25. TECHNOLOGIES FOR INFORMATION ACCESS IN LIBRARY AND INFORMATION CENTERS

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25.1 INTRODUCTION

Information access is a physical, psychological, social, cultural, and political issue. It involves more than calling up an item record on an on-line system or pointing to a book on a shelf and saying, "Ah, the small green book has everything I need" (Moholt, 1988). It is all the relationships that exist when users access information. Library and information science (LIS) researchers study users and information and how users access information. The relationships involve cognitive, affective, and physical components. They are moderated by cultural, sociological, and economic factors. They are subject to the constraints of technology, science, and education. This review focuses on LIS literature and research. It examines the theoretical and philosophical foundations for research in information access and discusses changes in focus and methodology.

25.2 CATEGORIES OF RESEARCH IN INFORMATION ACCESS

To organize the literature and provide a viewfinder, categories of research in information access were created. Research on information access is divided into three segments: users, access, and information. Each of these is discussed separately by looking at foundational research and inquiry. These three areas were identified using the basic question that initiated this review: How do people access information? In attempting to answer the question, an initial analysis revealed that researchers look at three separate issues: users, access, and information.

Users, both collectively and individually, engage in particular activities. The user plays a significant role in establishing and maintaining the problem situation. Various attributes and characteristics of users who want access to information are considered by researchers. Access is the second part of the research problem.

Access refers both to the technologies that provide access and to the factors that may enhance or limit access. Therefore, research in this area not only looks at technological capabilities but also at the impact of space, time, and culture.

Information is the goal of access, in the sense that information is what users want to access. What constitutes information and how information is constructed and stored creates the research foundation for this information access area.

Researchers studying users look at beliefs, behaviors, and needs. They attempt to describe user characteristics and variables important to information access. They examine ways to change users to create more efficient access. Researchers who study access look at technologies of access. They examine features related to mechanical technologies and social environments impacting user access. They may also study the system of information access, but from a system rather than user point of view. Information researchers study the characteristics and construction of information. They are interested in how information is represented, how the retrieval process is managed, and barriers to information access.

25.2.1 Users

Users initiate the information access process. Users can be students in a school library media center, engineers in a chemical corporation, agronomy professors on site in the field, doctors in their offices, or children at the zoo. Anyone looking for information is a user. There is a causal relationship between users and the other two pieces of the model. Without the initial problem, question, query, significant imbalance, or need, neither information nor a way to access it is necessary. Characteristics and issues related to users of information are essential to understanding information access. Research about users has generally focused in three areas:

- User studies
- Information seeking
- Information skills

User studies address such issues as different types of user groups, information needs of various people, and general characteristics of users that may impact information need. Information-seeking research examines the cognitive processes and search strategies that individuals use to access information. It often looks at differences between search intermediaries and end users. Information seeking can be considered a subset of cognitive characteristics. The concept of information skills focuses on knowledge and processes users need to improve information access effectiveness. This area has models of information skills development and research on the search process as a learning strategy.

25.2.2 Access

Access requires a user and a point of access. An access point could be a computer, a reference book, a phone directory, another person, a cage at the zoo, or any of a variety of other physical things. At some place in time, the user and the access point come together. An access point is a physical location. (*Question*: If a person accesses his or her own information, i.e., thinks about something, is there a physical access point? Are there other access instances where there is no way of construing physicalness?)

The access point is accompanied by physical factors that interact with the action of access. The point exists within near space: a work space, a library space, a classroom niche, a government waiting room, a kitchen with a telephone. This near space has physical, psychological, and social characteristics that influence access. The near space is surrounded by a room, a building, a facility, or a type of finite environment. The surrounding space is designed, developed, and maintained. It also interacts with characteristics of the user trying to access information. The space that contains the access point is located in a geographical relationship to the user. If the access point is a computer in the individual's bedroom, this is a close geographical relationship. If the access point is located at the university library, 50 miles away, this is a distant geographical relationship. Each of these factors has research and theory implications for information access in library and information centers.

Research in information access falls into three general areas: (1) research on the mechanical technologies of access points, such as on-line public access catalogs (OPACs), electronic mail (e-mail), on-line search services, and their associated social technologies, such as interface design and screen design; (2) research on the physical and social issues that impact the immediate use of an access point such as handicapped access, facilities design, and sign systems; and (3) research on larger issues that affect the use of the access point, such as public policies for use and geographic availability. LIS research on access to information is drawn from different theoretical backgrounds such as social and cognitive psychology, human factors, computer programming, and educational technology. Much of the research in this area is in the developmental stage for library and information centers.

25.2.3 Information

Access is only as useful as the information that is accessed. In general, information is defined by LIS researchers in the broadest terms to include antelopes and books and computers and rocks (Buckland, 1991). As raw information, access is focused on the relationship between the individual and the information source. A child watching an antelope eating at the zoo could be considered to be accessing from an information center. The zoo is a repository of live natural history information. Another type of information is that which is constructed into different formats. Databases (see 24.9), semantic nets (24.7), indexing and cataloging, and expert systems (see 24.8) are all forms of information construction. Access to constructed information may be different than access to raw information. Information is also affected by the influence of public policies and cultural norms on what information is made available and to whom. Researchers, such as Dervin (1992), suggest that information should be considered subjective: a personal construction created by human observers.

Information is used, analyzed, and made available in four different contexts: (1) as basic content or reality, (2) as this reality constructed in large sets, (3) as filtered by political and social constraints, and (4) as constructed by the individual. Research on information encompasses a broad scope and complexity. It has technical and social implications. For example, does the content of information influence access to information? Does mathematics literature have an inherently different structure for searching and sorting than poetry? This chapter will focus on the organizational structures developed in LIS to sort, categorize, and aid in the retrieval of information.

25.3 CHAPTER OVERVIEW

Each of the three areas of research in information access are now examined in depth: users, access, and information.

- Research and methodological issues are discussed.
- Analyses of significant studies are provided.
- Directions for future research are considered.

In addition, three longitudinal research projects that integrate users, access, and information are reviewed at length. The final section of the chapter summarizes LIS research and briefly discusses implications of access issues in library and information centers for research in educational communications and technology.

This chapter has three limitations for readers to consider: subject content, time frame, and scope of literature reviewed.

The subject content is the literature and research of library and information science related to information access. By focusing on one subject content domain, it is possible to identify patterns in the research. These can be matched with research in compatible areas such as educational communication and technology. The time frame is approximately a 15-year span beginning in 1980. Some earlier work is examined, and reviews of research that cover earlier periods are included. The scope is reviews of research as the first focus, and specific studies secondarily. Reviews of research provide foundations for exploring patterns. Specific studies provide exemplars and point to new research areas.

25.3.1 RESEARCH ON USERS

User research has undergone significant changes in the past 25 years. It has moved from a field that primarily studied identifiable groups and focused on system-centered questions to a field that looks at individuals and focuses on user-centered behavior and questions. The current foundations encompass communications theory, social psychology, and cognitive psychology. Methodology is moving from sociological surveys toward qualitative techniques such as case studies, ethnographic research, and grounded theory. Quantitative methods from communications theory and cognitive psychology are also being applied.

Research about users has formed a significant part of the research in library and information science (Krikelas, 1983). Emphasis on user groups predominated the early research efforts (Hewins, 1990) and still accounts for a large portion of research. Because of the specific characteristics and problems of groups in different content areas, the research literature on user groups is scattered among many content areas from medical science to agronomy research. A research trend is to explore characteristics of individual users rather than focus on specific content groups. Since the late 1970s, suggestions for focusing on individuals in practical contexts has become prevalent (Wersig & Windel, 1985; Wilson, 1981, 1984). Research on how people, whether collectively or individually, fit into information access can be divided into three areas:

- *User studies,* which include characteristics of users, information on how different user groups function, and identification of user needs
- *Information seeking,* which includes cognitive processes used to access information, user search strategies, and differences between end users and search intermediaries
- *Information skills,* which include creating models of information skills functions and developing research on the information search process

25.3.1.1. User Studies. The most important body of literature on user studies is the review series appearing in the *Annual Review of Information Science and Technology*

(ARIST) since 1966. These reviews provide an overview of a research area over an extended period of time.

1966	Menzel	1972	Lin & Garvey
1967	Herner & Herner	1974	Martyn
1968	Paisley	1978	Crawford
1969	Allen	1986	Dervin & Nilan
1970	Lipetz	1990	Hewins
1971	Crane		

They show the development of a field study over more than 25 years. Earlier reviews detail how user studies began. Later reviews build on earlier reviews by evaluating their ideas and analysis schemes. In the beginning, these reviews appeared every year, then every 2 years, and most recently on an unscheduled basis with 4 to 8 years between reviews. Krikelas (1983) believes this may be due to erratic and all-encompassing definitions of what user studies constitute. Bates (1971), for example, includes catalog use, use of reference services, use of library materials, and general library attendance, in addition to information-gathering habits of scientists. To examine current trends in user studies and definitions, this section elaborates on the two latest review articles (Dervin & Nilan, 1986; Hewins, 1990). An analysis of issues of concern related to user studies completes this section.

Dervin and Nilan (1986) review 1978 to approximately 1986, almost 8 years. They include all user studies since the previous review (Crawford, 1978). They approximate 300 overall citations related to users but narrow their focus to conceptualizations that drive the research. Past reviews have shown that the field may have conceptual limitations. Menzel (1968) explains that theory from the social sciences should drive user research. Crane (1971), Crawford (1978), Lin & Garvey (1972), and Paisley (1968) discuss the development of theory or conceptual frameworks within the context of user studies. Lipetz (1970) focuses on a methodological issue: improving predictive value. Allen (1969), Herner and Herner (1967), and Martyn (1974) ask for methodological choice and attitudinal perspectives.

Dervin and Nilan (1986) say the current literature, 1978–86, has a number of critical essays calling for reassessments of the type of research and a particular concern for conceptualization. They see two distinct areas: need for theory and need for better definitions and premises. They believe that definition is preliminary to theory and should be developed first. They state that innovative work in the time frame of the review does concentrate on definition.

Four research changes for user studies are identified. The first is to increase the match between information systems and users to serve the client better. This would result in greater accountability and fewer underserved clients. Their second research change would focus on user needs and uses. This would result in the user as a central issue for research, not the system or the technology. Their third research change would redesign the system to look more closely at person-machine links. Their fourth research change would focus on the technology of user access.

Dervin and Nilan (1986) also discuss their beliefs about changes in user studies research. Much of the work is the same as before (looking at users in terms of systems), but some research seems to represent a different direction (looking specifically at users). A common systems study looks at the degree that a user has actually used a system or systems, identifies barriers to the use of the system, or identifies satisfaction with attributes of the system. This research has also looked at demographics, sociological components, and life-style tasks. Problems with these types of studies have included ill-defined terminology and terms used interchangeably. They suggest that this systemic emphasis results in six approaches to needs assessment:

1. How much do users use the system?
2. How aware are users of the system?
3. What do users like and dislike?
4. What are the users priorities for information?
5. What are users interests, activities, and group involvement?

Researchers trying to change user studies suggest an alternative approach. Dervin and Nilan (1986, pp. 13–16) develop seven categories to contrast differences between the traditional and alternative approaches they believe are beginning to take hold in user research:

1. Objective vs. subjective information
2. Mechanistic, passive vs. constructivist, active users
3. Trans-situationality vs. situationality
4. Atomistic vs. wholistic views of experience
5. External behavior vs. internal cognitions
6. Chaotic vs. systematic individuality
7. Quantitative vs. qualitative research

Hewins's (1990) review updates Dervin and Nilan (1986) and reasserts the belief that research has shifted from sociological to psychological. Hewins's review states that Dervin and Nilan proposed a change from traditional empirical studies to user studies that provides rational frameworks and systematic bases for methods and definitions. Hewins restates Dervin and Nilan's belief that three new approaches are emerging: (1) user values, (2) sense making, and (3) anomalous states of knowledge (ASK). These new approaches focus on identifying user characteristics rather than on measuring system performance. In addition, Hewins says studies from the past have a common framework in that they are sociological or system based. The study of groups and the design of appropriate systems formed the foundation for the earlier work in user studies.

Hewins (1990) believes that few innovative methods have been developed, because questionnaires and surveys are still the norm. Dervin and Dewdney's (1986) time-line–critical-events approach is described as a new and interesting methodology. The National Library of Medicine's (1988) solution development record, a variation on critical-incident methods, is also discussed. In summary, Hewin (1990) states that new cognitively based approaches include categorization techniques, long- and short-term memory, learning

styles, motivation, personality types, and semantic factors. The need for more interdisciplinarity is discussed.

After reading both Hewins (1990) and Dervin and Nilan (1986), it is apparent that a change is taking place in the study of users, systems, and their interaction. This seems to reflect general changes taking place in the way educational researchers and scholars view research. There has been more emphasis on qualitative methodology, a swing from behavioral to cognitive psychology, and a greater tolerance for deriving theory from a broad spectrum of research areas.

User surveys, the most common method of data collection in user studies, are reviewed by Verhoeven (1990) and reflect some of the same issues discussed by Dervin and Nilan. Both methodological and conceptual problems with the user survey are discussed. Issues such as incomparable results, lack of generalizability, and confounding methods are examined. In a general review of research findings from surveys over time, Verhoeven reports the following:

- In public libraries, adult users are well educated; 20% of the population accounts for most of the adult use.
- Younger library users used public libraries almost exclusively for course work.
- On-line catalogs are popular.
- Microfilm has been dissatisfying to people who wear glasses.
- People who do not use libraries have no need or no time.
- Friends and colleagues are preferable to libraries for seeking information.
- Considerable variability exists in information-seeking behavior. One persons' easy search can be most difficult for another (p. 391).

New approaches to the user survey can be divided into two general areas: (1) improving surveying techniques, (2) finding new directions (Verhoeven, 1990). The first type of researcher turns to surveys as a research area. The attempt is to find out why traditional surveys do not work. The next step would be to use this knowledge to design better surveys. The second approach looks at a different aspect. Traditional surveys were predominantly questionnaires that examined user satisfaction and user interaction with specific researcher-generated services. A new research focus is to identify the situations that prompted the user need. The information problem is examined from the user rather than the system perspective. Verhoeven defines the first approach as positivistic and the second approach as phenomenological. The ongoing conflict between the two methods is summarized in this way:

Some commentators believe that, although the phenomenologists have destroyed positivist underpinnings, they have proffered little to put in their place. . . . On the other hand, there are those who find it not unreasonable to continue asking library users about their experience with libraries . . . (p. 394).

Applegate (1993) is one of the researchers suggesting a new method for determining user needs. Three models of

user satisfaction are evaluated in the 1993 article: (1) material satisfaction model, (2) emotional satisfaction model–simple path, and (3) emotional satisfaction model–multiple path. In material satisfaction models, measures of product performance such as recall and precision are the determiners of user satisfaction. This can often lead to false positive conclusions where the product performs well but users are not necessarily satisfied. Simple-path emotional models are built on measuring users levels of satisfaction through direct and indirect questions to the user such as, "Are you satisfied with the results of your search?" Again, a false positive can result. Users express satisfaction but have received poor results from the search. The multiple-path model uses both user satisfaction responses and additional factors such as setting and expectations.

These three models have implications for research in user satisfaction. Applegate (1993) suggests that researchers should clearly specify what definition of satisfaction they are measuring. Secondly, more standardized instruments for data collection are recommended. Finally, multipath models such as that described above are suggested as explaining more complexity in user satisfaction.

There also appear to be other areas where user studies research could direct greater effort. One of the issues Hewins (1990) addresses is that studies which are site, system, or service specific and that do not contribute to method, theory, or model building are not covered in the review. On the surface this seems reasonable. On the other hand, this may not fully represent local knowledge and the development of grounded theory. Informal and formal case studies can provide valuable information about site-specific user characteristics and needs. From the description, it is difficult to know what was not included in this review. However, further use of techniques that gather and develop theory from local knowledge, such as action research (see 9.7.5), might prove useful for research in user studies.

User-need studies look at the user and what she or he brings to the situation. The studies also need to examine social constraints, cultural influences, and the effects of demographic variables such as age, gender, and class. Chen and Herndon (1982) is one of the landmark research studies in user needs. One issue from the Chen and Herndon study that is still relevant today is underserved populations. They found two especially relevant groups to consider: (1) users who are not using library and information center services, and (2) users who are not able to use library and information center services. For example, in their survey many elderly users were not able to answer the questions asked, so their information needs were not known. A more recent study by Metoyer-Duran (1993b) demonstrates that for minority populations, the source of information can serve as gatekeeper to access for both the individual and the community.

Reneker (1993) sums up the basic problems with user studies in this way:

[This research] leaves one with little more than a sense of what kinds of materials are used by specific groups of scholars, researchers, or students. Most of these studies attempt to relate specific variables to particular pieces of information-seeking tasks or behaviors (p. 488).

The previous research of user studies was focused on systems and founded in sociological traditions both theoretical and methodological. The reason ARIST reviews in this area are becoming fewer and farther between may be that a new area of research is emerging which combines aspects of users with other research issues. Research focusing on the individual user rather than on groups is discussed in the "information seeking" section that follows.

25.3.2 Information Seeking

Information seeking is an active process: ". . . it begins when someone perceives that the current state of possessed knowledge is less than that needed. . . . [It] ends when that perception no longer exists" (Krikelas, 1983, p. 7). Researchers who study information seeking are looking at more than the specific user variables that relate to the system as described in the user studies above. Information-seeking researchers want to know the individual strategies and techniques users employ to look for and find answers. They are asking complex questions and using theories and methods that can provide breadth and depth to the answers. Two theoretical positions are foundational in information-seeking research: communication theory (Dervin, 1983a, 1983b, 1989b) and cognitive psychology (Belkin, 1990; Ingwersen, 1992; Reneker, 1993). In addition, two types of users are commonly considered by the information-seeking researcher: the end user and the search intermediary. End users are individuals who want to answer their own questions and use the information resources independently. Intermediaries are trained librarians who interpret users' questions and problems. Information seeking and search strategies can be different depending on who is seeking and searching.

The sense-making theory of Brenda Dervin and colleagues is founded in communication research and builds on constructivist principles (Savolainen, 1993). Its strength is that it is a programmatic research effort conducted over time, systematically examining problems and issues in information seeking and use (Dervin, 1983b, 1989a, 1989b). It focuses on a user-centered rather than a system-centered approach. In sense-making theory, sense-making behavior is considered to be communicating behavior. The theory has been tested over a series of 40 empirical case studies of information seeking and use. (A detailed discussion of Dervin's research is found in a later section of this chapter.)

A new trend in information-seeking research uses qualitative approaches, specifically ethnography (see 40.2; Reneker, 1993) and grounded theory (see 40.2.1; Ellis, 1993; Ellis, Cox & Hall, 1993). This research attempts to examine complex issues and provide information on the nature and effects of information seeking. These researchers want to go beyond superficial or surface layers. Reneker (1993), in a study of information seeking among academics, used a set of 2,050

information-seeking incidents as a foundation for analysis. These activities were drawn from personal, social, scholarly, academic, work-related, political, and other arenas. Conclusions from the study showed that information seeking is a part of daily tasks and relationships. It can result both from an articulation of a need and from available information.

Ellis (1993) and Ellis et al. (1993) used grounded theory to examine, respectively, the information-seeking patterns of academic researchers and to compare researchers in the physical and social sciences. The results of their research are the outlining of different categories to represent information-seeking patterns for four content specialists: social scientists, physicists, chemists, and English literature researchers. After analysis, the following six categories were developed for social scientists: starting, changing, browsing, differentiating, monitoring, and extracting. For physicists, five categories were identified: initial familiarization, chasing, source prioritization, maintaining awareness, and locating. The study of chemists identified eight categories: starting, changing, browsing, differentiating, monitoring, and extracting (the same as the social scientists), plus verifying and ending. The English literature researchers resulted in six categories also: starting, surveying, chaining, selection and sifting, assembly, and dissemination. Ellis states that even though different terminology and slightly differing numbers of categories were identified, they can be considered to represent fundamentally the same activities.

Another information-seeking research area focuses on information seeking within the context of electronic technologies. Marchionini, Dwiggins, Katz, and Lin (1993) exemplify studies conducted in this area. They review four previous studies and discuss implications for various types of users. They describe information seeking as a problem-solving activity and look at both content area experts and search intermediaries. They focus on five factors: an information seeker, an information problem/setting, a knowledge domain, a search system, and a set of outcomes. They conclude that content experts focused on search strategies that emphasized content, while search intermediaries were problem driven.

New studies (Reneker, 1993; Ellis, 1993) in information seeking are quoting the Dervin and Nilan (1986) review of user studies literature to verify that a paradigm shift has occurred. To date, no one has actually validated the assertion with an analysis of the literature or articulated the common components of the new paradigm. It seems that one statement has been influential in directing the beliefs of other researchers. These beliefs need to be confirmed through further analysis and study. With the exception of the Dervin sense-making studies, there are few longitudinal studies creating a body of sustained knowledge. Each researcher creates unique categories of the seeking process. Attempts to integrate the various points of view or to discuss the commonalities and differences between the results would be a valuable addition to the information-seeking literature. Research studies based on these common categories or focusing on the impact of theoretical differences could help extend the knowledge base of information-seeking research.

25.3.3 Information Skills

Information skills research is primarily undertaken within the context of school library media centers. It seeks to ". . . define the nature and scope of information processes" (Eisenberg & Spitzer, 1991, p. 265). Scholarly activity in this arena can be divided between model development and information skills process research. Cutlip (1988), Eisenberg and Berkowitz (1990), Irving (1985), Loertscher (1988), and Stripling and Pitts (1988) fall into the first category. Kuhlthau (1983, 1988, 1993b) is an example of a researcher with a systematic program in information skills: the information search process.

Kuhlthau has explored stages of the information search process through use of qualitative research methods to build grounded theory. Both affective and cognitive aspects of the process were developed based on longitudinal observations and interviews with high school students, public library users, and others. (A detailed discussion of Kuhlthau's work can be found in a later section of this chapter.)

Bartolo and Smith (1993) used Kuhlthau's information search process (ISP) theoretical model in a study of manual and on-line search methods in university journalism classes. The focus was on interdisplinarity, and the method was an eclectic mix of techniques. They found that: "the superior performance of the on-line group over the manual group supports the authors' hypothesis that on-line search methods are more effective than manual search methods in helping researchers handle the challenges of interdisciplinary work . . ." (p. 351).

Work in information skills and the development of research studies and a research agenda is emerging. Treasure Mountain Research Retreat 5 (Barron, Grover & Loertscher, 1994) shows future directions for information skills research including: further model development, longitudinal studies of integrating information skills with content areas, and alternative assessment measures.

25.3.4 Summary of Issues Related to User Research

Many of the early studies within user research are descriptive. They delineate characteristics of users and their needs. The populations of focus were groups of users such as chemists, doctors, and agronomists. The subject of focus was how the systems were used by these groups. Over time the emphasis shifted to look at more complex issues and began to examine the cognitive strategies of individuals. Models of user search strategies were created. Currently, the emphasis has shifted again to a qualitative focus. There are attempts to derive models from behavior rather than creating models to fit behavior. The greatest needs in user research are to integrate the results from studies and to develop long-term research agendas and projects. The work of Brenda Dervin and Carol Kuhlthau provide exemplars of longitudinal research based in strong theory and methodology.

There are also problem areas and questions that need to be more fully addressed in user research. Issues of use of

libraries and information centers by social class (see 6.4.2), ethnicity, gender (see 9.5.4), and age are still underrepresented in the research. Characteristics of these users and issues of effectiveness, access, and satisfaction could use more concentrated study. Younger children are also underrepresented as subjects of research. Emphasis seems to be predominantly in academic settings or with professional people. Studying users of library and information centers may focus on the available pool rather than on the possible pool. Extending the populations studied to nonlibrary users and nontraditional information users, and focusing on people as well as institutions and systems, could increase the range and usefulness of user needs research.

Ongoing research issues in user studies include identifying what is user research, defining terms, and differentiating between a system in which users are a component and research that concentrates on users. Researchers who focus on specific user characteristics such as information search strategies or the information skills process often incorporate access issues into their research. This section has identified the specific issues related to users who influence the research process. In the next section, patterns related to the access of information are explored. This chapter identifies common components in each area first. It examines how theory and methods are being applied to solving specific problems related to users, access, and information. Comparing similarities, differences, and potential for future studies can isolate trends and commonalities for application to library and information center problems.

25.4 RESEARCH ON ACCESS

Research on access in the context of this chapter focuses on the point of access and the surrounding environment. Current research emphasizes electronic technologies, the design of those technologies, and users' beliefs about the technologies. However, issues of workspace, facilities use, and public policies must also be considered part of access research. Access has technical and social issues impacting on how users access information. Scholarly literature in the context of access relates to design, implementation, and planning. Discussions of access issues often iterate what has been done and result in prescriptions based on logic, common sense, or rationality (e.g., Vickery & Vickery, 1993). These writings are the application of local knowledge to solving general problems such as choosing workstation locations, providing effective sign systems, or deciding on the location for a new library building. Access research also draws on theory from other disciplines and applies findings from human factors, human-computer interaction, cognitive science, and cognitive ergonomics to library and information center problems.

While research on users has been a significant component of library research for many years, LIS research on access issues is a growing field. Researchers are exploring theoretical foundations and developing research agendas.

Much of the research has focused on aspects of technologies such as on-line public access catalogs and on-line search services. The range of potential research questions in access is also influenced by the research on users. Issues that may influence access include all of those characteristics, needs, and components that were part of user research. This review focuses on research and issues that are founded in LIS literature. Some sections include discussions of directions for future research rather than results of research. There are still many unknowns about access point issues and how the environment impacts information use.

Research on access and the components that affect access can be divided in four areas:

1. *The access point,* which includes interface and screen design aspects of human computer interaction and common access technologies
2. *The work and use space,* which focuses on decisions about using an access point and use of the space for working once chosen
3. *The building and facilities space,* which looks at physical access issues such as handicapped access and cognitive issues such as sign systems
4. *The outside environment,* which could look at physical access issues such as geographic availability and public policy or social issues

25.4.1 The Access Point

The point at which the user and the gateway to information come into contact is referred to in this chapter as the access point. Two aspects of research on the access point will be examined: the human-computer access point interface and the technologies of access. The technologies of access discussed include:

- On-line public access catalogs (OPACs or PACs)
- On-line search services (e.g., DIALOG, BRS, Internet)
- CD-ROMs and optical media
- Full-text databases, including hypermedia and multimedia applications

The focus in this section on the technologies of access will be the way in which they relate to the user. In the following section on information, the internal construction of information stored in the technologies will be discussed. This section then examines cognitive aspects of access, while the information section looks at engineering and mechanical aspects of access, specifically the storage and retrieval of information.

25.4.1.1. Human-Computer Interactions to Access Information. Users can access information directly. They can read a book, view a videotape, listen to a recording, go to the zoo, or enjoy a painting in a museum. These are direct-access interactions between a user and a specific item. This section looks at interactions that have been created to

help users access large bodies of collected information. There are two predominating areas of literature in human-computer interaction. The first is advice, models based on practice, and examples of what seems to work. The second is psychologically based research, examining aspects of the interaction but specifically focusing on cognitive components of the user interface (see 21.4). This review examines the second type of literature, psychologically based research founded in LIS. The predominant research foundation for design and development in LIS is cognitive science.

Allen (1991) reviews the research implications of cognitive science in LIS for the design of information systems such as access points (for earlier reviews of cognition, human-computer interaction, and LIS, see Borgman, 1984, 1986; Daniels, 1986). The beginnings of cognitive research in LIS are believed to have originated in the International Workshop on the Cognitive Viewpoint in Ghent, 1977 (Belkin, 1990). From these origins, a design and research agenda was developed which continues to influence the development of user interfaces and human-computer interactions in LIS. This program is to improve information access and information transfer by developing models of users' knowledge that can be integrated with information system structures. The focus is on the point at which the user and the system come into contact: the access point.

Four types of knowledge related to users and cognitive models are suggested by Allen (1991): world knowledge, system knowledge, task knowledge, and domain knowledge. Each of these has implications for the interactions between users and systems. In addition, cognitive processes such as cognitive load, learning, memory, and problem solving are discussed and related to user knowledge. The methods used to research these issues are drawn directly from cognitive science. For example, Hancock-Beaulieu (1990) used interviewing and think-aloud protocol analysis in a problem-solving situation related to on-line catalog searching. Users adapted their search strategies and proceeded through a number of different stages in their attempts to interact with the public catalog system. The implications for design of access technologies from this study include developing on-line help for initially constructing a search strategy.

Allen (1991, pp. 23–24) concludes the review of cognitive research in LIS by identifying significant research issues for ongoing implementations:

- The need through further research efforts to increase the understanding of how cognitive processes, such as cognitive load, contribute to information behavior
- A continuing focus and ongoing research on knowledge-based information retrieval and the creation of prototype systems
- The development and testing of interface designs to guide search strategy creation and intelligent tutoring systems
- Greater emphasis in applying understandings of domain and task knowledge to increase the quality of information retrieval systems

Allen's review examined the agenda setting and research foundations of cognitive science in the design and development of LIS access points. The research discussed below looks specifically at the interface design and draws on the literature from human factors and ergonomics.

Shneiderman (1987) laid out three types of human-computer interaction: commands, menus, and direct manipulation. Research has compared and contrasted these interactions. Results have been mixed and inconclusive. Smith (1988) found that a menu improved performance with both novice and experienced users. Spavold (1990), working with 9- to 11-year-olds, also found that menus were more effective than command modes, as did Canter, Powell, Wishheart, and Roderick (1986) when studying novice users. However, Paap and Roske-Hofstrand (1988), in summarizing studies of menu-based vs. command interfaces, conclude that novice users find commands more natural than menus. Taylor (1986) offered a choice, and 60% chose the menu mode, which shows preferences but does not confirm effective access.

The mixed results reported above could be due to comparisons of command languages with menus exhibiting different features. Menus have changed and developed over time, with features becoming both more complex and simpler depending on the application. Research issues related to menus include: order of reading (MacGregor & Lee, 1987a, 1987b), vertical position (Allen, 1983), depth and breadth (Lee & MacGregor, 1985), size of categories represented (Paap & Roske-Hofstrand, 1988), and categorical rather than alphabetical presentation (Hollands & Merikle, 1987). Research comparisons need to take into account these and other features as significant variables when comparing menus with command languages.

Direct manipulation is a more recent interaction category. It includes characteristics such as continuous representation of the object and physical actions that show an impact on the object that is both immediately visible and reversible. Ziegler and Fahnrich (1988), in a review of empirical studies, indicate that using a mouse to manipulate objects can cause problems for novice users. Chiang (1989) compares commands, menus, and direct manipulation, and concludes that direct manipulation may help overcome both conceptual and mechanical problems.

Another ongoing research area in human-computer interfaces is the creation of evaluation mechanisms. Nielsen and Molich (1989) report a heuristic evaluation process for user interfaces. Chin, Diehl, and Norman (1988) discuss the development of QUIS (Questionnaire for User Interaction Satisfaction), which has demonstrated reliable results over time. Hartson and Hix (1989) discuss the impact of rapid prototyping on ongoing interface evaluation. Gomoll (1990) lays out the 10 steps used at Apple Computer for observing user/computer interactions.

Shaw (1991) provides an overall review of the human-computer interface in information retrieval for LIS applications. The general principles of interface design are discussed, including display features, modes of interac-

tions, and help/system messages. Research related to these three areas is examined, and implications for LIS research are discussed. Specific interfaces for information retrieval are also identified. Implications of these systems, such as on-line searching, CD-ROM, and on-line catalogs, are discussed in the following section.

25.4.2 Technologies of Access

Within LIS, the longest tradition of research on technologies of access relates to on-line search services and on-line public access catalogs (OPACs). It is only within the last few years that research has extended to other technologies such as CD-ROMs and more optically based information platforms. In addition, full-text access—including hypermedia/multimedia applications with sound, visuals, and moving images—is an emerging area. Internet (an example of an on-line search service with particular features) will also result in research related to access technologies.

25.4.2.1. On-Line Public Access Catalogs (OPACs).
OPACs were replacements for card catalogs. They began as card catalogs represented on a computer screen. Initially OPAC interfaces were not much different from those associated with traditional card catalogs. Due to economic conditions and user preferences, OPACs have developed features different from card catalogs. Some OPACs are incorporating on-line search services, electronic encyclopedias, and other full-text and multimedia applications. Research compares different types of OPACs, looks at similar features, and creates generalizations for the further development of better OPACs (Cochrane & Markey, 1985; Matthews, 1986).

Larson (1991) reviews research related to subject searching in the on-line public-access catalog (OPAC). Lack of effective subject access is identified as a primary problem with OPACs. The needs of users for subject searching are examined. Subject searching accounts for more than half of all searches in on-line catalogs, and two problems are most common. Search failure occurs when users fail to identify information relevant to the questions they wish answered. Information overload occurs when the responses to a question are overwhelming in number. Four forms of enhancements for OPACs are recommended to improve subject access: classification changes, subject heading revisions, keyword searching improvements, and special indexes such as subject thesauri. Earlier reviews summarizing aspects of OPAC research and study include Borgman (1986), Cochrane and Markey (1983), Lunde and Copeland (1989), and Markey (1984).

On-line public access catalogs (OPACs) draw together many issues of relevance to researchers in LIS. OPACs are used to study user behavior, human-computer interfaces, information retrieval mechanisms, and record design (Yee, 1991). Earlier in this chapter, research about user behavior and interface design was discussed. Later in this chapter, research related to information retrieval and record sets will be discussed. This section examines research in how OPACs perform as a system and how users interpret their interactions with the system. The focus of these research studies is on the OPAC. It includes issues such as users perceptions and beliefs on how well OPACs work.

Early studies of OPACs included Hildreth's (1982) study of the computer-human interface as a window. It investigated aspects of the technology. Matthews, Lawrence, and Ferguson (1983), in a classic study for the Council of Library Resources (CLR), analyzed user requirements and behavior. The study determined users' attitudes and levels of satisfaction about on-line catalogs. Replications of the CLR study included Steinberg and Metz (1983) at Virginia Tech and Baldwin, Ostrye, and Selton (1988) at the University of Wyoming.

A problem with card catalog studies was location, specific findings, and methods. The sites and the instruments were unique. It was difficult to draw conclusions and generalizations from the data collected. The CLR research provided a standard data collection instrument that could be used across situations and ensured that all users responded to the same set of questions (Broadus, 1983).

OPAC user research has consistently applied two methods: surveys and questionnaires (e.g., Matthews et al., 1983) and transaction log analysis (e.g., Kaske, 1988; Nielsen, 1986; Peters, 1989; Tolle, 1983). Focus groups (e.g., Markey, 1983), protocol analysis (e.g., Sullivan & Seiden, 1985), and observation (e.g., Solomon, 1993) have also been used. The survey questionnaire is the most popular research method for studying on-line catalog use in LIS (Peters, 1991). Surveys measure what users know, believe, and think about OPACs. Surveys can also ask for reports of behavior.

Actual behavior at an OPAC is most often measured through the use of transaction log analysis. This type of analysis can be accomplished at the macro- or microlevel. Macro-analysis combines information about OPAC usage and patterns (e.g., Kaske, 1988). Micro-analysis looks at how individual users make choices and the patterns of their searches (e.g., Tolle, 1983). Discussion of the merits and problems with transaction analysis constitutes a significant scholarly area in OPAC research (e.g., Cochrane & Markey, 1983; Crawford, 1987; Hildreth, 1985; Markey, 1983; Weiskel, 1986).

Research has included aspects of the technology and information about beliefs of the users related to OPACs. Research on the technology of OPACs has resulted in a mixture of findings:

> . . . the computer as an information retrieval tool solved some problems (e.g., keyword access to individual terms in author, title, and subject-heading fields), created others (e.g., inability to browse subjects, titles, and authors), and left some untouched (e.g., the provision of subject headings in the catalog that correspond to the language of users) (Solomon, 1993, p. 245).

Users studies have been more consistent in findings. Most library users report that they accept and like on-line catalogs (Peters, 1991).

Two studies of OPAC use are discussed to demonstrate trends in OPAC research. Solomon (1993) conducted a naturalistic study of elementary children's use of an OPAC. It is an example of qualitative research methods and theory that are beginning to be seen in many aspects of LIS research. Dalrymple and Zweizig (1992) completed a factor analysis of affective data gathered in comparing traditional card catalog use with OPAC use. It is an example of applying a quantitative analysis not generally used in LIS research to studying information access.

Research examining children's OPAC usage is limited (e.g., Borgman, Gallagher, Krieger & Bower, 1990; Borgman, Ballagher, Walter & Rosenberg, 1991; Marchionini, 1989; Edmonds, Moore & Balcom, 1990; Walter & Borgman, 1991). Solomon's (1993) study is the most in-depth analysis of issues about children's OPAC usage and information retrieval patterns to date. The results of the study are based on approximately 900 transactions performed by about 500 students over the course of a school year. Recommendations for adding features that enhance children's OPAC use were suggested.

Solomon (1993) observed occasions of success using the OPAC (66% of the transactions) and occasions where breakdown occurred. Three factors contributing to success were: finding assistance, applying search strategies, and using common terms. Breakdown exhibited more complex situations including knowledge, rules, and skills breakdowns. Each of these three areas were further analyzed into specific categories.

The process of OPAC searching was also examined, including initiating actions, intentions, opening moves, and search strategies. Specific examples from the observations and extended analyzes of these categories were provided. For example, it was found that first-graders were more likely to use assistance as a search strategy than sixth-graders. Based on this study, Solomon (1993, p. 263) suggests that information retrieval systems for children should provide:

• Specific user tools (e.g., subject domains and their underlying content structures)
• General user mechanisms (e.g., navigation tools to explore a subject heading domain)
• Management tools (e.g., interactive programs to add locally generated cross-references)

Dalrymple and Zweizig (1992) compared card catalog use with use of an OPAC. There were 20 subjects in each group, and each group was assigned the same problems to solve. After completing searches, subjects evaluated the results of the search and filled out an attitude questionnaire. Separate factor analysis solutions on the 11 attitude questions were completed for each group. The on-line catalog group yielded two strong factors: benefits, which explained 54% of the variance, and frustration, which explained 31% of the variance. The card catalog group analysis resulted in similar factors: frustration, which explained 27% of the variance, and benefits, which explained 43% of the variance.

In addition, these attitudinal dimensions were compared with reformulation behavior (trying the search in different ways), user beliefs about the results of their searches, and perseverance measures. Reformulation showed a positive relationship in the on-line group, with feelings about benefits of the system. Perseverance (spending longer times on the searches) showed a relationship with feelings of frustration for both groups.

The consistency of dimensions across groups, even though loadings as first and second factors were reversed, has implications for future research design. If benefits and frustrations are important components of users' attitudes toward information access with OPACs, they could be built into research designs to increase understanding of user behavior. Dalrymple and Zweizig (1992) suggest applying this research direction to search behavior, information systems design, and bibliographic instruction.

25.4.2.2. Other Access Technologies: On-Line Services, CD-ROM, Full Text, Multimedia. OPACs are an access technology unique to library and information center environments. The first OPACS were designed, developed, and sold by libraries. Today private vendors are the primary developers of OPACs. Researchers can examine different questions through the use of OPACs, such as information access, information retrieval, and user behavior. At one time, the research was applied directly to the design of OPACs. Now the research is used by developers in the design of other types of access technology including: on-line search services, CD-ROM and optical media, full-text databases, multimedia and hypermedia, and Internet.

Historically each of these other access technologies could be considered unique, like OPACs, with special features assigned to each technology. However, technological features are merging across technologies, and even OPACs have full-text and multimedia features. Some resources are available in different formats, such as ERIC on-line, ERIC on CD-ROM, and ERIC as paper index or electronic encyclopedias, which can be paper, CD-ROM, or accessed on an OPAC. The processes and strategies needed to access the information stored in these merging technologies are more similar than they are different.

Shaw's (1991) review examines research aspects related to these different technologies. On-line searching is particularly sensitive to issues of front-end and menu development. CD-ROM also has research questions surrounding interface diversity and different possibilities for front-end access. In addition, CD-ROM has large graphics storage capabilities and has design and research problems related to retrieval of visual and moving images. Full-text databases are also seen to have front-end software research implications for interfaces with the user. Another research agenda with full-text databases is comparison of electronic systems with their paper counterparts. Joseph, Steinberg, and Jones (1989) compared a print and on-line version of an army manual. They found that initially new users preferred the print index and table of contents. However, after experience with the on-line system, most users preferred the keyword search option from the electronic access. Two studies discussed below are also examples of comparisons of print and electronic access.

Shaw (1991) concludes the review by summarizing the issues and problems of research in human-computer interaction in LIS:

- Research in human-computer interactions is cross-disciplinary and requires searching a variety of resources for converging information.
- Significant gaps exist in understanding the relative value of interface features such as graphical interfaces and command-mode interactions. The research shows contradictory findings.
- The impact of cognitive styles, eye-hand coordination, and previous experience could be intervening variables to help understand the contradictory findings.
- There are differences among researchers about how and what to study related to human-computer interfaces in information environments (pp. 178–179).

Another significant factor in electronic-access technologies has been the change from their use by professional search intermediaries to their use by searchers who wish the information. The design and implementation of information resources whether on-line, CD-ROM, full text, or multimedia now considers the novice as well as the trained professional. This requires research on user interfaces, search strategies, and expert systems. The systems and features that worked for professionals who were willing to learn command languages and technical process such as Boolean strategies are not effective for end users (Mischo & Jounghyoun, 1987). With remote access and a home market, vendors need to develop features that help novices complete sophisticated and complex searches as end users. Recent research related to users and intermediaries has included: individual differences (Borgman, 1989), interactions between users and intermediaries (Kuhlthau, Spink & Cool, 1992; Saracevic, Mokros & Su, 1990), remote users (Kalin, 1991), search moves (Wildemuth, de Bliek, He & Friedman, 1992; Fidel, 1990), and user behaviors (Belkin, Chang, Downs, Saracevic & Zhao, 1990; Wildemuth, Jacob, Fullington, de Bleik & Friedman, 1991).

Research using CD-ROMs as the interface device is becoming more prevalent in LIS. Marchioni (1989; Marchionini & Liebscher, 1991) reported results on the use of electronic encyclopedias on CD-ROM. Marchionini (1989) examined elementary children searching on a full-text encyclopedia delivered via CD-ROM. Older searchers were more successful and took less time than younger searchers. Looking at search patterns showed that novices used highly interactive strategies. Marchionini and Liebscher (1991) looked at undergraduate student's mental models (see 5.3.7). These models were used to make quickly the transition from paper encyclopedias to a variety of electronic encyclopedias. Balaraman (1991) described a preliminary study examining the impact of individual differences on novice users of CD-ROMs. Large, Beheshti, Breuleux, and Renaud (1994) compared elementary students' use of a print and a CD-ROM encyclopedia. Four questions of differing complexity were searched by the students. The time it took to complete the searches was approximately equal for both print and CD-ROM. Both groups exhibited good skills in choosing appropriate search terms. Students seemed able to use the CD-ROM interface with only a short training session.

Other electronic access devices that are of interest to LIS researchers include: computer conferencing (Rosenbaum & Snyder, 1991), electronic mail (Gluck, Coliz & Rosenbaum, 1991; Tsai, 1992), hypertext (Grumling, 1992; Marchionini, et al., 1990), Internet (Dillon, 1993), multimedia (Schamber, 1991), videotext (Case, 1991), and voice mail (Rice & Danowski, 1991).

25.4.3 The Work and Use Space

The environment immediately surrounding the access point has two implications for users. When approaching the access point (i.e., an OPAC, a CD-ROM, an Internet terminal, or a paper index), users make choices about whether or not they want to be in that space. Some characteristics of the immediate environment may interact positively with users' choice to try an access point, and others may create barriers or problems. Once at work or using an access point, the characteristics of the space, which enhance or inhibit ongoing use of the access technology, also will interact with the individual user.

Issues related to the first aspect of the access point environment, initial choice, have to do with affective considerations, physical necessities, and cultural preferences. The colors of the space, the height of the ceiling, the lighting, and the size of the space could influence users' affective responses. Particularly, types of physical spaces are necessary for effective use by disabled users, exceptionally tall or short people, children, and the aged. Cultural and personal preferences could affect how users react to very crowded spaces or very wide open spaces.

The use of access point space for work related to information access is also important to understanding what affects users. For example, provision of a sufficient writing area for taking notes, writing down citations, or opening indexes is critical to effective use of the access tool. Lighting and air quality may also impact use of the access space, particularly for users who work for long periods of time in one space. Long-term use of computer terminals also has implications for screen placement, keyboard height, chair design, and flexibility to rearrange and change the space.

There is little research in LIS about these aspects of information access (see 36.3). Most literature related to the use of access points or space is prescriptive or descriptive rather than research oriented. Suggestions are made for where to place OPACs in the overall library scheme, such as close to the entryway, by the reference desk, or next to the card catalog. Explanations of how particular libraries chose the color scheme for their children's room or the furniture for their CD-ROM stations are also part of the literature. Research either quantitatively or qualitatively based

could be a valuable asset to understanding which aspects of the work and use space are significant factors in users' information access. Theories and methods from human factors research, such as the person-environment fit theory, could be effectively applied to use and workspace research.

25.4.4 The Building and Facilities Space

The immediate environment is critical in users' choice of a particular access point once a library or information center has been entered. It interacts with the user choosing the reference librarian, the OPAC, the CD-ROM, the card catalog, browsing, or any of a number of possible access points in a library or information center. The overall building and facility may impact whether or not a user chooses an access point in a library or information center or goes elsewhere.

Research on the relationship of buildings and facilities to information access is another area in which research is emerging. The following issues could be considered in conducting this research:

- Impact of physical access—not only disabled access but also elderly, children, and others
- Affective impressions of the building and its "friendliness"
- Sign systems and way finding, including maps
- Architectural design and its interaction with cultural and sociocultural preferences
- Availability of public transportation
- Parking space and ease of accessibility

25.4.5 The Outside Environment

Geographical access to a library or information center is also a critical component in use of the access point. Geographic access begins to interact with social and cultural factors particularly related to economics and class. Libraries are often built and maintained where they are supported by a strong economic or tax base. Some areas, particularly in urban environments, are considered to be safer for locating libraries than other areas. In rural areas, the available money may allow for only a few libraries within a large geographical area. These factors mean that some users may not have the money or the experience to travel to the sources of information. It may also mean that some users may never see the library as part of their neighborhood or social environment.

Making information available via remote access has become a way to meet user needs, as discussed above. State libraries have developed mail services for users who do not have easy access to a local library or information center. Phone reference services are available in most public and academic libraries. Newer technologies such as Internet, dial-in access to OPACs, and proprietary services such as America Online, Compuserve, and Prodigy are all attempts to widen access. The proposal for a national electronic highway is also a possible method for increasing access to information. Research stills needs to be conducted both on the issues of geographical access described above and whether or not remote access technologies will make a difference in socioeconomic equality for information access.

25.4.6 Summary of Issues Related to Research in Access

OPAC research is the strongest component of access research in LIS. User preferences, menu development, search strategies, and interactions between users and technologies have been essential to the OPAC research agenda. This research also uses a variety of methods including surveys, questionnaires, attitude studies, experimental research, and naturalistic inquiry. Theoretical foundations are primarily psychological, looking at the interaction of cognition and OPAC features or the social psychology of individual responses to OPACs. Research on OPACs can examine features and processes of interest to the use of other electronic technologies. As features merge in the new technologies, issues such as screen design, direct manipulation, subject access, and remote connections can be studied across technologies. The foundational research in OPACs can be used as a guide to the research in access to other technologies.

Literature and research related to cognition and technological access is spread across a wide interdisciplinary content spectrum and must be accessed using many different search terms (see 24.6):

> . . . cognitive engineering, cognitive ergonomics, computer-human interaction/interface (CHI), convivial computing, cooperative interface, human-computer interaction/interface (HCI), person-machine interface, software ergonomics, usability engineering, user friendly/cordial/oriented/centered, and user interface (Shaw, 1991, pp. 178–179).

This broad coverage of literature and research can result in difficulty accessing significant and relevant information on a specific aspect of human-computer interaction and its cognitive relationships. Another problem in cognitive research in LIS is generalizability of findings compared to applicability (Allen, 1991, p. 18). Research focusing on existing systems may lack generalizability, while research on more general cognitive processes may have limited applicability.

Another way to conceptualize access is to think of issues in terms of social technologies and mechanical technologies. The mechanical technologies are the things themselves: the physical hardware, desks, circulations stations, buildings, and parking spaces that people must use in order to access information. The social technologies are the processes that interact with the mechanical technologies. They are socially and culturally engineered features of access and include such things as interface design, human computer interaction, user preferences, and social acceptability. In examining LIS research and scholarly writing about access, an interesting pattern emerges. With the exception of OPACs, the design of the things is generally

not part of LIS. The mechanical technologies are created by structural engineers, physicists, computer scientists, and human factors engineers. LIS research on mechanical technologies is conducted to provide information for others or to help find instructional solutions to increase effective access to mechanical technologies. It is the social technologies that interact and result in the use of the access technologies that is the focus of LIS research.

25.5 RESEARCH ON INFORMATION

In this section, information is examined as a tangible entity and a tangible process (Buckland, 1991, p. 6). The focus is on information as a thing that requires processing and organizing to provide access. Access to knowledge as enhanced or restricted by public policies and private usage is also discussed. Early work on information in LIS tended to be structural, with the focus on mathematics, linguistics, and logic representation. More recently, other aspects of information have become prevalent in the research. Searching for pictorial information, representing audio data in a database, and finding moving images have become part of the information substructure. These have enlarged the foundations used to understand, construct, and interpret information. This review examines three general areas that relate to the tangible aspects of information: (1) What is information? (2) How is information organized? (3) How is information controlled? Issues such as group uses of information, using information to generate knowledge or to become informed, and information seeking are discussed in other sections of this chapter.

25.5.1 What Is Information?

This section defines information in terms of its use in the access process and looks at common characteristics of information as discussed within LIS. Because of its position in this review, information is seen as it relates to users and access issues. The information presented in this section builds on that presented in other sections. Order of presentation can affect interpretation of information. The linear presentation suggests that users come first, then access, and then information. It implies a causal chain of events. Another reviewer could have presented information research first, then users, and finally access issues. One of the constituents of information might be relative position in the information access sequence.

The characteristics of information that are important in the context of information access as discussed in this chapter have to do with the ability to organize, structure, and retrieve information. Each type of information—textual, visual, moving, iconic—will have different characteristics that interact with the need to store and retrieve information. Until recently, most major information storage and retrieval systems focused almost exclusively on retrieval via words and numbers. Even pictorial information was assigned indexing terms (words) to aid in retrieving maps, pictures, and slides.

The addition of computers has changed both information that is stored and its organization and retrieval. This has implications for characteristics of information that are considered essential to represent in storage systems. Another change that has occurred is the storage of entire documents or other original materials, as opposed to surrogate representations (e.g., bibliographic citations, abstracts). Until recently, libraries, document rooms, museums, or other large facilities were required for storage of original materials. The characteristics of information that were important to represent had to do with physical descriptions, subject or content representation, and methods of retrieval. With new electronic capabilities to store original materials, the range of characteristics that must be considered and the organizational sophistication necessary for retrieval are more complex.

Another aspect of understanding what constitutes information has to do with philosophical assumptions about the nature of human beings and their relationship to information. One position among researchers is that information does not exist without human construction. No matter what the storage medium, the organizational structure, or the retrieval mechanisms, there is no meaning until an individual creates meaning. Among researchers who deal exclusively with information, mathematical representations, and database structures, there would be those who agree and those who disagree with this assumption.

One of the difficulties in discussing information is the need to tie information to the retrieval system employed. Often the structure of the database or storage system is designed with specific retrieval capabilities. Some ways to access information are not possible due to the original system design. For example, the Colorado Alliance of Research Libraries (CARL) only allows keyword access. There is no subject access capability. Searches for a subject such as *library research* include all the materials that have the keywords *library* and *research*. This could be "The *Library* of *Research* in Primate Behavior." Another system would allow the retrieval of only information that had the subject heading *library research*. Systems restrictions can create problems in information access. Retrieval systems must interface with humans and must respond to human logic and needs. Information storage systems must function within the limitations and physical characteristics of the hardware used. These two needs are not necessarily compatible. The limitations of the hardware can be imposed on the retrieval system rather than the system being designed to meet retrieval needs. This basic incompatibility creates dilemmas for researchers (Peters, 1991). Should the limitations of the system be researched and suggestions for improvement created? Should the needs of the user be explored and instruction developed to improve the users skills to access the system? Should some other combinations of factors be employed in the research process? The construction of information and its storage systems have implications for both users and access.

The concepts of value, utility, relevance, pertinence, and acceptability are also characteristics of information. It is

possible to store all types of information. Everything from a child's finger painting on the refrigerator to a holographic image of a lion to complete sound and three-dimensional virtual reality of the Globe theater has the potential to be stored and retrieved. What actually is saved, the characteristics stored, the features considered unnecessary, and the method of storage have to do with decisions of value, utility, relevance, and acceptability. The decisions are affected by economic factors about who will pay for the initial storage, the long-term care, and the retrieval and maintenance costs. Information is sorted and discarded before it is ever stored. The characteristics of what should be saved related to what could be saved need to be considered.

To summarize what constitutes information: It is things (symbols, ideas, knowledge, wisdom, antelopes); it is the characteristics of those things (names, places, dates, subjects, content, values); and it is the process that is used to make decisions about which of those things actually are important or useful information (storing, saving, making available, selling).

25.5.2 How Is Information Organized?

Larson (1991) developed a four-part explanation of the functional components of an on-line public access catalog (OPAC) which described the steps that come between users and information:

- User interface
- Database management system interface
- Database management system
- Database

In a more generic sense, these four components can be used to account for all forms of information organization and will be used to guide the review of literature that follows.

Description of the user interface and associated research was discussed earlier in this chapter. It will be referred to here as it has bearing on information organization. Generically, the *user interface* must be conceptualized as human-human interactions, human-computer interactions, and all other forms of socially constructed human-information interactions (e.g., human beings using indexes, bibliographies, tables of contents, telephones, hypermedia nodes, Veronicas, Archies, gophers, and virtual-reality devices). The user interface is exactly what the user sees, hears, touches, and tries to interpret.

The *database system management interface* is hidden to the user. In an on-line public access catalog, it is the software that translates the information from the user interface into commands the system database manager can understand and handle. In human terms, the reference librarian could be considered a system management interface. The reference librarian helps the user interpret the language and structure of a system such as Social Sciences Citation Index or the Library of Congress Classification system.

In an OPAC, the *database system manager* is the software and sets of algorithms, rules, or heuristics that search

the database and retrieve information. In noncomputer applications, sets of rules, algorithms, or heuristics that organize and provide a view into information could be considered system managers. For example, the Anglo-American Cataloging Rules II Revised, the Dewey Decimal Classification System, Library of Congress Subject Headings or any indexing system provides structure and process windows into specific bodies of information.

The *database* (storage system) in an OPAC consists of information chosen to represent a collection of materials. This information is stored in some predefined structure, with limitations on the type and extent of characteristics that can be included. All other information storage systems such as libraries, on-line databases, CD-ROMs, laser discs, videotapes, or maps have structures that limit storage possibilities. Only certain information is chosen to be included in an information set. Limited characteristics or values related to that information are provided to help retrieve the information. (Even in full-text databases, there are limitations on how much and what is included and how it may be searched.) Some predefined structure for storage is developed. The storage medium and technical process limitations on the structure also have implications for retrieval. In the next three sections, organizational schemes, structures and research related to systems interfaces, the systems themselves, and the storage of information are explored.

25.5.3 The System Manager Interface

Vickery and Vickery (1993, p. 160) review and describe many prototype and operational interfaces. Their conclusion demonstrates the variety of techniques that information science has contributed to system management interfaces. Listed below are techniques and examples of interfaces:

- Technique: Thesaurus relations and classification hierarchies
  Systems: MAI, CITE NLM, INSERM INTERFACE, TOME SEARCHER, METACAT, BIBLIOGRAPHY MANAGER, CANSEARCH, CIRCE, EDOR, DIANEGUIDE/NLA
- Technique: Stoplists
  Systems: FASIT, CITE NLM, TOME SEARCHER, CIRCE, METACAT, LEXIQUEST
- Technique: Recognition of suffixes and stemming
  Systems: FASIT, CITE NLM, ERLI/MINITEL, METACAT, BIBLIOGRAPHY MANAGER, DIANEGUIDE/NLA
- Technique: Formation of Boolean search statements
  Systems: TOME SEARCHER, CANSEARCH, EURISKO, DIANEGUIDE/NLA
- Technique: Manipulation of Boolean search statements
  Systems: QUESTQUORUM, CIRT
- Technique: Near matching of search terms rather than exact
  Systems: CIRCE, METACAT

- Technique: Calculation of term relevance, document weighting and ranking
  - Systems: CITE NLM, CIRT, SABRE
- Technique: Query amendment by relevance feedback
  - Systems: CIRCE, EURISKO
- Technique: Co-occurence of terms within documentary items
  - Systems: LEXIQUEST, ESA ZOOM

The purpose of the system manager interface is to release human searchers from routine and technical acts of searching that can be effectively automated. Different system interface managers can be created for different users, such as expert searchers, end users, and novice users. Expert search intermediaries need system interfaces that help them access unfamiliar systems and databases. Experts have strong search skills but may need aid in applying those skills to new systems. End users and novice users are more likely to need system interfaces that aid them in choosing and using search strategies. End users need their natural-language queries translated into system language. Novice users need help in learning how to search. Expert systems are being developed as system management interfaces to provide multiple approaches for all levels of users. Specific examples of these systems are discussed in the next section on system managers.

25.5.4 The System Manager

The *system manager interface* and the *system manager* are conceptualized as performing different functions. Their definitions provide a viewfinder for thinking about information retrieval at different levels of mechanical access. In reality the differences can be difficult to separate. Functions are becoming merged due to technical advances and innovations. A program with the appearance of a system management interface may also serve as a system manager, and the reverse. The previous section briefly reviewed system interface techniques applied to information retrieval. This section details information retrieval research. A brief review of information retrieval history is followed by examining the two most prevalent retrieval methods: statistical/probabilistic and cognitive. Expert systems, hypermedia, and future issues in information retrieval conclude the discussion.

Scholars of information retrieval date its beginning to the early 1950s. The Cranfield projects (reviewed in Ellis, 1990, pp. 3–14) were early information retrieval research programs. They developed operationalizations for three dependent variables that are still used in retrieval research. These measures are recall, precision, and relevance. Relevance measures whether an item retrieved contains information to meet the search request (see Eisenberg, 1988; Park, 1993). Recall and precision are ratios that relate to relevance (see Buckland & Gey, 1994). Recall is the ratio of all relevant items in a data set to the number of relevant items that were actually retrieved by the search. For example, if a database contained 20 items about frogs, and 10 of those items were

retrieved during a search, the recall for frogs would be .5. Precision is the ratio of the total number of documents retrieved to relevant items retrieved. For example, if a search resulted in 40 items, and 10 of those items were about frogs, the precision for frogs would be .25.

In the period following the Cranfield projects until the 1980s, intense debate in information retrieval surrounded the concept of relevance. Relevance is a judgment about whether or not a particular item meets the search request. Personal and economic factors can influence the judgment about an item's relevance. For example, in a study to test a new proprietary system that would automate the assignment of indexing terms, two differing judgments of relevance were found (reviewed in Ellis, 1990, pp. 1–3). The company's representatives found that the items retrieved were relevant. The representatives from professional indexing found the items retrieved less relevant. Each of these parties had personal and economic values attached to the outcomes. The company wanted to sell its product. The professional indexers may have seen the product as a threat to their livelihood. Another explanation would be that each group had different set points or standards about how much information was necessary in an item to achieve relevance. In relevance judgments, issues of variability (how much information is necessary for an item to be considered relevant) and consistency (can different individuals apply the criteria in the same way?) are critical and can effect judgments about what is relevant. Saracevic (1970, 1975) provides extensive reviews of the relevance controversy during the 1960s and early 1970s.

Current information retrieval research focuses in two areas: statistics and probability research (for an overview of issues see Belkin & Croft, 1987, and Fidel, 1987) and cognitive research (for reviews of current issues see Ingwersen, 1992, and Jacobs, 1993). Statistics and probability research uses techniques such as automated indexing, classification, searching, and abstracting. Statistics and probability measures are based on matching the query as expressed in the search statement with the representations in the database searched (query needs). They look at physical representations, mathematical probabilities, and logical rules. Cognitive research creates models of users (see 5.3.6), develops expert systems (see 24.8.1), and applies other methods to help the users match their needs with the system. Other techniques looking at the integration of users and information systems include user modeling, expert systems, and hypermedia applications (see 21.1). User modeling involves creating a representation of the user to interact with the system. Expert systems are designed to help the user understand and interact with the system more effectively. Hypermedia applications are designed to improve browsing, navigation, and user interaction capabilities (e.g., Chang & Rice, 1993; Newby, 1990).

Statistical and probability efforts can be divided in two types of retrieval techniques: exact matching and partial matching. Exact matching indicates that the search request and the items found in the database or retrieval set are identical.

Techniques such as Boolean searching, full text, and string matching represent exact matching. Most operational information retrieval systems are based on exact matching techniques.

Partial matching techniques are those where the retrieved documents or their representatives are not a complete match with the search request. Belkin and Croft (1987, p. 112) provide a schematic classification system that depicts types of partial match techniques and their relationships. The most frequently studied partial match techniques are: (1) networking techniques that look at groups of documents and include clustering, browsing and spreading activation, and (2) individual techniques that examine one item at a time and include fuzzy set, vector space, and probability techniques.

Networking Techniques

- Document clustering: Closely linked documents are relevant to the same requests (e.g., Willett, 1988).
- Browsing: User browses through nodes and connections in a network (e.g., Croft & Thompson, 1987).
- Spreading activation: Similar to browsing, but the system rather than the user activates parts of the network and their relationships (e.g., Cohen & Kjeldsen, 1987; Lee, Kim & Lee, 1993).

Individual Techniques

- Fuzzy set: Integrates Boolean queries with ranking techniques (e.g., Bookstein, 1985).
- Vector space: Represents documents by weighted term in dimensional space where each dimension corresponds to an index term (e.g.. Buckley & Lewit, 1985; Wilbur, 1992).
- Probability ranking principle: Similar to vector space, attempts to estimate how relevant a document will be to a search request (e.g., Bookstein, 1983; Croft, 1986).

Cognitive-based research in information retrieval looks at the interaction of the user and the information system. The attempt is to create, via system enhancements or changes, a better representation of the user request. Allen (1994) is an example of this type of research. Two experiments on the relationships between users' cognitive abilities and information system features were conducted. In each experiment, systems that included different approaches to the design of information were explored. In addition, cognitive abilities of participants were tested and randomly assigned to the different systems. A general linear modeling statistic (a statistic that combines features of ANOVA and linear regression) was used to test the hypothesis that there would be an interaction between system design and individual differences in cognitive ability. In one study, results showed an interaction between logical reasoning and order of presentation of references. In the other study, no interaction was discovered between perceptual speed and the way index terms were presented in browsable displays. Allen (1994) interprets these results for the overall design of information systems. System designers may wish to consider different orders of presentation as user-selected options to take into account the logical reasoning differences. On the other hand, since the browsable

displays showed no impact on search precision, other factors may be more relevant in the choice of browsing displays.

Belkin's anomalous states of knowledge (ASK) model (Belkin, 1980; Belkin, Oddy & Brooks, 1982a, 1982b) is an example of cognitive user modeling in LIS research. ASK looks at a network of associations between items on a database. Two aspects are critical: (1) the author's decision to communicate and (2) the users' decision to search and the decision that a particular item meets the search need. ASK relates to the second component. The searcher is aware of an anomaly in his or her state of knowledge about a problem or issue. The searcher examines items from a knowledge structure to interact with the searcher's request. This process continues until the ASK is resolved.

Two features underlie this cognitive approach to information retrieval: (1) construction of a model of the user of the system and (2) derivation of this model from cognitive characteristics of the user (Ellis, 1990, p. 67). The searcher interacts with a database via the creation of a model of her or his perceptions and requirements. In theory, conceptual associations are at the foundation of the model constructed. In reality, term associations are more likely to be used. Most of the research and development in this area are prototypes rather than operational systems.

Expert systems (see 24.8) and expert system intermediaries are more likely to be operational systems than user-modeling prototypes. Some expert systems have user-modeling components and some do not. Most expert systems are founded on assumptions about cognition and the user of the system (for reviews see Borko, 1987; Croft, 1987; Hawkins, 1988; Smith, 1987). Brooks says, "The influence of expert systems has shifted [information retrieval] research from a paradigm concerned largely with retrieval algorithms to one in which users, retrieval heuristics, knowledge, and human-computer interaction are key themes" (1987, p. 379). Expert systems have been influential in adding the users' perspective to information retrieval research. Expert systems engage users in dialogue to acquire a detailed request model or provide multiple retrieval techniques. Expert systems are used for query formulation, database selection, retrieval in subject domains, user modeling, and knowledge acquisition (Drenth et al., 1991).

Drenth et al. (1991) suggest three categories of expert systems that are under development in LIS: search advisors, intelligent front ends, and intelligent intermediaries. Search advisors teach users how to accomplish such tasks as search an on-line system. Intelligent front ends provide search tactics, search formulations, selection of terms, selection of databases, and search strategies. Intelligent intermediaries draw on knowledge of users and search tactics to interpret and elaborate search requests. They also use conceptual knowledge from the database or storage system. Information retrieval expert systems are primarily intelligent intermediaries (see Gauch, 1992, for an introduction to intelligent information retrieval). They serve to bridge the system gaps between the user and the stored information. Examples of expert system development in LIS include

Croft and Thompson, 1987; Fox, 1987; Gauch and Smith, 1993; Khoo and Poo, 1994; Shute and Smith, 1993.

I3R (Croft & Thompson, 1987) is an example of an intelligent intermediary expert system in information retrieval. I3R (Intelligent Intermediary for Information Retrieval) is a prototype system that optimizes the system's picture of the user's information need. It uses both probabilistic and clustering algorithms for retrieval. It also adds browsing, domain knowledge, and natural language processing. It is a multiple retrieval strategy system including both statistical and cognitive techniques. The system tries to build an accurate picture of the user's request by incorporating query analysis, domain knowledge, and browsing. This is then used with probabilistic and cluster retrieval techniques to retrieve documents through an inference process. User evaluation and further browsing provide a feedback loop to refine the request model and lead to more retrieval.

Multimedia- and hypermedia-based retrieval have looked at two functions: (1) integrating database management and information retrieval systems into a single model and (2) applying hypermedia as a browsing interface (retrieval by association). Agosti (1993) suggests that these new hypermedia retrieval models need to incorporate the concept of navigation as well as direct search. In one navigation model, Arents and Bogaerts (1993) developed a concept-based retrieval system that includes three-dimensional index navigation and semantic hyperindexing. They indicate that this type of navigation based on concept indexing could result in more effective retrieval of information in hypermedia environments.

Other LIS approaches to retrieval in hypermedia environments include plausible inference, subject browsing, and the use of classification systems. In most hypertext systems, retrieval can be accomplished through browsing or searching. In a plausible inference system (Lucarella & Zanzi, 1993), these two strategies are combined to increase retrieval effectiveness and search efficiency. Pollard, on the other hand, suggests improving efficiency in hypertext through the use of subject thesauri as navigational aids. The outcome is improved access to the subject content of the bibliographic database. Rada, Wang, and Birchall (1993) use a similar thesaurus approach in the development of their MUCH (Many Using and Creating Hypertext) system. Aboud, Chrisment, Razouk, Sedes, and Soule-Dupuy (1993) suggest the application of another traditional method from LIS to increase effective use of hypermedia. They describe a navigation approach that uses classification processess with the graphical interface. Selected nodes are ordered through their relevance, thus favoring some entry points in the database over others. This could reduce the disorientation to users in browsing space.

LIS retrieval research within hypermedia environments also addresses problems such as full-text retrieval, application of search strategies, and user interactions. Full-text databases create special problems for information retrieval via hypermedia methods. Browsing-based hypermedia systems may provide ease of access for beginners, but they often perform poorly with large document bases (Dunlop & van Rijsbergen, 1993). Dunlop and van Rijsbergen (1993)

conducted experiments to test a hybrid variation on the problems of browsing from large databases and retrieval through multimedia access. They used the results of the experiments to design a prototype system that minimizes the negative effects. Croft and Turtle (1993) examine another retrieval issue in hypertext: search strategies. They designed a probabilistic model based on inference nets. Results showed this retrieval strategy to be as effective as the more standard spreading activation technique. Belkin, Marchetti, and Cool (1993) designed a user interface that focused on user interactions for retrieval of bibliographic information. It used a two-level hypertext model and many different search strategies to increase interactions with users.

Whether the research is statistical/probabilistic or cognitive, whether the applications are expert systems, hypermedia, or another system, research in information retrieval has four ongoing areas of concentration:

- Operational systems compared to experimental systems
- Effectiveness of the different retrieval techniques
- Use of multiple strategies as opposed to a single-strategy search
- Retrieving information other than text

Belkin and Croft (1987) discuss the relationship between currently operational systems and experimental techniques. They ask ". . . why has the experimental experience had little effect on the operational environment?" (p. 112). It appears that most operational retrieval processes are based on exact-match retrieval and use Boolean, string searching, or full-text match as their basis. Suggestions for why new techniques are not applied include cost, time, and the need to learn to use new systems. In addition, the experimental techniques often have been tried on limited data sets and have not shown their effectiveness for large-scale database application. The addition of expert systems and hypermedia applications to LIS has increased the operational systems that used alternative retrieval methods.

All retrieval techniques seem to have certain areas where they are more effective. This leads to the belief that since current systems function, there is no need to add the time and cost of the experimental techniques. On the other hand, often experimental or theoretical techniques perform better than those in current use. Salton, Fox, and Vorhees (1986) found that, in general, partial-match techniques have been shown to respond better than exact match. One suggested reason is that cumulative results mask the effects of individual queries in comparison experiments. Information retrieval techniques are ways of comparing the search query with the document (or item) to be retrieved. Representations of items (e.g., citations, abstracts) interact with retrieval techniques and influence the retrieval of relevant items.

One of the consistent findings across retrieval research is that use of multiple retrieval strategies are more effective than use of a single strategy (e.g., Saracevic & Kantor, 1988b). Expert systems are one method for providing users with access to multiple retrieval strategies. Ongoing issues in this research are how to choose the strategies that will be

accessed for any particular search and which strategies should be made available (Belkin & Croft, 1987).

New areas of retrieval that go beyond text and document retrieval are being explored, particularly in expert system, multimedia, and hypermedia environments. Other research areas include: pattern recognition, image matching, numerical representation, and chemical structures. A complete listing of new research areas in information storage and retrieval is provided at the end of the "Information Storage and Structure" section.

25.5.5 Information Storage and Structure

Information storage is a highly technical area of research and development in LIS. Because of its complexity and depth, the literature and research of how materials are stored will not be extensively addressed in this review. Key issues are briefly discussed below. Interested readers can find entry points to the literature in the following: Burt and Kinnucan, 1990; Fox, Levitin, and Redman, 1994; Lancaster and Warner, 1993; Meadows, 1992; Pao, 1989; Soergel, 1985; Tremblay, 1985; Wiederhold, 1987.

The storage of information is related to characteristics of the information such as format, size, and retrieval needs. These characteristics can interact with the different types of information storage:

- Information representations (e.g., subject headings, descriptive cataloging, bibliographic citations, sound bytes, thesauri, abstracts)
- Original materials (e.g., books, videotapes, maps, speeches, holograms)

An OPAC, an on-line search service such as ERIC, and a bibliographic index such as *Psychology Abstracts* could be considered storage of representations of original materials. A library, a full-text database, a CD of Martin Luther King's speeches, or a museum could be considered storage of original materials.

Creating, organizing, and storing representations of information is a core area of LIS. The development of rules, procedures, algorithms, heuristics, and other organizational structures has been a cornerstone of LIS research development since the profession began. Before computers, this work was in the form of card catalogs, indexes, and abstracts. Some of the conventions from these earlier structures have been translated into use with computerized storage. Some processes, such as the Anglo American Cataloging Rules II (AACRII), have well-established conventions for describing and representing the information housed in libraries and information centers. Others such as subject analysis and content code (cataloging) of materials have no equivalent to the AACRII conventions. Research issues in this area include: models of data structure (e.g., linear, relational, hierarchical, network), semantic nets, indexing, subject analysis (including automated analysis), natural and artificial language, and information representation.

Storage of original materials is advancing with changes in electronic technologies. Mechanical access media such as microfilm and microfiche are being replaced by electronic media such as laser discs and computer discs. There are technical implications about length of storage, speed of access, and cost of replication. Research in storage of original materials includes such issues as: knowledge base construction, access to very large databases, database construction, information construction, storage of nontextual information, hypermedia and multimedia, and data compression.

The 1994 request for proposal for a digital library initiative from the National Science Foundation and the Advanced Research Projects Agency laid out three areas for future research: capturing data, advanced algorithms, and networked databases. The details of this proposal are provided below as an overview of future research areas for information storage and retrieval.

1. Capturing data of all forms and categorizing and organizing electronic information in a variety of formats

- Optical character reader (OCR) page layout
- Speech recognition, audio segmentation, broadcast capture
- Graphics understanding (image, drawing, graphs)
- Indexing, interpretation, classification, and cataloging of electronic information
- Multilingual indexing
- Hypermedia structuring and linking
- Graphical interfaces
- Browsing technology

2. Advanced software and algorithms for browsing, searching, filtering, abstracting, summarizing, and combining large volumes of data, imagery, and all kinds of information

- Retrieval theories and models for data, metadata, information, knowledge bases, evaluation methods
- Formal structures of documents and texts, query languages
- Feature-based image analysis and classification, pattern recognition
- Spatial-temporal feature indexing of video
- Filtering, routing, alerting and selection, dissemination of information
- Natural language analysis
- Adaptive learning systems
- Pictorial feature recognition, image classification
- Multiscale displays, zooming
- Data visualization, interactive visualization control, simulation to improve visualization
- Navigation, hypermedia, metaphors, virtual reality

3. Research on networking protocols and standards needed to ensure the ability of the digital network to accommodate high volume and worldwide distribution

- Network security
- Protocol design
- Data compression

- Scalability for large numbers of simultaneous users
- Knowbots, agents, mediators, intelligent gatekeepers
- Personalized interactive news, magazine, and journal services
- Modeling and simulating usage
- Collaboration technology

25.5.6 How Is Information Controlled?

In a democratic society, we prefer to believe that information is not controlled, that access to any type of information is available to every citizen. Yet we all know cases where information is not available for reasons of government security, because no one thought it was important enough to distribute widely, because it would limit sales, or because the library or information agency was required to remove the item due to complaints. Even in a democratic society, there are controls placed on both the information that is made available and the access to that information. It is in balance, understanding, and constant vigilance that those controls do not become repressive. One significant control on information is economic. The availability of information can be limited by the cost of making it available.

Three issues that have social, economic, and cultural implications to information access are discussed. Public policies about information availability and information gatekeepers are explored. Access through United States government resources is examined. Proprietary aspects of information access are discussed. The control of information can have positive and negative connotations. Control can limit, reduce, and provide barriers. Control can also add access points, increase public awareness of information availability, and raise questions for consideration and reflection.

25.5.6.1. Public Policy. Libraries and public information agencies are an example of a U.S. public policy for making information easily available to all of its members. These agencies are the results of ongoing policies and cultural belief systems that indicate free access to all types of information is important. Through research on users, user needs, user feelings, and user beliefs, library and information centers try to balance services, facilities, and materials to make the most available to the most people. This public policy to provide information and access to all citizens is an example of a positive element. Other elements, however, can serve to hamper this general policy. Local policies such as library hours, information center location, type of access (e.g., telephone reference, electronic access), and services for special populations can provide barriers and constraints to all members of a community sharing equal access to information resources. Economic issues can also limit access to information in libraries and information centers. Selection and collection development policies are created to take into account the economic necessities, but they can also limit what is made available. For example, with limited funding, a school library media center may restrict purchases to curriculum-related items. Students with special interests in personal reading or viewing may not be able to find items of interest in their school library media center.

Cheryl Metoyer-Duran (1993a, 1993b, 1993c) describes another aspect of control: gatekeepers. Gatekeepers are individuals who influence the access of others to information. In a large body of literature, gatekeepers are considered to form the function of restricting access to information and providing negative controls. Metoyer-Duran suggests that gatekeepers, particularly in ethno-linguistically different communities, can improve access to information for community members.

25.5.6.2. United States Government Access. The United States government is a special case of information collection, storage, and dissemination. One purpose of government is to educate and inform the people it serves. It tries to do this through information dissemination that is economically viable. There is also a need to protect national security and other sensitive areas of government. Hernon and McClure divide government information into two types: (1) public information, which they define as that collected or developed by the government, not classified personal or proprietary; and (2) private information, which is for use only by the government for reasons of a privacy right or statutory obligation (1987, pp. 6–7).

Public service, economic constraints, and legal obligations create conflicting values and needs that influence the collection, storage, and dissemination of government information. Three emerging areas of research and discussion related to government information are discussed below: electronic information, access for special-needs populations, and economic conflicts. While the discussion for this review centers on U.S. federal government access, the issues discussed are equally relevant to local and state government information. For further research on government access to information, see: access (Hernon & McClure, 1988), electronic information (Hernon & McClure, 1993), federal statistics (Sy & Robbin, 1990), Internet (Kalhin, 1991; Lynch & Preston, 1990), National Resources in Education Network—NREN (McClure, Bishop, Doty, & Rosenbaum, 1991), privatizing government information (Stewart, 1990), and technology and information policies (Ballard, 1987).

A new issue in government access to information is electronic availability (Hernon & McClure, 1993). Government agencies are attempting to reduce cost and increase information access through electronic availability such as government files through Internet and alternative formats such as microfiche and CD-ROM. Sprehe (1992) suggests that federal agencies will need to organize and administer public access to maintain the greatest benefit to the user with the least disruption to the agency.

Other issues related to government access include information availability to special populations. Marshall (1992) suggests a number of issues related to the print disabled (blind and others who cannot read print). Information needs to be formatted in specific ways in order for it to be read by speech synthesizers or translated into Braille copy. There

may be limited access that relates to hardware, software, and standards. Economic constraints to access also exist. Certain products are too expensive to purchase and translate (e.g., the Federal Register). Significant barriers to access to government information by print-disabled persons are created.

The cost for government agencies to gather, organize, and disseminate information is both in real dollars and resolving conflicts created by agency policies. Different groups have needs that may conflict in regard to the price of government information and the ease of accessibility. A summary of economic problems and issues associated with access to electronic government information is provided by Hernon and McClure (1993, p. 76):

- Librarians want to increase access but limit cost.
- Budgeters want to decrease the federal deficit and increase revenue.
- Economists want marginal cost pricing in order to maximize efficiency.
- Lawyers want precedents and consistency with other laws.
- Political scientists want an equitable process for setting prices.
- Researchers and scientists want data available, they want to know the format, and they are not much interested in prices.
- Statisticians want to maintain the integrity and accuracy of the data.
- Computer specialists want controls to ensure efficient use (e.g., price controls).
- Computer users want friendliness and flexibility in access.

While these economic factors were developed to account for differing needs around electronic access, they also are relevant to information access in general. Information has differing values and meanings to groups and individuals. For some, cost is a serious consideration in accessing information. For others, cost is unimportant, but the nature of the information's storage is critical (e.g., Braille, computer tape, hologram). For still others, it is the policy issues that regulate the dissemination of information that is crucial. Information needs can conflict and create confusion and dissent in policy development and implementation of access procedures.

25.5.6.3. Proprietary Interests. Services such as the Internet are resulting in mixtures of public and proprietary information sources that may have conflicting values, beliefs, and needs about who accesses information, what information is made available, and how much it costs. Some recent information scenarios illustrate conflicting values in information access between proprietary and public interests. The first scenario is an example of a conflict between public access to information and the proprietary use and sale of government information. The second scenario is related to public access to proprietary information. Both examples can be interpreted to respond to different public and private needs and pressures.

In the mid-1980s, a lobbying campaign by information industries resulted in information produced directly by government agencies becoming a commodity for sale to private companies (Smith, 1985). Private firms organize, package, and sell government information. This in itself is not a problem. The problem occurs because government versions of the same information, which used to be free to the public, now are difficult and sometimes impossible to obtain. Proprietary and public interests are in conflict.

Another example of conflict between proprietary and public interests is reported by Pfaffenberger (1990, p. 12). A librarian for the AFL-CIO attempted to search a DIALOG database produced by Dun & Bradstreet. The AFL-CIO had paid all the appropriate subscription and on-line fees for usage of DIALOG databases. They were denied access to the Dun & Bradstreet database. Dun & Bradstreet had sent a list to DIALOG indicating approximately 240 groups that were not allowed access. These groups were predominantly labor, consumer, and environmental organizations. There is a conflict between a proprietary organization's right to limit sales of its product and a strong societal belief that information should be available to everyone.

Services such as Internet provide access to both free and private information. Issues of who should have access to the proprietary and public information will continue to be part of a debate about information control. In addition, other issues are being raised about certain groups of people and their access to information. For example, should students be allowed free access to all resources of Internet, including the sexual and incendiary?

Doctor (1992) summarizes many of the research issues related to information technology and social equity. Five areas are discussed (p. 45): (1) the relationship between society and technology, (2) implementations of democracy and control relationships, (3) social justice and social equity, (4) information needs, sources, and uses, and (5) mass information delivery systems such as high-capacity computer networks. A common theme related to research in technology and society is the nature of their interactions. No technology is free of social pressures for its application and use. Technology and society are interdependent. These interactions can be seen in such research questions as: How is equity of access to technology achieved? What are implications of cultural lag in the workplace?

In discussing power and control in a democracy, Doctor (1992) addresses social justice and the distribution of power. Information-based power is considered as one of the possible outcomes of increasing technological implementation. Disparities in wealth and information access can also be seen to affect other aspects of social justice and social equity. "The gap between the wealthiest people in America and the poorest is increasing. Disparities in income, and therefore in the ability to acquire information resources, are worsening" (p. 54).

Doctor (1992) discusses the impact of mass information systems in terms of the distribution of information resources across society. Federal funding has helped some

community-based agencies, including libraries, experiment with different types of information and referral systems. More recently, computer technologies are affecting the interactive delivery of information. Doctor suggests that there are two basic types of systems: specialist based and consumer based. Specialist-based systems are services such as DIALOG, BRS, and CompuServe. Consumer-based systems are services such as library-based community information systems, free-nets, Prodigy, and telephone company gateway systems. However, few of these current systems serve the daily information needs of the poor. "They are designed to serve upper- and upper-middle-income groups; only incidentally do some effectively reach down to middle- and lower-income groups" (p. 79). Doctor suggests that the development of programs to ensure distribution of resources to the one-third of the population that is information poor is both a research and a professional challenge.

25.5.7 Summary of Research Issues Related to Information

Information retrieval processes that interface with the storage of information are a substantive research area in information access. Two methods predominate in information retrieval: statistical/probabilistic and cognitive. Statistical and probability techniques focus on the development of management systems. They look at improving technological processes and retrieval functions. Cognitive retrieval efforts attempt to create models of users and develop interfaces for storage systems. They look at translating user needs into useful system retrieval methods. An example of cognitive research is the provision of multiple search strategies via an expert system interface.

Early cognitive research in information retrieval focused on developing prototype models. More recently, expert system intermediaries and hypermedia interfaces have been put into operation and their effects studied. The problems associated with applying both the prototypes and the operational systems to large databases are still under consideration. In addition, research to integrate sound, pictorial, and three-dimensional and moving images into the interface and retrieval processes is beginning. Issues such as image classification, spatial-temporal indexing of video, and hypermedia structuring are becoming part of the research of LIS. Merging features in electronic technologies are beginning to indicate that future research will focus on the processes—such as interface design, retrieval strategies, and knowledge construction—rather than on the specifics of technologies such as CD-ROM, OPACs, or on-line search services.

Technical considerations are one component of information research in LIS. Social, political, and economic issues that affect public policy and information access are another area of research and development. What gets stored must be considered. Who has access to the stored information is part of the decision-making process for building information structures. Information has inherent meaning and value. Suf-

ficient mechanical storage and retrieval by technical means does not necessarily meet the meaning and value needs of users. Some researchers concentrate on improving storage and retrieval mechanisms, technologies, and process. Other researchers focus on social, political, and economic issues (see 13.6.1) that affect information access. A future research direction might be to integrate the technical and social aspects of information into a wholistic research agenda.

25.6 INTEGRATING USERS, ACCESS, AND INFORMATION: THREE LONGITUDINAL STUDIES

Research suggesting linkages between users, access, and information supplies the meaning to information access. Examining each of the research areas of users, access, and information is one way to compare and contrast the existing state of knowledge about information access. However, at some point, all three areas need to be integrated into a meaningful process. Finding out that something exists, one definition of access, does not imply that the information is meaningful or useful. Access does not even necessarily imply retrieval of the information. In a limited sense, access might simply indicate that a given item or piece of information exists. In this section, three long-term research projects that examine the relationships between users, access, and information are examined in detail, namely the work of:

1. Tefko Saracevic and associates on information seeking and retrieval
2. Brenda Dervin and associates on sense making in information access
3. Carol Kuhlthau on the information search process

These projects are similar in that they are longitudinal; they address all three aspects of information access discussed in this chapter; and they focus on the process of information access. They are substantially different in methodology, theoretical orientation, process focus, and population studied. Taken together, these three research projects represent the most substantive and influential work on information access in LIS.

25.6.1 Information Seeking and Retrieval

The information-seeking and retrieval project of Tefko Saracevic and associates discussed below began in 1980 with the development of a model and a research methodology (Derr, 1982, 1984, 1985a, 1985b; Pao, 1983; Saracevic, 1980, 1983, 1984, 1985). The model has five components: user, question, searcher, search, and items retrieved. Each of these components is measured in multiple ways, including Likert scaling, categorical variables, standardized tests, and numbers of items. The methodology is quantitative and uses traditional regression and analysis of variance techniques. However, ". . . regression analysis and analysis of variance

proved to be disappointing in uncovering significant relationships" (Saracevic, Kantor, Chamis & Trivison, 1988, p. 213). The use of the cross-product ratio, traditionally found in biomedical research, was a more powerful statistical method for application in LIS research on information seeking and retrieval. The results of the application of this technique are detailed in the study described below.

Between 1985 and 1987, Saracevic et al. (1987, 1988) conducted an extensive research study on the model's five components and obtained significant results using the cross-product ratio statistic. The study consisted of 40 research questions submitted by 40 different academic and industrial workers. These questions were researched by 36 experienced users of DIALOG. In addition, the same 40 questions were researched in four different ways by three project researchers. This resulted in a total of 200 outside searches on the 40 questions, and 360 project searches on the 40 questions. A total of 5,411 unique items were identified as solutions to the problems posed in the 40 questions. Of these, 1,343 were judged as relevant, 1,448 as partially relevant, and 1,620 as not relevant by the original question askers.

Each of the five components of the model was operationalized with multiple measures. Use of the cross-product ratio resulted in significant effects for the following aspects of the model's components:

- Of the four measures for *users* (problem, intent, public knowledge, and internal knowledge), only problem and public knowledge showed a significant positive impact on retrieving relevant items.
- Of the five measures for *questions* (domain, clarity, specificity, complexity, and presuppositions), low clarity, low specificity, high complexity, and many suppositions showed a significant positive impact on retrieving relevant items.
- Of the four measures for *searchers* (Remote Associations Test-RAT, Symbolic Reasoning Test-SRT, Learning Style Inventory-LSI, and search experience), only high RAT scores and high Abstract Conceptualization on the LSI showed a significant positive impact on retrieving relevant items. Concrete Experience on the LIS was negatively related to retrieving relevant items.
- Of the six measures of *search tactics and efficiency* (commands, iterative cycles, search terms, preparation time, on-line time, and total time), high numbers of cycles, low numbers of search terms, below-average preparation time, and below-average total time showed a significant positive impact on the retrieval of relevant items.
- Of the six indicators of *item retrieval* (relevant, partially relevant, not relevant, evaluated items, not evaluated items, and total items), if the number of relevant, partially relevant, and total items were high, then there was a significant positive impact on the retrieval of relevant items.

In addition to examining relationships to relevance, this study also looked at all categories described above as related to precision and recall. These measures are both traditionally used in overall macrowise retrieval research. While there were some significant findings for these categories, the more important information was gained from the microwise item analysis discussed above related to relevance. This study made no attempt to aggregate the effects of the variables, which showed positive relationships to relevance, precision, and recall.

One of the most significant results of this study was from pairwise comparisons of all 200 outside searches done for the 40 questions. This resulted in 800 pairs of comparisons examining the overlap of terms selected for searching and items retrieved by searchers. The overlap of search terms was relatively low. In 56.4% of the cases, the agreement was less than 25% (Saracevic & Kantor, 1988a, p. 204). In item retrieval, 69% of the items were retrieved only once. If an item was retrieved more than once, it was more likely to be relevant. The odds of an item retrieved once being relevant was 10:10. The odds of an item retrieved by five different searchers being relevant was 57:10.

This research project has implications for all three areas of information access discussed in this chapter: users, access, and information. In terms of access, the project demonstrates the importance of questions and users on the development of access points and interfaces. Interactions—whether between a search intermediary as described in this study or a system such as an OPAC, an expert system, or an on-line database—require sophistication in interpreting users' questions. The use of keywords from a question was the least effective search method found in this study. The most effective method was information compiled from a number of searchers using different terms and search strategies.

In terms of information, this study clearly demonstrated the lack of overlap in the use of search terms and the retrieval of relevant information. This has strong implications for indexing, database construction, and information organization. There is not a simple correspondence in choosing an exactly correct term or series of terms to solve a complex problem. Information structures that restrict the ability of searchers to create complex and iterated searches reduce the possibilities for effective information problem solving.

In terms of users, implications from the searcher's strategies can be applied to developing instruction for individual users as well as professional searchers. The use of many search terms and concrete linear strategies resulted in retrieving fewer relevant items. Focusing instruction on developing word association skills and abstract conceptualizations of information problems could improve user's solutions to information problems and increase feelings of satisfaction.

The Saracevic information-seeking and retrieval project developed a model and implemented a quantitative statistic new to information science research: the cross-product ratio. Testing the model is a step toward theory building. The project created hypotheses and questions that need to be tested further and used to develop an information-seeking and retrieval theory. Saracevic and Kantor state in the conclusion of the 1988 report that the theory still needs to be devel-

oped. They suggest the need for a theory of information seeking and retrieving that has the following characteristics:

- Be part of a broad theory of human information behavior
- Not use computer logic as a model because it is inadequate
- Incorporate both context and content of information in addition to syntax and logic
- Incorporate individual differences in patterns
- Be dynamic and interactive rather than linear and unidimensional
- Account for both human-human and human-computer interactions
- Allow for dynamic changes over time (Saracevic & Kantor, 1988b, p. 213)

25.6.2 Sense-Making Theory

The longitudinal research projects of Brenda Dervin and associates (Atwood & Dervin, 1982; Dervin, 1983, 1989a, 1989b; Dervin & Clark, 1987; Dervin, Johnson & Nilan, 1982) uses both qualitative and quantitative measures. It is based in communication theory and examined populations of different ethnicities, age groups, and sociocultural backgrounds. The studies have been performed with other information agencies as well as libraries. Dervin's work focuses on process and identifies the user as the foundational element in that process.

In the literature, this body of work is generally called *sense-making theory.* Dervin describes her work in this way: "Some people call sense making a theory, others a set of methods, others a methodology, others a body of findings. In the most general sense it is all of these" (Dervin, 1992, p. 61).

Dervin's sense-making research covers 40 projects over 17 years (Dervin, 1992). They include Asian, Hispanic, Afro-American, and Anglo populations, as well as teenagers, preschoolers, and adults. Subjects range from blood donation to politics to completing class assignments. Information agencies include libraries, health organizations, and government bodies. These series of projects are quite possibly the broadest and most wide ranging in LIS related to information access.

The foundation of sense making is a series of assumptions about information and communication. Sense making is founded on the assumption of discontinuity: discontinuity in time, in space, between people, and within an individual. Dervin conceptualizes this discontinuity as a gap. In information access, the goal is for the individual to create a bridge from the problem situation and over the gap through the use of information resources. This process is depicted as a triangle, with the points being situation, gap, and helps (or resources). Sense making can be applied to intrapersonal, interpersonal, small group, organizational, telecommunications, databases, societal, or other information use and information-seeking environments.

Three aspects of information drive both sense-making theory and the implementation of specific methods:

1. Information is constructed by the individual.
2. Information use, therefore, must center on the perspective of the actor.
3. Processes and behavioral strategies and tactics are the focus of research.

Methods develop from these three foundations in the following ways. A person constructs information through a series of steps to bridge gaps. A discontinuity occurs when the step stops. This is the point at which the researcher needs to acquire information about what processes and strategies are being used by the individual. Dervin has developed a set of interview techniques to help understand and obtain appropriate information. The foundational interview method is called the *micro-moment time-line interview.* A respondent is asked to recall what happened (the situation), what the gap was, and what the goal was (or the help that was needed). This type of interview results in detailed, time-focused information related to all points of the sense-making triangle. Three other interview techniques have also been developed but are not as intensive and focus on more specific issues. The abbreviated time-line interview is used to concentrate on one point of the triangle and elicit specific information about that factor. The help chain looks at the help point of the triangle. The question is asked: How did the library, the book, the video, etc., help? With each response, the interviewee is asked again: And how did that help? The question is repeated until the respondent feels his or her answer is completed. Message queing is the third focused interview technique. Respondents focus specifically on the gap-bridging or gap-defining portion of the sense-making environment.

Information gathered from the interviews is analyzed in both qualitative and quantitative ways. One of the primary methods, however, is content analysis. Results of studies provide data for both hypothesis testing of aspects of sense-making theory and data to inform and help solve the problem of practice on which the research study is based. Dervin's goals are both the development of theory and the solving of problems of practice. Each is equally important to the use of sense making (Dervin, 1992).

In a study for the California State Library (Atwood & Dervin, 1982), content analysis was used to classify how individuals identified and described gaps. The hypothesis tested was that the nature of a gap would be consistent across race. It was found that race did not predict information seeking in terms of questions asked. Race did interact with the channels and sources individuals used to get answers. The practice component of the California study provided descriptive information on need, questions, barriers, strategies, and successes of the people interviewed to help the California State Library develop and deliver services of value to users and potential users of all races.

A theory-building result across studies was the identification and naming of categories of stops, gap definings, and

helps. Stops included such components as barriers, spin-outs, and washouts. Gap definings have related to self, others, objects, actions, and events. Help categories included creating ideas, acquiring skills, calming down, and reaching goals. These categories were consistent across populations and problem situations.

Dervin's research has implications for all three areas of information access discussed in this chapter. In terms of users, this is a strong, theoretically based explanation of how users access information, deal with problems of access, and identify helps and resources. It provides the necessary foundation to develop hypotheses within a framework and test those hypotheses about users with validated and reliable methods that are directly cogent to the theory.

In terms of access, the results of these studies have implications for the design and development of user interfaces and human reference interactions. One of the particularly interesting cross-situational and cross-participant stops identified is the idea of someone (or something) leading the individual down a road they do not wish to travel. No matter how correct that road may seem to the computer, the reference librarian or the teacher who is trying to lead it becomes a stop to the individual with the problem. The need for flexibility and using the paths of the questioner should be integrated into human-human interactions and human-computer interactions.

In terms of information, an example from a study of blood donors (Dervin et al., 1982) demonstrates information issues that were addressed by the sense-making research. A series of different predictors were compared to see how donors wanted information to help them. They wanted and needed different information at different steps in the donation process. Sometimes they wanted details. Sometimes they wanted reassurance and no details. Different donors might also want information from different sources. To the question, "Will I faint?" one donor might want a doctor's response, while another might want statistical counts of how many people faint, and a third might want information from a previous donor. The solution in this instance was to construct a computerized question-answering system that could be accessed at the five points identified by donors as gaps or stop points. Typical questions were displayed on the screens, and a variety of question-answering strategies was made available, including responses from various sources such as doctors, statistics, and previous donors.

25.6.3 Information Search Process

The research projects of Carol Kuhlthau (Kuhlthau, 1983, 1988, 1989, 1993a, 1993b, 1993c) were qualitative and resulted in the creation of grounded theory about the information search process. The research looks at information access in instructional environments. The purposes of Kuhlthau's work are to develop a theory of the information search process and to provide guidelines for instruction in

this process (Kuhlthau, 1993c). This research concentrates on process and identifies the user as the foundational element in that process.

Kuhlthau's (1983) research began as a test of Kelly's personal construct theory. Kuhlthau explored the stages of the information search process and believed that ". . . the search process is, in itself, a process of construction" (Kuhlthau, 1988, p. 233). All of Kuhlthau's studies use field-based qualitative research methods to build grounded theory about the information search process. The original high school study (1983) was followed with further studies varying the population and refining the theory. Across-studies (Kuhlthau, 1989) looked at high school students, college students, high-, middle-, and low-achieving high school seniors, and academic and public library users. The final theory is a three-by-seven matrix of stages by process. The three states are feelings, thoughts, and actions. The seven stages are: task initiation, topic selection, prefocus exploration, focus formulation, information collection, search closure, and starting writing. For each of the three stages, a continuum of activities is developed along the seven processes. For example, feelings range from uncertainty to relief, thoughts from ambiguity to specificity, and actions from seeking relevant information to seeking pertinent information.

Kuhlthau used these studies and the grounded theory to create a principle of uncertainty for information seeking (1993a). This principle has six corollaries and seeks to integrate the cognitive processes of information seeking with affective considerations. In the 1993a article, Kuhlthau clearly indicates the constructivist focus of her information-seeking research and examines the influences of Dewey, Kelly, and Bruner on the development of the principle's conceptual framework. The basic uncertainty principle represented by this research is stated as: "Uncertainty is a cognitive state which commonly causes affective symptoms of anxiety and lack of confidence" (Kuhlthau, 1993a, p. 347). The six corollaries to this principle are: the process corollary, the formulation corollary, the redundancy corollary, the mood corollary, the prediction corollary, and the interest corollary. This principle and the associated corollaries are a strong conceptual framework for further research in information needs and uses.

Kuhlthau's research has implications for all three areas of information access discussed in this chapter: users, access, and information. In terms of users, Kuhlthau's work is highly focused on the impact of mood and internal affect on the process of seeking and finding information. She clearly delineates cycles that users can refer to and gauge their own feelings. The user's feelings of helplessness or frustration can be acknowledged as part of the information-seeking process.

Both Dervin and Saracevic also addressed affective issues. Saracevic looked at user satisfaction with items received to answer questions posed. Dervin examined users' perceptions of institutional images. Dervin also considered feelings, emotions, and affect as part of the process that may be gap defining or barrier producing. The differences

between Saracevic, Dervin, and Kuhlthau are in degree of focus. Kuhlthau's work relies the most heavily on the impact of feelings on behavior.

In terms of access, Kuhlthau's grounded theory provides observations on the information-seeking process. It appears that information may not be as important as an individual's state of mind at the time the information is accessed. Information accessed early in the seeking process may be considered too difficult, not relevant, or unintelligible. At later stages of the seeking process, the same information, from the same access point, under the same delivery conditions, could be perceived differently. In designing access systems, the different states of users when they access the system, either human or machine, need to be taken into consideration.

In terms of information, the notion of value-free information comes into play. Often databases, indexing systems, and other forms of information organization assume that information can be sorted into value-free categories and structures. Individuals carry values and feelings into the information search process. Those beliefs interact with information structures no matter how they were constructed. A related idea from Kuhlthau's work is the difference between relevant information and pertinent information. Most information structures are designed to provide relevant but not necessarily pertinent information. Pertinence is a measure of value.

25.6.4 Comparing Three Longitudinal Information Access Projects

Each of the three projects discussed above has applications to user, access, and information research. They each use distinct methodologies, focus on process, and take the user as their center of study. In addition, these researchers have continued their projects over 10 years or longer. There is longevity and growing complexity in their ideas and theoretical positions. They have set ideas out, tested them, and refined and revised.

These three projects demonstrate three different organizational structures for conducting research. Dervin's projects include both qualitative and quantitative methods and are based in communication theory. Kuhlthau's qualitative methods and grounded theory provide an examination of personal and affective characteristics. Saracevic demonstrates how a quantitative method from another research area can be successfully adapted for use in LIS. All three projects use constructivist assumptions in thinking about users' behaviors and beliefs. They acknowledge the role of the user in constructing information. They also demonstrate that quantitative, qualitative, and a combination of quantitative and qualitative methods can all be successfully used to understand differing aspects of information access.

Taken together these three longitudinal research projects suggest the range of theory use, methodological differences, and organizational foundations that can be applied to studying the overall process of information access, including users, access, and information.

25.7 CONCLUSION

The categories of research presented in this chapter looked at issues related to foundational components associated with information access: users, access, and information. Other organizational structures could be equally useful in understanding the research of information access. For example, each theoretical position such as cognitive psychology, information processing, or human factors could be examined for how it is used within the context of information access. The areas that the theoretical position is applied to could be looked at for consistencies, inconsistencies, and general patterns. Another approach would be to examine methodology. Are certain methods used more frequently in certain content areas related to information access? Are they accompanied by a single theoretical framework? Is theory developed from the method? Is a new theory generated for use with a particular method? This chapter focused on reviewing information access from the point of view of content. Other methods could be used to look at processes, theories, or methodologies.

When information is structured, modeled, or defined, some of its inherent reality is lost. The map is not the place. The picture is not the person. The signature is not the signer. The social artifacts are not the reality . . . and the environment requires agreement among the players about the rules and the playing field. This chapter set up a clearly defined playing field and rationally designed rules for inclusion or exclusion of information. The results are patterns of research, theory, and methods applied to solving problems in information access related to users, access, and information in LIS.

25.7.1 Summary of Information Access Research Issues from LIS

User research addresses needs, characteristics, and strategies of the user of access services in libraries and information centers. It attempts to understand cognitive, affective, and learning issues about the people who wish access to information. Current user research can be characterized in the following ways:

- User research moved from sociological to psychological foundations.
- The emphasis on groups of users changed to an emphasis on individuals.
- Quantitative, qualitative, and combinations of quantitative and qualitative research are part of user studies.
- User needs and their search processes are being combined through information-seeking research. The emphasis is on cognitive search strategies.

Access, in this chapter, is defined as the point at which the user meets the information system. It is characterized by physical, social, and technical components. Physical issues associated with access include workspace, remote access, building and facilities design, and geographic availability.

Social issues include public policies and laws, cultural factors, and users' attitudes and beliefs. Technical issues include interface design, human computer interaction, and attributes of the technologies. Access research can be characterized in the following ways:

- Access research related to the use of OPACs can be applied to understanding emerging technologies such as CD-ROM, Internet, and full-text databases.
- Methods commonly used in OPAC research are surveys and questionnaires and transaction log analyses.
- Areas such as workspace use, the interaction of facilities, remote access, and geographic accessibilities could use methods and theory from human factors such as person-environment fit.
- Human-computer interaction, interface design, and evaluation research from other content areas is applied to research in the technologies of information access in libraries and information centers.
- New technologies such as CD-ROM, multimedia, and Internet demonstrate merging of features from more-established technologies. Continuing research on common issues such as front-end design, menus and commands, direct manipulation, and graphics retrieval could benefit all access technologies.

Information research examines both the structure and content of information. It looks at how to define and categorize information and the processes used to retrieve information that are not transparent to the user. Information research considers barriers and constraints related to who has access to what kinds of information at what cost. Information research can be characterized in the following ways:

- Cognitive science is a theoretical foundation for information retrieval and storage research.
- Research in information retrieval strategies that connect the user interface and the information storage system uses statistical/probabilistic and cognitive methods.
- Expert systems that provide multiple search strategies can be applied across information technologies such as CD-ROM, hypermedia, and multimedia.
- Information storage looks at both original information and information representations in all formats.
- Research on policy issues related to government and private ownership and access is a growing concern in LIS.

Longitudinal studies such as those by Dervin, Kuhlthau, and Saracevic can contribute to understanding how users, access, and information issues are an integrated process. Different theoretical foundations and methodologies can be applied to studying information access with positive results. Each provides a viewfinder on the overall process. One significant contribution to information access research would be the development of models based on theory which integrate components from various research projects. The following models have been created and perhaps could form a foundation for comparison and examination of crucial aspects of the information access process:

- Bates (1986), subject access in on-line catalogs
- Belkin (1980), anomalous states of knowledge
- Brown (1991), information-seeking behavior
- Dervin (1992), user sense making
- Fidel & Soergel (1983), conceptual framework for bibliographic retrieval
- Hert (1992), information retrieval interfaces
- Kuhlthau (1993a), information search process
- Meadow (1992), information retrieval
- Saracevic et al. (1988), information seeking and retrieval

25.7.2 Relevance of Information Access Research to Educational Communication and Technology

In a wide-ranging review of literature and research, Palmquist (1992) discusses issues relevant to the impact of information technology on the individual. The emphasis on how computer-based technologies affect the individual is particularly relevant to the research of educational communication and technology (ECT). The individual's need for social experience is a critical element of education and instruction. One of the ongoing criticisms of computerization of instruction is the potential for mechanizing and dehumanizing the learner. The effect of electronic technologies in isolating individuals is reviewed by Palmquist. Topics such as electronic dating, intolerance of boredom, and computer hackers are investigated. In addition, Palmquist reviews issues of cultural shifts, the use of television to acquire synthetic culture, and dissolution of identifiable roles due to increased information access. Other areas for examination include the individual at home and the individual in the community. These social impacts of computer use on the individual can provide an arena for further discussion and evaluation in ECT research.

The social environment of the workplace has been particularly affected by information technology (Palmquist, 1992). One group of researchers sees social interactions becoming minimized due to technologies like e-mail, fax, teleconferencing, and group-decision support systems. Other researchers see these new technologies as increasing cohesiveness and decreasing group tensions and difficult problem situations. De-skilling is a common concern among researchers looking at information technology and jobs. The quality of worklife and job satisfaction are also part of the complexity of changes that information technology is bringing. The area of instructional design and development within ECT may wish to examine these social influences on the training environment.

Palmquist (1992) concludes by indicating that the overall impact of information technologies on the individual is still primarily unknown. Many of the technologies are new and still novel. Their influences cannot be accurately assessed. There is evidence that household management may be improved by computering technology, but it also results in an increase in loneliness and lack of social integration. Infor-

mation technology can both enhance and detract from job satisfaction and the overall quality of worklife. Integrating some of the questions and problems posed by Palmquist into the research of ECT could provide an added social dimension to understanding the impact of access technologies on users and their acquisition of knowledge.

Library and information science literature related to information access can also contribute specific understandings, methods, and theory for consideration by ECT researchers. The strengths of traditional LIS research for ECT to consider are: information-seeking strategies, on-line public access research methods, and information retrieval techniques. Each of these three areas has built a tradition of theory, research methodology, and ongoing findings that could be added to the existing knowledge within ECT. LIS research complements and adds to the research of ECT. Two new LIS research areas could provide relevant theory and methodology for ECT researchers: social construction of technology (Case, 1991; Pfaffenberger, 1990) and information gatekeepers (Metoyer-Duran, 1993a, 1993b, 1993c). Social construction of technology looks at the relationships between technology, principle actors, social artifacts, and the process of integrating technology into the environment. Metoyer-Duran's work on information gatekeepers demonstrates the positive effects of community and individual involvement with information in ethno-linguistically diverse communities.

25.7.3 Conclusions

There are strengths and areas for further development in LIS research about information access. Information access is an interdisciplinary and growing research area because it cuts across psychological, sociological, political, economic, and technical issues. The technicalities of information retrieval that are related to computers and mathematics cannot be separated from the social issues about who will be allowed access and at what cost. The human factor design issues of how to create effective interfaces cannot be separated from the needs, preferences, and changing strategies of the user over time and space. The effect of users with special needs and interests cannot be separated from the technological limitations created by the economic environment. The increasing number of access tools and multiple methods for accessing information cannot be separated from the instructional and educational needs of the user. The issues of information access are related and interdependent. Some researchers and research areas will focus on different pieces in greater or lesser depth, but it is important to look at larger issues and draw together the research from various areas at points in time. This chapter attempts to make the research of LIS more accessible to educational communication and technology researchers.

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