digital library environment. Very few studies have explored the application of search tactics in digital libraries. Joo (2013) examined how users incorporated search tactics in terms of frequency, time, changes in a session, and transition patterns in their interactions with digital libraries. Adopting the tactics identified by Xie (2008) and Xie and Joo (2010), Joo (2013) analyzed the application of nine types of tactics: create search statements, explore information, modify search statements, organization of search results, access forward, access backward, evaluation of results, and evaluation of individual documents. The results show that users apply different search tactics for different types of search tasks. The accessing forward, browsing information, and evaluating results tactics are the top search tactics used in accomplishing a known-item search. Evaluating results, accessing forward, accessing backward, and evaluating individual documents are the top search tactics chosen in achieving a specific information search task. In fulfilling an exploratory task, evaluation of individual documents, accessing forward, accessing backward, and evaluating results are the top search tactics employed. Interestingly, the exploring tactic takes the longest for a known-item search; the evaluation

of result tactics takes the longest for a specific task; and the evaluation of an individual document tactic takes the most time to complete for an exploratory task. The findings of tactics applications in digital libraries offer significant implications for system design to support different types of search tactics in the search process.

INFORMATION SEARCH STRATEGIES

Search strategies consist of combinations of tactics or moves and can be characterized by types and dimensions. Research has indicated that there are unique qualities in terms of information search strategies as applied in the online database environment. Building blocks, pearl growing, successive fractions, most specific facet first, and lowest postings facet first are the top strategies cited by researchers (Markey and Atherton, 1978). The known-item instantiation strategy, the search-option heuristic strategy, the thesaurus-browsing strategy, and the screen-browsing strategy represent strategies associated with system features (Chen and Dhar, 1991). Plan strategies occurring before the first move are comprised of author, title, concepts, external support, system features, etc. Reactive strategies are exercised based on the previous move including focus shifts, search-term relationships, error recovery, etc. (Soloman, 1993).

Search strategies in web search engines have similarities as well as differences from other digital environments. Search strategies inferred from log analysis show similarities and differences compared to an OPAC environment. The similar strategies include specified, generalized, and building blocks, etc., while the following different strategies have been found: dynamic, multitasking, and recurrent (Bruza and Dennis, 1997; Lau and Horvitz, 1999; Rieh and Xie, 2006). The novel design and features of the web and web searching environment have also spurred the identification of new strategies. Wang et al. (2000) highlight 10 problem-solving strategies in web searching: surveying, double checking, exploring, link following, back and forward going, shortcut seeking, engine using, loyal engine using, engine seeking, and metasearching.

Information search strategies in digital library environments also have their uniqueness. The design of digital libraries is rooted in the associated search strategies: query searching and browsing. Reuter and Druin (2004) discuss the differences in using query search and browsing strategies in children's interactions with digital libraries. Marchionini and Geisler (2002) specify three types of search strategies in video digital libraries: searching, browsing, and contributing. Matusiak (2006) studied how university students and community members interact with digital libraries and found that users started either with browsing or keyword searching, and applied both strategies as they continued their interactions with the system. Albertson (2015) reviews research conducted on visual information searching. Search and browse are the two common strategies in information searching. Although searching occurs throughout the information search process, it is the most common starting point for users. Search can also be the product of exploratory browsing. Search for visual items in general starts from broad and moves to narrow searches. Browsing plays a more important role in visual systems, including digital libraries, because these systems' browsing mechanisms facilitate users' navigation through their collections, and can serve as an exploratory action. Compared to searching, browsing is still considered as a secondary strategy.

Joo (2013) further looked into search strategies based on the order of a series of tactics. In a known-item search, users implemented a search result evaluation strategy and a browsing strategy. A specific

task search was found to be similar to a known-item search, in that users selected the same search strategies, with the difference being that search result evaluation strategies were more frequently used with iterative loops. In an exploratory search, iterative browsing and iterative search result evaluation strategies were most frequently chosen. Search strategies consisting of various tactics need to be further scrutinized to identify search patterns. A deeper understanding of the patterns arising out of search tactics and strategies could be translated into design implications for more effective interaction with digital libraries.

USAGE PATTERNS

Log analysis is an effective approach to illustrate usage patterns, in particular how users interact with digital libraries. Digital libraries were not frequently used compared with other types of online resources, especially in the early age of digital library development. In a study in 1996, 35% of users accounted for 80% of the usage (Entlich et al., 1996). Fifteen years later, many college students still do not use digital libraries (Booker et al., 2012; Gross and Latham, 2011).

Query analysis is one research area that log analysis has focused on. Research has shown that short queries and a lack of the use of advanced searches typify digital library searches. A single search term was used in 81.5% search operations, and only 18.49% searches used Boolean operators, with a 0.1% subset of the Boolean searches incorporating previous result sets (Sfakakis and Kapidakis, 2002). According to Lowe's (2013) search log analysis of the ARTstor Cultural Heritage Digital Library, the average number of terms per query is 1.88 terms. Nearly 80% of the queries contain two or less terms, with half of the queries as one-term queries (49.70%) and 30.07% as two-term queries. The unique queries, nonunique queries, and queries with refiners comprise 54.89%, 21.39%, and 23.73%, respectively. Remarkably, queries become more generalized, simplified, and shortened across time. The findings are echoed by another log analysis study of digital libraries reporting an average 1.96 terms per query (Han et al., 2014). In searching for folktales, searchers on average entered 1.4 terms in a single query when conducting simple searches, but most of the queries (75%) consist of only a single term. In advanced searches, the queries are composed of 1.95 terms per query. The most noteworthy finding is that 3.4 result pages are viewed on average (Trieschnigg et al., 2013).

The special focus of a digital collection determines whether users search for mostly names of events, people, places, and actions. Choi and Rasmussen (2003) discover that the most popular searches generated by college faculty and students in searching the American History Digital Collection are the names of an event, action, or condition; individual names; and place names, consisting of 64.87% generic terms and 26.49% specific terms. In searching the ARTstor Digital Library, people, locations, and objects account for approximately 30% of the submitted queries (Lowe, 2013). A recent study (Han et al., 2014) yields similar results. Query analysis of digital collection usage shows that personal names and geographical locations are the main foci of searches. Of course, the top type of query is related to the nature of the digital collection. For example, art historical information and local information represent the top queries in the above two studies, respectively. Trieschnigg et al. (2013) notice that simple searches and advanced searches are used for different purposes. In their study of the Dutch Folktale Database, these researchers indicate that searching for subgenres and main characters are more often satisfied by simple searches. Advanced searches concentrate on particular stories or collections, subgenres, and story types. Duffy (2013) performed a study on historians' searches in HathiTrust. The

findings show that historians use more open book repositories to search for relevant information, but searching full text is a big challenge for them. In addition to primary sources for historians, HathiTrust offers Library of Congress Subject Headings (LCSH), which enable historians to increase the precision of their searches. It is important to teach researchers and students alike to learn how to incorporate LCSH in their searches.

Among all the features in the digital libraries, search features, organizational features, and viewing features are the most frequently utilized. For example, the search function was found to be the most used based on the transaction logs of a Korean digital library (Zhang et al., 2001). In particular, the author search was the most popular search, accounting for 32.1% of all searches. Research also reveals that syntax and format errors occurred in 17.6% of searches (Entlich et al., 1996). In a similar finding to that of the investigation of the Korean digital library, Lowe (2013) concludes that the most frequently used type of search in the ARTstor Cultural Heritage Image Database is an artist name search. An artist name search and an author search can both be considered searches for the creator. Organizational feature scaffolds were the most utilized in the context of finding science information among high school students (Lumpe and Butler, 2002). In another study, "search" and "present" corresponded to more than 80% of the operation usage. Few users employed the "browse" operation (4%) or the "search history" operation (1%) to refine their search results (Sfakakis and Kapidakis, 2002). Users' viewing behaviors and content viewing also have been investigated (Nicholas et al., 2005, 2006).

Usage pattern research has also extended to mobile users' interaction with digital libraries. After analyzing log data of Europeana mobile users, Nicholas and his associates (Nicholas et al., 2013; Nicholas and Clark, 2014) find that mobile users are the fastest-growing user groups, and they exhibit unique interaction behaviors compared to nonmobile users. They prefer to use personal mobile devices to interact with Europeana rather than their office desktop or laptop devices. They are less interactive and view less content. In addition, they do not spend a long time on the site, and they normally visit on evenings and weekends. Cultural institutions and their members are loyal users. Interestingly, Europeana user growth from the site itself is higher than the overall visitors from social media referrals.

Moreover, usage patterns have been analyzed to identify the impact of digital libraries, which includes research trends, the value of digital libraries, and a deep understanding of users' information-seeking behaviors. Bollen et al. (2003) compared digital library usage patterns to the Institute for Scientific Indexing (ISI) Impact Factor values during the same years to identify local research trends in the institution. Similarly, Górny et al. (2015) uncover the impact of digital library use on users' interest based on survey results of Polish digital library use from nonacademic users. They discover the emergence of digital libraries in Poland leads to great interest in genealogical or local historical research because of the content coverage of digital libraries. Kurtz et al. (2005) introduce the concept of utility to assess the value of digital libraries. By integrating usage logs, membership statistics, and gross domestic product (GDP) data, the impact of the NASA Astrophysics data system digital library is assessed. They also assign specific values for digital library evaluation. To be more specific, the value of the digital library in 2002 equaled 736 full-time researchers, or $250 million. Employing deep log methods of analysis of a million users' request to a digital library, researchers (Nicholas et al., 2005, 2006) explore users' view behaviors, especially what a user is viewing, to understand their degree of penetration of a system.

Notably, usage patterns do not show much difference in different environments. Most of the users apply their mental model of web search engines to digital libraries. Short queries, short sessions, minimum view of search results, and similar unique queries are shown in web search engine, OPACs, and digital library environments (Xie, 2008). More queries contain Boolean operators in digital library

environments than in web search engine environments (Jones et al., 2000; Wang et al., 2003). Wolfram and Xie (2002) define the context of digital libraries as representing a hybrid of both "traditional" IR, using primarily bibliographic resources provided by database vendors, and "popular" IR, exemplified by public search systems available on the World Wide Web. Users' search topics are suited to online databases, but their search behaviors are more similar to searching web search engines. After analyzing log data from two large-scale digital libraries, the National Science Digital Library and Opening History, Zavalina and Vassilieva (2014) conclude that users prefer a basic keyword search rather than an advanced search, which is consistent with users searching online catalogs and other information retrieval systems. However, users opt for more advanced searching in both large-scale digital libraries than when searching on the web or in online databases. This is mainly attributed to the case that there might be a large number of domain expert users in digital-scale domain-specific digital libraries. Contrary to other research findings, this study also reports that the average search query length in digital libraries is shorter than in most transaction log analysis studies of online catalogs and web search engines. It seems the results of usage patterns from log data vary among different types of digital libraries. More research is needed to better understand the commonalities that do exist from one digital library to another. Design library designers should be extremely mindful of the specific usage patterns of their target user groups.

USER INVOLVEMENT AND SYSTEM SUPPORT

PREVIOUS RESEARCH

While users take leading roles in applying some search tactics, systems play dominant roles in other tactics. Users need to be intellectually engaged while the system assists them by providing different system features. According to Xie et al. (in press), user involvement is defined as users' behavioral and cognitive activities in applying different types of search tactics during the search process. System support refers to types of functions that IR systems provide to users to facilitate the effective completion of users' search processes. Researchers have long investigated the extent of user control and system support for handling different types of search tactics (Bates, 1990; Beaulieu and Jones, 1998; White and Ruthven, 2006; Xie and Cool, 2000; Xie, 2003; Xie et al., 2013, in press). In IR processes, users are requested to be an active participant rather than a passive recipient of, and reactor to, output from the system (Belkin, 1993).

Since Bates (1990) initiated the issue of balancing user involvement and system support in terms of IR system design, it has become an ongoing research topic (Bates, 2002; Hendry and Harper, 1997; Savage-Knepshield and Belkin, 1999; White and Ruthven, 2006; Xie, 2003; Xie et al., in press). In particular, two studies specifically have investigated the issue of ease of use and user control. Xie (2003) directly compared users' perceptions of ease of use versus user control in fulfilling their search activities. The major finding of her study is that the extent of system support and user control differed by various search activities. The proposed model of optimal support for ease of use and user control highlights different roles that systems and users play in achieving various IR subtasks. Focusing on user control, White and Ruthven (2006) find that users prefer more control during search result evaluation, but expect system assistance in query reformulation and making search decisions.

Researchers have recognized the importance of offering different options to support both basic and advanced interfaces (Vilar and Zumar, 2005). Matching user behaviors and system support is another

area for research. Marki et al. (2008) identify different types of information behaviors and associated system supports. More specifically, different types of supportive techniques are proposed for different types of users' involvement in search processes (Yuan and Belkin, 2007, 2010). Faceted interfaces for effective browsing are suggested to support users with poorly defined goals (Wilson et al., 2009).

Accordingly, new measurements have been proposed to judge user engagement and system support. With respect to user engagement, four elements have been identified, including the point of engagement, the period of sustained engagement, disengagement, and reengagement (O'Brien and Toms, 2008). Turning to system support, how the usefulness of system features is measured depends on how users' search tactics, search strategies, and goals are supported (Belkin et al., 2009; Wilson, 2009). The main contribution of these studies in IR system evaluation is that they not only focus on interaction outcomes but also interaction processes.

AN IN-DEPTH LOOK AT USER INVOLVEMENT AND SYSTEM SUPPORT IN DIGITAL LIBRARIES

Recently, Xie et al. (2013; in press) explored various types of user involvement and system support relative to different types of search tactics occurring during interactions with four type of IR systems: web search engines, OPACs, online databases, and digital libraries. In this section, the report of the findings concentrates on user involvement and system support in digital libraries. Information-searching diaries and questionnaires serve as data collection instruments to study 61 subjects. Three categories of search tactics are derived from quantitative analysis: user dominated, system dominated, and balanced tactics. User-dominated tactics consist of selecting databases/collections, creating search statements, exploring, and evaluating tactics. System-dominated tactics include monitoring, organizing, accessing, and recording. Balanced tactics consist of learning and reformulating tactics. While users and the system have to play dominant roles in accomplishing user- and system- dominated tactics respectively, users and systems are equally engaged in applying balanced tactics. The authors propose a model that illustrates user involvement and system support in applying user-dominated tactics, system-dominated tactics, and balanced tactics.

Some examples may help shed light on user-dominated, system-dominated, and balanced tactics in the digital library environment. Considering user-dominated tactics, participants had to make intellectual decisions by applying their domain knowledge, system knowledge, and information-retrieval knowledge and skills to the Select, Create, Explore, and Evaluation tactics. Participants clearly knew what they wanted and hoped digital libraries could enhance their knowledge to make quick decisions. In order to effectively explore information, participants had to have some knowledge on the organization of the browsing mechanism. A typical quote sums it up, "When exploring information I would like the IR system to organize the topics into headings or subcategories. American Memory does this a little with photos and prints, and then once the user's clicks on that topic, it breaks into subcategories about what types of pictures." In the process of evaluation, participants also needed to understand how the results are organized so they could effectively select the relevant item. As one participant put it, "For the IR system that I dislike the most in terms of organization is American Memory. American Memory organizes in terms of relevance but was not clear to me at first of how it might be relevant without further exploration."

Moving to system-dominated tactics, systems play a major role, while users are the originators of these tactics. Participants decided when and what to monitor, organize, access, and record, and they expected the system to implement their decisions. Participants delegated execution of system-dominated

tactics to the system. To this end, they needed more features capable of achieving these tasks. Without these features, participants had to spend more time and effort to get the work done. Monitoring is essential in the search process for users to know their current status and their paths, and participants relied on system features, such as search history, to lead them. One participant complained, "The National Science Digital Library does not have a way for me to view search history or to return to previous search screens. This makes it difficult for me to return to other search results I find helpful or to return to the original search after I've modified the results." Again, another complaint regarding the lack of a zoom feature when accessing individual documents, "I was most disappointed by American Memory's access to written documents. When I was looking at some of Lincoln's letter, I could not view the larger image along with the transcription. I was also not able to zoom in on a particular word that I might have trouble reading."

Balanced tactics require that both users and systems collaborate together. For example, in the process of learning how to use a digital library, users have to interact with the help mechanism. Users need to identify the problem and select appropriate help features while systems need to provide understandable explicit and implicit help features regarding how to solve the problem. It was difficult for participants to find the help they needed. One participant revealed a problem with a lack of context-sensitive help, "The search help page on the American Memory was ambiguous, and if the direct question was not listed under FAQ's, then one must attempt to browse more collections by 'trial and error.' This particular feature was not one I felt was easily explained through the help section."

In order to support user-dominated tactics, it is important for digital libraries to adapt to users in their search process. One approach is to offer knowledge support based on user profiles, search patterns, and click-through data. Social media, in particular social tagging, can be also beneficial to users to extend their topic knowledge by allowing users to see how others provide relevant terms for an item. In support of system-dominated tactics, digital libraries need to offer more options for users to monitor their search process, organize their search results, access individual documents, and record different formats of documents. It is also essential to remove all unnecessary paths and provide one-click solutions for users to effectively apply system-dominated tactics. To assist users with balanced search tactics, it is vital to promote interactions between users and digital libraries. Offering relevant feedback is an implicit way for digital libraries to interact with users to assist them in modifying their search statements. Context-sensitive help is one good example of initiating effective interactions from the digital library side for users to acquire system, domain, and information-retrieval knowledge.

FACTORS AFFECTING DIGITAL LIBRARY USE

Fig. 8.1 summarizes and illustrates the factors—user personal infrastructure, tasks, digital libraries—that affect information search tactics, strategies, and digital library use.

USER PERSONAL INFRASTRUCTURE

User personal infrastructure, consisting of domain knowledge, system knowledge, information retrieval-knowledge learning/cognitive styles, and self-efficacy, has been demonstrated as one of the key factors affecting IR system use. Among the three types of knowledge, domain knowledge has influenced

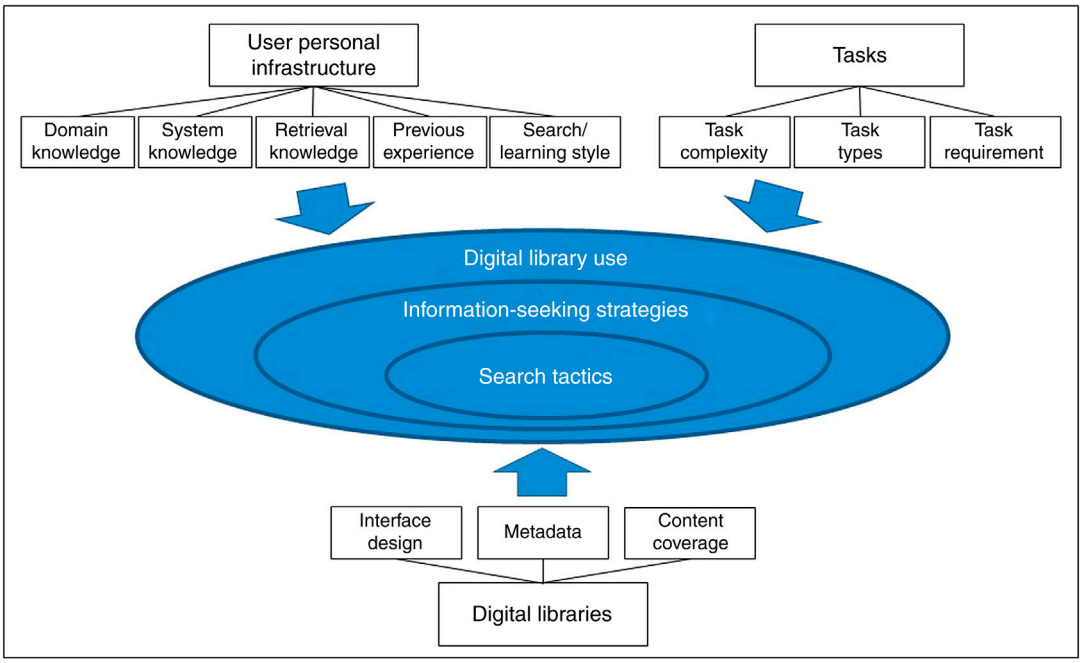

FIGURE 8.1 Types of Factors Affecting Digital Library Use

information search tactics, information search success, and information-seeking behavior (Bilal, 2001; Hirsh, 1997, 2004; Hsieh-Yee, 2001; Marchionini, 1995). In particular, domain knowledge affects the selection of search tactics, change of search tactics, the creation of complex queries versus ineffective search strategies, and making physical moves (Hembrooke et al., 2005; Hsieh-Yee, 1993; Shiri and Revie, 2003; Wildemuth, 2004). Kelly and Cool (2002) state that as users' familiarity with a topic increases, their searching efficacy increases and their reading time decreases.

Research has shown that domain knowledge has a particular impact on children's information searching and their outcome. Hirsh (1997, 2004) finds that children with high domain knowledge perform better in information searching than children with low domain knowledge. Hirsh (2004) notices that children with high domain knowledge are able to modify their search queries based on the retrieved results. These same children prefer keyword searching, while children with low domain knowledge favor using the browsing strategy. One plausible explanation is that the limited domain knowledge of children causes difficulties in formulating queries via keyword search (Gossen et al., 2013). Despite the work of some, not all researchers generate the same results. Bilal (2001) emphasizes that the influences of children's domain knowledge are not significant based on her research results, but "this finding was mainly due to the unequal distribution in the number of children who had high ratings on these variables and those who had low ratings" (p. 130).

In the digital library environment, user studies yield similar results regarding the impact of domain knowledge. Albertson (2010) investigated how users' familiarity with visual search topics influenced their interactions with interactive video digital libraries. The variables associated with user interactions consist of the keyword, title browse, color, shape, texture, all visuals, textual promote, and details.

The results show that topic familiarity affects users' use of details, use of promotes, use of color, and use of textual promote. Information-retrieval knowledge and search experience also influence users' search behaviors. The number of pages, task solution time, and types of items accessed are different between novice and expert users (Saito and Miwa, 2007). Just as those with domain knowledge, expert users are better at searching than novice users, whereas the novice users tend to browse (Lazonder, 2000). Users who have advanced digital library knowledge create advanced queries (Trieschnigg et al., 2013).

In most of the cases, different types of user knowledge codetermine users' behaviors in searching a digital library. Users, who have better knowledge in searching digital libraries and their topics, use more complex structures, and more specialized and informative access points. Moreover, user behavior changes over time. Users decrease the number of operations in their sessions, as they get more experienced with digital libraries (Sfakakis and Kapidakis, 2002). Collecting data from 120 subjects, Xie and Cool (2009) identify 15 types of help situations which can be further characterized into seven categories: (1) inability to get started, (2) inability to identify relevant digital collections, (3) inability to browse for information, (4) inability to construct search statements, (5) inability to refine searches, (6) inability to monitor searches, and (7) inability to evaluate results. Sixteen factors lead to the 15 types of help situations that subjects encounter in their interactions with digital libraries. These 16 factors represent four categories: personal knowledge structure, task dimensions, system design, and interaction outcome. Personal knowledge structure is composed of knowledge related to the digital library that users interact with, retrieval knowledge related to how to search for information, users' past experience in searching for information in different types of IR systems, as well as their preference in searching for information. Each type of knowledge either determines or codetermines different types of help-seeking situations. Based on the data collected from 60 subjects constituting different academic disciplines, Huang (2014) explored how learning styles affected novice users' help-seeking behaviors in searching digital libraries. The results indicate that novice users with different learning styles select different types of help features. Quantitative data supports the finding that learning styles have an effect on help-seeking interactions. Fifteen help-seeking approaches occurring in users' interactions with digital libraries are identified. Self-efficacy is another factor that plays a role in users' interactions with digital libraries. Tang and Tseng (2013) investigated the relationships between distance learners' self-efficacy and their information literacy skills in using digital libraries. The results show that learners with high self-efficacy in information searching in digital libraries demonstrate higher self-efficacy in online learning. In addition, learners with high self-efficacy show better skills in selecting digital resources than learners with low self-efficacy.

TYPES OF INFORMATION-SEARCH TASKS

Just like user personal infrastructure, the task is another crucial factor that affects information search behaviors. Both work tasks and search tasks have an impact on information search behaviors (Byström and Järvelin, 1995; Li, 2009; Xie, 2009). Xie (2009) identifies nature, stages, and time frame as dimensions of work task; and origination, types, and flexibility as dimensions of search task. She finds that information-seeking processes, such as planning, search strategy selection, and shifts in tactics, vary in different work and search tasks. In addition, task complexity has been demonstrated to have a direct impact on information-seeking activities and search performance (Byström, 2002; Byström and Järvelin, 1995; Li, 2010).

The relationships between types of search tasks and tactics have been investigated, although there is discrepancy in the results. According to Hsieh-Yee (1998), there is no significant differences among search tactics (tactics for starting, tactics for too many items retrieved, and tactics for no relevant items retrieved) enacted for known-item searches and subject searches. In contrast, search task types of known-item searching and subject searching have been found to significantly affect search tactics, such as web site views and search tool use (Kim and Allen, 2002). Children select more natural language queries in addition to looping and backtracking more on fact-based tasks, and browse more on self-generated tasks. They also apply more analytic searches on these two tasks than on research tasks (Bilal and Kirby, 2002).

Meyyappan et al. (2004) created a task-based digital library in which three different information organization approaches (alphabetical, subject category, and task based) are used to organize heterogeneous resources. The results of the comparison of three approaches indicate that the task-based approach is the most effective in organizing information in the digital library. Xie (2006) investigated human-work interaction in a corporate setting for the development of a digital library. In her study, the first type of interaction activity consists of task activities. The author identifies three dimensions of work tasks:

- The nature of task (routine, typical, or new)
- The type of task (updating information or looking for specific information, a known item, or items with common characteristics)
- The time frame of the task (extremely urgent, urgent, or nonurgent)

The three dimensions of task activities greatly affect three types of interaction activities: decision, collaboration, and in particular, strategy activities. "Updating information corresponds to a 'browsing strategy,' in which a user scans to find a match with his or her information need. Looking for specific information is associated with an 'analytical search' whereby a user analyzes his or her needs and compares relevant aspects of information resources. Looking for items with common characteristics corresponds to an 'analytical search' and 'search by analogy' wherein a user finds items that are similar to a known item. Looking for known items is related to a 'bibliographical search' in which a user knows some information regarding an item, such as author, title, etc." (p. 134). It is important to investigate the multiple dimensions of tasks and how they influence users' information-searching behaviors.

In digital library environments, different types of tasks have been demonstrated as one of the key determining factors affecting users' information-searching behaviors. In a help-seeking situation study (Xie and Cool, 2009), three types of task dimensions represent a task: task requirement, task type, and task complexity. Task requirement refers to a special condition for a task, such as time, identifying different approaches, etc. Task type refers to different types of tasks, such as looking for specific information, items with common characteristics, and different aspects of a topic. Task complexity refers to the level of difficulty of a task. The findings of the study show that task requirement, although codetermined with other factors, influences the help situations related to browsing and refining searches; task type affects the help situations related to creating search statements, refining searches, and evaluating results; and task complexity determines the help situations related to creating search statements and refining searches.

SYSTEM DESIGN

User personal infrastructure, tasks, and system design are the three parallel factors having an impact on information-searching behaviors and search performance. The interface design of IR systems has

a huge impact on children's search behaviors (Jochmann-Mannak et al., 2008). Complex interfaces, in particular, have affected children's information-seeking behavior (Bilal, 2004). Hutchinson et al. (2006) investigated whether the flat and the hierarchical interfaces influenced children's search performance. Children were able to perform searches faster on the flat interface than on the hierarchical interface. Likewise, it was easier for them to use the flat interface than the hierarchical one.

In digital library environments, interface design, collections, and metadata are all part of a digital library. After examining the usage data of different access points, Sfakakis and Kapidakis (2002) conclude that the type of content in a collection and the detail of the existing metadata play a role in how users choose different access points. Focusing on museum practitioners, Chen's (2007) study suggests that both the context of the collection and the system itself, including cataloging practices, have an impact on the information-seeking behaviors of the user. The organization of search results also leads to unusual viewing behaviors. While users view far fewer result pages in other types of IR systems, on average they viewed 3.4 result pages in a digital library. One explanation for the large number of result pages viewed might be the fact that the results are not ranked by relevance, but by ID number (Trieschnigg et al., 2013). In a log analysis study of two large-scale digital libraries, users engaged in more advanced searches in the National Science Digital Library (NSDL) than Opening History (OH) because NSDL offered more search limit options than OH. In addition, the coverage of the digital libraries also impacts the content that users search for. While NSDL users searched more for concepts and objects, OH users searched more for place, person, corporate body, ethnic group, event, and class of persons (Zavalina and Vassilieva, 2014).

Joo (2013) examined how users applied different search tactics in conjunction with the associated system support in the digital library environment. In this study, system support refers to "the representation of system features to assist users' behavioral activities or cognitive intention to facilitate user-system interactions during an IR process" (p. 14). His results show that system support significantly affects users' satisfaction with the search process, their satisfaction with the search results, and aspectual recall. Adapting Skov's nested diagram model, Joo (2013) adds contextual factors into the diagram to illustrate the features that influence the information-retrieval process.

The diverse needs of different user groups, consisting of children, college students, scholars, elderly people, and people with disabilities, and their unique information-searching behaviors pose a challenge for the development of digital libraries with diverse collections built in different content management systems. The questions are: Should we design a one-size-fits-all digital library for everyone? How can we design digital libraries to satisfy diverse user needs and behaviors? Moreover, the Google generation is used to web search engines. The impact of web search engines on digital library use is obvious. A related question is: Is it possible to keep the unique design (e.g., browsing features) of digital libraries and also adopt simple interface design? Therefore, user needs and behavior studies should take system design implications into consideration and offer recommendations to promote and facilitate the interactions between users and systems.

REFERENCES

Albertson, D., 2010. Influences of users' familiarity with visual search topics on interactive video digital libraries. J. Am. Soc. Inf. Sci. Technol. 61 (12), 2490–2502.

Albertson, D., 2015. Visual information seeking. J. Assoc. Inf. Sci. Technol. 66 (6), 1091–1105.

Bates, M.J., 1979. Information search tactics. J. Am. Soc. Inf. Sci. 30 (4), 205–214.
Bates, M.J., 1990. Where should the person stop and the information search interface start? Inf. Process. Manag. 26 (5), 575–591.
Bates, M.J., 1992. Search and idea tactics. For information specialists: interpretations of reference and bibliographic work (183–200). Norwood, NJ: Ablex.
Bates, M.J., 2002. The cascade of interactions in the digital library interface. Inf. Process. Manag. 38 (3), 381–400.
Beaulieu, M., Jones, S., 1998. Interactive searching and interface issues in the Okapi best match probabilistic retrieval system. Interact. Comput. 10 (3), 237–248.
Belkin, N.J., 1993. Interaction with texts: information retrieval as information seeking behavior. Inf. Retr. 93, 55–66.
Belkin, N.J., Cole, M., Liu, J., 2009. A model for evaluation of interactive information retrieval. In: Proceedings of SIGIR Workshop on the Future of IR Evaluation. Boston, pp. 7–8.
Bell, L., Peters, T., 2005. Digital library services for all: innovative technology opens doors to print-impaired patrons. Am. Lib. 36 (8), 46–49.
Bertot, J., Snead, J.T., Jaeger, P.T., McClure, C.R., 2006. Functionality, usability, and accessibility: iterative user-centered evaluation strategies for digital libraries. Perform. Meas. Metrics 7 (1), 17–28.
Bilal, D., 2001. Children's use of the Yahooligans! Web search engine: II. Cognitive and physical behaviors on research tasks. J. Am. Soc. Inf. Sci. Technol. 52 (2), 118–136.
Bilal, D., 2004. Research on children's information seeking on the Web. In: Chelton, M.K., Cool, C. (Eds.), Youth Information-Seeking Behavior: Theories, Models, and Issues, vol. 1, Scarecrow Press, Lanham, MD, pp. 271–291.
Bilal, D., Bachir, I., 2007. Children's interaction with cross-cultural and multilingual digital libraries. II. Information seeking, success, and affective experience. Inf. Process. Manag. 43 (1), 65–80.
Bilal, D., Kirby, J., 2002. Differences and similarities in information seeking: children and adults as Web users. Inf. Process. Manag. 38 (5), 649–670.
Bilal, D., Sarangthem, S., Bachir, I., 2008. Toward a model of children's information seeking behavior in using digital libraries. In: Proceedings of the Second International Symposium on Information Interaction in Context. ACM, New York, pp. 145–151.
Bollen, J., Luce, R., Vemulapalli, S.S., Xu, W., 2003. Usage analysis for the identification of research trends in digital libraries. D-Lib Mag., 9 (5). Available from: http://www.dlib.org/dlib/may03/bollen/05bollen.html.
Booker, L.D., Detlor, B., Serenko, A., 2012. Factors affecting the adoption of online library resources by business students. J. Am. Soc. Inf. Sci. Technol. 63 (12), 2503–2520.
Bruza, P., Dennis, S., 1997. Query reformulation on the Internet: empirical data and the Hyperindex search engine. In: Proceedings of the RIAO'97 Conference on Computer-Assisted Information Searching on Internet. ACM Press, Montreal, pp. 488–499.
Butcher, W., Street, P.A., 2009. Lifelong learning with older adults. APLIS 22 (2), 64–70.
Byström, K., Järvelin, K., 1995. Task complexity affects information-seeking and use. Inf. Process. Manag. 31 (2), 191–213.
Byström, K., 2002. Information and information sources in tasks of varying complexity. J. Am. Soc. Inf. Sci. Technol. 53 (7), 581–591.
Chen, H., Dhar, V., 1991. Cognitive process as a basis for intelligent retrieval systems design. Inf. Process. Manag. 27 (5), 405–432.
Chen, H.L., 2007. A socio-technical perspective of museum practitioners' image-using behaviors. Electron. Lib. 25 (1), 18–35.
Cheng, Y.M., 2014. Why do users intend to continue using the digital library? An integrated perspective. Aslib J. Inf. Manag. 66 (6), 640–662.
Choi, Y., Rasmussen, E.M., 2003. Searching for images: the analysis of users' queries for image retrieval in American history. J. Am. Soc. Inf. Sci. Technol. 54 (6), 497–510.
Connaway, L.S., Dickey, T.J., Radford, M.L., 2011. "If it is too inconvenient I'm not going after it": convenience as a critical factor in information-seeking behaviors. Lib. Inf. Sci. Res. 33 (3), 179–190.

Czaja, S.J., Charness, N., Fisk, A.D., Hertzog, C., Nair, S.N., Rogers, W.A., Sharit, J., 2006. Factors predicting the use of technology: findings from the Center for Research and Education on Aging and Technology Enhancement (CREATE). Psychol. Aging 21 (2), 333–352.

Decker, E.N., 2010. Baby boomers and the United States public library system. Lib. Hi Tech 28 (4), 605–616.

Dougan, K., 2012. Information seeking behaviors of music students. Ref. Serv. Rev. 40 (4), 558–573.

Druin, A., Foss, E., Hutchinson, H., Golub, E., Hatley, L., 2010. Children's roles using keyword search interfaces at home. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. ACM, New York, pp. 413–422.

Duffy, E.E., 2013. Searching HathiTrust: old concepts in a new context. partnership. Can. J. Lib. Inf. Prac. Res. 8 (1), 1–13.

Entlich, R., Garson, L., Lesk, M., Normore, L., Olsen, J., Weibel, S., 1996. Testing a digital library: user response to the CORE project. Lib. Hi Tech 14 (4), 99–118.

Fidel, R., 1985. Moves in online searching. Online Inf. Rev. 9 (1), 61–74.

Fiske, A., Wetherell, J.L., Gatz, M., 2009. Depression in older adults. Ann. Rev. Clin. Psychol. 5, 363–389.

Foss, E., 2014. Internet searching in children and adolescents: a longitudinal framework of youth search roles (Doctoral dissertation). University of Maryland.

Foss, E., Druin, A., 2014. Roles of reaction: developing and non-motivated searchers. In: Marchionini, G. (Eds.), Children's Internet Search: Using Roles to Understand Children's Search Behavior: Synthesis Lectures on Information Concepts, Retrieval, and Services #34. Chapel Hill: Morgan & Claypool, pp. 37–44.

Gross, M., Latham, D., 2011. Experiences with and perceptions of information: a phenomenographic study of first-year college students. Library 81 (2), 161–186.

Górny, M., Catlow, J., Mazurek, J., 2015. Evaluating Polish digital libraries from the perspective of non-academic users. Electron. Lib. 33 (4), 714–729.

Gossen, T., Hempel, J., Nürnberger, A., 2013. Find it if you can: usability case study of search engines for young users. Pers. Ubiquit. Comput. 17 (8), 1593–1603.

Han, H.J., Joo, S., Wolfram, D., 2014. Tales from transaction logs: user search session patterns in an image-based digital library. In: Proceedings of the Annual Conference of CAIS/Actes du congrès annuel de l'ACSI.

Hembrooke, H.A., Granka, L.A., Gay, G.K., Liddy, E.D., 2005. The effects of expertise and feedback on search term selection and subsequent learning. J. Am. Soc. Inf. Sci. Technol. 56 (8), 861–871.

Hendry, D.G., Harper, D.J., 1997. An informal information-seeking environment. J. Am. Soc. Inf. Sci. 48 (11), 1036–1048.

Higgins, S., 2013. Access to digital libraries for disadvantaged users. Lib. Philos. Pract. (e-journal), p. 916. Retrieved from: http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=2280&context=libphilprac.

Hirsh, S.G., 1997. How do children find information on different types of tasks? Children's use of the Science Library Catalog. Lib. Trends 45 (4), 725–745.

Hirsh, S.G., 2004. Domain knowledge and children's search behavior. In: Chelton, M.K., Cool, C. (Eds.), Youth Information-Seeking Behavior: Theories, Models, and Issues. Scarecrow Press, Lanham, MD, pp. 241–270.

Hsieh-Yee, I., 1993. Effects of search experience and subject knowledge on the search tactics of novice and experienced searchers. J. Am. Soc. Inf. Sci. 44 (3), 161–174.

Hsieh-Yee, I., 1998. Search tactics of Web users in searching for texts, graphics, known items and subjects: a search simulation study. Ref. Lib. 28 (60), 61–85.

Hsieh-Yee, I., 2001. Research on Web search behavior. Lib. Inf. Sci. Res. 23 (2), 167–185.

Hu, C., Hu, Y.h., Yan, W., 2014. An empirical study of factors influencing user perception of university digital libraries in China. Lib. Inf. Sci. Res. 36 (3/4), 225–233.

Huang, C., 2014. Understanding Novice Users' Help-seeking Behavior in Getting Started with Digital Libraries: Influence of Learning Styles (Doctoral dissertation). University of Wisconsin-Milwaukee.

Hutchinson, H.B., Bederson, B.B., Druin, A., 2006. The evolution of the International Children's Digital Library searching and browsing interface. In: Proceedings of the 2006 Conference on Interaction Design and Children. ACM, New York, pp. 105–112.

Hutchinson, H.B., Druin, A., Bederson, B.B., 2007. Supporting elementary-age children's searching and browsing: design and evaluation using the international children's digital library. J. Am. Soc. Inf. Sci. Technol. 58 (11), 1618–1630.

Hutchinson, H.B., Rose, A., Bederson, B.B., Weeks, A.C., Druin, A., 2005. The international children's digital library: a case study in designing for a multilingual, multicultural, multigenerational audience. Inf. Technol. Lib. 24 (1), 4–12.

Jochmann-Mannak, H.E., Huibers, T.W.C., Sanders, T.J.M., 2008. Children's information retrieval: beyond examining search strategies and interfaces. In: The Second BCS-IRSG Symposium: Future Directions in Information Access. British Computer Society: London, pp. 64–72.

Jones, S., Cunningham, S.J., McNab, R., Boddie, S., 2000. A transaction log analysis of a digital library. Int. J. Digital Lib. 3 (2), 152–169.

Joo, S., 2013. Investigating User Search Tactic Patterns and System Support in Using Digital Libraries (Doctoral dissertation). University of Wisconsin-Milwaukee.

Kapusiak, R.B., 2015. Baby Boomers and Technology: Factor and Challenges in Utilizing Mobile Devices (Doctoral dissertation). University of Wisconsin-Milwaukee.

Kelly, D., Cool, C., 2002. The effects of topic familiarity on information search behavior. In: Proceedings of the Second ACM/IEEE-CS Joint Conference on Digital Libraries, ACM, New York, pp. 74–75.

Kim, K.S., Allen, B., 2002. Cognitive and task influences on Web searching behavior. J. Am. Soc. Inf. Sci. Technol. 53 (2), 109–119.

Kurtz, M.J., Eichhorn, G., Accomazzi, A., Grant, C., Demleitner, M., Murray, S.S., 2005. Worldwide use and impact of the NASA astrophysics data system digital library. J. Am. Soc. Inf. Sci. Technol. 56 (1), 36–45.

Lau, T., Horvitz, E., 1999. Patterns of search: analyzing and modeling Web query refinement. In: Proceedings of the Seventh International Conference on User Modeling, Banff, Canada, June 1999, Springer, New York, pp. 119–128.

Lazonder, A.W., 2000. Exploring novice users' training needs in searching information on the WWW. J. Comput. Assist. Lear. 16 (4), 326–335.

Li, Y., 2009. Exploring the relationships between work task and search task in information search. J. Am. Soc. Inf. Sci. Technol. 60 (2), 275–291.

Li, Y., 2010. An exploration of the relationships between work task and interactive information search behavior. J. Am. Soc. Inf. Sci. Technol. 61 (9), 1771–1789.

Liu, Z., Luo, L., 2011. A comparative study of digital library use: factors, perceived influences, and satisfaction. J. Acad. Librar. 37 (3), 230–236.

Lowe, H.A., 2013. Search Log Analysis of the ARTstor Cultural Heritage Image Database. University of California, Los Angeles (Doctoral dissertation).

Lumpe, A.T., Butler, K., 2002. The information seeking strategies of high school science students. Res. Sci. Ed. 32 (4), 549–566.

Makri, S., Blandford, A., Cox, A.L., 2008. Using information behaviors to evaluate the functionality and usability of electronic resources: from Ellis's model to evaluation. J. Am. Soc. Inf. Sci. Technol. 59 (14), 2244–2267.

Marchionini, G., 1995. Information Seeking in Electronic Environments. Cambridge University Press, Cambridge.

Marchionini, G., Geisler, G., 2002. The open video digital library. D-Lib Mag. 8 (12), 1082–9873.

Marcus, A., 2003. Universal, ubiquitous, user-interface design for the disabled and elderly. Interactions 10 (2), 23–27.

Markey, K., Atherton, P., 1978. ONTAP: On-Line Training and Practice Manual for ERIC Database Searchers. ERIC Clearinghouse on Information Resources, Syracuse University, Syracuse, NY.

Martens, M.M., 2012. Issues of access and usability in designing digital resources for children. Lib. Inf. Sci. Res. 34 (3), 159–168.

Martyn, H., Gallant, L.M., 2012. Over 50 and wired: Web-based stakeholder communication. First Monday, 17 (6) Available from: http://firstmonday.org/ojs/index.php/fm/article/view/3449/3262.

Mates, B., 2004. Who aren't you serving digitally? Lib. Technol. Rep. 40 (3), 6–9.
Matusiak, K.K., 2006. Information seeking behavior in digital image collections: a cognitive approach. J. Acad. Librar. 32 (5), 479–488.
Matusiak, K.K., 2012. Perceptions of usability and usefulness of digital libraries. Int. J. Humanit. Arts Comput. 6 (1–2), 133–147.
Mead, S., Sit, R., Rogers, W., Jamieson, B., Rousseau, G., 2000. Influences of general computer experience and age on library database search performance. Behav. Inf. Technol. 19 (2), 107–123.
Meyyappan, N., Foo, S., Chowdhury, G.G., 2004. Design and evaluation of a task-based digital library for the academic community. J. Doc. 60 (4), 449–475.
Nasmith, W., Parkinson, M., 2008. Senior citizens embrace change and make a new technology work for them. Electron. Lib. 26 (5), 673–682.
Nicholas, D., Clark, D., 2014. Information seeking behaviour and usage on a multi-media platform: Case study Europeana. In: Library and Information Sciences: Trends and research. Springer: Berlin, Heidelberg, pp. 57–78.
Nicholas, D., Clark, D., Rowlands, I., Jamali, H.R., 2013. Information on the go: a case study of Europeana mobile users. J. Am. Soc. Inf. Sci. Technol. 64 (7), 1311–1322.
Nicholas, D., Huntington, P., Watkinson, A., 2005. Scholarly journal usage: the results of deep log analysis. J. Doc. 61 (2), 248–280.
Nicholas, D., Huntington, P., Monopoli, M., Watkinson, A., 2006. Engaging with scholarly digital libraries (publisher platforms): the extent to which "added-value" functions are used. Inf. Process. Manag. 42 (3), 826–842.
Nicholas, D., Huntington, P., Jamali, H.R., Rowlands, I., Fieldhouse, M., 2009. Student digital information-seeking behaviour in context. J. Doc. 65 (1), 106–132.
Nov, O., Ye, C., 2008. Users' personality and perceived ease of use of digital libraries: the case for resistance to change. J. Am. Soc. Inf. Sci. Technol. 59 (5), 845–851.
O'Brien, H.L., Toms, E.G., 2008. What is user engagement? A conceptual framework for defining user engagement with technology. J. Am. Soc. Inf. Sci. Technol. 59 (6), 938–955.
Reuter, K., Druin, A., 2004. Bringing together children and books: An initial descriptive study of children's book searching and selection behavior in a digital library. In: Proceedings of the 67th Annual Meeting of the American Society for Information Science and Technology, Medford, NJ: Information Today, pp. 339–348.
Rieh, S.Y., Xie, H.I., 2006. Analysis of multiple query reformulations on the web: the interactive information retrieval context. Inf. Process. Manag. 42 (3), 751–768.
Saito, H., Miwa, K., 2007. Construction of a learning environment supporting learners' reflection: a case of information seeking on the Web. Comput. Ed. 49 (2), 214–229.
Savage-Knepshield, P.A., Belkin, N.J., 1999. Interaction in information retrieval: trends over time. J. Am. Soc. Inf. Sci. Technol. 50 (12), 1067–1082.
Sfakakis, M., Kapidakis, S., 2002. User behavior tendencies on data collections in a digital library. In: Research and Advanced Technology for Digital Libraries. Springer: Berlin, Heidelberg, pp. 550–559.
Shiri, A.A., Revie, C., 2003. The effects of topic complexity and familiarity on cognitive and physical moves in a thesaurus-enhanced search environment. J. Inf. Sci. 29 (6), 517–526.
Shute, S.J., Smith, P.J., 1993. Knowledge-based search tactics. Inf. Process. Manag. 29 (1), 29–45.
Smith, A.G., 2012. Internet search tactics. Online Inf. Rev. 36 (1), 7–20.
Smith, M.W., Sharit, J., Czaja, S.J., 1999. Aging, motor control, and the performance of computer mouse tasks. Hum. Factors 41 (3), 389–396.
Soloman, P., 1993. Children's information retrieval behavior: a case analysis of an OPAC. J. Am. Soc. Inf. Sci. 44 (5), 245–264.
Stronge, A.J., Rogers, W.A., Fisk, A.D., 2006. Web-based information search and retrieval: effects of strategy use and age on search success. Hum. Factors 48 (3), 434–446.
Tang, Y., Tseng, H.W., 2013. Distance learners' self-efficacy and information literacy skills. J. Acad. Librar. 39 (6), 517–521.

Theng, Y.L., Mohd-Nasir, N., Thimbleby, H., 2000. Purpose and usability of digital libraries. In: Proceedings of the Fifth ACM Conference on Digital Libraries. ACM, New York, pp. 238–239.

Trieschnigg, D., Nguyen, D., Meder, T., 2013. In search of Cinderella: A transaction log analysis of folktale searchers. In: The Proceedings of the First Workshop on the Exploration, Navigation and Retrieval of Information in Cultural Heritage, Thirty Sixth Annual ACM SIGIR Conference, SIGIR 2013: Dublin.

Vakkari, P., Pennanen, M., Serola, S., 2003. Changes of search terms and tactics while writing a research proposal: a longitudinal case study. Inf. Process. Manag. 39 (3), 445–463.

Vilar, P., Zumar, M., 2005. Comparison and evaluation of the user interfaces of e-journals. J. Doc. 61 (2), 203–227.

Wang, P., Berry, M.W., Yang, Y., 2003. Mining longitudinal Web queries: trends and patterns. J. Am. Soc. Inf. Sci. Technol. 54 (8), 743–758.

Wang, P., Hawk, W.B., Tenopir, C., 2000. Users' interaction with World Wide Web resources: an exploratory study using a holistic approach. Inf. Process. Manag. 36 (2), 229–251.

White, R.W., Ruthven, I., 2006. A study of interface support mechanisms for interactive information retrieval. J. Am. Soc. Inf. Sci. Technol. 57 (7), 933–948.

Wildemuth, B.M., 2004. The effects of domain knowledge on search tactic formulation. J. Am. Soc. Inf. Sci. Technol. 55 (3), 246–258.

Wilson, M.L., 2009. An analytical inspection framework for evaluating the search tactics and user profiles supported by information seeking interfaces. (Doctoral dissertation, University of Southampton).

Wilson, M.L., Schraefel, M.C., White, R.W., 2009. Evaluating advanced search interfaces using established information-seeking models. J. Am. Soc. Inf. Sci. Technol. 60 (7), 1407–1422.

Wolfram, D., Xie, H., 2002. Traditional IR for web users: a context for general audience digital libraries. Inf. Process. Manag. 38 (5), 627–648.

Wu, K.K., 2015. Affective surfing in the visualized interface of a digital library for children. Inf. Process. Manag. 51 (4), 373–390.

Xie, H., 2006. Understanding human-work domain interaction: implications for the design of a corporate digital library. J. Am. Soc. Inf. Sci. Technol. 57 (1), 128–143.

Xie, I., 2003. Supporting ease-of-use and user control: desired features and structure of Web-based online IR systems. Inf. Process. Manag. 39 (6), 899–922.

Xie, I., 2008. Interactive Information Retrieval in Digital Environments. IGI Global Inc., Hershey, Pennsylvania.

Xie, I., 2009. Dimensions of tasks: influences on information-seeking and retrieving process. J. Doc. 65 (3), 339–366.

Xie, I., Babu, R., Jeong, W., Joo, S., Fuller, P., 2014. Blind users searching digital libraries: types of help-seeking situations at the cognitive level. In: iConference 2014 Proceedings. pp. 853–857.

Xie, I., Babu, R., Joo, S., Fuller, P., 2015. Using digital libraries non-visually: understanding the help seeking situations of blind users. Inform. Res., 20 (2), Paper 673. Available from: http://InformationR.net/ir/20-2/paper673.html.

Xie, I., Cool, C., 2000. Ease of use versus user control: an evaluation of Web and non-Web interfaces of online databases. Online Inform. Rev. 24 (2), 102–115.

Xie, I., Cool, C., 2009. Understanding help seeking within the context of searching digital libraries. J. Am. Soc. Inform. Sci. Technol. 60 (3), 477–494.

Xie, I., Joo, S., 2010. Transitions in search tactics during the Web-based search process. J. Am. Soc. Inform. Sci. Technol. 61 (11), 2188–2205.

Xie, I., Joo, S., Bennett-Kapusniak, R., 2013. User engagement and system support in the search process: user dominated, system dominated and balanced search tactics. In: Proceedings of Seventy Sixth ASIS&T Annual Meeting. Montreal, Canada, November, 2013.

Xie, I., Joo, S., Bennett-Kapusniak, R., in press. User involvement and system support in applying search tactics. J. Am. Soc. Inform. Sci. Technol.

Yuan, X., Belkin, N.J., 2007. Supporting multiple information strategies in a single system framework. In: Proceedings of the Thirtieth Annual International ACM SIGIR Conference on Research and Development in Information Retrieval. SIGIR 2007. ACM Press, New York, pp. 247–254.

Yuan, X., Belkin, N.J., 2010. Investigating information retrieval support techniques for different information-seeking strategies. J. Am. Soc. Inform. Sci. Technol. 61 (8), 1543–1563.

Yue, Z., Han, S., He, D., 2012. A comparison of action transitions in individual and collaborative exploratory Web search. In: Information Retrieval Technology. Springer: Berlin, Heidelberg, pp. 52–63.

Zhang, Y., Lee, K., You, B.J., 2001. Usage patterns of an electronic theses and dissertations system. Online Inform. Rev. 25 (6), 370–377.

Zhang, W., Song, L., Li, C., 2012. An analysis of the development of China digital library for visual impairment website. Electron. Lib. 30 (6), 756–763.

Zavalina, O., Vassilieva, E.V., 2014. Understanding the information needs of large-scale digital library users. Lib. Res. Tech. Serv. 58 (2), 84–99.