The Dynamics of Classification Systems as Boundary Objects for Cooperation in the Electronic Library

HANNE ALBRECHTSEN AND ELIN K. JACOB

ABSTRACT

THE NOTION OF THE CLASSIFICATION SCHEME as a transitional element or "boundary object" (Star, 1989) offers an alternative to the more traditional approach that views classification as an organizational structure imposed upon a body of knowledge to facilitate access within a universal and frequently static framework. Recognition of the underlying relationship between user access and the collective knowledge structures that are the basis for knowledge production indicates the dynamic role of classification in supporting coherence and articulation across heterogeneous contexts. To this end, it is argued that the library should be an active participant in the production of knowledge, and that this role can be effected by the development of classificatory structures that can support the needs of a diverse information ecology consisting of a complex web of interacting agents, users, and technologies. Within such an information ecology, a classificatory structure cannot follow a one-size-fits-all paradigm but must evolve in cooperative interaction between librarians and their user groups.

INTRODUCTION

A bibliographic classification system is intended to provide both an overall structure for a document collection and a set of concepts that will guide the information searcher into the knowledge domains encompassed by the collection. Traditionally, classification research has approached these objectives by developing schemes based on a one-size-fits-all-search-

Hanne Albrechtsen, The Royal School of Library and Information Science, Copenhagen, Denmark
Elin K. Jacob, Indiana University, Bloomington, IN 47401
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ers paradigm—i.e., We have created a standard system, because, deep down, all users are the same. Such classificatory tools often fail to fulfill their function of supporting the searcher's access to, and navigation through, the domain structure. In most databases, including catalogs on the Web, the searcher may find it difficult to comprehend the organizational structure that has been imposed upon the materials. This is not due simply to the often exotic notations of a scheme or to the surface characteristics of the classificatory data. Rather, the problem is often a product of a lack of match between the structure imposed upon the retrieval system by the classification scheme and the user's individual knowledge structures and search strategies.

Classification research has responded to this problem by collecting the terminology of individual users and compiling the results to generate larger, broader, and, it is hoped, more successful sets of access points for users—i.e., If we design an end-user thesaurus, that should do the trick. In his recent book on information seeking and subject representation, Hjørland (1997) argues that such endeavors to compile end-user vocabularies are generally conducted without recourse to an underlying theory of knowledge. Because failure of the classificatory structure to support user access is generally interpreted as a mechanical question of matching between different individual knowledge structures—i.e., among those of the searcher, the author, and the librarian as mediator (compare, for example, Ingwersen, 1992)—the underlying relationship between user access and the collective knowledge structures that are the basis for knowledge production has not been widely recognized.

From the perspective of the sociology of science, Star (1989) has argued that the Turing test, which is intended to measure the degree to which an expert system is able to perform as a human expert in its interaction with individual users, should be replaced by a "Durkheim test," where the system is evaluated on its ability to support the goals of a specific community of users. Star points out that scientific work is not all one piece but is distributed and heterogeneous, with differing viewpoints emerging only to be reconciled within the existing knowledge base. In her view, information systems should not be designed simply to represent consensus but to accommodate the dissent that can be expected to appear among the various communities participating in their use. To this end, she brings forward the concept of boundary objects as a method for resolving problems of heterogeneity in knowledge production and use or, in terms of library and information science (LIS), problems of variation or inconsistency in the representations by information producers, information mediators, and information users.

In this article, we will investigate how classificatory structures can act as transitional elements or boundary objects (Star, 1989) to support coherence and articulation in the heterogeneous and sometimes distributed

contexts where knowledge is produced and mediated. In particular, we will review, within the context of the library, two perspectives put forward by Hjørland (1997) and by Star (1989) that analyze information systems as dynamic social constructs. We will build an analogy between a scientific enterprise and the library as an active participant in the general production of knowledge and use this analogy to develop a view of modern classification research that engages the library directly in the development of classificatory structures that can accommodate information searching by heterogeneous user groups. Following Nardi and O'Day (1996), we regard the library as a diverse information ecology, comprising a complex web of interacting human agents, users, and technologies. And we will argue that, within such an information ecology, a classificatory structure cannot follow a one-size-fits-all paradigm but must evolve in cooperative interaction between librarians (and other information intermediaries) and their user groups. In this context, we draw on examples of information systems in Danish public libraries—i.e., the Book House (Pejtersen, 1980) and Database 2001 (Albrechtsen, 1997).

Classification Systems: From Rationalism and Empiricism to Social Constructivism

Hjørland (1997) argues for a philosophical and sociological orientation for classification research. In his view, the problem of the searcher's uncertainty is a function of relative task uncertainty in the user's problem domain. Because information searching takes place within a particular social framework—e.g., an academic discipline—task uncertainty in searching is often the result of the relative task uncertainty within the discipline itself. Albrechtsen and Hjørland (1994) have earlier shown how such task uncertainty within knowledge domains may be a function of various social factors involved in the production of knowledge, such as the degree of interdisciplinarity or maturity within a domain. Such uncertainties will not only be manifest in the searchers' difficulty in formulating queries for IR-systems but will also be inscribed in the relative plasticity and variety of the concepts and terminology applied within the domains.

Classification research has too often neglected such broader social backgrounds that inform information searching and knowledge organization and has relied, more or less implicitly, on either a one-size-fits-all paradigm (rationalism) or on the accumulation of data about user behavior (empiricism). While the rationalist approach argues that we just need to get everyone to understand this, the empiricist counters that we just need to get more data about users and proceeds to collect more or less meaningful sets of "facts" on the individual user's relative success measured as the number of "hits" resulting from a series of search queries.

Figure 1 divides the different approaches to classification research and practice into two broad epistemological categories: Rationalism/

Empiricism on the one side and Historicism/Social Constructivism on the other. Both rationalism and empiricism are based on assumptions regarding the nature of truth and the objectivity of knowledge. From the empiricist approach, knowledge is reduced to sensory observations or facts. In classification research, empiricism is the prevalent epistemology in bottom-up thesaurus construction based either on user warrant or on terminology warrant, particularly when the process lacks grounding in a theory of knowledge. In contrast, rationalism strives to reduce knowledge to an all-embracing structure of concepts that is intended to be universally comprehensive. It is, for example, the epistemological foundation for Ranganathan's notion of universal facets. Rationalism is also closely related to more sociopolitical actions undertaken by a particular agency or from a specific disciplinary viewpoint—i.e., actions which are intended to impose one view of knowledge on all research and practice within that domain. In a paper discussing the role of dialogue in the development of classificatory structures, Jacob and Albrechtsen (1997) have shown how the American Psychiatric Association's construction of *DSM-IV* (American Psychiatric Association, 1994), the international classification for mental disorders, used dialogue to create a device for marginalizing and eliminating the viewpoints of competing professions such as psychology (see also Kirk & Kutchins, 1992). In short, both empiricist and rationalist approaches to classification are primarily looking for invariant *structures* that can be imposed on encyclopedic knowledge (universalist approaches) or data compiled from local observations (e.g., grounded theory approaches).

In contrast to these more formalized structure-seeking approaches to classification, social constructivism, or historicism, offers a view of knowledge as a product of historical, cultural, and social factors, where the fundamental divisions and the fundamental concepts are products of the divisions of scientific/cultural/social labor in knowledge domains. According to a social constructivist epistemology, the concepts and the structures are inseparable in a classification system, and hence the schemes must reflect the development, variety, plasticity, and use of both within a particular knowledge domain. This implies that scheme designers are not primarily looking for ways to impose one single structure on knowledge, including one set of all-embracing facets. Rather, the designers should operate as "epistemic engineers," attempting to articulate and represent the dynamics of knowledge in such a way that the searcher can proceed from the topic of his initial query to other related perspectives on the same topic or to related materials within the same knowledge domain. In this manner, epistemic engineering of classificatory schemes can provide for multidimensional classification schemes where the concepts are represented in a variety of different conceptual structures, functioning to articulate the multiple discourses performed in different domains. In the

	Rationalism/Empiricism	*Historicism/Social Constructivism*
Basic view on knowledge in information systems:	Knowledge is infallible and objective.	Knowledge is historically, culturally, and socially determined.
View of concepts in information systems:	Concepts are objective and exist as modules of knowledge or universal facets.	Concepts are culturally determined, domain-dependent, and evolve from experience and use.
View of language and dialogue:	Dialogue is secondary to objective knowledge and can be controlled through standard classifications. Example: *DSM-IV*	Dialogue is central to knowledge production and mediation and should be facilitated, not controlled. Example: HIV/AIDS vocabulary
View of information systems and their designers:	Information systems are value-free gateways to knowledge. Designers are engineers whose primary function is to exert control in support of performance.	Information systems are meaningful historical products—social and cultural constructs. Designers are epistemic engineers and knowledge catalysts whose primary function is facilitation.
View of mediating tools, such as classifications systems:	*What* is a classification?	*When* is a classification?

Figure 1. Division of the Approaches to Classification and Research.

role of epistemic engineer, then, the scheme designer operates as an active participant in the process of knowledge production and mediation.

Such involvement on the part of the classificationist is particularly evident in areas of interdisciplinary research that engage participation from many different professions. The HIV/AIDS vocabulary, developed by Huber and Gillaspy (1996), provides an illustrative example of such involvement on the part of the scheme designers. This system, which was not intended as a classification per se but as a mediating vocabulary, was developed to support dialogue between the different communities involved with the HIV/AIDS epidemic, including clinical and medical researchers,

practitioners of alternative medicine, nutritionists, psychotherapists and other professionals, as well as those individuals who are either living with the disorder themselves or are caring for someone who has contracted the disease. The HIV/AIDS vocabulary is built on a theory of knowledge generation that explicitly eschews the standard life cycle for knowledge production in medicine—a knowledge cycle that proceeds in a top-down fashion from theory developed at universities and other research institutions, to applied clinical research, to daily clinical application. Rather, according to the epistemological view driving the HIV/AIDS vocabulary, research in lived experience must necessarily feed into basic clinical research. Accordingly, this scheme was not developed solely as a tool for retrieval of information in the database of the local community, but as a tool for facilitating communication both within and across diverse interest groups, from the so-called layman to the cloistered scientist. In its role as communicative facilitator, the scheme is also hospitable to adaptations and extensions as an indexing language in local contexts. For instance, specific drug names are not articulated in the scheme but are left to local instantiations of the indexing language. In Star's (1989) terms, the HIV/AIDS scheme serves as a boundary object precisely because it supports cooperation and common understandings among the various interest groups touched by this epidemic.

Classification and Boundary Objects

The notion of "boundary objects" was developed by Star (1989) as a structure for coordinating distributed work, such as may occur with a scientific enterprise that not only involves heterogeneous actors, elements, and goals but also incorporates different research methods, values, and languages. From her field work with scientific communities, Star has found that scientists are able to cooperate without consensus or shared goals. They can work together successfully because they create objects that function in the same way as a blackboard in a distributed artificial intelligence system:

> I call these *boundary objects*, and they are a major method of solving heterogeneous problems. Boundary objects are objects that are both plastic enough to adapt to local needs and constraints of the several parties employing them, yet robust enough to maintain a common identity across sites. They are weakly structured in common use, and become strongly structured in individual-site use.
>
> Like a blackboard, a boundary object "sits in the middle" of a group of actors with divergent viewpoints. Crucially, however, there are *different types of boundary objects depending on the characteristics of the heterogeneous information being joined to create them.* (Star, 1989, pp. 46-47. Emphasis in original)

Accordingly, Star (1989; Star & Griesemer, 1989) has identified different types of boundary objects in her various case studies, including:

- *repositories*—databases, libraries, or museums;

- *ideal types or platonic objects*—diagrams, atlases, or abstract concepts such as, for example, the concept of "species" used by both the creators of a zoological museum and other interested parties involved in its construction;
- *coincident boundaries*—common objects with the same boundaries but having different internal contents, such as maps of a geographical area that cover the same terrain but are outlined according to different knowledge interests such as, for example, the life zones identified by biologists contrasted with the trails and collection sites identified by museum conservationists;
- *standardized forms*—forms created as methods of common communication across distributed work groups such as, for example, the forms completed during field work or the cataloging formats used for cooperation and networking between libraries where the content fields may or may not be part of each repository's database.

Unlike the model of the ideal universal computing machine whose goal, as proposed by Turing, is to emulate individual human mental capacities in all domains, boundary objects are advanced as an ecological concept—i.e., a concept that respects local contingencies and the viewpoints of different knowledge interests. In a case study on the formation of Berkeley's Museum of Vertebrate Zoology (Star & Griesemer, 1989), a classificatory structure of the species and subspecies of mammals and birds in California constituted an important boundary object. Thus the scientific classification scheme served as a shared conceptual structure and provided a shared vocabulary that facilitated communicative exchanges and cooperation across the different social and intellectual worlds represented by the scientists and the groups of amateurs who were involved in building the museum's collection.

Although they approach the problem of classificatory structures and knowledge access from two different angles, Star's exposition of the communicative and integrative functions of classificatory structures in the general knowledge production of the sciences is closely related to Hjørland's (1997) discussion of the epistemological positions adopted in classification research and his argument for following a more pragmatic philosophy of classification. Star builds on case studies and theoretical work in scientific communication and knowledge production, while Hjørland builds on case studies and theoretical work in the area of information searching for knowledge production. Both argue that classifications always serve pragmatic purposes in the same way that science serves human action. According to Hjørland's theory, scientific classifications reflect a highly abstract and generalized method of knowledge organization, in contrast to classifications with more local contingencies, such as categorizing fruit and vegetables in a supermarket or the amateur horticulturist's

categorization of plants by use or cultural preferences. Such variations in taxonomic structure could be argued to reflect different levels of ambition among the interested parties and thus to function as boundary objects, created and negotiated by different social worlds, with the scientific structure functioning as a more specific taxonomy dictated by the needs of the scientific community itself. However, with respect to its specific role within the praxis of a formal disciplinary community, the scientific taxonomy is just as concrete as the pragmatic systems of classification that reflect local contingencies. Indeed, when viewed from a broader sociological perspective, these latter systems may actually be interpreted as more abstract or generalized.

The Role of Classifications in Diverse Information Ecologies

American anthropologists Nardi and O'Day (1996) have introduced the concept of "diverse information ecology" to describe the sociotechnical network of heterogeneous materials, people, and practices that constitutes a modern library:

> What we learned in the library suggests the possibility of a socio-technical synthesis, an opportunity to design an information ecology that integrates and interconnects clients, human agents and software agents in intelligent ways congenial to extending information access to, potentially, all of humanity. As we design the global information infrastructure, the ultimate goal should be to design an ecology, not to design technology. (p. 83)

Because information ecologies are situated within human practice, they are dynamic and constantly changing. An information ecology cannot be controlled by any one single agency but evolves through the collaboration of heterogeneous socio-technical networks, whose elements strive constantly to achieve coherence and wholeness. The notion of an information ecology also implies a collective view of information systems as striving to meet heterogeneous community goals rather than the goals of a single agency or individual. In their study of two research libraries in software companies in the United States, Nardi and O'Day (1996) explored how the work practices and expertise of librarians can serve as a model for the design of computerized information services. They found that librarians are exemplary agents who evince particular expertise not only in communicating with users but also in searching for information. These two skills are closely interrelated in that the librarian's search strategy tends to evolve in collaboration with the user's project. Nardi and O'Day propose to extend this working relationship between the librarian and the user to the collaborative design of information ecologies.

In an information ecology, a classification system should function as a boundary object, supporting coherence and a common identity across

the different actors involved. In its role as boundary object, a classification would be weakly structured in common use, while remaining open to adaptation in individual communities. Across diverse information ecologies, classification schemes would function as discursive arenas or public domains for communication and production of knowledge by all communities involved. This approach to the development of classification schemes also implies that the task of constructing such a scheme would no longer be invisible work. This view of classification systems is in line with the concept of "coordination mechanisms" in distributed collaborative work, as put forward by Schmidt and Simone (1996). More importantly, the understanding and appreciation of classification schemes as boundary objects and discursive arenas, in cooperation with heterogeneous user groups and technology, engages the library as a facilitator of connections and ensures its continuing participation as an active contributor in the general process of knowledge production.

In the following discussion, we will illustrate how the role of classification systems is changing within the information system that is the library, shifting from reliance on a single standardized or mainstream view of order, where classification is the invisible precursor to the organization of a collection, toward the creation of more diverse information ecologies, where the development of a classification scheme takes place within an arena of discourse to create a shared order across heterogeneous social worlds.

Something Old, Something New, Something Universal, Something Local

As indicated in Figure 2, classification systems have served different pragmatic purposes in the history of libraries and information retrieval systems. In a recent European study of public libraries in the information society (Thorhauge & Segbert, 1997), it was demonstrated that public libraries have progressed through three distinct stages, evolving from manual paper-based services, via the automated library, to the current phenomenon of the electronic multimedia library. This progression should not be understood to imply that the current status of libraries has been driven entirely by technology. Rather, the electronic multimedia library must be understood from a more integrated socio-technical point of view, where the various actors, including librarians, computer suppliers, and researchers in computing and information science, constitute a heterogeneous network of agencies that bring certain technologies to the foreground while marginalizing others. In the recent development and use of communication technology, for example, there is a convergence of hitherto separate, even disparate, media and activities. This is apparent in the development and application of Web technology, which integrates text-based materials, graphic illustrations, and audio materials with interactive

features such as online conferences and e-mail. It is characteristic of this development that the technology is not only plastic and customizable to almost any context of use, rather like a boundary object, but is constantly renegotiated and redeveloped through such use.

	Manual Paper-Based Services	*The Automated Library*	*The Electronic Library The Digital Multi-Media Library*
Primary means of access to knowledge:	Collection building.	Circulation, acquisition, stock control, etc.	Local access to global information. Networking.
Technology:	Cards, phone, fax.	IT for housekeeping functions. OPACs.	Internet multimedia Web catalogs.
Organizational culture:	Introvert and bureaucratic.	Some change in attitude toward users.	Project oriented culture.
Role of classification systems:	Order and control of collections. Invisible work.	Order and control. Subject access via OPACs. Some experiments with thesauri.	Support of dialog in information services. Integration and infrastructure in diverse information ecologies.
Examples from Denmark:	DDC is adapted and maintained in Denmark by central agency.	Verbal indexing in Danish national catalog.	Local experiments with classification and indexing in Danish public libraries.
Dominating classification research approach:	Development of standard, universal classifications.	Indexing, thesauri. OPAC R & D. Automated indexing.	Communication studies. Domain analysis and science studies. Social construction of classificatory structures.

Figure 2. Classification Research and Use in Different Stages of Public Library Development.

In the recent past, manual paper-based libraries focused on collection building. Intermediaries, or librarians, served both as collection builders and as agents controlling and interpreting the order of the libraries. Classification systems were frequently standardized in order to support interlibrary cooperation with the result that classification research was itself dominated by the development of universal schemes which could be adopted by central agencies to control the organization of knowledge across libraries. As a result of such standardization, classification became invisible work performed without regard to the needs of the local community of users. And, because maintenance and development of these classification schemes was often based on literary warrant, reflecting only those subjects represented in large national collections, they can be interpreted as imposing an implicitly empiricist view of knowledge. There was, then, at this stage in the library evolution, a mix of rationalist and empiricist epistemologies underlying classification research and development.

The role of the librarian as intermediary was challenged during the 1980s by the development of online retrieval systems and, in particular, by the introduction of online public access catalogs (OPACs) for end-user searching. During this decade, classification research was dominated by work on thesauri and indexing systems. There were numerous experiments with automated indexing, including the application of text analysis techniques developed in computational linguistics. OPAC development was often based on studying users, sometimes in naturalistic settings, but generally without prior analysis of their different social worlds or the functional role of libraries in knowledge production and mediation. Research in information retrieval systems was very much oriented by a mechanistic conception of human competence in information searching, indexing, and classification, thereby neglecting the variety and heterogeneity with which human agents (both librarians and users), information sources, and technology interact in different settings. Furthermore, as technological fixes were thrust to the foreground, displacing the search competence of the librarians, the librarian's role as intermediary between the searcher and the collection was gradually becoming marginalized as invisible work—the preliminary work of representing and organizing the collection that occurs in isolation from, and therefore without recognition by, the users.

During the 1990s, the library has increasingly switched its service emphasis from building and guarding the collection or offering users access to the collection through the local OPAC to providing local access to global information resources available on the World Wide Web. This represents a shift from a closed to an open system. In some European public libraries, for example, traditionally introverted and bureaucratic organizations have migrated toward a project-oriented culture, where librarians and users cooperate on the development of new services, using the interactive affordances of Web technology and the Internet. In general, such

projects have not involved the library schools in Europe, the traditional research communities in the library and information sciences. Close cooperation between libraries and the community of LIS researchers in Europe has yet to be manifested (Albrechtsen & Kajberg, 1997). In the United States, communities of LIS researchers have come together in workshops and research projects related to the social informatics of what are called "digital libraries" but could equally well be termed "electronic libraries" (Bishop & Star, 1996). In this research area, major topics include how knowledge is structured in digital libraries, including cataloging and classification, and how digital libraries are used—i.e., how knowledge is produced, communicated, applied, and recycled in distributed social worlds. Research methods comprise ethnographic studies of communication and knowledge production in (digital) libraries as well as comprehensive sociological studies of professional classification schemes in medicine (Bowker & Star, 1994) and nursing (Bowker, 1996). Thus it seems apparent that classification research is gradually evincing a more sociological and historical orientation.

Classifications as Boundary Objects in Libraries: Librarians and Users in Mutual Design Activity

Ballerup Public Library is a medium-sized Danish library on the outskirts of Copenhagen. There is, in this library, a tradition of direct collaboration between the librarians and their users. Until recently, a majority of the librarians regarded themselves as cultural workers—as intermediaries between collection and user, very much in line with the traditional perspective described above for libraries in the manual stage. In 1995, the library started a new project called Database 2001. This project, which was evaluated by Albrechtsen (1997), involved the development of an enriched multimedia catalog on the Web. In addition to the evaluation researcher, the project group for Database 2001 included six librarians with different areas of expertise: several in the group were experienced intermediaries and online searchers, while others were specialists in catalog design and in the management of the library's technological resources. However, none of the librarians had experience with Web design or Internet browsing.

During the development of Database 2001, the project group collaborated with user groups and colleagues in the library to identify different kinds of materials, including books, musical recordings on CD, CD-ROMs, and audiotapes of books. Text, pictures, and sound were selected as enrichment for the database, the idea being to emulate a kind of virtual library on the Web. The menus were designed as graphical layers of icons representing both user groups and the kinds of materials available. The subject icons in Database 2001, which represent the subject content of materials in the database, went through several iterations. In addition,

the interface designed for browsing the menus was customized for both children and adults. The librarians arranged evaluation sessions with users who represented different user communities and their evaluations were very positive; users with different interests were able to use the icon-based interface for browsing in the database even though they had very different interests and different goals for searching.

In the database, documents were indexed using standard call numbers from the Danish variant of the Dewey Decimal Classification (DDC). Even though indexing by class number would take advantage of the hierarchical structure of DDC and thus would be potentially useful for browsing by users, the librarians knew from their practice as intermediaries that users found it very difficult to understand the standard classification. They experimented with a more pragmatic and much more weakly structured classification which could reflect the kinds of questions actually posed to library staff by the different user groups. For example, for subject browsing by children, they worked with the seven categories listed below and designed a unique icon to be used on the Web site:

1. computers;
2. astronomy, nature, animals, environment;
3. first love, star signs, being young today;
4. horses;
5. excitement, humor;
6. fantasy, science fiction; and
7. books that are easy to read.

From a semantic or disciplinary point of view, the separation of subjects like animals and horses would appear to be "incorrect" or "illogical." For the children, however, this classification worked very well. Category 2 (astronomy, nature, animals, environment) was intended for a broad group of interests, including fact literature, whereas category 4 (horses) was intended, in particular, for girls interested in novels about horses. There is, in Denmark, a special research tradition within children's librarianship, based on Wanting's (1984) research on how children ask questions in libraries, that advocates mediating literature according to the different user interests of children. Pejtersen (1994) has also studied children's use of libraries in Denmark and their communication with librarians. In her development of the Book House system in the 1980s, Pejtersen used a collaborative prototyping approach, engaging librarians, information scientists, and users in Danish public and school libraries, and subsequently designed a special interface of subject icons for browsing of the Book House system by children. Database 2001 took advantage of both of these research approaches to children's information searching.

The Book House (Pejtersen, 1994) is a retrieval system for fiction and is based on a general conceptual model that seeks to surround users with

an adequate resource space within which to situate their own search spaces. The design involves multidimensional representations of different kinds of user needs, search strategies, and literary paradigms as well as authorial intentions. This multidimensional structure for subject access is intended to match the different levels of user interest. The system interface is constructed around the metaphor of a "house of books," guiding the users through the rooms of a library where they can browse the collection. Users can also switch between different search strategies, including analytical search in the multidimensional database structure, visualized as icons for each dimension, and browsing of subjects, visualized as icons in a picture gallery. The design of these icons involved classification experiments using both word association experiments and evaluations of suggested icons in Danish public libraries.

The icons for browsing subjects in the Book House and in Database 2001 serve similar functions—to provide the users with an overview of the subjects included in the databases. Because the Book House system builds on the central design metaphor of rooms in a library, it provides a single uniform interface. Database 2001, in contrast, is realized as a mixture of interfaces that include the Web layer of icons, designed by the librarians; a more or less standard search client offering conventional text-based searching; and a database structured according to a standard cataloging format that uses traditional call numbers to represent the subject content of the documents. While the Book House is a general system for fiction retrieval, which in its present form cannot be customized by individual libraries to support the idiosyncratic needs of specific user communities, Database 2001 is a localized experiment with system design and classification drawing upon a range of technologies that reflect the heterogeneity of tools used in today's libraries, from conventional customizable applications such as the closed systems of the database and the search client to the open systems supported by interactive Web technologies.

Collaborative Development and the Agency of Libraries

Both the Database 2001 project and the Book House system were realized using a collaborative approach among librarians, users, researchers, and technicians. In this way, users were involved in negotiating classificatory structures and the design of subject icons in the interfaces of the two systems. Because the Book House was a new approach for interface and database design in the 1980s, it had to be developed technically from scratch. Database 2001, on the other hand, was able to take advantage both of the design ideas generated during development of the Book House system and of the possibilities for integrating modern Web capabilities within existing technology. The process of designing an interface adapted for local needs quite naturally involved local experiments with

classification. In Database 2001, the graphic Web layer and its icons were intended to represent both the users' needs and the existing technology. Decisions regarding the subject icons, as well as those pertaining to the search client and the database, were determined as much by the users as by the demands of the Web technology itself. Thus the icons employed in the graphic interface constitute an integrated system of boundary objects that mediate among the library, the users, and the technology. In this way, Database 2001 exists as an open system in that it makes the library available not only to local users but to other users as well through the medium of the technology. Without the interface of icons, the system would have been technically open but conceptually closed.

Design of the Book House and Database 2001 involved heterogeneous human actors, elements, and goals, which are also found in Star's (1989) description of a scientific enterprise. Star draws upon the example of a scientific enterprise to put forward a more collective concept of design than the psychological approach generally employed for the design of AI systems. Traditionally, design of library systems is based on a consensus model, or a one-size-fits-all approach. Multidimensional classifications providing different views of concepts in IR systems are still the exception (Albrechtsen & Hjørland, 1994; Jacob, 1994). But in the Book House system and in Database 2001, classificatory structures can perform as boundary objects by accommodating both the heterogeneous information needs and the various search strategies of different user interests as well as different knowledge communities.

Figure 3 juxtaposes some important boundary objects developed in the Book House and Database 2001 with Star's typology in order to illustrate the analogy between boundary objects in a scientific enterprise and the creation of a library system. Obviously, this analogy between the library and a scientific enterprise, even when supported by parallel structures, does not establish that what goes on in a library is isomorphic to what goes on in a scientific enterprise. Hjørland (1997) has proposed a theory of classification at multiple levels, from specific classifications developed in accordance with local contingencies to those general classifications developed by the so-called "hard" sciences, such as biology and medicine. However, analysis of the role of dialogue in the creation of classificatory structures indicates that traditional classification schemes frequently function as control structures that forestall an interpretive approach to scheme design through the imposition of controlled vocabulary that limits the impact of dissonant viewpoints (Jacob & Albrechtsen, 1997). In this manner, current developers of classification systems do not function as epistemic engineers, creating a discursive arena or forum for multiple views of knowledge, but rather as engineers of one episteme or worldview seeking to control the flow of knowledge production within a given domain by systematically legitimizing a single universal classificatory scheme,

thereby disenfranchising those researchers and practitioners who do not participate in the resulting structure.

Star's Types	*Book House*	*Database 2001*
Repositories:	Database with multiple orderings of information. Multiple kinds of materials.	Enriched database.
Ideal type:	Icon for subjects and ordering dimensions. Multimedia enrichments.	Icons for subjects and target groups.
Coincident boundaries:	Design metaphor. Rooms in library.	Web pages. Interactive features (e-mail etc.).
Standardized forms:	Database structure.	Database structure.

Figure 3. Boundary Objects in the Book House and Database 2001 Viewed in Relation to Star's Typology of Boundary Objects.

In general, however, the library and its organizational structures must be viewed as important actors in the general process of knowledge production because their primary goal is to mediate between knowledge producers and users. This role is generally realized through the provision of information services to users and producers who are very often members of the same knowledge communities. Although the scenario sketched here is traditionally understood as a closed world—i.e., where librarians mediate between documents and users— it could equally well be described as an information ecology—i.e., as a practice that builds environments by bringing together heterogeneous materials and actors.

The librarians' practice of building information ecologies is based on both explicit and tacit knowledge. The explicit knowledge is typically based on principles and formalisms for presenting classificatory structures in the form of universal classifications or faceted thesauri. The tacit knowledge includes knowledge of the interests of their user communities, the users' levels of computer and information literacy, and preferred tactics for "mediated" versus "unmediated" information services. In mediated services, the librarians communicate with the users, either directly or by e-mail, and guide them to relevant information sources. In unmediated services, such as the Book House system or Database 2001, the users may search a card catalog, a database, or a contingent local classification scheme prior to browsing the conceptual space within a domain. Such

"unmediated" services are, in fact, "silently" mediated by librarians or other information professionals who designed or customized a conceptual space for end-user searching. The librarian's service to the users has been "translated" or formalized through the classification scheme. It has been abstracted or "disembedded" from the work context of a human intermediary interacting with a user.

Following Star and Strauss (1999), much of the mediating practice of librarianship may be considered "invisible work." Even though the librarian as human intermediary is visible within the traditional library setting, his or her work is frequently considered to be "background work" involving the identification and delivery of books or other materials in support of the "real thing"—i.e., the user's immediate work task or particular interest. When the work of the intermediary is abstracted from the work setting, this "invisible work" may become "visible" in that the task now falls to the user, but the dialogue between the user and the intermediary is effectively silenced. No longer is there a human intermediary to inform the user and ensure equality of services.

Gross and Borgmann (1995, cited in Bishop & Star, 1996) point out that: "Even home shopping requires informed consumers" (p. 904). When the librarian's mediation work is silenced in the high-tech home shopping environment of electronic libraries—when the task of the user is no longer supported by, or facilitated through, dialogue with the human intermediary—some users will not be informed but will be reduced to mere consumers of standardized information services. Obviously, then, the information ecology of the electronic library cannot be responsive to the needs of the individual user without achieving a balance between visible and invisible work. As Star and Strauss (1999) point out: "Making visible can incur invisibilities; obscuring may itself become a visible activity." In "unmediated" information services, cooperation between librarians and users in the design and maintenance of classificatory structures may be one method for achieving this balance between the visible and the invisible and for ensuring the evolution of an information ecology that is contingent upon the needs of an informed public.

Conclusion

Classification systems and indexing languages have been constructed as organizational tools in order to provide structure to a body of knowledge, but they frequently have the effect of limiting or restructuring individual conceptual structures during a process of information searching (Tang & Solomon, 1998). Established approaches to classification research and development appear to suffer from a fear of touching the real thing—the social worlds constituting an information system and the collective conditions for knowledge production. However, in LIS and the sociology of science, new approaches to classification research are emerging,

approaches that build on the idea of information systems as open and collaborative systems. A similar trend toward development of open systems has been identified in the public libraries in Europe which are evolving from manual, paper-based services to the electronic multimedia library. In the modern electronic library, classification is similarly transformed from a tool for establishment of order and control over the collection to a boundary object functioning to create cohesion across diverse information ecologies. The modern information ecology is a socio-technical network comprised of heterogeneous materials, people, and practices. Within this emerging network, the classification scheme constitutes a discursive arena facilitated by the library and functions as a boundary object for the various interests that exist among users and librarians. Such an information ecology is at the same time a situated network and an open system wherein the classification scheme supports coherence and articulation across the domains encompassed by the network both locally and globally.

The practice of classification is changing from invisible work carried out in centralized agencies to articulation work emerging within socio-technical networks. As the role of the library evolves from collection guardian to facilitator of connections, the role of classification is similarly transformed from control of collections to facilitation of communication, maintenance of coherence, and establishment of a shared conceptual context. From this perspective, then, the intelligent intermediaries of today are the human agents in diverse information ecologies who facilitate the process of knowledge production by collaborating with communities of users in the creation and use of boundary objects such as classification schemes.

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