Knowledge Domains: Multidisciplinarity and Bibliographic Classification Systems

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Beghtol, Clare (1998). Knowledge Domains: Multidisciplinarity and Bibliographic Classification Systems. *Knowledge Organization*, *25(1/2)*, 1-12. 71 refs.

ABSTRACT: Bibliographic classification systems purport to organize the world of knowledge for information storage and retrieval purposes in libraries and bibliographies, both manual and online. The major systems that have predominated during the twentieth century were originally predicated on the academic disciplines. This structural principle is no longer adequate because multidisciplinary knowledge production has overtaken more traditional disciplinary perspectives and produced communities of cooperation whose documents cannot be accommodated in a disciplinary structure. This paper addresses the problems the major classifications face, reports some attempts to revise these systems to accommodate multidisciplinary works more appropriately, and describes some theoretical research perspectives that attempt to reorient classification research toward the pluralistic needs of multidisciplinary knowledge creation and the perspectives of different discourse communities. Traditionally, the primary desiderata of classification systems were mutual exclusivity and joint exhaustivity. The need to respond to multidisciplinary research may mean that hospitality will replace mutual exclusivity and joint exhaustivity as the most needed and useful characteristics of classification systems in both theory and practice.

1. Introduction

Three closely interrelated problems exist for bibliographic classification systems: 1) the academic disciplines as the main structural principle; 2) the fiction/non-fiction distinction as one secondary structural principle; and 3) information retrieval techniques that call into question whether a whole document (e.g, book, article) is the most appropriate unit of analysis in online retrieval systems.

First, the intellectual province of general bibliographic classification systems is the whole universe of knowledge, and this domain has habitually been analyzed into classes and subclasses on the basis of the academic disciplines. Special classification systems, too, have often selected one or more academic disciplines and analyzed that domain on the basis of classes or facet categories thought to be fundamental to the discipline(s). At the same time that systems were being created with the disciplines as a structural tool, however, theorists and practitioners alike were criticizing that practice. The members of the Classification Research Group (CRG), for example, embraced the principles of Ranganathan's faceted classification partially because the facet concept would allow the expression of interdisciplinary topics (CRG, 1955).

Second, within this basic disciplinary structure, classification systems have relied on the distinction between fiction and non-fiction documents (i.e., "literary or topical") that Cutter identified as the third objective of the catalogue (Cutter, 1904, p. 12). Like initial division on disciplinary lines, the fiction/non-fiction distinction has lost much of its force (cf Beghtol, 1996). For example, although the study of narrative has traditionally fallen within the arts and humanities (e.g., literature, history), science and social science disciplines now regularly borrow concepts and research on the structure and function of narrative discourse for their own (non-fiction) purposes. Two examples may be given. First, in a study of medical language processing, Sager, *et al.* recommended

"treating the texts of physicians like the myths of native peoples" (1995, p. 142). Second, Clark compared the narrative structures of four histories of science in an attempt to "mobilize literary criticism as an aspect of science studies" (1995, p. 1). The active study of narrative in widely divergent fields is a multidisciplinary phenomenon that provides evidence for the increasing permeability of fiction/non-fiction and disciplinary boundaries alike.

Third, computer technology allows us to retrieve units of information of any size. In particular, units smaller than a whole document have been retrievable for many years from full text databases such as those for newspapers and certain reference publications (e.g., *Who's Whos*). Currently, some journals are available only electronically (e.g., *Psycoloquy*), and large-scale retrospective conversion projects for other journals are being conducted (e.g., JSTOR ("LC Catalogs...", 1997)). Under these circumstances, it is appropriate to consider classificatory techniques for the internal elements of documents, i.e., for their "more granular components" (Murray, 1996, p. 209), and for the relationships among those components. One example of this kind of project is Denno's (1987) indexing system for interdisciplinary research on crime, violence and mental disorder that made special provision for differing terminologies, orientations, and publication patterns in such disparate fields as medicine, biology, criminology, psychology, sociology, social work, and law. The system described the research methods of the works indexed. For example, the types of major variables, the research design, the data gathering process, and the statistical techniques used, among others, were coded for each article, book, or research report.

These three general problems are not mutually exclusive, but it is useful to treat them initially as if they were. All three are aspects of the important questions surrounding domain analysis[2] for bibliographic classification systems. Previous research addressed the problems of the fiction/non-fiction distinction by investigating some issues surrounding the analysis of 1) the documentary universe on the basis of text types (Beghtol, 1996) and 2) the internal structure of narrative documents, whether fiction or non-fiction, on the basis of their basic constituents (Beghtol, 1997b). The present paper deals with the universe of knowledge as the domain of general bibliographic classification systems in the context of the phenomenon of multidisciplinarity. In particular, we need to know whether, how, and to what extent current bibliographic classification principles and practices support multidisciplinary knowledge creation, analysis and retrieval. Further, some initiatives that may help reduce the problems of multidisciplinarity are considered. These papers, including the present one, assume the use of electronic information storage and retrieval systems. Specific implications of this assumption remain to be addressed.

2. Multidisciplinarity as a Phenomenon

Multidisciplinarity in all areas of knowledge has become the norm rather than the exception, but "the established academic disciplines and our current systems of information do not always explicitly represent newer territories and the interdisciplinary associations that link them" (Palmer, 1996, p. 129-130). Rapidly increasing multidisciplinary knowledge creation makes it critical to reconsider the traditional reliance on discipline-based classification and to try to solve the problems that orientation has created. Similarly, methods of identifying the language of an emerging field need to be devised so that systems can be created for new areas of knowledge (e.g., von Ungern-Sternberg, 1995).

Langridge believed that one fundamental principle of classification was the "absolute distinction between forms of knowledge [i.e., disciplines] and phenomena" (1992, p. 8) and objected to discussions of discipline-based systems because no system has main classes that

> contain all or nothing but the form of knowledge [i.e., discipline] specified, such as philosophy, science or history[3]. ...A great deal of philosophy, history and even some science is distributed through the scheme, while each of these classes contains 'foreign' elements (1992, p. 9).

In Langridge's opinion, main classes are based on the field of interest principle, not on disciplinary forms of knowledge. His analysis obscures an important distinction between, for example, science-as-form and science-as-phenomenon. A document may be created on "the history of the philosophy of science". In such a document, history and philosophy may be called forms of knowledge, but science is treated as a phenomenon, i.e., the object of study. Similar distinctions would need to be made for topics such as "the philosophy of the history of science" or "the scientific study of history and philosophy" in which a form of knowledge is treated as a phenomenon. Langridge acknowledged this blurring of his distinction, i.e., "...Science includes philosophy and history of science among other things" (1992, p. 9), but did not discuss its implications. The distinction between disciplines and phenomena is not, therefore, absolute, because whether something is to be considered a discipline or a phenomenon depends on its treatment and context in a particular document topic. It is justifiable to relax Langridge's distinction and terminology and to un-

derstand, for the purposes of bibliographic classification, a discipline to be a field of interest. This analysis is similar to Svenonius' discussion of "perspective hierarchies" in classification systems (1983, p. 79)[4] and reminiscent of the *Broad System of Ordering* (BSO) (e.g., UNISIST..., 1975), which is based upon institutional warrant, so that the focus of interest of any information agency warrants a class.

No consensus has developed either on a typology of multidisciplinary phenomena or on the terms used to express their various techniques and results.[5] Numerous typologies have been proposed.[6] In this paper, "multidisciplinarity" is taken as the broad term that encompasses any method of combining any number of existing or emerging subject domains. The possible methods of combination, splitting, and recombination are not further specified because we are interested in the phenomenon as a whole and in its general relationship to bibliographic classification systems. As proponents of faceted classification have consistently pointed out, no logical limit to the potential number(s) or kind(s) of combinations exists. What bibliographic classification systems therefore need is to be able to respond accurately and immediately to all possibilities. This need (variously called „hospitality" or „flexibility") has been identified before, and was partially responsible for the CRG's efforts to create a freely-faceted system. We are thus addressing an old problem for bibliographic classification, but we now accept that the increase in multidisciplinary knowledge generation and the increase in computing power are dominant influences in information storage and retrieval systems. These two phenomena add an unmapped dimension to the problems both of achieving hospitality in principle and of implementing it in new practices.

Various techniques have been used in attempts to measure multidisciplinarity. For example, Qin (1994) studied research collaboration in one journal, *The Philosophical Transactions of the Royal Society of London*, between 1901-1991. Qin found that multidisciplinarity increased dramatically after the 1960s, especially in interinstitutional and international research, but noted that the *Transactions* preferred multidisciplinary research, so that generalizations cannot be made. Similarly, a group of journals can be studied for the extent to which they cite and are cited by materials in other fields. For example, Tomov and Mutafov (1996) used a combination of co-classification and co-citation analysis to assess multidisciplinarity in andrology. As McCain and Whitney (1994) noted, however, no one method of analyzing a multidisciplinary literature is adequate in itself, and Gomez *et al* (1996) noted that different methods of delimiting the topic of a field in order to conduct bibliometric research prevents meaningful comparisons between the results of different studies.[7] Comparing the results of different measurement techniques (e.g., Hinze, 1994) would help resolve some of these problems.

An example of the failure of discipline-based structures appeared in Kern's study (1983) of changes in how people experienced time and space between 1880 and 1918. In planning the organization of his work, Kern rejected the orientation of previous writers whose works had been "framed according to conventional academic disciplines and artistic genres" (1983, p. 5) because he wanted to concentrate on the essential philosophical concepts of time and space, i.e.,

> I originally planned to organize the new thinking [about my topic] according to traditional artistic genres and academic disciplines, however much of it cut across those dividers [of time and space]. I finally decided to base the theoretical framework on philosophical concepts, because that allowed me to treat concepts such as simultaneity as a whole and not scatter them throughout various genre and discipline chapters. ...Such broad cross-classification and cross-genre constructions involve a radical gerrymandering of traditional cultural areas. ...This method of grouping thematically related developments without an apparent causal link occasionally led to the discovery of a link [e.g., between Cubism and camouflage]. (1983, p. 6-7)

In this passage Kern referred to the organization of one book[8], not to the representation of the entire domain of knowledge, but his discussion mirrors the concerns of those who want to modify substantially or to abandon entirely discipline-based classificatory structure. Authors like Kern, who are not primarily interested in classification, find it necessary to forego discipline-based organization because of the constraints it places on knowledge creation. This circumstance provides a compelling isomorphic argument against discipline-based bibliographic classification systems. If a discipline-based structure is inadequate for one book, then it seems likely to become increasingly deficient for the whole of knowledge. Nelson noted that "the order of a group of books is greater than the sum of their texts" (Nelson, 1997, p. 30). Nevertheless, bibliographic classification systems--traditionally the "order of a group of books"--have tried to respond in this century to literary warrant. They inevitably influence and are influenced by the documents they attempt to order and they are now therefore constrained to respond to the literary warrant of multidisciplinary documents.

3. The State of the Art

Bibliographic classification systems express multidisciplinary topics easily if one assumes a classified catalogue (manual or electronic) with multiple notational access points for each document. The virtues of subject heading or thesaural systems are often praised as superior to classificatory access. This putative superiority arises, however, not from theory but from the practice, especially in North America, of assigning multiple verbal descriptors, but only one notation, to individual documents. The success of a particular classification system at expressing a particular multidisciplinary topic through multiple notations will obviously depend on the topic, the system, and how they interrelate. In principle, however, multiple notations allow description of the salient aspects of a topic, each with its own notational expression as an access point.

In the following sections, we consider the potential of a single notation for multidisciplinary description in four general classification systems (i.e., *Dewey Decimal Classification* (DDC), *Library of Congress Classification* (LCC), *Universal Decimal Classification* (UDC), *Bliss Bibliographic Classification*, 2nd ed. (BC2)). The ability to describe a multidisciplinary topic within one notation does not, of course, solve the problem of the scatter of topics throughout different disciplinary main classes. Such an ability does, however, imply that relatively specific notations for multidisciplinary topics could be developed and used for machine gathering of materials on these topics.

This approach is justified on the assumption that it is unlikely that a library would choose to add multiple notations retrospectively to existing records. Some evidence for the validity of this assumption appears in literature describing the librarian's role in multidisciplinary research. According to Drake (1975), fragmentation of literatures and disciplines is one of the problems facing academic librarians who help faculty members develop multidisciplinary courses. Drake believed that producing multidisciplinary bibliographies was difficult both logistically (because of the decentralization of many university libraries) and intellectually (because of the librarian's inexperience in multidisciplinary searches). Drake did not, however, discuss the possibility of expressing multidisciplinary topics in classification notations. Similarly, SantaVicca (1986) emphasized the fundamental arbitrariness of all classification systems, and described a five-step method of bibliographic instruction that would train students in comparing different classification and indexing systems for the purposes of multidisciplinary literature searching. Like Drake, SantaVicca did not suggest that multiple notations might overcome some of the problems of literature searching across disciplinary boundaries. Thus, Drake, who addressed the needs of academic librarians, and SantaVicca, who addressed the needs of students, stressed the importance of understanding relationships among the disciplines without discussing how these might be expressed either in catalogues or bibliographies. In contrast, however, the draft OCLC research agenda for DDC includes the "study of the impact on subject retrieval of the addition of *multiple facets or multiple full numbers* to bibliographic records" (DDC, 1997, italics added).

For illustrative purposes, an informal example helps describe the treatment many multidisciplinary topics might receive in current bibliographic classification systems. *Geography and Literature: A Meeting of the Disciplines* (1987) is a book of essays to which "professional geographers as well as literary critics and creative writers have contributed their appraisals of literary places" (1987, p. xi). The rationale for asking geographers to write about literature was that

> most literary landscapes...are rooted in reality, and landscapes have long been the domain of geographers. Their knowledge can help ground even highly symbolic literary landscapes in reality (1987, p. xi).

Literature/geography does not begin to exhaust all possible multidisciplinary topics, nor can it be considered representative of all possible disciplinary mergers. It has the advantage, however, of bringing two traditionally diverse disciplines into a fairly simple, but interdependent, relationship that we might be required to express notationally. In addition, since literature/geography has no established name and is not considered an emerging discipline in its own right, it should pose a relatively difficult classification problem.[9]

3.1 Dewey Decimal Classification System

DDC is the most widely used general bibliographic classification system and includes various options from which a classifier may choose. The general purpose of these options is to allow emphasis or preference for a topic of local importance and to accommodate cultural differences. Options were first introduced in DDC12 in 1927 (Mitchell, 1995). Multidisciplinary topics, however, were not mentioned in the Introduction to DDC until DDC17. Users of that edition were advised to classify a subject treated from

> two or more points of view or aspects, i.e., within two or more disciplines, with the aspect that receives the most emphasis. ...[If there is no apparent emphasis] with the one that preponderates. ...[If there is no emphasis or preponderance] with the underlying or broader discipline. ...[Or] lacking any other principle, class in the

discipline that comes first in the schedules. (Dewey, 1965, p. 30, v.1)

Interdisciplinary notations, which were first introduced in the eighteenth edition and of which there were in that edition "relatively few" (Dewey, 1971, p. 38, v. 1), were to be applied only if there was no apparent emphasis. Interdisciplinary notations have increased in each subsequent edition, and DDC21 gives explicit instructions for their use (Dewey, 1996, p. xxxvii, v. 1). In addition, DDC's various synthetic devices offer some opportunities for combining topics (e.g., by the use of Table 1, Standard Subdivisions).[10] Our informal literature/geography example, however, has no interdisciplinary number in DDC and there are no useful synthetic devices. The book is classified at 809.92 [literatures displaying specific qualities and elements; realism and naturalism][11] because the work is "about" literature to which geographic analysis has been applied, but it is not limited to one literary form or to one literature. This notation is inaccurate because, as the quotation above showed, *Geography and Literature* is not confined to works displaying realism and naturalism. A more accurate, although very broad, notation would be 809.9 [literature displaying specific features].

3.2 *Library of Congress Classification System*

Originally designed for the collection of the Library of Congress, the LCC is widely used in North American academic libraries. In contrast to the development of DDC, LCC provided some alternative placements in earlier schedules, but newly developed or revised schedules have no alternative numbers (Chan, 1995). Alternative numbers are still provided in LCMARC records, however, for subject bibliographies, monographic series and sets, incunabula, and microforms. In addition, LCMARC records sometimes contain notations from other classification systems, such as DDC, the National Library of Medicine Classification (NLM), and the Superintendent of Documents Classification (SUDOC). As the largest almost purely enumerative classification, the LCC schedules have no specific synthetic devices that would allow combination of numbers from different disciplines to express multidisciplinary topics.[12] Lack of an index to the whole system militates against the establishment of multidisciplinary topics, although "Cf." notes, "Prefer" notes, and "see" references point to alternatives and offer the classifier a way to possibly "better" numbers. Our literature/geography example can be classified at PN56.L55 [PN 56: General literature. Theory. Philosophy. Esthetics. Relation to and treatment of special elements, problems, and subjects. L55: Local color].[13] The LCC notation is similar to DDC's in its generality. The addition of "Local color" is somewhat more specific, but inaccurate.

3.3 *Universal Decimal Classification System*

Modelled on DDC, the UDC was intended for a classified bibliography, not for shelving in libraries, and it has developed somewhat differently from its parent. It does not have a standard citation order and thus allows a variety of optional placements for users. It also has a relatively large number of auxiliary tables and notational elements, some of which are used with the whole system and some of which are used only in specified places. Recently, UDC has undergone changes in management. In 1988, a limited life Task Force was drawn up to determine UDC's future, and one of the concerns of the Task Force was to examine issues raised by multidisciplinary fields (McIlwaine, 1990). A number of revisions are being considered for the system. Even without those revisions, however, UDC has synthetic elements lacking in DDC and LCC. Of particular interest in connection with multidisciplinarity is the use of the colon (:), a relational symbol that states the existence of an unspecified relation between two or more topics and that can be used to express relationships that exist between different main classes.[14] Our literature/geography topic, for example, can be clearly expressed as 91.26:82 [91.26: Evaluation or interpretation of literature, maps and other documents from a geographical point of view; 82: Literature in general]. This notation expresses the intention of *Geography and Literature* very well. This particular example illustrates one way in which UDC "is, in many respects, less out of date than its competitors" (McIlwaine, 1990, p. 24).

3.4 *Bliss Bibliographic Classification System*

The BC2 (1977-), which is based on the first edition (BC1) by H.E. Bliss (1940-1955), is as yet incomplete. Like BC1, BC2 offers more than the usual number of alternative locations, alternative arrangements, and synthetic devices. BC2 features an alphanumeric retroactive notation with devices for shortening class numbers within main classes. For multidisciplinary works, BC2, like UDC, allows combinations of notations from various main classes either by means of explicit directions in the schedules or on the initiative of the classifier. In addition, BC2 provides a "phenomenon class" that allows the option of gathering documents treating an abstract or concrete phenomenon (e.g., justice; the horse) in order to obviate scatter of that phenomenon throughout the schedules.[15] The phenomenon class occurs at the notation 6 in the Auxiliary Schedules, but its details have not yet been published. BC2 plans to offer three possible treatments for phenomena and their relationship to

disciplines, which are tabulated in Thomas (1992, p. 206, Table 3) and summarized here:

1) A single discipline work may go in the appropriate discipline class. A multidisciplinary work may go in the same discipline class with the number 1 appended to the notation to denote multidisciplinarity;
2) A single discipline work may go in the appropriate discipline class. A multidisciplinary work may go in the phenomenon class with the number 6 preceding the notation so that all multidisciplinary works gather at 6;
3) A single discipline work may go in the phenomenon class with 6 preceding the notation. A multidisciplinary work may go in the same phenomenon class with a 6 preceding and a 1 following the notation to denote multidisciplinarity.

Thus, one may eventually choose not to use the phenomenon class at all, to use it only for multidisciplinary works, or to use it for all works on the phenomenon of interest. Obviously, each library would need careful study of the possible options. Our example of the treatment of literature/geography cannot be classified specifically at the moment in BC2 because the appropriate schedules (i.e., L/O, History, including geography; X/Z Language and Literature; and Auxiliary Schedule 6, phenomenon class) have not been published. The Introduction to BC2 stated that "literature on a given concept (entity, attribute, process) [treated] from the viewpoint of *several or all disciplines*....seems to be growing, although at a relatively slow rate" (1977, p. 52, original emphasis). The growth rate of multidisciplinarity is now remarkably fast, and BC2 appears to offer more complete treatment of these works than the other systems discussed.

4. Some New Approaches

Developments in the methods of creating knowledge and in the practices of information storage and retrieval make it important to examine alternative structural principles for bibliographic classification systems. This kind of investigation has been done before. For example, the CRG tried to base its general system on general systems theory and the theory of integrative levels. Also, in an experimental course on the universe of knowledge at the University of Maryland in 1967, Langridge's (1969) students examined seven different analyses of knowledge types in order to decide whether any of these analyses could replace the academic disciplines for bibliographic classification systems.[16] In spite of extensive discussion, however, no consensus has been reached on how to replace or to modify discipline-based systems. The following sections describe briefly some selected projects that have been undertaken and some ideas that seem likely to be fruitful.

4.1 Use of Existing Systems

Three projects use existing classification systems in novel ways to deal with multidisciplinary issues and to make these systems more flexible and hospitable. All these projects are as yet unfinished and their respective solutions to these problems have not yet been fully tested, but all offer methods of building new perspectives into old systems.

First, one possibility is to provide multiple notations for multidisciplinary documents using an established system. A web-based classified catalogue for newly analyzed documents is being created for Iter[17], the Bibliography of Renaissance Europe. This bibliography uses the abridged DDC to provide notations needed to express various aspects of journal articles about the Renaissance (Castell, 1997). For example, an article about Michelangelo's horses, clothing, and the journey of one of his statues to its destination (Wallace, 1994) has been given three notations, i.e.: 1) the mules and horses Michelangelo owned: 636.10045 [horses and related animals; Italy]; 2) the clothing Michelangelo bought, wore, and gave to others: 391.00945 [costume and personal appearance; Italy]; and 3) the journey of Michelangelo's sculpture *Risen Christ* from Florence to a church in Rome: 730.92 [sculptors; biography]. This last notation is very general and does not bring out the "journey" concept. Nevertheless, this project is significant in that it uses DDC to structure a multiple access classified catalogue. It is important to note that it is unnecessary to provide general time periods in the notations, because all articles concern the Renaissance, which has been defined for the database as 1300-1700.

Second, Olson (1997; Olson and Ward, 1997) is conducting ongoing research using women's studies as an example of an multidisciplinary marginalized field and DDC as an example of a putatively universal classification. In this project, terms from *A Women's Thesaurus* have been linked to DDC and checked for three variables[18] to ascertain the extent to which DDC can express topics in women's studies. On one level, this project has created an electronic women's studies index to DDC, so that DDC can be browsed from a women's studies' perspective in libraries that use DDC. On another level, it has created a methodology that can subsequently be applied to other domains, and perhaps to other classification systems, in order to moderate the effect of disciplinary scatter and to bring a topic of interest into the foreground of a discipline-based classification system. This approach provides a way of creating BC2-like phenomenon

classes. Foskett (1991) suggested a similar use of BC2 as the basis for a number of special systems.

Third, McIlwaine and Williamson (1994) are undertaking an exploratory study to determine whether UDC might be restructured class by class using the facet framework of BC2 wherever possible. The first class studied was 61 Medical Sciences (UDC) and Class H (BC2) Medicine. The process involved three phases: 1) integration of the two systems for preclinical medicine and for one body system; 2) integration of the remainder of the class; and 3) development of a thesaurus from the restructured integrated system. Subsequently, relationships between the classification system and the thesaurus will be assessed, and the restructured UDC will be used to classify a random selection of documents already classified by the old UDC. The results from the old and new UDC class 61 will be compared and evaluated and the usefulness of the thesaurus assessed. Currently, tentative new class numbers are being developed and assigned to the restructured schedules and the development of new auxiliary tables has begun (McIlwaine and Williamson, 1996).

4.2 Proposed New Structural Principles

Few suggestions have been made for entirely new structural principles for either general or special systems. Langridge devised a preliminary plan for the Avalon Library, Glastonbury, based on his analysis of the need for a "New Age" classification (1992, p. 11). This system has three general main classes: Nature, Human Affairs, Mind and Spirit) and a fourth for the Library's special collections. Short (1995) recommended a variation on Bliss' concept of scientific and educational consensus when he proposed that a system be organized around the educational purposes of higher education: general education; specialist education; research education; and the education of educators. Elliott's (1985) advice for classifying historical documents was based on the functional relationship(s) of documents to events. A more fully developed non-disciplinary structure is Dahlberg's Information Coding Classification (ICC) (e.g., Dahlberg, 1995). The first two levels of ICC are contained in a matrix called a „systematifier". The systematifier consists of rows of general forms (e.g., 01 Theories, principles) and columns of areas of study (e.g., 1 Form & structure area). According to Dahlberg, ICC has the „unlimited but organized possibility to combine all its elements with each other according to any need arising" (1982, p. 92). Combinations may be made either within or among groups. Detailed subdivisions of some sections of ICC have been developed and have been used to produce a classified index of knowledge organization literature published regularly n *Knowledge Organization* (e.g., vol. 24, no. 3 , 1997, p. 194-203).

Traditionally, the desiderata for any classification system are that the classes be both mutually exclusive (i.e., do not overlap) and jointly exhaustive (i.e., account for all possibilities). If one takes the whole domain of knowledge as the starting point for a general classification system, the first level of subdivision determines the fundamental structural principle that governs all lower levels of subdivision. As we have seen, previous systems used disciplinary fields of interest as the first level of subdivision. The first problem that arises is that disciplines are not mutually exclusive. For example, human beings may be studied from different perspectives (e.g., biological, chemical, psychological, spiritual) and each of these disciplinary standpoints overlaps the others. If we group the disciplines into the three commonly acknowledged disciplinary areas of science, social science, and the humanities, the same predicament of non-mutual exclusivity may be discerned.[19]

A similar problem, and the one that has a close relationship with the multidisciplinary phenomenon, is that the disciplines are not jointly exhaustive. The inability of existing systems to deal suitably with multidisciplinary topics confirms this lack of joint exhaustivity. Langridge (1995) suggested subdividing the sciences on the basis of categories of phenomena and subdividing the humanities on the basis of forms of knowledge, but, as discussed above, this principle of division does not produce mutually exclusive and jointly exhaustive classes. Modern classification theory posits that the analytico-synthetic method is the most suitable for deriving the contents of classes in classification systems, but the success of this method depends ultimately on the ability to achieve mutually exclusive and jointly exhaustive groupings at every level of generality.

Research on human categorizing behaviour and the development of fuzzy set theory suggest that true mutual exclusivity and joint exhaustivity may not be possible or desirable. The work of Rosch (e.g., 1978) and ongoing research based on her findings showed that human beings do not rely on mutual exclusivity and joint exhaustivity when forming categories for natural objects. Instead, people appear intuitively to create and accept fuzzy boundaries between categories for natural objects (e.g., between "fruit" and "vegetable"). Similar findings have been reported for conceptual categories. For example, Ranney *et al*, (1996) found that the basic distinction made in scientific reasoning between hypotheses (i.e., theory) and data (i.e., evidence) is not entirely clear to either novices or experts, and it is therefore doubtful that these categories, upon which all scientific research is based, are

mutually exclusive. The need for projects modifying existing systems (as described above) attests to the absence of joint exhaustivity in current systems. Two classification systems, one experimental (Beghtol, 1994) and one widely implemented (*Standard...*, 1980), provide devices for dealing with unclassifiable instances in order to address the problem of non-joint exhaustivity. It is doubtful whether joint exhaustivity can be fully attained in a world of rapidly changing knowledge and increased knowledge-making activity.

In this situation, one may question whether the traditional desiderata should remain the primary ones for bibliographic classification systems. We may postulate that modern systems have a greater need for hospitality and flexibility than they have for mutual exclusivity and joint exhaustivity. ICC and the BC2 phenomenon class may provide a new kind of flexibility and a possible way of introducing various viewpoints into a standard system. In addition, however, we need new theoretical frameworks that allow us to establish hospitality and flexibility as primary desiderata. Parsons developed theorems showing that "for any domain, a class structure can be constructed... [that] for any relevant universe containing more than one property, there exists more than one class structure... [and that] every potential class belongs to some class structure" (1996, p. 135). Parsons argued that these theorems underlay the need for classification systems that support "multiple views" (1996, p. 135) and developed the MIMIC system along lines reminiscent of the CRG's search for a freely-faceted system. Albrechtsen and Jacob (1997) arrived at the same general conclusion based on the literature of the sociology of science and argued that the needs of heterogeneous and complex communities of users can be integrated into classification systems that are flexible, loosely structured, and robust in practice. In Albrechtsen and Jacob's paper, a classificatory structure is likened to a blackboard on which different groups can communicate their varying viewpoints.[20] As these examples show, the view that hospitality is a primary requirement for classification systems is gaining theoretical ground and may encourage new theoretical vocabularies to emerge. One possible source of insight may come from Watson, who pointed out that different perspectives "are...incompatible only in the sense that one cannot adopt different perspectives at the same time or mix them indiscriminately" (1985, p. 40). Watson's viewpoint posited that recognition of perspectival differences allowed one to make reasoned choices about which perspective would be appropriate for a particular purpose and to activate the desired perspective at will.

5. Conclusion

This paper demonstrates that a paradigm shift in bibliographic classification research is needed and may be developing. The most flexible of the present general classifications of knowledge do not adequately support multidisciplinary topics or respond hospitably to the requirements of multidisciplinary documents. The next century of classification theory, practice and research will need to react rapidly to multidisciplinary literary warrant and to build responsiveness to different discourse communities into the concept of consensus. In order to promote intellectual exchange, research, and education that, in the electronic environment, are not limited by time, place, or a static discourse community, basic research is needed on structural principles and creative design criteria for classification systems.

Notes:

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2 Domain analysis has been defined as "the process of identifying and organizing knowledge about some class of problems--the problem domain--to support the description and solution to those problems" (Arango and Prieto-Diaz, 1991, p. 9).

3 Langridge later (1995) included "art" in this list of forms of knowledge.

4 An interesting variation on this view appeared in Nelson, who viewed LCC Class N as "both perspectival and hierarchical. Like nothing so much as that famous Saul Steinberg drawing [*View of the World from Ninth Avenue*, in Steinberg (1978, p. 79)], the LC gaze proceeds as if looking across the United States from somewhere in New England, first south, then west. Outside the national borders, the classificatory gaze turns north to Canada and then south. Appearing next in view is Europe, where the exceptions to alphabetical order are telling. Listed first is Great Britain, with which the United States has that 'special relationship.'" (1997, p. 32)

5 An overview of the history of terminological discussions of multidisciplinarity from theoretical and applied perspectives appears in Klein (1990, p. 55-73).

6 For example, Dahlberg (1994) proposed "cross-disciplinarity" as a broad term composed of five types: interdisciplinarity; transdisciplinarity; multidisciplinarity; pluridisciplinarity; syndisciplinarity. Ranganathan identified twelve methods of subject formation: loose assemblage 1; loose assemblage 2; loose assemblage 3; lamination 1; lamination 2; fission; dissection; denudation; fusion; distillation; clustering/subject bundle; agglomeration/partial comprehension (Binwal, 1992). Ac-

cording to Klein (1990, p. 64) four basic kinds of interaction occur in practice. These are: borrowing; solving problems; increasing consistency of subjects or methods; emergence of an interdisciplinary area.

7 Recently, a complementary area of study has arisen, i.e., the study of "undiscovered public knowledge" (Swanson, 1986) and of "mutually isolated literatures" (Swanson, 1990). Here, in contrast to studies of literatures that intersect, the focus is on literatures that do not cite each other. Davies (1989) suggested that classification systems could promote the identification of mutually isolated literatures that may potentially benefit each other.

8 Chartier (1994) discussed order in individual books.

9 Some fields that have not been named are well established. For example, intersections between history and climatology have generated a large literature, but the field has not received a joint name (Rabb, 1980).

10 Langridge's (1992) distinction between disciplines and phenomena is partially handled in DDC by Table 1 Standard Subdivisions for, e.g., philosophy (-01), science (-015 or -072) and history (-09). There is no Standard Subdivision for art, although -221 is used for Pictures and related illustrations.

11 This notation was assigned by the Library of Congress from DDC19 as in MARC record control number 86022968. No changes in this notation appear in DDC21.

12 Class N, Fine Arts, has been criticized because its "positivistic, antiquarian nature...isolates art from other fields, subjects, or ways of understanding knowledge. It even frustrates the most traditional of art historical methods, artistic biography. Unlike literature in the LC system, for example, works by and about a single artist are grouped first not by maker but by medium" (Nelson, 1997, p. 33). The same complaint could, of course, be made about DDC's treatment of literary authors in the 800 class.

13 This notation is from LCMARC record control number 86022968 (Class P, 2nd ed.). No changes to this notation occur in Class P, 3rd ed.

14 The non-specificity of the UDC colon is an advantage in considering multidisciplinary topics, but it has also been considered a disadvantage and suggestions for the expression of various kinds of relationships have been made (e.g., Perreault, 1994).

15 This practice is reminiscent of J.D. Brown's *Subject Classification* (1908), the "one place" scheme in which all documents on, for example, roses, which were considered to be "concrete", were classified in one place regardless of the disciplinary perspective from which the topic was approached. According to Langridge (1992), Bliss was influenced by Brown's work, but modified its application in various ways.

16 For example, Machlup had proposed five types of knowledge: Practical knowledge; Intellectual knowledge; Small-talk and pastime knowledge; Spiritual knowledge; and Unwanted knowledge (Langridge, 1969).

17 "Iter" means "journey" or "the way" in Latin. The url is: http://iter.library.utoronto.ca, where a guest database is available.

18 1) Coextensiveness: how well the term in general can be linked to a notation; 2) Gender coextensiveness: how well the term as it relates to women can be linked to a notation; 3) Rhetorical space: whether or not the notation occurs in an appropriate context.

19 Watson analyzed various perspectives (including the academic disciplines) that one may take when viewing all of knowledge and argued that these perspectives can be seen as "mutually inclusive insofar as a perspective can be a perspective on other perspectives" (1985, p. 38). An example might be that one can take a philosophical perspective on the history of physics. The concept of mutual inclusivity does not seem to have been studied in bibliographic classification theory, but it is a useful concept for explaining why the distinction between forms of knowledge (disciplines) and phenomena, as discussed above, is not absolute.

20 The blackboard metaphor is strikingly different from the tree metaphor that has dominated the classification literature (Beghtol, 1997a). Cronin and Hert (1995) suggested that a change to a foraging metaphor for searching behaviour would capture the variety of behaviours in which scholars engage in the pursuit of new insights. It remains to be seen whether a blackboard metaphor suggests classification-making methodologies that the tree metaphor has not supported.

References:

Albrechtsen, H., & Jacob, E. K. (1997). Classification Systems as Boundary Objects in Diverse Information Ecologies. In E. Efthimiades (Ed.). *Advances in Classification Research: Proceedings of the 8th ASIS SIG/CR Classification Research Workshop.* Medford, New Jersey: Information Today. [forthcoming]

Arango, G. & Prieto-Diaz, R. (1991). Introduction and Overview: Domain Analysis Concepts and

Research Directions. In R. Prieto-Diaz and G. Arango (Eds.). *Domain Analysis and Software Systems Modeling.* Los Alamitos, California: IEEE Computer Society Press. 9-26.

Beghtol, C. (1994). *The Classification of Fiction: The Development of a System Based on Theoretical Principles.* Metuchen, New Jersey: Scarecrow Press.

Beghtol, C. (1996). Stories: Applications of Narrative Discourse Analysis to Issues in Information Storage and Retrieval. In H. Albrechtsen and C. Beghtol (Eds.). *Proceedings, Research Seminar, Fiction - OPACS - Networks: Research and Development in Electronic Access to Fiction, Multicultural Knowledge Transfer and Cultural Mediation Via Networks,* Nov. 11-13, 1996, Copenhagen. [forthcoming]

Beghtol, C. (1997a). Graphic Representations of Hierarchical Systems. In P. Solomon (Ed.). *Advances in Classification Research: Proceedings of the 7th ASIS SIG/CR Classification Research Workshop*. Medford, New Jersey: Information Today. 22-43.

Beghtol, C. (1997b). What is an Event? Domain Analysis of Narrative Documents. In *Knowledge Organization and Information Retrieval: Proceedings of the 6th International Conference on Classification Research*, 16-18 June, 1997, London. [forthcoming]

Binwal, J. C. (1992). Ranganathan and the Universe of Knowledge. *International Classification, 19(4)*, 195-200.

Bliss, H. E. (1940-1955). *A Bibliographic Classification*. New York, New York: H. W. Wilson.

British Standards Institution. (1993). *Universal Decimal Classification*. (International Medium Ed., English Text. Part 1, Systematic Tables). London: British Standards Institution.

Brown, J. D. (1908). *Subject Classification, with Tables, Indexes, etc. for the Subdivision of Subjects*. London: Library Supply.

Castell, T. (1997). Maintaining Web-based Bibliographies: a Case Study of Iter, the Bibliography of Renaissance Europe. In *Digital Collections: Implications for Users, Funders, Developers and Maintainers: Proceedings of the ASIS Annual Meeting, 1997*. Medford, New Jersey: Information Today.

Chan, L. M. (1995). Library of Congress Classification: Alternative Provisions. *Cataloging & Classification Quarterly, 19(3/4)*, 67-87.

Chartier, R. (1994). *The Order of Books*. Cambridge: Cambridge Univ. Press.

Clark, W. (1995). Narratology and the History of Science. *Studies in History and Philosophy of Science, 26(1)*, 1-71.

Classification Research Group. (1955). The Need for a Faceted Classification as the Basis of all Methods of Information Retrieval. *Library Association Record, 57(7)*, 262-268.

Cronin, B, & Hert, C. A. (1995). Scholarly Foraging and Network Discovery Tools. *Journal of Documentation, 51(4)*, 388-403.

Cutter, C. A. (1904). *Rules for a Dictionary Catalog* (4th ed.). Washington: U.S. Bureau of Education.

Dahlberg, I. (1982). ICC--Information Coding Classification--Principles, Structure and Application Possibilities. *International Classification, 9(2)*, 87-93.

Dahlberg, I. (1994). Domain Interaction: Theory and Practice. In *Knowledge Organization and Quality Management: Proceedings of the Third International ISKO Conference*, 20-24 June 1994, Copenhagen, Denmark, *Advances in Knowledge Organization*, vol 4. Frankfurt: Indeks Verlag. 60-71.

Dahlberg, I. (1995). The Future of Classification in Libraries and Networks, A Theoretical Point of View. *Cataloging & Classification Quarterly, 21(2)*, 23-35.

Davies, R. (1989). The Creation of New Knowledge by Information Retrieval and Classification. *Journal of Documentation, 45(4)*, 273-301.

DDC. (1997). Research: Dewey Decimal Classification System Research Agenda. http:/www.oclc.org/oclc/fp/research/agenda.htm (accessed 07/09/97).

Denno, D. W. (1987). Indexing of Interdisciplinary Literature on Crime, Violence, and Mental Disorder. *Journal of Information Science, 13*, 117-122.

Dewey, M. (1965). *Dewey Decimal Classification and Relative Index* (17th ed.). Lake Placid Club, New York: Forest Press, Inc.

Dewey, M. (1971). *Dewey Decimal Classification and Relative Index* (18th ed.). Lake Placid Club, New York: Forest Press, Inc.

Dewey, M. (1979). *Dewey Decimal Classification and Relative Index* (19th ed.). Lake Placid Club, New York: Forest Press, Inc.

Dewey, M. (1996). *Dewey Decimal Classification and Relative Index* (21st ed.). Albany, New York: Forest Press.

Drake, M. (1975). The Librarian's Role in Interdisciplinary Studies. *Special Libraries, March*, 116-120.

Elliott, C. A. (1985). Communication and Events in History: Toward a Theory for Documenting the Past. *American Archivist, 48(4)*, 357-368.

Foskett, D. J. (1991). Concerning General and Special Classifications. *International Classification, 18(2)*, 87-91.

Gomez, I., Bordons, M., Fernandez, M. T. & Mendez, A. (1996). Coping with the Problem of Subject Classification Diversity. *Scientometrics, 35(2)*, 223-335.

Hinze, S. (1994). Bibliographic Cartography of an Emerging Interdisciplinary Discipline: The Case of Bioelectronics. *Scientometrics, 29(3)*, 353-376.

Kern, S. (1983). *The Culture of Time and Space 1880-1918*. Cambridge, Massachusetts: Harvard Univ. Press.

Klein, J. T. (1990). *Interdisciplinarity: History, Theory, and Practice*. Detroit, Michigan: Wayne State Univ. Press.

Langridge, D. (1969). *Universe of Knowledge: Essays by Members of the Special Seminar Held During the Fall Semester, 1967.* College Park, Maryland: Univ. of Maryland, School of Library and Information Services.

Langridge, D. (1992). Bliss, the Disciplines and the New Age. *Bliss Classification Bulletin, 34*, 8-13.

Langridge, D. (1995). Alternative Starting Points in Classification. *Cataloging & Classification Quarterly, 19(3/4)*, 7-15.

LC Catalogs JSTOR TITLES. (1997). *LC Cataloging Newsline: Online Newsletter of the Cataloging Directorate, Library of Congress, 5(9).*

Library of Congress. Subject Cataloging Division. (1978). *Classification, Class P, Subclasses PN, PR, PS, PZ. General Literature, English and American Literature, Fiction in English, Juvenile Belles Lettres* (2nd ed.). Washington: Library of Congress.

Library of Congress. Subject Cataloging Division. (1988). *Classification, Class P, Subclasses PN, PR, PS, PZ. Literature (General), English and American Literature, Fiction in English, Juvenile Belles Lettres* (3rd ed.). Washington: Library of Congress.

Mallory, W. E. & Simpson-Housley, P. (Eds.). (1987). *Geography and Literature: A Meeting of the Disciplines.* Syracuse, New York: Syracuse Univ. Press.

McCain, K. W. & Whitney, P. J. (1994). Contrasting Assessments of Interdisciplinarity in Emerging Specialties. *Knowledge: Creation, Diffusion, Utilization, 15(3)*, 285-306.

McIlwaine, I. C. (1990). The work of the System Development Task Force. In A. Gilchrist and D. S. Strachan (Eds.). *The UDC: Essays for a New Decade.* London: Aslib. 19-27.

McIlwaine, I. C. & Williamson, N. J. (1994). A Feasibility Study on the Restructuring of the Universal Decimal Classification Into a Fully-Faceted Classification System. In H. Albrechtsen and S. Oernager (Eds.). *Knowledge Organization and Quality Management: Proceedings of the Third International ISKO Conference.* Frankfurt: Indeks Verlag. 406-413.

McIlwaine, I. C. & Williamson, N. J. (1996). Restructuring of Class 61 - Medical Sciences. In *Extensions and Corrections to the UDC* 18: 15-17. The Hague: International Federation for Documentation.

Mills, J. *et al.* (Eds.). (1977-). *Bliss Bibliographic Classification* (2nd ed.). London: Butterworths.

Mitchell, J. (1995). Options in the Dewey Decimal Classification System: The Current Perspective. *Cataloging & Classification Quarterly, 19(3/4)*, 89-103.

Murray, P. C. (1996). Business Productivity and Organization of Knowledge: a Look at Emerging Requirements. In *Knowledge Organization and Change.* Proceedings of the Fourth International ISKO Conference, 15-18 July 1996, Washington, DC, *Advances in Knowledge Organization*, vol 5. Frankfurt: Indeks Verlag. 206-212.

Nelson, R. S. (1997). The Map of Art History. *The Art Bulletin, 79*, 28-40.

Olson, H. A. (1997). Feminist Locales in Dewey's Landscape: Mapping a Marginalized Knowledge Domain. In *Knowledge Organization and Information Retrieval: Proceedings of the 6th International Conference on Classification Research*, 16-18 June, 1997, London. FID publication 716. The Hague: FID. 129-133.

Olson, H. A. & Ward, D. B. (1997). Ghettoes and Diaspora in Classification: Communicating Across the Limits. In B. Frohman (Ed.), *Proceedings of the 25th Annual Conference/Association canadienne des sciences de l'information: travaux du 25e congres annuel.* Toronto, ON: Canadian Association for Information Science. 19-31.

Palmer, C. L. (1996). Introduction. In *Navigating Among the Disciplines: The Library and Interdisciplinary Inquiry, Library Trends, 45(2)*, 129-133.

Parsons, J. (1996). On the Relevance of Classification Theory to Database Design. In R. Fidel *et al.* (Eds.). *Advances in Classification Research: Proceedings of the 5th ASIS SIG/CR Classification Research Workshop.* Medford, New Jersey: Information Today. 131-140.

Perreault, J. (1994). Categories and Relators: a New Schema. *Knowledge Organization, 21(4)*, 189-198. (Reprinted from Perreault's *Towards a Theory for UDC.* London: Bingley, 1969.)

Psycoloquy. (1997). http://www.princeton.edu/~harnad/psych.html#inst.

Qin, J. (1994). An Investigation of Research Collaboration in the Sciences through *The Philosophical Transactions* 1901-1991. *Scientometrics, 29(2)*, 219-238.

Rabb, T. K. (1980). The Historian and the Climatologist. *Journal of Interdisciplinary History, 10(4)*, 831-837.

Ranney, M. *et al.* (1996). 'I Know One When I See One': How (Much) Do Hypotheses Differ from Evidence? In R. Fidel *et al.* (Eds.). *Advances in Classification Research: Proceedings of the 5th ASIS SIG/CR Classification Research Workshop.* Medford, New Jersey: Information Today. 141-158.

Rosch, E. (1978). Principles of Categorization. In E. Rosch and B. B. Lloyd (Eds.). *Cognition and Categorization.* Hillsdale, New Jersey: Lawrence Erlbaum. 27-48.

Sager, N. *et al.* (1995). Medical Language Processing: Applications to Patient Data Representation and Automatic Encoding. *Methods of Information in Medicine, 34(1/2),* 140-146.

SantaVicca, E. F. (1986). Teaching Research Skills in Linguistics: An Interdisciplinary Model for the Humanities and the Social Sciences. *Research Strategies, 4(4),* 168-176.

Short, E. C. (1995). Knowledge and the Educational Purposes of Higher Education: Implications for the Design of a Classification Scheme. In A. R. Thomas (Ed.). *Classification: Options and Opportunities.* New York: Haworth Press. 59-66.

Standard Industrial Classification. (1980). Ottawa: Statistics Canada. Standards Division.

Steinberg, S. (1978). *Saul Steinberg.* Commentary by H. Rosenberg. New York: Knopf.

Svenonius, E. (1983). Use of Classification in Online Retrieval. *Library Resources & Technical Services, 27(1),* 76-80.

Swanson, D. R. (1986). Undiscovered Public Knowledge. *Library Journal, 56(2),* 103-118.

Swanson, D. R. (1990). Somatomedin C and Arginine: Implicit Connections Between Mutually Isolated Literatures. *Perspectives in Biology and Medicine, 33(2),* 157-186.

Thomas, A. R. (1992). Options in the Arrangement of Library Materials and the New Edition of the Bliss Bibliographic Classification. In B. H. Weinberg (Ed.). *Cataloging Heresy: Challenging the Standard Bibliographic Product: Proceedings of the Congress for Librarians, February 18, 1991.* Medford, New Jersey: Learned Information. 197-211.

Tomov, D. T. & Mutafov, H. F. (1996). Comparative Indicators of Interdisciplinarity in Modern Science. *Scientometrics, 37(2),* 267-278.

UNISIST Advisory Committee. (1975). *Second session, May 5-9, 1975: Broad System of Ordering.* Paris: UNESCO.

von Ungern-Sternberg, S. (1995). Knowledge Organisation and a Macro Language for Indexing in Biotechology. In R. P. Schwartz, *et al.* (Eds.). *Advances in Classification Research: Proceedings of the 6th ASIS SIG/CR Classification Research Workshop.* Medford, New Jersey: Information Today [forthcoming]

Wallace, W. E. (1994). Miscellanea curiositae Michelangelae: A Steep Tariff, A Half Dozen Horses, and Yards of Taffeta. *Renaissance Quarterly, 47(2),* 330-350.

Watson, W. (1985). *The Architectonics of Meaning: Foundations of the New Pluralism.* Albany, New York: State Univ. of New York Press.

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