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Metadata as a Realm of Translation: Merging Knowledge Domains in the Design of an Environmental Information System

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ABSTRACT: Bringing together document collections in merged information resources is becoming more common, but presents the problem of integrating content and metadata that have been created in different knowledge domains, using different classification schemes. This paper describes how a multidisciplinary team attempted to integrate metadata structures from several different collections in the development of an environmental information system. The results of this qualitative study suggest that though designers and users from diverse backgrounds could conceptualize and articulate the potential new knowledge the merged system might reveal, the perceived informational value of different access points varied with disciplinary membership, and the compromises forced by this merged collection created barriers and missed opportunities for the creation of new knowledge. However, people with a variety of backgrounds were able to contribute to negotiations about metadata decisions, suggesting that this may be a key realm of translation between diverse individuals in future collaborative environments. Consequences for domain-specific knowledge organization, and for a translation and integration role for those in the field of information science, are discussed.

1. Introduction

Those in the field of information science have only begun to explore the challenges and possibilities of conceptualizing knowledge domains as discourse communities (Hjørland & Albrechtsen, 1995), each with particular histories, philosophies and practices. Increasingly, members of diverse communities are being brought together in collaborative research and design projects, with the assumption that by merging ideas and methods from several fields, innovation or new knowledge might result. Similarly, Swanson's (1986) classic work on undiscovered public knowledge, where he searched across two separate literatures and found a link between the blood disorders associated with Raynaud's disease and fish oil, helped to demonstrate the potential value of merging disparate document collections as well.

The term hybrid knowledge is used to conceptualize one desired outcome of integrating diverse perspectives, such as when ideas in one field are applied in another. Hybridity suggests intentionality, a conscious effort to "breed" certain new knowledge from known "parents,'" distinct from serendipitous cases. This immediately points out the importance of understanding how types of knowledge are different, each with unique histories and contexts of creation and expression. Just as members of discourse communities have specialized languages, practices, and senses of what knowledge is, the documents they

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create are also embedded in specific knowledge domains. However, conceptualizing hybrid knowledge is just the first step. In order to put this concept into practice in a working system, some process of translation must take place.

This paper describes one such process of translation in a participant observation study of the design of a Web-based environmental information system[1]. Based at a university library, the system brought together research scientists, historians, archivists, librarians, programmers, educators and administrators from diverse institutions in its design. The system collocates rare longitudinal data sets with mission logs of research expeditions, oral histories of research scientists, field guides, photographic collections, archival materials and Web resources in an attempt to provide an integrated, multifaceted overview of environmental science. Combining these wide-ranging collections, and having researchers and professionals come together to design the system, was undertaken by the project participants in an explicit attempt to create new knowledge, in the sort of "integrative synthesis" Julie Klein (1990, p.118) says typifies true interdisciplinarity. This was the primary rationale for the selection of this design project as both a research environment and an object of study.

Members of particular discourse communities are sometimes able to make effective use of documents from outside their areas of expertise. Indeed, creating new connections across disparate knowledge domains is often a source of innovation. But much more often, the different vocabularies, practices and senses of "valid" knowledge,which are learned as part of membership within particular communities, can hinder potential connections.

When documents are represented using classification systems, the task of translation and assessment becomes at least somewhat more manageable. By searching a merged collection with a common metadata scheme, one might unearth hundreds of potentially fruitful items from an unfamiliar collection, juxtapose diverse views of a common topic, and create a new, hybrid knowledge. However, creating a merged metadata scheme is more than just selecting a list of common terms. Understanding and reconciling the diverse communities and contexts represented in the merged collection is important, yet often implicit or ignored. How these translations and negotiations take place in practice needs to be better understood.

This work is part of a larger qualitative study using observation, interviews, document analysis and social network analysis to study the nature of hybrid knowledge in the design of an environmental information system. The focus of this paper is on the particular challenges of providing access to this merged collection through metadata.

2. Background

Whether they are called disciplines (Klein, 1990), communities of practice (Wenger, 1998), epistemic communities (Van House, 2002), epistemic cultures (Knorr Cetina, 1999) or discourse communities, each group defines, processes and generates knowledge in characteristic ways, and studying these domain-based discourses should be central to the concerns of information science as a field (Hjørland & Albrechtsen, 1995).

The concept of discourse communities adds a strong social component to our view of how knowledge is produced, but other social forces also influence knowledge production and the resulting information infrastructure (Fuller, 2002). Ideals of pragmatism and efficiency, economic concerns about potential innovation and leveraging research funds, and democratic notions of including many voices and perspectives, all help undergird initiatives that encompass multiple domains. Similarly, publicly funded science is under increasing pressure to deliver measurable results and to have its activities benefit society more widely and more directly. The U.S. National Science Foundation Digital Library Initiatives (DLI) illustrate this shift. The goal of DLI Phase 1 (1994 to 1998) was to "dramatically advance the means to collect, store, and organize information in digital forms, and make it available for searching, retrieval, and processing via communication networks" via six large-scale digital library projects (U.S. National Science Foundation, 1998). In contrast, DLI Phase 2 (1999 to present) places a greater emphasis on wider applications of these repositories, as evidenced in undergraduate education (Borgman et al., 2000).

Studies of actual practice can expose weaknesses in purely pragmatic approaches to knowledge organization, and provide evidence for the inclusion of sound theory. Buckland et al. (2000; 2001) provide empirical support for Hjørland's domain-analytic view in several studies where researchers created different indexes of the same collection for different user groups, which led to evidence of improved retrieval performance. However, from its inception, the environmental information system studied here

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adopted the reverse approach: several collections would be merged and described with one index for a diverse user base. This compounded the challenge of subject analysis:

> Because a document does have an infinite number of subjects, the process of subject analysis is a process of giving priority to those subjects which best serve the needs of the users of the information system in question. (Hjørland, 1998, p.610)

But as the breadth of the user population increases, it becomes less and less possible to make generalizations about their needs. In formulating social epistemology as the foundation of a theory of bibliography, Egan and Shera (1952, p.126) write:

> ...there must be appropriate bibliographic communication (1) within each group, (2) among the several groups of scholar-specialists, and (3) between groups at the scholarly level and the various groups of practitioners, operators, educators and lay public.

One of the core mandates of the grant which funded the design of the system was to provide wider access to environmental information for both researchers and the public. Therefore, the core of the design team included content specialists (a range of research scientists, or scholar-specialists in Egan and Shera's parlance), systems specialists (builders and designers), and information specialists (librarians, archivists and curators of special collections), along with managers, educators and support staff. These boundaries were not rigid, as many individuals could claim membership in two or more of these areas. In practice, effective communication across these boundaries is difficult on several levels, primarily due to the specialized languages used by particular communities:

> When there is a group of people, each of whom speaks a special professional jargon but each of whom also speaks a common language, it is sometimes necessary to drop the special languages and learn to understand each other in terms of the common tongue, that is, to communicate in neutral terminology. (Luszki, 1958, p.270)

In the project studied here, the "common tongue" that the content, systems and information specialists

could share was the descriptive metadata used to merge the disparate collections. Classification systems, however, are anything but a "neutral terminology" (Bowker & Star, 1999). Choices about the metadata structure included which set of fields would be used to describe the collections, in other words, which facets "mattered" and which did not. Metadata content negotiations centered around which terms would be used to populate the fields, be they from subject headings and authority lists, thesauri or even uncontrolled text; here as well, these choices carry social and epistemological consequences. Design decisions included which of these fields would be searchable in the final system, which would be displayed, and which would be given visual primacy. In other words, the metadata structures of the constituent collections and the merged collection served as boundary objects, which ideally both inhabit several communities of practice and satisfy the informational requirements of each (Star & Griesemer, 1989). It is important to note that the word "satisfy" is not used here in the sense of total fulfillment as when repaying a loan, but in the weaker sense of incomplete, though passable, success (OED, 2003). This sense of partial understanding has been a recurring theme in the larger study: individuals who could articulate partial understanding of the roles and concerns of other project members were better able to conceptualize and express the "side-benefits" of hybrid knowledge within the merged collections.

On a subtler but no less challenging level, communication across communities is also influenced by issues of prestige and trust. Suchman (1994, p.51) raises the concern that multidisciplinary design projects may have significant disparities in:

> [the] relative power and resource distribution among the "disciplines" (or more broadly, knowledges ...) engaged in design activities. Are they in fact equally valued, or do some dominate while others are seen as providing peripheral, albeit crucial services?

Budd (2002) links social epistemology and praxis in library and information science, and argues that aspects of cognitive authority and warrant be considered; that is, the extent to which someone's claim to expertise is accepted by another person. Van House (2002) has studied a digital library of plant observation records and images (CalFlora), which relies on data provided by amateur observers as well as professional botanists; several levels of "credibility assess-

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ment" measures for contributors are built into this system. But warrant also extends to documents, and even parts of documents:

> The problem of the relative informational value of different subject access points such as titles, abstracts, citations, descriptors or words from full-text records is perhaps the most central problem in IS. (Hjørland & Albrechtsen, 1995, p.417)

Within established discourse communities, warrant is formalized: only certain interpretations of data or information, from certain sources, are considered valid knowledge. And this sort of warrant is rarely portable from one domain to another.

In an ongoing project to reconcile overlapping concepts from Medical Subject Headings and the UMLS Metathesaurus, Nelson et al. (2001) stress the importance of human review in considering the diverse views of the world that the controlled terms represent, prior to any attempt at integration:

> As in a marriage, sharing of a worldview, a common approach to the operational problems, and a fair and equitable reconciliation process is necessary to bring two separate and distinct entities into unity.

Establishing a common framework for what constituted both valid and useful content, and valid and useful descriptive metadata, was a core challenge of this project.

3. Methodology

Data collection related to the metadata integration aspects of the system was done primarily by observing the work practices of the individuals involved in the design of the system, and by analyzing project documents over a ten-month period. Since this was a project that involved people from several different institutions, much of the collaboration took place via e-mail. Documents included the grant proposal, meeting notes, design documents, metadata standards and several versions of the system in various stages of development. The data was focused through subsequent semi-structured interviews with project participants (n=19) who worked with the metadata at any level, even tangentially. During these interviews, project documents were present for consultation.

Another phase of the investigation included a formal usability analysis of the system by both environmental scientists and social scientific researchers and educators, as well as graduate students in each of these areas (n=12). None of the usability subjects were members of the design team.

The usability analysis took the form of a think-aloud protocol, and was conducted in two stages. Stage 1 assessment took place in parallel with the construction of the site and elicited subjective comments and opinions in time to feed back into ongoing design and development. Stage 2 assessment added realistic search and browse tasks once the site and collections were nearly complete. At the close of each of these assessments, participants were asked open-ended questions in a semi-structured interview about their perceptions of the overall goals and usability of the system, as well as questions concerning the usefulness of the collections and the metadata used to describe the collection items.

In a think-aloud protocol, the participant is asked to vocalize his or her thoughts and opinions while interacting with the resource to be evaluated. Think-alouds can be used at any stage of system development and are a cost-effective way to gather qualitative feedback (Nielsen, 1993). They are designed to explore how the users approach the interface and what considerations they keep in mind during actual use. For example, if the users feel that the system imposes an unnatural or convoluted series of steps to accomplish a task, having them express this confusion or frustration aloud can lead to concrete recommendations for evolving a more usable system.

Subjects were recruited via an e-mail call to participate in a usability assessment of a unique environmental information resource. This message was posted to the listservs of several university departments. Respondents were then asked to recommend others in their field. This snowball sample approach yielded a total of 12 participants:

– 4 in environmental sciences
– 4 in information science
– 3 in history of science
– 1 in education (with science education as a specialty)

Subjects sat at a computer in a room on a university campus, with the researcher sitting alongside as subjects explored the site. They were asked to articulate their thoughts as they explored the site, but longer periods of silence or non-verbal cues were met with

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simple prompts, e.g. What were you trying to do there? Once subjects had become familiar with the site and its collections, the semi-structured interview commenced.

4. Results and Discussion

Findings related to both the design and the usability of the site are interlinked in this section. On the design side, project members from different disciplines tended to have divergent views about the usefulness of certain collection items, metadata structures and terms, though they were able to articulate and negotiate these differences in reference to the metadata. However, the breadth of the source collections and the disparities in their native metadata proved too great an obstacle for project members to overcome and complete integration of the collections was abandoned. In both the design and the usability study of the site, subjects' practices and interview responses supported the idea that people trained in different discourse communities value different types of information forms and access points.

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The main constituent collections of the environmental information system are:

– University Archive photographs
– University Archive research expedition mission logs
– Historical Society photographs
– Historical Society oral histories
– Environmental data sets
– Web resources
– Field guides
– Bibliographies of research publications

In their native format, each of these collections had a different metadata structure, different access points, and used mostly different standards and classification schemes to describe collection items. For example, while general topical terms were drawn from the Library of Congress Subject Headings in several collections, some had separate fields for geographic names and features, which were populated using the much more focused Alexandria Digital Library Gazetteer. Fields such as Expedition Name and Research Vessel, which appeared in some of the collections of the University Archive, used local authority lists and were very consistently applied. Authority lists of named persons, however, commonly varied across collections in form, content and application. Particularly challenging were instances where equivalent descriptive terms came from controlled vocabularies in one collection, and uncontrolled text entries in another.

The problem of integrating disparate forms of metadata was exemplified in the oral histories collection. While the primary access points of a standard bibliographic record are Title, Author and Subject, the metadata structure of the oral histories collection gave primacy to personal names. The name of the person giving the oral history was recorded in no less than four of the 14 fields used to describe each collection item (Title, Creator, Contributor, and Subject). However, classifying these items by Subject, according to one design team member, was "a nightmare." Even with relatively focused interview questions structuring the oral histories, transcripts commonly wandered from topic to topic, including names of missions, equipment, places, half-remembered names of other researchers, and so on. Items of this sort simply do not lend themselves to description with a few topical terms. The Subject field for these items consisted of the name of the person interviewed, and their high-level subject specialty (e.g. Meteorology). All other significant descriptive terms were placed in the Summary field, which allowed free text, comma-delimited entries. Since this field was unique to the oral histories collection, and populated with uncontrolled text, the oral histories could not be easily integrated with the rest of the collection in any meaningful way. Similar problems arose with other collections. Their metadata structures might have worked well for their originally intended audiences, but when repurposed as part of a merged information resource, they interfered with one another.

Subject terms carry contextual baggage which can work against easy integration. Differences in the scope, intent and syndetic structure of the source vocabularies made comparing Subject fields across collections problematic. Merging unstructured vocabularies like lists of local fish species (120 terms) with terms from the hierarchical LCSH thesaurus (approximately 232,000 terms) creates obvious inequalities in scope. In the former, the names of local fish species are the entire universe. In the latter, fish can be described in any number of senses, from biological to economic to aesthetic.

The members of the design team soon realized the enormity of the task of metadata integration and

item description for multiple audiences. With time and funds running short, and a need to demonstrate "good usability" of the system for the final grant report, a compromise was struck. In the words of one design team member:

> We figured we could get by in terms of the integration requirement just by applying high-level terms across what collections we could, then also by having all the different resources accessible from the same page on the site. But for good usability, targeting the different resources to different audiences was pretty much inescapable.

So the collections were scarcely merged at all. Upon visiting the home page, users must first select a collection of interest, be it photographs, environmental data sets, oral histories or any of the others, then search it separately, using subject terms and other access points specific to that collection.

In the end, the only collections that could be integrated to any extent were the photograph collections of the University Archive and the Historical Society. To unify these two collections, project archivists created a list of very broad terms called the Category field, and assigned one or more terms to each image, such as this list of fourteen terms related to oceanography:

– Aerial Views
– Beaches
– Diving
– Events
– Fishing
– Fishing Industry
– Harbors
– Navigation and Communication
– Ocean Life
– Ocean Resources
– Oceanography
– People
– Scientific Equipment
– Vessels

This list was developed using the Thesaurus for Graphic Materials (TGM) (U.S. Library of Congress, 1995), a thesaurus of about 6,300 terms designed specifically for indexing pictorial materials. The thesaurus is split into two sections: TGM I provides a controlled vocabulary for describing a broad range of subjects depicted in pictorial materials, in-

cluding activities, objects, types of people, events, and places, while TGM II provides terms for the genre and physical description of these items. After assessing the contents of the merged collection, candidate headings were chosen and considered. For example, though many of the photographs in this subset of the collection are of boats, and Boats is a term in TGM, this was considered too narrow for a collection of environmental resources, so the broader term Vessels was chosen instead.

Examining the Category list reveals that different classificatory models are at work simultaneously, a common problem when classification schemes favor practical concerns over theoretical consistency, such as in many Web portals and directories (Zins, 2002). In this case, percepts and concepts are mixed together. For example, one can easily imagine pictures *of* Beaches, Harbors, People or Vessels. But what does a picture of Oceanography look like? And Aerial Views is more a description of a photograph than a subject. In subsequent interviews, many of the project participants felt that the Category headings were the best solution under the circumstances, but fell well short of meeting the integrative goals of the system. One of the Archivists reported that she had to be "dragged kicking and screaming" into accepting this compromise solution.

Why did the metadata integration attempt fail? Despite the stated goal of creating a system that would "catalyze" new cross-domain knowledge, in practice the metadata negotiations settled into a more traditional pattern, where information specialists simply reacted to stated or perceived user expectations. This gets to larger issues of cognitive authority of discourse communities, and who is entitled to make knowledge claims. Environmental scientists did not see themselves as creators of information systems, and information specialists did not see themselves as potential creators of new environmental knowledge. This "contested collaboration" (Sonnenwald & Pierce, 2000) played itself out in a variety of ways outside the scope of this paper, but the failure to penetrate this barrier in terms of metadata was evidenced in the results of the usability analysis.

4.2 Access Points, Forms and Warrant

In the design of this project, the researchers and the information specialists had vastly different conceptions of both the goals of the system and the level of collaboration that they expected to take place. The

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researchers saw the project primarily as the means to digitize the environmental data sets, and one researcher thought other collections were "just along for the ride." Researchers tended to be interested in metadata issues only insofar as they made the environmental data sets accessible. This suggests a difference in the "relative informational value" of different collection items and access points, in terms of Budd's (2002, p.97) sense of warrant. A common access point in many databases is a statement about the item's form, which sometimes appears as a Resource Type or Document Type field, with a value like text, image or data set. In the usability study, members of different disciplines often suggested that the forms of information are an indicator of whether an item is likely to be useful or not. As a group, information specialists thought all forms were equally useful. This was less true for the researchers, who said they found the most value in the environmental data sets.

Perceived differences in the relative informational value of collection items can obscure the potential new knowledge a merged collection might reveal. For example, the environmental data sets were derived from rainfall measurements, fish catch statistics and similar data, which had been reported in rare local serial publications, some of which were more than eighty years old. Once digitized, the data sets were available in several downloadable formats and could be imported into spreadsheets or databases for further analysis. However, from the data sets alone there was no way to tell what standards and equipment had been used to collect the data, or how comparable and consistent the numbers were from year to year. Some issues published errata, correcting the reports of previous issues, but items were digitized as found, and never edited.

Ideally, users would be able to access and view the full text of the serial publications, the downloadable data sets derived from them, and related content from other collections in some sort of integrated display, where the links between disparate collection items would be made more explicit. This would provide more context to any given subset of data, allow users to identify potential inconsistencies, and possibly help users create new hybrid knowledge.

Some of the people involved in designing the system – primarily librarians and archivists – were able to conceptualize and articulate connections between the disparate collections. For example, some photographs in both the University Archive and Historical Society collections included images and names of the people and equipment that had collected some of the

environmental data. These could have been linked with the data sets, perhaps across a common geographic, topical or temporal descriptor, to view the numbers more critically, and in the context of how they were originally collected. Perhaps the notion that the photograph collections had less perceived value in the eyes of the researchers helps explain their low level of involvement in the attempt to integrate them with the data sets.

Historians and sociologists of science understand that what is reported in journal articles and data sets is just one version – a heavily filtered one – of the actual practice of science. Evidence of how science is actually done, when it is captured at all, is recorded in forms like archival photographs, mission logs, lab notes and oral histories. It is not surprising that historians of science in the usability study found these forms most useful.

An interesting and somewhat unexpected finding was that regardless of their disciplinary membership, participants in the usability study initially perceived the system as a Web site, as distinct from an information resource created by professionals. Reasons given included the site's attractive design, and its use of graphics and non-technical language. This resulted in an initial assumption that the site's main page would have a prominent search box where uncontrolled textual queries could be entered. As they explored the site, users discovered that it was more of a Web portal, a collection of links to separate but related content. But it is worth noting that the perceived genre of an information resource apparently creates expectations as to its usability.

In analyzing possible reasons for the lack of warrant environmental scientists tended to have for the archival photographs, the age of the resources were considered as a possible factor. Bibliometric studies of the literature of different disciplines implies that the age of information tends to be characteristic of how each discourse community uses and assesses information resources (Burton & Kebler, 1960). But since the environmental data sets included longitudinal data nearly as old as the photographs, this seems unlikely. Lack of warrant for information in photographic form is another possibility. When asked if the archival photograph collections would be useful to them, this comment from a physical oceanographer was typical:

It might be. I don't know. But I don't have time to chase down things like that. I might have a grad student do it, but I guess if I needed data

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for a research article and they brought me back old-time photographs, I wouldn't be too happy.

But this same researcher dealt routinely with satellite imagery and other photographic data in his research. He later commented that it would be nice if the fish catch statistics contained links to pictures of the fish ("that would be a really good teaching tool"). So perhaps the act of being linked with highly valued content can create warrant, and raise the perceived informational value of different information forms.

These observations underscore the need to learn more about which communities value what kinds of information and access points, revealing diverse conceptions of what knowledge is, and who is entitled to create it. Framing document collections, specialized languages and metadata structures in the context of the communities that create them is a challenging yet necessary prelude to meaningful integration.

5. Conclusion

The research described in this paper is ongoing and the results here must be considered preliminary. That the current system falls short of its initial integrative aspirations, should not, I think, be seen as a failure of the system, but rather as empirical support for the idea that people and documents in particular knowledge domains require nuanced understanding by information scientists, to provide effective access in a world where merged collections and multidisciplinary collaborations are becoming increasingly common. Though the attempt to integrate different metadata schemes in this project could not be completed as originally imagined, these negotiations did take place in the realm of metadata, of subject terms and access points. From both a social and technical standpoint, the challenge is the same: integrating diverse views of the world.

Through organization and access, people in information science have had a key role in transforming the knowledge generated by different domains into the overall information infrastructure. Somewhat paradoxically, the field simultaneously attempts to create and impose universal standards, while advocating more flexible notions of service to diverse user communities.[2] It is a continual balancing act, but this merged perspective reflects the perennial trade-offs inherent in the design of any information system. People who deal with information in the abstract, and with determining the context of information needs by members of different discourse communi-

ties, are well-positioned to take on this role of translation, integration and synthesis.

Notes

1 The name and certain details of the system are withheld to protect the privacy of the project participants, in accordance with UCLA Office for Protection of Research Subjects policy.
2 I thank Jenna Hartel and Jonathan Furner for this insight.

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