Beyond Subject Headings

A Structured Information Retrieval Tool for Interdisciplinary Fields

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Higher education at the start of the twenty-first century is characterized by an increasing number of interdisciplinary fields. Accordingly, the library world is grappling with several important information access issues, including the need to identify relationships within interdisciplinary topics where information is proliferating and locating appropriate resources is increasingly difficult. The relevance and usefulness of controlled vocabularies such as the Library of Congress Subject Headings in emerging interdisciplinary fields and the suitability of conventional library tools for organizing and accessing digital information are in question. This paper discusses the role an ontology representing a subject domain can play in addressing these issues and uses women's studies as an example of an interdisciplinary field. This paper also proposes a methodology to identify ontology terms and their relationships in the field of women's studies that has potential application to other interdisciplinary fields.

Interdisciplinary fields in higher education are continuing to increase. Traditional organization and classification of knowledge is, in consequence, less relevant, as scholars from different backgrounds produce research that spans familiar boundaries. In response, the libray world struggles with:

- the need to identify relationships within interdiscliplinary topics where information is proliferating and locating appropriate resources is increasingly difficult;
- questions about the relevance and usefulness of controlled vocabularies, such as the Library of Congress Subject Headings (LCSH), in emerging fields; and
- the suitability of conventional library tools for organizing and accessing digital information in the age of Google.

This paper will explore the role an ontology representing a subject domain (specifically, women's studies) can play in addressing these challenges.

Noy and McGinness define ontology as "a common vocabulary for researchers who need to share information in a domain. It includes machine-interpretable definitions of basic concepts and the relations among them."[1] The ontology representing a subject domain can be used in many applications to enhance access to relevant information through its ability to explicitly specify the semantic relationship between concepts expressed in mark-up language computers can parse. The ontology can support libraries in the organization and discovery

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of information to benefit their users. Its use behind the scenes can contextualize user-generated keyword searches and direct searches to relevant library resources by mapping to corresponding LCSH in library catalogs, thus providing meaningful overlay and optimizing access to interdisciplinary information. LCSH generally expresses relationships in a hierarchical manner, through topics and subtopics. However, in interdisciplinary fields, terminology represents both peer and subordinate concepts. An ontology can provide the end user with a macro-level view of the predominant concepts and also can drill down to contextualized and domain-specific terms and relationships that can then explicitly map behind the scenes to the hierarchical approach taken by LCSH. This paper proposes a methodology to identify ontology terms useful in the field of women's studies and their relationships. This methodology has potential application to other interdisciplinary fields.

Interdisciplinarity and the Web

Interdisciplinarity requires key knowledge of the concepts in more than one field, as well as familiarity with theoretical methodologies from different disciplines. The impact of this research trend for information organization and access is significant. LCSH terms, used in libraries as subject access points in integrated library systems, are a legacy system, heavily hierarchical in design, authority-based, and slow to define and represent new terms for emerging fields and concepts. Although new headings are added regularly as a result of Library of Congress established procedures, they are still insufficient to represent the interdisciplinary relationships of current research and fields of study. In addition, LCSH terms are designed to classify information for the broadest class of users and information uses.

Another significant element that shapes the present scholarly environment is the Internet. The explosion of digital information distribution provides researchers easy access to information in all disciplines. While this new environment encourages researchers to contemplate creative and novel formulations from different disciplines, information abundance increases the complexity of traditional information gathering, raises user expectations for information discovery, and challenges the traditional, linear, subject-based access points that library catalogs provide. The ability to customize search and retrieval strategies according to use, such as curricular support or a particular research focus within a university department, becomes a critical strategy for ensuring that users find the most appropriate resources. An ontology is one tool that can overlay vast amounts of legacy cataloging to provide a specific focus for user access and enhance the catalog's relevance without requiring that materials be recataloged. For example, an ontology can be constructed

that utilizes the terminology and predominant concepts from sources, including course titles, course descriptions, and syllabi. This ontology can be used as a search tool to drill down to relevant resources through both keyword and mapped LCSH searches. Unlike a Google search, a carefully constructed domain specific ontology can insure that relevant information explicitly supporting the curriculum is always discovered.

Information Access in Women's Studies

Information access, management, and retrieval of women's studies resources have been mired in problems. Scarcity of existing resources and research tools historically required librarians to use unconventional methods for the collection of nontraditional literature.[2] The discipline's interdisciplinarity and inadequacy of coverage are addressed in the literature, along with useful evaluations questioning the coverage and appropriateness of LCSH terms.[3] Positive changes have occurred to LCSH that reflect a better understanding of the discipline and user needs, but the evaluations also found that LCSH has remained inadequate for classification and coverage of women's studies over time.[4] The use of LCSH for the representation and organization of information in library catalogs provides uniformity and consistency, but its rigidity allows little room to express relationship, context, and other attributes that often form the very identity of the resource.[5]

To illustrate the interdisciplinarity in women's studies, the author examined one topic within gender and development (women working at a Nike sneaker factory in South Korea) to demonstrate the complexity and the interrelatedness of concepts within women's studies topics, the difficulty in assigning corresponding subject headings, and the resultant arduous search strategies necessary for locating meaningful resources. To find contextually appropriate resources, a user must be versed in key concepts in economics and women's studies as well as be familiar with theoretical methodology, data, and information on East Asia. Westbrook uses the concept of "scatter" to illustrate interdisciplinary information and defines the field of women's and gender studies as "high scatter," which makes the information seeking process even more challenging.[6] The complexity of information retrieval in this highly interdisciplinary field is further magnified by the lack of familiarity with women's studies concepts among catalogers, who are often generalists providing cataloging for a multitude of disciplines.

Although established subject headings capturing women's studies concepts exist, they are often not included in bibliographic records due to the cataloger's unfamiliarity with the new terms.[7] Cataloging is a highly collaborative endeavor. Catalogers cope with an ever-increasing work-

load by relying on copy cataloging from trusted sources. This cataloging is often acquired and reused with minimal revision or no revision. Automated tools, such as subject authority systems and those supplied by vendors, provide a safety net for catalogers by matching subject headings against authoritative Library of Congress terms, thus justifying the uncritical acceptance of subject headings provided in existing cataloging records. This reliance on acceptance of existing cataloging makes the frequency with which the subject headings will be evaluated and examined unlikely in most libraries, unless the resource is local in nature, such as a dissertation or thesis at the university, or a unique resource requiring original cataloging. Subject headings are authoritative in the sense that they represent actual LCSH terms, but increasingly they are not evaluated for currency and relevance against competing terms within the LCSH.

Over time, in response to deficiencies in LCSH and compounded by attention in collecting and organizing resources on women to support scholarly and activist interests, major thesauri emerged in the United States, facilitating access and organization for women-related resources.[8] Similar thesauri were also published in Canada, Latin America, and the Netherlands.[9] Although these tools define concepts and relationships in a systematic manner, they are less expressive and flexible compared to machine-readable ontologies.[10]

Issues surrounding access to information in women's studies are an ongoing challenge for users as well as librarians. These difficulties relate closely to the existing gap between available controlled vocabularies and the representation of knowledge in a subject field. Vocabularies are cultural artifacts that evolve over time and have specific meanings within distinct subject domains.[11] In the case of women's studies, the discipline evolved from the first debates about the legitimacy of its institutionalization and the effects of discrimination against women to programs where scholars from diverse disciplinary backgrounds focus on women's issues from multiple viewpoints.[12] Changes in curriculum and research reflect new interests and new paradigms denoting a significant evolution of the field, requiring new tools for optimum information retrieval.

Continuing difficulties in access and potential solutions to the problem are illustrated by scholars' efforts to alert students to the limitations of LCSH and classification. Class readings on the limitations of controlled vocabularies and course assignments that require students to locate useful keywords demonstrate creative and unconventional efforts by scholars to overcome existing challenges to information access.[13] Access to interdisciplinary information in a particular context represents a newer and increasingly significant challenge that affects users and librarians in all disciplines, and is a serious issue for shaping future library services.[14]

Impetus for the Study

From a public service perspective, the impetus for this study was twofold: first, to address the continuing difficulty in identifying specific resources on women; and second, to provide a flexible and extensible approach to classifying information that is more responsive to faculty and student needs in a complex, interdisciplinary field of study. At the Rutgers University Women's and Gender Studies Department, two faculty members recently developed a course curriculum with a focus on the "intercultural factors underlying war and terror that encourage student understanding of gendered legacies of lived experiences, cultures and historical contexts of war and terror, and of the intercultural factors underlying these forms of human aggression."[15] The course incorporates six three-week modules that examine the intersection of gender and women with topics from other disciplines. The course module titles are "Gendered Legacies of Dirty Wars and Bureaucratic Authoritarianism," "Partitions, Nations, Gendered Identities," "Neo-Liberal Terror and the Washington Consensus: Gendered Practices," "War, Terror, Gender, and Representation: Erotic Victimhood and the Colonial Legacy," "Representation, Spectacle, and Terror," and "Gender, Sexuality, War, Empire, Militarism." The information needs for these modules defy a particular disciplinary focus and require an integrated and multifaceted approach to accessing relevant information.

The information needs for students taking the above courses force the women's studies librarian to find alternative and creative methods to adapt to the new demands for information discovery and curricular support. In online public access catalogs, LCSH terms alone often do not express these interdisciplinary and dynamic relationships. A list of useful keywords in context is always necessary to supplement the search process in order to obtain responsive quality information. The situation is no different for scholars in all disciplines who pursue research beyond the domain of their discipline. In order to support their research, librarians need to create a mechanism that concatenates disparate terms and concepts from different disciplines and place them in a specific context or structure of knowledge.

Ontology Applications in Libraries

While controlled vocabularies, such as LCSH, can provide authoritativeness, consistency, and standardization in terminology, relationships among concepts as expressed by terminology are equally critical for effective information

discovery. Much is to be gained from identifying the terms and relationships that express the structure of knowledge embedded in a domain. Recently, the development of the ontology has been used in applications on the Web, such as Yahoo!, which is based on large taxonomies categorizing Web sites, and Amazon.com, which categorizes products and their features to appeal to the potential customer. Standards, such as the Resource Description Framework (RDF) developed by World Wide Web Consortium (WC3) provide tools that make knowledge understandable to search engines and interoperable among different information systems.[16] The Defense Advanced Research Project has developed the Ontology Web Language (OWL) by extending RDF with more expressive constructs aimed at facilitating information sharing on the Web.[17] Many disciplines now develop standardized domain specific ontologies in an attempt to develop vocabularies for shared use. Biology, for example, has established Gene Ontology, which is intended to draw together information from heterogeneous sources for shared use in different fields of biology.[18] Qin and Paling introduce efforts to convert the controlled vocabulary at the Gateway to Educational Materials into an ontology to address issues in representing interrelated digital resources.[19] In any particular field, a well-defined ontology should capture the nuances of the knowledge domain as manifested in the research outputs and teaching tools by defining the concept relationships and explicit domain assumptions central to its research community.

In the context of information access, what are the advantages of an ontology representing a subject domain? Once established, this ontology can be both flexible and portable, existing as an independent information tool that interacts with other information tools and resources. For example, if several institutions create women's studies ontologies and express them using structural machine-interpretable standards, their Web sites could share and reuse the same underlying ontologies and aggregate information dynamically for different uses. The result is greater flexibility that enables reuse for different applications.

Using the previously cited example of globalization, the established heading in LCSH is as follows:

Globalization
Used for/See from: Internationalization
Search also under: International relations
                        Anti-globalization movement
                        Art and Globalization
                        Architecture and globalization
                        Education and globalization
                        Culture and globalization
                        Sports and globalization

The preceding relationship is sufficient to point successfully to general information. However, for access to information pertaining to globalization in the context of women's studies, the existing relationship is inadequate. In contrast, the following ontology on a specific facet of globalization presents a contextualized domain knowledge that establishes important relationships as it is in the field of women's studies. Figures 1 through 3 provide an example of a specific facet of globalization ontology, the relationship among concepts, as well as the ontology expressed in OWL. The proposed ontology consists of three elements:

1. class and subclasses;
2. attributes (such as property) of each concept (classes and subclasses) describing various features; and
3. instances (restrictions providing specificity for abstract concepts).

The class "Globalization" has four subclasses: "Exploitative dynamics," "International trade," "Transnationalism," and "Off-shore Manufacturing." "Off-shore manufacturing"
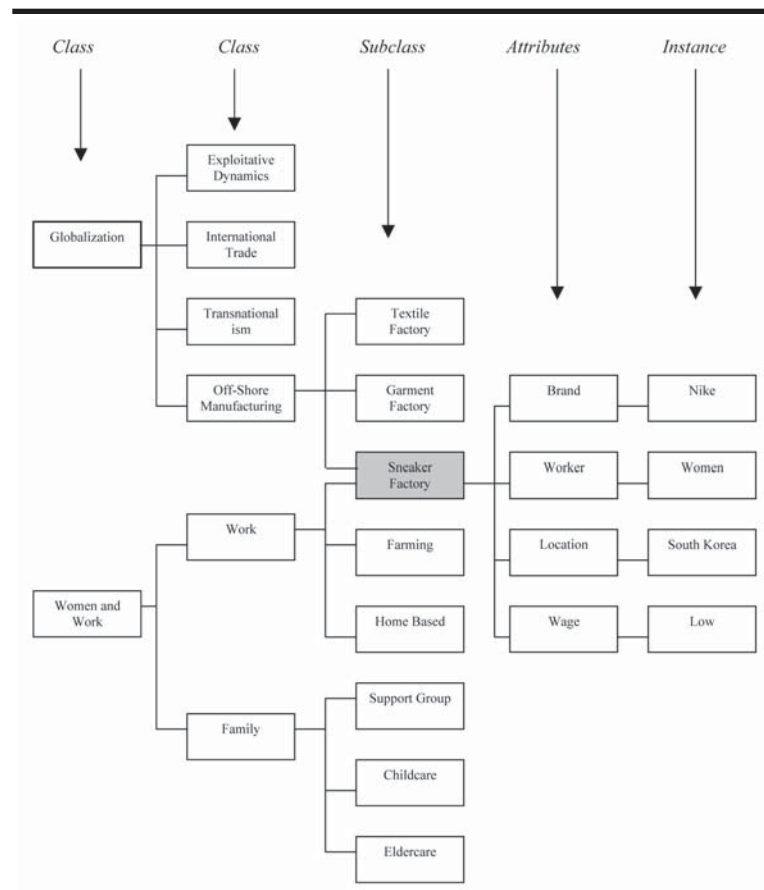

Figure 1. Globalization and women and work ontology

subdivides into three subclasses consisting of factories manufacturing different products: "Textile Factory," "Garment Factory," and "Sneaker Factory." The subclass "Sneaker Factory" has four attributes: "Brand," "Worker," "Location," and "Wage," which have instances "Nike," "Women," "South Korea," and "Low" respectively.

When examining the consequences of globalization on women's work in South Korea, another relevant class is "Women and Work," subdivided into "Work" and "Family." "Work" has three subclasses: "Sneaker Factory," "Farming," and "Home Based." The subclass "Sneaker Factory" is simultaneously a subclass under "Off-shore Manufacturing" and "Work." This cross-class relationship enriches the relationship among classes, thus providing explicit connections for a holistic knowledge representation in a particular context. In this case, it provides the linkage between the concepts "Globalization" and "Women and Work," one of the critical interests among women's studies scholars today. At the same time, the ontology allows search engines to aggregate information dynamically. More different classes can be brought together and dovetailed for a different research or teaching focus; these established ontologies can be reused in a different context.

The globalization ontology can sit at the top of a Web portal, for example, as a searchable discipline-specific tool in a research guide that enables the user to drill down to the desired context to launch searches against the library's catalog. Because it is an overlay and not embedded in metadata, it can be readily revised, customized for local practices or specific needs, and repurposed for different uses. A mapping between the ontology and LCSH in library online public access catalogs would occur behind the scenes to retrieve information seamlessly from the user viewpoint. This mapping combined with keyword searching of ontology concepts adds currency for a new disciplinary focus that is appearing in syllabi and in conference programs, but not yet captured in LCSH. The ontology offers an approach with minimal overhead to adding specificity, currency, and interdisciplinarity to the organization of a tremendous amount of legacy library resources cataloged utilizing LCSH. The ontology can also serve as a bridge between digital library initiatives that often employ newer metadata standards and many different vocabularies and the legacy data, both print and electronic, that most libraries describe using the AACR/MARC cataloging standard and LCSH. The ontology can also be used for collection development, particularly in conjunction with a mapping to LCSH or to the classification system in use, to determine gaps in the collection with regard to curriculum and research support. The ontology thus represents an additional tool to improve overall information exchange between the user and resources. The diagram in figure 4 illustrates the relationship between the user, the

Figure 2. Globalization and women and work ontologies and relationships

ontology, the LCSH terms, and resources. The ontology serves as the translator behind the scenes that provides the user more contextualized access to the information in library catalogs.

Harvesting Concepts for the Ontology

How can librarians identify and harvest specific concepts of a domain to create an ontology? This study used the discourse analysis methodology in an attempt to isolate tacit knowledge grounded in women's studies practices and structures.[20] It took the approach that researchers' and activists' writings, including books and dissertations, course syllabi, conference programs, and curricula, collectively form the current knowledge structure of women's studies as a disciplinary field. Writing and teaching are

part of a cognitive process that is embedded not only in what the author or teacher knows, but also in how the topic is treated, how the topic is structured, and the relevant components, from the author or teacher's viewpoint. The incorporation of the subject domain's tacit knowledge is fundamental to developing an ontology that can be an effective tool in mediating between the user and the resource. Strong and Drott discuss the importance of increasing the number of thesaurus term relationships in order to create a meaningful information retrieval application for all users.[21] This effort is even more critical in facilitating the predominantly unassisted and frequently off-site information seeker.[22]

Ontology editors such as Protégé (developed by Stanford University), OntoEdit (developed by Institut für Angewandte Informatik und Formale Beschreibungsverfahren at Karlsruhe University), and COBrA (developed at the University of Maryland Baltimore County) exist. These tools let domain experts build knowledge-based systems by defining classes and class hierarchy, the relationship between classes, and the attributes of these relationships.[23] The central question is how to identify relevant concepts to build a domain-specific ontology. Using women's studies as a case study, the author examined selected material to gather the key concepts and learn the current organization of this interdisciplinary field. The current domain knowledge reveals relationships established by actual usage within research and the curriculum rather than a more generic and generally applicable traditional subject hierarchy. This is particularly suited toward the customization of information for specific use and for its relevance and currency in the field. The terms identified and their contextual relationships thus reflect the active usage of professional terminology—the terms that the students hear in class and capture in notes or that faculty use when writing research articles. The focus was on identifying persistent and highly relevant text elements and relationships in the current discourse of women's studies, including new patterns of approach, theoretical frameworks, and different methodologies and manifestations. Van Dijk states that "by mentioning something repeatedly in the discourse, subjects can be led to believe that this item plays an important role in the microstructure of the discourse."[24] The sample material examined represents a cross-section of teaching material, research output, and mission statements and foci expressed in departmental descriptions in homepages. These were:

- American universities and colleges women's and gender studies undergraduate and graduate courses' syllabi.[25]

```
<owl:class rdf:ID="globalization"/>
    <owl:class>
        <owl:oneOf rdf:parseType="Collection" >
            <owl:Thing rdf:about="#ExploitativeDynamics" />
            <owl:Thing rdf:about="#InternationalTrade" />
            <owl:Thing rdf:about="#Transnationalism" />
            <owl:Thing rdf:about="#Off-shoreManufacturing" />
    </owl:class>

    <owl:restriction>
        <owl:onPorperty rdf:resource="#OffShoreManufacturing" />
            <owl:somevaluesFrom rdf:resource="#SneakerFactory />
    </owl:restriction>

        < OffShoreManufacturing rdf:ID="SneakerFactory" />
            <hasBrand rdf:resource rdf:ID="#Nike" />
            <hasWorker rdf:ID="#Women" />
            <hasFactoryLocation rdf:ID="#SouthKorea" />
            <hasWage rdf:ID="#Low" />

<owl:class rdf:ID="WomenAndWork"/>
    <owl:class>
        <owl:oneOf rdf:parseType="Collection" >
            <owl:Thing rdf:about="#Work" />
            <owl:Thing rdf:about="#Family" />
    </owl:class>

    <owl:restriction>
        <owl:onPorperty rdf:resource="#Work" />
            <owl:somevaluesFrom rdf:resource="#SneakerFactory />
    </owl:restriction>

        < OffShoreManufacturing rdf:ID="SneakerFactory" />
            <hasBrand rdf:resource rdf:ID="#Nike" />
            <hasWorker rdf:ID="#Women" />
            <hasFactoryLocation rdf:ID="#SouthKorea" />
            <hasWage rdf:ID="#Low" />
```

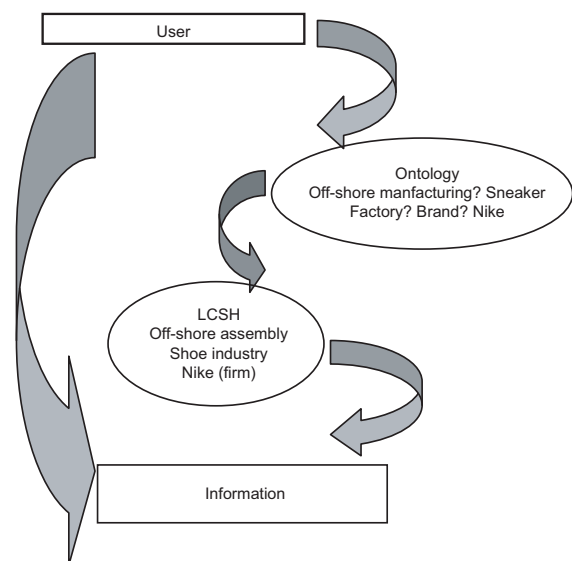**Figure 3.** Globalization and women and work ontologies expressed in OWL

Figure 4. Relationship between user, ontology, LCSH and information

- Undergraduate and graduate course syllabi and required reading lists from Rutgers University Women's and Gender Studies Department from 2001 to 2004.
- Women's and gender studies departmental foci as expressed in American university home pages.[26]
- Abstracts of dissertations in UMI Proquest Digital Dissertations with the title word "women" from 2000 to 2004.

The above resources were analyzed to identify terms expressing important themes as well as relationships in the text elements of each title/resource. A record was created for each resource, with categories of information classifying the resources holistically and comprehensively. The record for departmental foci and monographs consisted of seven categories: title, level, concept, theory, approach, terminology, and geo-political context. For course syllabi, the record also included course level (undergraduate or graduate), resulting in eight categories. Finally, for dissertation abstracts, the record included the department and institution where the work originated, resulting in nine categories. Captured data contained the text elements highly prevalent in each resource by categories. When analyzed collectively, more weight was allocated for prominent text elements, such as course syllabus objectives or required readings title phrases. The frequency of appearance was also considered a primary indication of how important the term was in the field of women's studies. In addition to the predominant presence of gender, race, ethnicity, sexual orientation, and class, the texts revealed women's issues from around the world, focusing on historical as well as contemporary issues and exposing traditionally unrelated facets and concepts, such as "citizenship" and "feminism," or "conflict" and "women," thus creating a composite structure less orthodox and narrow taxonomic discipline categorization in the LCSH. Women's studies is an interdisciplinary field characterized by broad subject coverage, diverse approaches in both scholarship and teaching, and changes in the discipline generally. It is therefore an excellent test case for the ontology application.

Although outside of the scope of this paper, further analysis of collocation and proximity of terms in two or more categories could reveal areas that are frequently juxtaposed and investigated together in contemporary women's studies. Prevalent approaches in graduate or undergraduate instruction; commonly explored concepts, methodologies, geographical areas of interest; and persistently used reading materials are some examples of data that can be identified. Collection and analysis of this data can produce more in-depth information on research and teaching trends of a specific research community, thus providing the library with data for a focused direction in the provision of its services, including collection development, cataloging, reference services, and instruction.

Existing Strategies for Optimization of Information Retrieval

Strategies for optimizing electronic information retrieval are well represented in literature. In libraries, approaches generally involve analysis of user interaction with specific databases or subject resources. In an effort to identify and include the user's perspective in the information retrieval process, Jantz identifies keywords for the Rutgers Alcohol Studies Database by analyzing the user query statements during the information retrieval process.[27] Based on a cognitive viewpoint, López-Huertas discusses a methodology to harvest salient concepts and relationships from the body of representative texts in the field of music to formulate a thesaurus structure, also an intermediate structure, on the topic of musical instruments.[28] Thesauri provide relationships between concepts through broader term, narrower term, and related term. The fundamental difference between a thesaurus and an ontology is the level of abstraction and the stronger expression of context and relationships between terms in the ontology. The aforementioned strategies from Jantz and López-Huertas demonstrate efforts to align information retrieval strategies with successful access to relevant information.

In the commercial sector, database, search engine, and integrated library system vendors are aggressively marketing portals with federated search capabilities and modules where the mapping between the user-generated keyword and relevant information occurs seamlessly. Unlike online public access catalogs, these new initiatives use vocabularies from unspecified sources, which does not provide the user with confidence that the controlled vocabularies are rigorously established and maintained.[29] The vocabulary harvesting and ontology creation proposed in this paper offers an additional strategy that can serve as a model for providing access to information in interdisciplinary fields.

Discussion

The knowledge structure represented in texts reflects the current reality of the field and the elements of a domain, that is, the key competencies necessary for understanding the domain as well as emerging concepts representing new developments, and anticipation of the discipline's growth areas. Librarians can use such ontologies as a guide in collection development to align resource purchases more closely to course offerings and curricula, support core dis-

cipline competencies, and directly address research clusters in the departmental or program structure. The ontology of a field can be customized to reflect the particular focus of the university's department or a research institute, which is often based on the research interests of its faculty and may change over time as the faculty body itself changes. The ontology can customize the structuring of information resources by working in tandem with the more generally applicable LCSH. It can connect legacy resources and digital resources that may be part of a digital repository. An ontology may be tailored to the specific needs of individual researchers. The ontology's flexible structure can adapt to new and evolving disciplinary demands and local needs and create a bridge to appropriate information, whether collected in legacy databases, created as the result of a research grant, or housed in a digital repository.

Currency

Current publications representing research and practice in a field are known collectively as "generators' texts."[30] Harvesting terms and concepts from generators' texts aligns information description and discovery to current domain concepts and enables new strategies in the provision of library services. Maintaining an ontology as an effective, cutting-edge tool is a challenge for libraries. The collection of natural vocabulary identified directly from the scholarly output, which is then organized into a domain-specific ontology that reflects terms and relationships, can be an innovative tool to insure relevance and timeliness of resource discovery, particularly for interdisciplinary and volatile fields of study. However, an ontology cannot be a one-time project, but instead requires systematic attention, including automatic generation of terms for continuously reviewed information sources and evaluative revisions to keep the ontology responsive to user needs. The user community, particularly the faculty that do research and provide teaching, should be involved in the evaluation of an ontology. Fortunately, involving users in ontology evaluation is much more achievable than involving users in the analysis of LCSH.

Comprehensiveness

The strength of the ontology model for information description and retrieval lies in its flexibility as a tool for capturing and documenting concepts and relationships within a discipline to explicitly display the current knowledge structure for users. Users often do not know what they do not know. Providing the knowledge structure holistically, so that all relationships between terms are exposed, helps users to understand the breadth and scale of a discipline. This can enable them to focus their research in the context of the discipline and understand the nuances and the extensibility

of the domain, which may challenge the traditional discipline boundaries.

Flexibility

As an external element to the object metadata or bibliographic elements, an ontology enables easy addition or deletion, as necessary, of terms representing local needs and the interests of local users and operations. A single ontology in a discipline can be repurposed for use within a subdiscipline, a course within the discipline, or even by a complementary field of study. Alternatively, an institution-specific women's studies ontology, for example, can be repurposed and made compatible with that of another institution. Users from both institutions can access each other's resources, thus benefiting collaborative research and teaching. This model is particularly attractive for collaborative projects between units located at different campuses or institutions, where the participants are geographically separated but in need of a common body of resources. The ontology is intended to supplement, rather than supplant, the relevant LCSH terms. As noted above, it is intended to bridge newer access methodologies and digital collections with the vast array of legacy resources in the library's catalog. As library information systems evolve into a personalized portal that organizes broad search results into narrowly defined categories, a well-designed domain specific ontology can be an essential tool to ensure effective information access.

Further Research

In order to validate and assess the benefits of this approach, further tests in different interdisciplinary areas, such as bioinformatics or Latin American studies, are needed. Due to the differences in structures of knowledge in the sciences or area studies, the approach described in this paper may be insufficient. In the sciences, for example, because grant awards directly shape research direction, grant reports (frequently maintained in grants and contract departments rather than libraries) should be considered as additional texts for analysis. A rigorous examination and analysis of all text elements selected to create the proposed ontology is needed to gauge its value and to assess its universal significance. The resulting refined methodology could substantially increase relevance in the user information discovery process.

Another data source with valuable information is the community of faculty members, researchers, students, and activists in a discipline. Direct interviews, or data gathering, can supplement and add new and emerging areas of research interest that have yet to materialize as research outputs. Attendance at lectures and presentations sponsored by academic units and centers offer opportunities for librar-

ians to educate themselves on the new interests of the users they serve. This proactive measure can provide a valuable glimpse of the direction of research.

Finally, while contemporary resources are useful for identifying current concepts and relationships, the ontology needs to be extended to historical structures of knowledge in order to reflect the abstract structure of knowledge not just in current expression. The ontology described in this paper reflects the state of the art of a discipline and serves the immediate and emerging needs of users. However, a more historical focus would provide a clearer understanding of the evolution of the field itself. This role was beyond the scope of this project, and the author acknowledges the need to accommodate the historical development of the field, particularly to accommodate the older research outputs that are available in a library's collection.

Conclusion

Using the example in women's studies, this paper discusses the value of an ontology representing a subject domain and its applications for information classification and discovery and access in interdisciplinary fields. The paper suggests that the methodology described can serve as a model to identify structures of knowledge in women's studies and in other interdisciplinary fields. The quality of information retrieval can be measured according to the degree of match between the user and resources. If tools, such as ontologies, mirror the paradigm of a particular research community, research should be more effective. By connecting users to relevant information not possible in LCSH, libraries can provide better information services.

Ontologies have other applications in libraries, ranging from knowledge organization to evaluative categories for collection development. Defining a proper ontology with complex relationships provides the user improved access to significant resources within libraries. In the case of women's studies, ontologies can increase the interoperability of women's studies Web portals and provide better access to online nontextual collections in digital libraries. This process in turn would greatly contribute to the broader dissemination of women's resources and would open new frontiers of knowledge organization and exchange on the Web. The flexible nature of ontologies enables libraries to develop, repurpose, and share domain specific ontologies with other institutions. Collaborations in this manner benefit collaborative research and will enhance access to information for all users. Given the current academic research environment, interdisciplinarity will continue to grow, thus challenging the traditional boundaries of disciplinary fields. Information access and organization are areas of ongoing responsibility for libraries. This paper presents one potential tool for moving libraries forward in the development of innovative strategies for organizing information and making it more accessible to users.

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