# Chapter 2
# The Needs of Interdisciplinary Research

We begin this chapter by outlining a set of interdisciplinary information needs derived from our discussion in Chap. 1. We then discuss each of these in turn. We close the chapter by discussing how disciplinary scholars would be affected by the adoption of KOSs that met interdisciplinary needs.

## Identifying Interdisciplinary Needs

The review of the nature of interdisciplinarity in Chap. 1 sets the stage for a detailed discussion in this chapter of what interdisciplinarians need from KOSs.[1] Though there is diversity in interdisciplinary practice it is still quite possible to identify key challenges that will face interdisciplinary scholars and students in general. These needs can be summarized in Table 2.1. They are also expressed figuratively in Fig. 2.1.

### *Needs Justification*

Note that the first five desiderata outlined in Table 2.1 reflect both our understanding of what interdisciplinarians do *and* our understanding of the defining characteristics of the disciplines that interdisciplinarians need to navigate (on the latter see Table 1.2).

[1] There is no detailed model of interdisciplinary search practices (Palmer 2010, 182). We have thus pursued the strategy of first identifying what interdisciplinary researchers and students are trying to do, and then discussing what sort of information-seeking strategies are required.



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**Table 2.1** Interdisciplinary needs

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| Interdisciplinarians will wish to know what has been said by all scholars (and indeed those beyond the academy) about a particular phenomenon (that is, the things or variables that we study) and especially about the relationships that might exist among two or more phenomena. |
| Interdisciplinarians will wish to know what theories have been applied to the phenomena and relationships that interest them. |
| Likewise interdisciplinarians will wish to know what evidence supports different theories, and this means knowing which methods have been applied to the phenomena and relationships that interest them and which data has been collected in exploring these things and relationships. |
| Interdisciplinarians will need to understand the meanings attached to particular terms. |
| Interdisciplinarians generally appreciate that each discipline has its own disciplinary perspective, and will thus wish to evaluate disciplinary insights in the context of that disciplinary perspective.[a] They will thus generally wish to know the disciplinary affiliation and outlook of authors, and also have access to works describing disciplines. [They will likewise need similar information regarding interdisciplinarity itself.] |
| We very briefly saw when discussing the León Manifesto, that it will be easier to facilitate the classification of diverse relationships if we pursue a synthetic approach to classification, such that a work can be classified by a combination of terms. We will develop this idea in future chapters. We can thus add 'synthetic' approach as an indirect interdisciplinary need. |

[a]Recall that disciplinary perspective embraces a host of philosophical attitudes. We shall see in later chapters that users may wish to see works classified in terms of various perspectives—feminism, postmodernism, and so on—that an author brings to a work

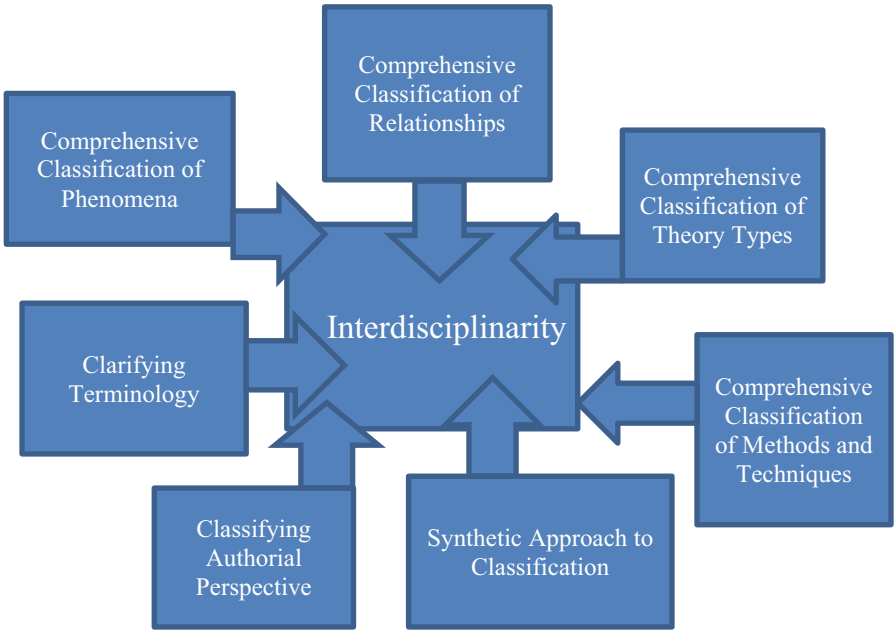


**Fig. 2.1** Concept map of interdisciplinary knowledge organization. *Source*: Table 2.1

We do not mean to suggest that classification by theory, method/data, phenomena, concepts, and discipline are the *only* sorts of classification needed by scholars: like disciplinary scholars they will also care about such things as time and place and type of document. The desiderata of Table 2.1 are, however, by far the most important objectives currently ill-served by classificatory practice. As was suggested in our discussion of undiscovered public knowledge, classification schemes could, but generally do not, strive to capture within subject headings the key causal relationships investigated in a work. Only rarely are the theories or methods employed in a work captured in subject headings. And discipline-based classifications can employ terminology quite differently in different fields.

Davis and Shaw (2011, 31–2) list five types of general information need. These can each be related to the interdisciplinary needs identified above. The first is procedural (how to do things). For the interdisciplinarian this will include understanding multiple theories and methods. The second is substantive. This is where the interdisciplinarian wishes to find out what has been said about particular phenomena and relationships. The third is muddled, where the user is not sure what to seek. This is common in interdisciplinary practice for the researcher cannot know in advance what useful information might exist in other disciplines. They must thus be facilitated in searches both when they know what they are looking for and when they do not. The fourth type is verificative. The interdisciplinary researcher will be particularly curious as to whether similar causal arguments have been made in different fields, and what the evidence for these has been. The fifth is educational: the user may not understand what they find and need further resources in order to understand. One key source of misunderstanding is unclear terminology; classification can reduce ambiguity. Another is not understanding theories, methods, or disciplinary perspective; it is thus important to classify works in terms of these and guide user to works about them.

Mai (2008) concurs that the design of classifications should be grounded in an understanding of user needs. He worries that the descriptive literature on user behavior provides little guidance. He thus suggests that we perform 'cognitive work analysis': identify the constraints faced by particular user groups and then attempt to cope with these. Mai advises us to look first at the work environment, and then ask what sort of work is done, how is it organized, what strategies (for search especially) are involved, and what expertise is possessed by those doing the work. His approach thus supports the approach taken here of asking what interdisciplinarians do and how, and deducing their informational requirements on the basis of their work activities (see Szostak 2010). His particular five questions reinforce in turn the importance of knowledge organization to interdisciplinarity, and are summarized in Table 2.2. They also provide further justification for the specific needs of interdisciplinarians that were identified above.

It is also useful to revisit briefly our discussion of undiscovered public knowledge, for the needs identified in that literature bear a striking resemblance to those we have described above. Beghtol (1995) explored the implications of 'undiscovered public knowledge' for information science. Drawing on previous research by others, she noted five resulting problems:

**Table 2.2** Cognitive work analysis of interdisciplinarity

| |
|---|
| *Work Environment*. Universities are generally organized around disciplines. The vast majority of scholars thus interact mostly with scholars with a shared disciplinary perspective. If they need or wish to look beyond their domain, they will need to rely either on the kindness of strangers or on useful guidance from the field of information science. Interdisciplinary scholars will be hobbled if they must master several domain-specific classifications or seek out many disciplinary experts for advice. |
| *What Work is Done?* A growing body of scholars defines themselves as interdisciplinary. This must mean that they do not take any one domain-specific terminology for granted, but must consciously master multiple domains. Even specialized researchers are expected to have some familiarity with how their research fits within the broader scholarly enterprise. We saw in Chap. 1 that interdisciplinary work involves investigating phenomena, relationships, theories, methods, perspectives, and terminology across disciplinary boundaries. |
| *How is this Work Organized?* An increasing number of scholars operate within interdisciplinary teams. These almost universally face 'translation' problems: scholars speak past each other because they use words in slightly different ways. Boundary work across disciplines is thus characterized by the use of 'pidgins': limited dialects that allow cross-disciplinary communication (Galison 1997; Klein 1990). Since pidgins are limited in scope, it would be difficult to classify all works relevant to such a cross-disciplinary endeavor in terms of the shared dialect. Conversation across all disciplinary boundaries would be better served by the sort of supra-language embedded in a general classification which does not employ different terminology in different fields. |
| *What Strategies are Involved?* In the absence of reliable guidance from information science, scholars wishing to pursue questions across disciplinary boundaries are forced to rely on a host of time-consuming and ineffective search strategies: seeking out scholars in other fields, chasing citations (the strategy recommended by Bates 1996, and Palmer 1996), following 'big names' in other fields, and so on (Palmer 1996). |
| *What Expertise is Possessed?* The vast majority of even interdisciplinary scholars received their training exclusively within one discipline (with perhaps a token course or two outside of their chosen discipline). They are thus not taught how to access information from outside their discipline, and perhaps even sub-discipline (though this is beginning to change). Nor are they taught any familiarity with the theories or methods or phenomena addressed by others. That is, scholars tend to know a lot about one thing, but have little or no training in how to connect that knowledge to related understandings in other fields. They rely on information science to facilitate this. |

- Evidence that might refute a hypothesis is not recognized;
- Evidence that might add additional support to a hypothesis is likewise not appreciated;
- Analyses of missing links in a causal chain are ignored;
- Solutions to analogous problems are missed; and
- Unimagined correlations between concepts are not recognized.

It is notable that though these problems were identified in a quite different context, they point also toward the importance of relationships, methods/evidence/data, and concepts. Beghtol notes that the strategies generally recommended for uncovering 'undiscovered public knowledge' rely heavily on serendipity. Moreover they tend to be discipline-specific, whereas the likelihood of undiscovered public knowledge increases with interdisciplinary interaction

(Beghtol 1995, 195–6). The solution, it must seem, is to facilitate searches by phenomenon, relationship, theory, and method across disciplinary boundaries.

It is not just scholars pursuing big breakthroughs that need the sorts of information identified above. The vast bulk of scholarship involves the application of one or more scholarly theories and scholarly methods to the study of the relationships among one or more phenomena (see Szostak 2004). Scholars performing such research are naturally curious as to whether the theory and/or method they wish to apply to the study of their particular set of phenomena has been applied before. They thus wish to be able to search primarily by theory applied, method applied, and phenomena or relationship studied. Yet documents are generally classified exclusively by subject matter, by what a work is 'about.'

The needs addressed above also accord with Kleineberg's (2013) advice that we should capture the 'what,' 'why' and 'how' of arguments and documents. 'What' will be captured through phenomena and relationships; 'how' through methods and perhaps theory; 'why' through perspective in general. And our approach to identifying needs accords well with the pragmatic approach to knowledge organization urged by Hjørland and Nissen Pedersen (2005). They recommend 'classification in response to an objective' (584). We, like Spärck Jones (2005) to whom their paper is a response, respect their preference for a pragmatic approach. We also agree that classifications are to be judged, in large measure, by their congruence with the objectives of those who utilize them, and are thus best constructed with careful attention to those objectives. Indeed, the main contention of this book is that as scholarly research (and public policy analysis) becomes increasingly interdisciplinary, a—perhaps 'the'—key purpose of systems of classification is to facilitate interdisciplinary research and information sharing.

## *Extensions and Clarifications*

We have naturally emphasized to this point the challenges faced by interdisciplinarians in searching. But once the interdisciplinary researcher has found relevant literature, they then need to understand it. Understanding terminology is important at the search stage—the interdisciplinarian needs to know what terms to search for—but also critical for then comprehending the literature. Information scientists should not forget that an appropriate classification clarifies the meaning of terminology. We will often return to this point in later chapters.

Since we will often have cause to discuss terminological ambiguity in this book, it is important to clarify our own terminology here. Strictly speaking a 'concept' is an idea. Concepts themselves cannot then be ambiguous. But humans attempt to signify concepts through the use of terms. Different individuals or groups may use different terms to describe the same concept or the same terms to describe different concepts. We strive in this book to speak of 'terms' rather than 'concepts' when ambiguity is emphasized. We follow common parlance, though, in referring to ambiguous 'complex concepts.'

We might also briefly note that successful 'search' itself depends on there being works to find. As Searing (1996) appreciates, library requisition budgets and responsibilities are generally divided by fields. An interdisciplinary work might be viewed as of tangential interest to all relevant acquisition librarians. If libraries were organized around phenomena rather than disciplines the value of interdisciplinary works would be more transparent.

Once the interdisciplinarian has (hopefully) identified a wide array of relevant literature, it will prove invaluable to organize this literature in terms of theories and methods applied. Interdisciplinary scholars will then wish to evaluate, build upon, and synthesize the insights they find. These steps need not trouble the information scientist greatly, except for the simple but critical requirement that works on how to perform interdisciplinary research can be readily identified by the interdisciplinarian. Despite recent efforts to consolidate this literature (Repko 2012; Bergmann et al 2012, AIS 2013) it is also scattered across many fields. A KOS designed for interdisciplinarity would thus provide easy access to the literature on interdisciplinarity. Since interdisciplinarity is itself a phenomenon, a KOS designed to facilitate search by phenomena would do this.

Last but not least the interdisciplinary scholar will wish to transmit their findings back to all relevant scholars. The interdisciplinarian will have to ensure that they employ terms in a manner that makes sense to diverse audiences. KOSs should then ensure that the work can be readily found by all relevant users, which of course reinforces the need for facilitating interdisciplinary searches.

The field of knowledge organization could try to meet the needs of interdisciplinarians in three ways (Kyle 1960):

- Adaptation of existent, discipline-based classifications to new uses;
- Creation of alternative hybrid classifications;
- Creation of new forms of classification.

This book will in general argue for at least hybridity if not complete novelty (see Chaps. 3 and 5). In order to establish that case we will, as we address each of the needs of interdisciplinarians in turn below, review how present systems of knowledge organization fail to meet those needs. It must then seem that only marginal changes to existing KOSs will not suffice. Given that the major KOSs in use today were all conceived decades ago when disciplines provided the dominant framework for the partitioning of knowledge, this result should not be surprising.

## Classifying by Phenomena

Interdisciplinarians will obviously wish to identify works from various disciplines that address a particular phenomenon (thing that is studied). In turn, they will want their published research to be found readily by all other scholars interested in the same thing.

In present classification systems, though, documents are not classified according to some universal scheme of phenomena but according to the different terminology employed by diverse disciplines. As Hjørland and Nissen Pedersen (2005, 586) note, a single term can take on diverse meanings in the context of different disciplinary discourses. Thus even thesauri—which seek to identify the relationships among concepts (see below)—cannot flawlessly guide the scholar to relevant works in other disciplines. Works on the same phenomenon will be classified differently, and often using different terminology, depending on the discipline of the work. The 'Relative Index' of the Dewey Decimal Classification (DDC) guides cataloguers to the often dozen or more places that works on a given phenomenon might be classified; not only is this guidance imperfect but most library users are blissfully unaware of its existence. Likewise, subject catalogues provide a limited solution to this problem, in part because the logic of subject headings is opaque to most researchers (Julien et al. 2013). Full text searching is often thought to be the solution, but simply fails to identify works that utilize different terminology.

The fact that works about the same phenomenon can be found in many disciplines might be thought to be merely an inconvenience.[2] But of course the very reason that classifications were organized around disciplines rather than things in the first place was a recognition (often implicit) that each discipline organized its understandings in its own way (Langridge 1992; Svenonius 1997). And, in practice, quite different terminology is used in different disciplines (a challenge to keyword searching and also to subject searching if different controlled vocabulary is used across disciplines). The researcher will miss relevant works if they do not know what terms to search for. They could fall back on general works about disciplines, but this is a time-consuming strategy for identifying terminology. Moreover such a strategy presumes that they know at the outset which disciplines to investigate. Yet one of the challenges of interdisciplinary research is to identify relevant disciplines (Repko 2012). And as noted above the most useful information is often the most surprising, and this will usually be information the researcher would not have searched for (Palmer 2001). For all these reasons, the disciplinary base of current KOSs becomes more than an inconvenience but an active barrier that prevents scholars from finding relevant research in disciplines with which they are unfamiliar (see Palmer 2010).

As Bulick described as early as 1982, this disciplinary approach to classification has caused great confusion as disciplinary boundaries have shifted and interdisciplinary fields have emerged. Three broad types of problem occur: phenomena that are studied by more than one discipline are classified under different, often widely scattered, headings within a given classification; subjects that are inherently

[2] 'Since works on women's health are shelved in the *R*'s with other medical guides, literary criticism of the works of women authors shelved in the *P*'s by nationality and period, studies of female psychology in the *BF*'s, and so on, one cannot engage in the sort of browsing and serendipitous discovery that should ideally support interdisciplinary scholarship' (Searing 1992, 8). Arguably, though, browsing the shelves has become less important with digitization of both works and catalogues.

interdisciplinary have no obvious place; and subjects that combine existing subjects have no obvious place. This last problem, it might be noted, afflicts complex subjects even within disciplines. Existing KOSs necessarily grapple with these challenges. A synthetic non-discipline-based classification would face no difficulty.

Hoetzlein (2007, 73) discusses the example of 'energy':

> 'Many terms, such as that of energy, may easily appear in all of them [disciplines]. In the physical sciences, that is between chemistry, biology and physics, the concept has one and the same physical meaning but with different interpretations and formulations. In ecology the definition of energy may differ, but the idea must be linked to its more basic physical interpretation to fully appreciate it. In theology and philosophy the idea of energy has many other meanings, but these should be linked to the same singular concept as they provide a historical foundation for our modern definitions. Real relationships are lost when concepts, databases, and research areas become distinct. Only by connecting terms across disciplines is it possible to recover this understanding.'

Palmer (1996) outlined several further advantages of being readily able to track terminology across fields. Metaphorical use of a term from one field in another is often important for theory construction. Mapping terms across disciplinary boundaries can help us identify, and perhaps even predict, interdisciplinary knowledge structures. And she notes that we will want to track how meanings change as terms cross borders. We will devote much attention in this book to discussing how (and how best) to capture both similarities and differences in meaning.

Special note might be made of the problem of 'scatter': the fact that very similar works may be found in quite different places in a classification or physical library. User studies find that scholars in high-scatter fields (such as interdisciplinary scholars) consult multiple databases and have trouble keeping up with the literature (Hood and Wilson 2001). Cross-database keyword searching proves problematic for such researchers. They thus spend much time 'probing': searching for relevant information outside of their area of expertise. Nor can they be satisfied with just one reference from another field but appear to devote yet more time to verification (Palmer 2010, 181–3). They would clearly benefit if the interdependent literature they search for was not so widely scattered.

While the academy relies upon the complementary efforts of specialized and interdisciplinary researchers, even specialized researchers can benefit from familiarity with related work in other disciplines: this will not only suggest new avenues of research but remind them of the biases that could affect their disciplinary approach (Szostak 2004). Such knowledge would be much more likely if works on the same topic from different disciplines were classified and perhaps even shelved together (we address shelving decisions in more detail below).

In the contemporary world a further problem arises that plagues both specialized and interdisciplinary research. Searches for information increasingly span multiple digital databases; libraries, museums, archives, and private and governmental websites all possess valuable information organized in diverse ways.[3] Yet different

[3] It is increasingly important to access 'behind the scenes' records of scholarship (Lambe 2011). But this is generally held in archives or online databases rather than libraries.

databases employ quite different classification systems (Gnoli 2010). The lack of consistent controlled vocabularies across databases is a huge barrier to interdisciplinarity in particular, given the broader search interests of the interdisciplinarian (Kutner 2000). Landry (2004) has investigated the possibility of linking different subject heading lists and finds this feasible but time-consuming. The only common denominator that might allow seamless searches across multiple digital databases is the phenomena (and relationships) addressed in each, assuming these were given the same names across databases.[4]

The Semantic Web is an enterprise that aspires to allowing computers to navigate across diverse digital databases (Hart and Dolbear 2013). The key is to classify diverse databases in a common format such that a computer is able to draw inferences across databases. We shall see in later chapters that the approach to classification pursued in this book, with its emphasis on phenomena (and relationships), may support the Semantic Web.

Gnoli (2010) notes that we should classify the things we study, not just the documents that carry information about these. Knowledge organization should transcend libraries, after all, and allow, for example, museums and archives to better classify their contents. This again would require a classification grounded in things (phenomena) rather than disciplines. Museums, we shall see, have increasingly essayed to classify (some sorts of) objects. Notably they have eschewed the use of bibliographic classifications for this purpose. We will in later chapters explore the possibility that a phenomenon-based classification might serve the needs of both libraries and museums (and indeed archives and galleries).

In the foregoing we have stressed the obvious cost of the present system: that relevant information is not found or is found only with great difficulty. This means that interdisciplinary research is harder and less useful than it might be. Opportunities for productive synthesis of ideas are missed. There is a further cost: scholars often 'reinvent the wheel' through ignorance of previous work. This cost is borne not just by interdisciplinarians but by disciplinary scholars as well.

## Classifying by Relationships Among Phenomena

As noted above, interdisciplinary research often examines links between phenomena that are investigated by different disciplines (see Fig. 2.2). The interdisciplinary researcher must first identify the set of relevant phenomena, and this task will be particularly difficult in the absence of a common classification of phenomena. Yet the problems identified in the previous section are only the beginning.

[4] In a different context, Boteram and Hubrich (2010) argue that a subset of relationships is needed to provide interfaces between different classification systems).

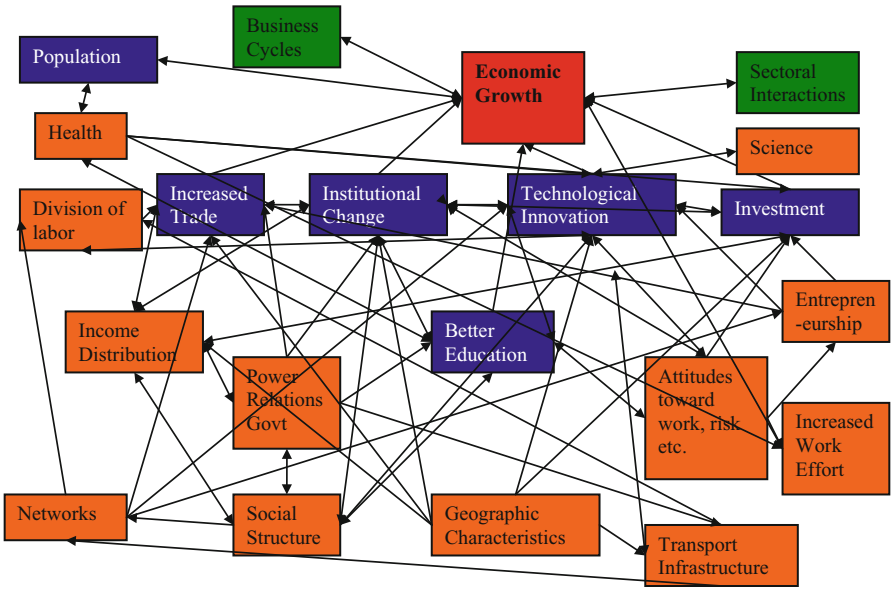


**Fig. 2.2** The causes of economic growth 38. *Source*: Repko et al. (2014, 174) with permission of Sage Publishers

## *The Present Situation*

Imagine that an interdisciplinarian is interested in a particular causal relationship: the effect of a certain pharmaceutical on a certain disease, a certain cultural attitude on a particular economic outcome, or a certain political institution on artistic production. We have seen in the previous section that tracking down all relevant works on any of these phenomena will be difficult. And in this case much of that effort will be wasted. The researcher will uncover many works on the drug that do not mention the disease and many works on the disease that do not mention the drug. It would be far better if the researcher could search directly for works that address the effect of the drug on the disease. [Of course the researcher might find that some of these other works are of some use, but that does not mean that the researcher should not be facilitated in identifying the works that most directly address their research interest.]

A work about how A affects B may be classed under just A or just B. It may be classed under both A and B if both are recognized subject headings, and the classifier recognizes that both are important. If so, a Boolean search—which allows the user to search by combinations of terms using 'AND' or 'OR' between terms—will uncover the work. But now the terminological problems identified in the preceding section are multiplied: in searching for a relationship the user needs to know all of the terminology that might be used to describe each concept in the relationship. Moreover, works that address how A influences B will be

indistinguishable in a Boolean search from works that address how B affects A or works that simply happen to discuss A and B separately. All such works may be shelved with works on A or B. A work on how A, B, C, and D combine to influence E, F, G, and H will almost certainly not be classified under each of the relationships posited (though modern digital technologies make it quite feasible to do so). The ideal would be for the user to search for 'A causes/influences B' and be rewarded with all works that study whether A influences B. [We hasten to stress that the word 'cause' is used in the most general sense here to indicate any influence that A might exert on B.]

Classifiers have generally been satisfied with identifying the main thrust of documents. It is worth noting here that we could aspire to a classification of not just documents but the key insights that these contain. The latter will become increasingly enticing as open source publishing extends its reach. And such an exercise might be quite useful for the interdisciplinarian in particular. A specialized researcher will consult a constrained literature and absorb both the main and subsidiary arguments critical to their work. An interdisciplinarian might find that the most interesting insights from a particular discipline are not ideas that the discipline itself recognizes as particularly important. These subsidiary ideas will generally not be captured in the subject entries for the works in which they appear. But if works were exhaustively indexed in terms of a general classification of phenomena and relationships then even these ideas could be uncovered readily.

Despite the centrality of relationships to knowledge organization (and advancement in human understanding), existing KOSs fail to express these as usefully as they could (Green 2008, 154). As we shall see the norm is a singular subheading (s) rather than a subject heading that captures a relationship. It cannot be stressed too much that knowledge organization practice in this respect is quite at odds with scholarly practice. The vast bulk of scholarly research—both disciplinary and interdisciplinary—in fact addresses how one or more phenomena influence one or more others. This is also often the case for non-scholarly works of non-fiction (dogs biting mail carriers, gardeners growing flowers). And thus the easiest way of capturing the focus of a work would be in terms of the relationship(s) among phenomena being investigated. Yet the tradition in knowledge organization is to identify a work in terms only of one or more phenomena that are addressed.

As for works of fiction both general users and especially scholars would often like to search by causal relationship there as well (failed romance leads to suicide; mistaken identity generates friendship), but—beyond classification by genre such as western or romance—works of fiction are rarely if ever classified in terms of what happens within them (Šauperl 2013; Szostak 2014a; Beghtol 1994). Notably, Beghtol (1994, 113–5) found that there was 'no limitation' to what either literary scholars or literary authors might write about. Moreover, interdisciplinary scholars might be curious as to how (and if) any causal relationship they investigated was

treated by authors of fiction. It thus seems that works of fiction also are best classified in terms of any possible relationship within a general classification.[5]

## *Web of Relations*

If the researcher is able to identify all relevant works addressing the influence of A on B, they may thus be alerted to different ideas from different disciplines that when integrated provide a much better (more nuanced but also more comprehensive) understanding. This will be especially the case if they can readily distinguish different works in terms of the key arguments proposed (see below). Researchers will often be led to wonder about other possible influences on B: these again would be easily searchable and the results might also lend themselves to synthesis. Or, the researcher might become intrigued by the possibility of some causal chain, and find upon investigating studies of influences on A that much of the observed difference in the behavior of B can in fact be traced to factors that influence A. Or the researcher could be curious about feedback effects and find unrecognized parallels between the way B influences A and A influences B.

Olson (2007) discussed how users would often wish to follow such a web-of-relations. They might start out with an interest in A and B, but then become curious about influences on A or effects of B or just other phenomena associated with either of these. Importantly, Olson argued that a KOS which pursued a web-of-relations approach would better reflect feminist epistemology. For our purposes, we can well imagine that interdisciplinary scholars will often wish to pursue their curiosity from a phenomenon or relationship discussed in one discipline to a related phenomenon or relationship in another.

Börner (2006) suggests indeed that in the near future scholars might just add 'nuggets' or 'nodes' to the web of knowledge. That is, the present practice of writing stand-alone papers will be replaced by a practice of adding insights to a pre-existing structure. A scholar might, for example, provide evidence of a novel way in which a particular phenomenon affects another. Börner reviews various efforts over the last century to develop links between related bits of information (such as citation indices). New technology creates an opportunity to finally achieve this goal. But search engines are like inserting a needle in a haystack, and usually do not place search results in context: they 'fail to equip scholars with a birds-eye view of the global structure and dynamics of scholarly knowledge and expertise' (Börner 2006, 186). In a somewhat similar vein, Smiraglia and van den Heuvel (2013) seek to identify the most basic units of knowledge. They follow in the century-old steps

[5] Beghtol (1994, 143) notes that a synthetic approach is very useful in describing unreal things or processes such as (trees) (talking). She also (126) reports on research that suggests readers summarize fictional works in similar ways. She surveys many works that argue that it is both feasible and desirable to classify the relationships in fiction, though the precise classifications suggested are each problematic.

of Otlet, who also hoped to break works into their constituent parts and then re-combine these. They argue that works are comprised of ideas, and ideas are comprised of concepts which exist in relationship to each other and are represented by signs. This book also argues that works should be classified in terms of their ideas, and that these comprise relationships between things.

Such an approach has benefits beyond facilitating interdisciplinarity. Even within scholarly communities it can be difficult to keep up with all relevant literature. The inevitable result is that some books and papers are read by few if any scholars. This is especially likely if the author is not a leader in the field, and/or if the work does not have an obvious connection to the research interests of others. The danger, of course, is that other scholars may simply ignore the most novel published ideas. A better cataloguing system which recognized the ideas outlined in each work could render the scholarly enterprise much less wasteful of new ideas.

Moreover, scholars are often observed to 'talk past' each other by misunderstanding what each other is saying. Repko (2012) recommends mapping complex causal interactions in large part to clarify which particular causal arguments different authors are making. Classifying works in terms of the key causal relationships they contain will both facilitate interdisciplinary synthesis and reduce the likelihood that scholars will think they disagree when in fact they are addressing different relationships.

## *Types of Relationship*

To this point we have stressed the importance of simply classifying works in terms of relationships. Further advantages would flow from taking another step and specifying types of relationship that might hold between A and B. Information scientists have indeed long speculated regarding the advantages of classifying the relationships that exist among things. Several complex schemes for doing so have been proposed (see Perrault 1994 for a summary), but none of these have been utilized in any major classificatory scheme (we are excluding for the moment consideration of thesauri which do adopt a limited set of relationships; see Chap. 3). Classificationists—those who develop classifications—have apparently decided that the proposed schemes do not deliver enough classificatory benefit to justify the cost of mastery by classificationist, classifier (those who place items within a classification), and user.

The reason might simply be that none of these preceding efforts started from an assessment of needs. As noted above, most scholarly works—and many if not most general works of both non-fiction and fiction—address how one or more things affect one or more other things. Thus, by far the most important relationships that must be investigated by the classificationist are those that involve some sort of causation or influence. Any proposed scheme for classifying relationships that does not devote the bulk of its attention to causal relations will of necessity fail to maximize the value versus cost ratio of employing the classification. Recall that the

word ‘causal’ is used in the broadest sense to refer to any instance where (it is alleged that) one thing exerts some influence on another; the word ‘causal’ in no way implies that this influence need be large and certainly not that it is the only influence on the thing being affected, nor that there is any simple deterministic process at work.

Even scholars who disdain words such as ‘cause’ or even ‘influence’ often speak of how one thing affects another (for example, how a work of art moves an audience). And this implies that the classificationist needs not just to signal the directions of influence posited in a particular work—though this on its own would be an important step—but to capture all of these different types of cause/influence. In Chap. 5 we will address the feasibility of distinguishing a wide variety of relationships. These include direct causation, creation, cooperation, conflict, constraint, control, partial influence, mediation, selection, damage, and destruction (see Perrault 1994), and many others (see Szostak 2012). We can recognize for now that searches by ‘type of influence’ would be particularly important in uncovering analogous arguments made across distinct literatures (a form of ‘undiscovered public knowledge’).

Philosophers, it might be noted, debate the grounds on which we make causal statements. When we see a child kick a ball, we infer from the movement of the child’s leg and the subsequent movement of the ball that the child caused the ball to move. But arguably we have no solid basis for making this inference, but rather have chosen to organize our perceptions around the idea of causation (Hume 2000). The information scientist need not enter this debate. Traditionally we have classified works with regard to what they are ‘about’ without feeling any need to pass judgment on the veracity of subject matter: we can classify works on astrology without feeling that we thereby endorse astrology. Likewise we can classify the idea ‘child kicks ball’ without endorsing any particular philosophical attitude toward causation.[6]

The importance of causal relationships, broadly defined, has often been stressed in the knowledge organization literature.[7] The excellent survey by Bean et al. (2002) speaks of three broad types of relationship: equivalence, hierarchical, and associative. They note that there is no agreement on types of associative relationship, but laudably focus their attention on cause-effect relationships. Zeng et al. (2011) provide what they believe is an exhaustive list of types of associative relationship that should be—but often are not—captured in subject authority files. One of their ten types is hierarchical (whole/parts), and another two can generally be captured by the non-causal relator ‘of’ (object/field of study and concept/properties). The rest are each a type of or component of a causal relationship:

[6] We need to embrace—and perhaps distinguish—different types of causation/influence identified by philosophers: individual instances (child kicks ball), causal laws (the laws of thermodynamics), and causal possibilities (aspirin can reduce headaches).

[7] Most documentary reports, although usually dealing with phenomena, do so from the viewpoint of a particular activity, so both aspects are needed in order to state its “subject” (Vickery 2008).

cause/effect proper, the action/process that an agent undertakes (speedometer measures), the result of that action (cloth woven), the agent that is affected (student taught), counter-agent (pesticides control pests), raw material (wine is made from grapes), and properties of actions (communicates well). Although there is thus recognition of the need for a classification of causal relationships, the only recent effort to develop such a classification seems to be Szostak (2012).

While the focus here is on causal linkages, the strategies for classification advocated here could be applied as well to other sorts of relationships among phenomena such as comparisons or analogies. Both interdisciplinary and specialized scholars often draw comparisons and analogies; indeed interdisciplinarity in the humanities is particularly associated with analogy or metaphor. A user who wishes to search for works on the basis of analogies and/or metaphors will not want to search for works on causal relationships, and vice versa. We thus should carefully distinguish different types of associative relationship.

## *Summing Up*

We will return to issues of feasibility in Chap. 5. It is useful to close by reiterating what interdisciplinary scholars (but also many other types of user) need in terms of relationships. Ideally, the interdisciplinary scholar interested in the influence of A on B (or less commonly some other type of relationship between A and B) would like to be able to search in the handful of ways outlined in Table 2.3.

Existing classification systems are imperfect in all of these respects (Cousson 2009). Even in faceted[8] classifications (with the notable exceptions of the Integrative Levels Classification [ILC] and Basic Concepts Classification [BCC]), the same phenomenon is placed in different (discipline-based) main classes, is often labelled by different terms when it occurs in different disciplinary main classes, and is not infrequently represented by different notational symbols when occurring in different disciplinary main classes (Gnoli 2007). Works describing how A influences B are often classified under one or the other, or under both with no indication of the direction of influence. If compound notation is provided, this may also differ by class, with causal facets having different notations in different disciplines, hence not being retrievable by a cross-disciplinary search for causal relationships: as above a work on culture and poverty will be treated differently by discipline. Moreover, existing faceted classifications all treat causal links within a class (agent facets) quite differently from causal links across classes (influence phase relationships): this practice makes it difficult to search for a particular type of

[8] Faceted classifications take a synthetic approach, and seek to identify the key attributes of a work. They are contrasted with the more common enumerative approach which seek to enumerate a large set of often complex subject headings. This distinction is further explored at the start of Chap. 3. See Integrative Levels Classification (2004) and Szostak (2013) respectively. See also Chap. 4 below.

**Table 2.3** Interdisciplinary search of relationships (A to B)

| |
|---|
| Users should be able to search by A, where all works about A are identified by a unique search term A*. |
| Users should be able to search by B, where all works about B are identified by the search term B*. Since works can only be placed physically in one place, the usual prescription is that works on B influenced by A be placed with other works on B. Thus an added desideratum for printed holdings would be that all works about 'determinants of B' would be physically collocated. [Users interested in A in our example will have to move about the shelves to find the work on A affecting B.] |
| Users should be able to search for the relationship from A to B. This usually has to be extracted at present by a Boolean search for A *and* B (which will not distinguish desired works from those that address A and B in some other fashion): this approach is clumsy and often not possible because works are not classified under all key subjects. If Boolean 'AND'ing is not employed, the search will locate huge numbers of works that address A in some fashion or B in some fashion but do not relate A to B. Note that in a library of printed documents all works on how A affects B should ideally be filed in close proximity (though perhaps not next to each other; see the following bullet point). |
| There will often be different ways that A might affect B. The researcher may be able to learn much about the focus of works in this respect if these are classified in terms of the theories (and to a lesser extent methods; see below) applied in a particular work. Nevertheless, it would be useful if different types of causation/influence could be distinguished. Works about B might then be subdivided with respect to different types of causal influence on B. |

influence which might occur both within and across classes. Notably, the Bliss Classification (BC2) provides general rules for how links can be drawn across classes, but also provides specific instructions at many points in its schedules regarding how particular links can be made; since these deviate from the general rules, similar influence phase relationships will be treated differently depending on whether general or specific rules are to be followed. Furthermore, its non-expressive notation cannot be exploited for automatic searches. [We are told that the editors of the Bliss Classification are working on these challenges, and find them easier to address in a digital age than when Bliss was first developed.] This distinction is abolished in the *freely faceted classification* invoked by Austin (1976; see also Gnoli and Hong 2006), although no such general scheme was actually produced before the recent ILC project (ILC 2004). Last but not least, existing classifications all focus the bulk of their attention on concepts expressed in terms of nouns and noun phrases containing adjectives; there is much less development of (nominalised) verbal forms, such as "producing" or "damaging," (though some verbs such as 'communicate' are treated in the noun form: 'communication') but it is verbs that describe different types of influence.

## *A Typical Example*

Typical examples of the challenges of classifying complex subjects come from experience with classifying the BioAcoustic Reference Database (Gnoli

et al. 2008). One representative paper in this database (Reijnen and Foppen 1994) is entitled 'The Effects of Car Traffic on Breeding Bird Populations in Woodland, 1: Evidence of Reduced Habitat Quality for Willow Warblers (*Phylloscopus trochilus*) Breeding close to a Highway.' This paper reports on a study investigating possible causal links between a technological installation (a highway on which traffic produces noise) and an organic phenomenon (the size and health of a bird population). It is thus representative of a type of interdisciplinarity very common in contemporary research. Taken separately, such phenomena could be thought as the subjects of completely different disciplines, engineering and biology respectively. However, the main contribution of the paper is not providing standard information *about* this bird species, nor *about* highways. Rather it is the assessment of some influence of one of them on the other one. This is emphasized in its title by the words "Effects" and "Evidence". Note that the latter term expresses the fact that not only are the effects of the highway noise upon the bird species discussed, but new data are presented to support the hypothesis that they actually occur. In linguistic terms, what is relevant is thus not just the 'theme' of the paper—that is, what it is about—but its 'rheme'—the new information that it provides on the theme (Hutchins 1977).

## Classifying by Theory Applied

Interdisciplinary research in practice tends to be problem-oriented. That is, an interdisciplinary project might tackle a complex societal issue such as inner-city poverty, seeking to analyze all relevant causal links (in isolation and in interaction) and drawing on all relevant theories and methods in doing so. Of course, no one research project can aim for exhaustive coverage in all of these respects, and thus even interdisciplinary analyses can be incomplete.[9] Skeptical concerns regarding the possibility of enhancing scholarly understanding may thus not be entirely alleviated by familiarity with interdisciplinary practice (Szostak 2014b). Yet the strategy of integration can potentially be applied across all research, integrating all available insights and identifying areas where additional research is necessary. It can thus yield a coherent understanding of how the world in its entirety operates: this will most often not be a simple understanding encapsulated in one theory but a complex understanding where a diverse body of theories casts light on different (and likely overlapping) parts of the puzzle.

Interdisciplinary scholarship thus urges integration across different theories, as well as across different methods and disciplinary perspectives. In this way, the

[9] Szostak (2002) developed a 12-step process for interdisciplinary analysis. It was argued that even though these steps could not all be followed exhaustively in any project, it was very important for researchers to reflect on what had been omitted. Szostak (2009) is organized around these 12 steps. Newell (2007) outlines a slightly different but complementary approach. Repko (2012) synthesizes these and other approaches, and shows how these can be applied.

partial insights of diverse communities of scholars (and insights from beyond the academy) can be combined into a more accurate and holistic analysis of any complex issue or theme. That is, the answer is not generally to be sought in one overarching theory (or ideology or method) but rather through recognizing the strengths—and weaknesses—of a variety of theories, and then integrating the best of these.

Interdisciplinary scholars are thus guided to ask what range of theories has been applied to the study of a particular phenomenon or (more likely) a particular type of relationship among certain (classes of) phenomena. They may in a particular research project need to focus on only a subset of these. Or they may wish to embrace all relevant theories. Alternatively, they may wish to focus on just one theory. In any of these cases it will be invaluable to be able to identify works in terms of the theory or theories that are applied. If a particular theory has not been applied to the particular phenomenon or relationship of interest, the interdisciplinarian may wish to search for the theory's application to other questions that are similar in certain respects: that address similar phenomena or similar types of relationship.

While interdisciplinarians are usually problem-oriented, they could also be interested in testing theories. This will be especially the case for those interdisciplinarians who still hope that some general theory will explain (or at least provide insight into) a large set of causal relationships. Such an interdisciplinarian will then wonder to what set of relationships a particular theory has been applied, and how successful the various applications of this theory have been in accounting for these relationships. Note in this regard that one of the key scholarly tasks is to identify the range of applicability of a particular theory: to which phenomena and relationships does a theory seem to apply? This is a task that natural scientists have often pursued more diligently than human scientists, but it is a task that all scholarship should embrace. In the absence of such an effort it is all too easy to assume that a theory that seems powerful in one application is universally powerful or alternatively to extrapolate from one example where a theory had little explanatory power to conclude that it is useless.

## *Present Practice in General Classifications*

Works are *not* usually classified at present in terms of the theories or methods employed in a piece of research. Theories and methods are classified only when a work is about theory or method, not when these are applied. Weinberg (1988) famously noted that researchers in general are poorly served by classifications (indeed indexing languages of any type) of documents solely in terms of what these are 'about': novices search for books 'about' a particular topic, but scholars seek works that express certain 'ideas.' They seek works that apply particular scholarly perspectives (Weinberg stressed theories but addressed methods) to particular subjects:

> 'Whereas the student or layman is looking for literature on or about a topic, the scholar/researcher's information need is, in most cases, substantially different. This group of users deals in ideas and theories, and wants to know whether specific ideas have previously been expressed in the literature. For example, a historian may have a new explanation for the cause of the Civil War, and going to this heading in a subject catalog or periodical index is not likely to answer precisely the question "Has anyone ever expressed this theory in print before?"' (Weinberg 1988, 3).

Palmer (1996) also urges the classification of documents in terms of theory and method applied. It is notable that while Palmer specifically addressed the needs of interdisciplinarians, Weinberg's concern was for all scholars. Knapp (2012) appreciates likewise that 'Scholars of all kinds of fields, interdisciplinary or not, could benefit from a system that classified knowledge in terms of methods and theories.'

Even the classification of works about theories can be problematic for the interdisciplinarian. Different disciplines intend quite different causal processes by the same nomenclature: for example, Hjørland and Nissen Pedersen (2005) noted that the term 'activity theory' can be used in three distinct senses. Even more troubling are cases where quite similar theories or techniques go by quite different names in different disciplines. In such cases, researchers cannot readily identify all relevant works about a particular theory or technique. The disciplinary specialist may only need to engage with one version of a theory operating under one name, or may be acquainted with a handful of related theories and the names by which they are known. The interdisciplinarian will often be confused by different theories operating under the same name and ignorant of applications of a single (type of) theory applied under different names in different contexts. As with phenomena, the interdisciplinarian thus needs some sort of general classification of theories that clearly identifies all instances of the same type of theory. We will explore in Chap. 5 the feasibility of developing and applying such a classification of theory types.

## *Summing Up*

In sum, interdisciplinarians in particular but scholars more generally are interested in asking the following questions:

- What theory types and methods have been applied to the study of a particular set of phenomena in the past?
- To what set of phenomena has a particular theory type or method been applied?
- What problems have been encountered in these endeavors? (This question cannot be entertained until the more basic questions are answered.)

## *An Example That Adds a Wrinkle*

How should disagreements between mainstream and alternative medicines be handled? A domain-specific approach would classify these two literatures

separately (Hjørland and Nissen Pedersen 2005, 592). The interdisciplinary impulse is to facilitate awareness across these two fields. Though Hjørland and Nissen Pedersen are open to the idea of classification by theory and method applied, and they recognize the advantage of juxtaposing different perspectives, their basic approach ensures that the literatures of these different communities of scholars are classified separately. Only if documents are classified with respect to a general classification of theories and methods can a researcher easily locate works within one or the other tradition. Likewise, given the different terminologies used within the two fields, searches by causal link will turn up both perspectives on the link in question only if documents are classified in terms of a common set of phenomena (and of course if both literatures are classified together). Given the differences in terminology between the domains of mainstream and alternative medicine, separate classifications will ensure that practitioners of one type of medicine will have difficulty accessing relevant information from the other, assuming that they are motivated enough to look at the alternative classification in the first place. A unified classification puts alternative perspectives at their fingertips, but distinguishes these so that the researcher can also choose to ignore them. In this example, the classification of works in terms of theory and method applied would allow users to easily distinguish mainstream approaches to a particular disease from alternative approaches. It is thus a useful complement to the approach of classifying works in terms of a common list of phenomena.

## Classifying by Method Applied

The arguments made in the preceding sections regarding theory can be applied with equal force to the case of methods. Interdisciplinary scholars will want to know which methods have been applied to the study of which causal relationships. While each discipline tends to value only one or two methods, the interdisciplinarian sees complementary strengths and weaknesses in each of the dozen methods employed by scholars (Szostak 2004 classified the key strengths and weaknesses of the dozen methods employed by scholars). One of the key challenges of interdisciplinary research teams is coming to appreciate the methods employed by other team members (Palmer 2010, 182). Given that no method is perfect, interdisciplinarians advocate the 'triangulation' of results achieved by employing different methods. Triangulation is the technique used by land surveyors of identifying a precise location by taking readings from different locations and seeing where these intersect. With respect to methods it involves evaluating and balancing the results obtained from different methods. Interdisciplinary scholars will thus wish to know what methods have been applied to a particular problem. In their efforts to evaluate the strengths and weaknesses of each method, they will also wish to know to what problems (and how successfully) each method has been applied.

The use of multiple methods is especially important when different theory types are compared. Scholarly understanding advances by comparing theoretical

explanations, and seeing which is most important along a particular link (but not necessarily dismissing other theories as completely unimportant). If only one method is used in such a test, the results will generally be biased toward whichever theory that method is particularly well suited to investigating. This result is particularly noteworthy, for disciplines tend to choose a mutually supportive set of theory and method (and phenomena), and can be blissfully unaware of or hostile to contradictory evidence produced using other methods. Such close-mindedness is not conducive to enhancing our understanding of the complex world we inhabit.

The literature on interdisciplinarity overlaps with but is distinct from the literature on mixed-methods research (Szostak 2015). Mixed-methods research can be practiced even within a discipline, as when sociologists blend quantitative and qualitative analysis. The literature on mixed methods research celebrates the advantages of using multiple methods within the same research project. This is sometimes done as above to facilitate the comparison of results across methods. Alternatively, the results of one method may be utilized as inputs into the application of another (as when survey results are subjected to statistical analysis). In either case the mixed methods researcher will be curious about previous applications of the methods engaged. The advantages of classifying works in terms of method applied thus are not limited to interdisciplinary research.

A choice of method has implications for the types of data one will engage. And thus searches across different theory types and methods would be hugely important in identifying commonalities or differences across disciplines in the evidence for similar hypotheses. Nevertheless it may be useful at times to identify the type of data employed in a work. Note that data is here used in its widest sense so that interview transcripts and indeed any written, oral, or visual text could be considered data.

Hjørland (2012) speaks approvingly of 'evidence-based practice' and wonders what sort of judgment the classificationist and classifier might employ in order to guide users to the most reliable resources. While the phrase 'evidence-based practice' is itself fairly innocuous (though some postmodernists might disdain any recourse to evidence), and could/should refer to evidence of any sort gathered by any method, in practice those who employ the phrase (especially in the medical field) tend to value only the evidence acquired through use of the experimental method. Yet both those who favor a broad definition of evidence and those who favor a narrow definition can benefit from a classification of works in terms of method employed. Those who value only experiments can seek only works that have employed experiments (and indeed particular techniques in experimental design that might be particularly valued). The interdisciplinary researcher should appreciate that no method is perfect and thus potentially value works that employ multiple methods. They will thus benefit from a classification that signals any method and technique employed. Of course, all users can benefit from some indication of how well a particular method was employed in a particular work. Such judgments are likely beyond the scope of classification itself, but digital libraries might try to link individual works to critiques or commentaries of these. And of course if researchers have ready access to treatments of the method itself

(and especially common weaknesses in its application) they will be in a better position to themselves judge if it has been applied properly.

## Clarifying Concepts

As noted earlier, one of the main sources of difficulty in interdisciplinary searches is that the terms by which concepts are designated have different meanings across disciplines. The same concept thus may have different names, and—more confusingly—different concepts may be designated by the same name. But this problem of terminology affects the interdisciplinarian far beyond issues of search. Interdisciplinarians struggle to understand the works that they uncover. 'Studies across interdisciplinary fields have indicated that most interdisciplinary researchers need to be familiar with the terminology of other disciplines in order to understand the literature they consult and to carry out their research projects;' this need for 'translation' comprises one of the most difficult and laborious components of the interdisciplinary research process (Palmer 2010, 183).[10] Interdisciplinary teams struggle to understand each other. Interdisciplinarians struggle to communicate their research results to diverse audiences.

An example may be useful here. When economists speak of 'investment,' they mean only expenditures on buildings or machines that are used to produce goods or services. An accountant uses 'investment' in a manner more similar to common parlance to refer to any expenditure intended to earn a financial return through time. Buying a bond is investment to the latter but not the former. Such instances of differing definition are common. Yet disciplinarians will not feel any need to define words that they use all the time.

Scholars of interdisciplinarity have thus long worried about how to cope with ambiguity. O'Rourke et al. (2014) is devoted to transcending communication challenges in interdisciplinary research. In the editorial introduction the editors note that 'Researchers trained in different disciplines often use different vernaculars and belong to different disciplinary cultures, creating the need for translation on multiple levels ... Linguistic differences can lead collaborators to use the same term for different concepts, such as *dynamic* or *triangulation*, impairing communication by creating both false disagreement and false agreement' (2014, 2). Scholars have observed that 'pidgins' or 'creoles' are often created along disciplinary boundaries so that scholars from those disciplines can interact (Galison 1997; Klein 1996; Baird and Cohen 1999). Notably scholars from third disciplines would still struggle.

The implication for information science deserves to be stressed: *Any success achieved by knowledge organization systems* (*KOSs*) *in clarifying the meaning of*

[10] Palmer notes that while vocabulary is central to the challenge of translation so also are 'research conventions and culture.' These will be addressed below under 'disciplinary perspective.'

*terminology will not only aid user search but will significantly alleviate the communication problems that plague interdisciplinary research*. Lambe (2011) thus maintains that the first duty of classification is to clarify concepts in order to facilitate conversation. Scholars of knowledge organization should not take ambiguity for granted but should appreciate that we have some significant ability to reduce it through our own efforts.

How can this be done? Szostak (2014c) discusses how breaking complex concepts—terms for which there are not shared understandings across groups or individuals—into basic concepts can facilitate interdisciplinary communication. This is a strategy we will explore later in this book. It is worth noting that this strategy will prove useful both in the development of a comprehensive classification as well as in directly aiding interdisciplinary communication.

The very act of classification itself can also support clarity in terminology. Placing a concept within a logical hierarchical classification establishes clearly what sort of thing it is and what sort of thing it is not, and often the sorts of subsidiary elements of which it may be comprised. Wittgenstein (1953) famously argued that the best way to define a concept was to provide examples of it (game: chess, soccer, poker). He did not appreciate that a classification that provided an exhaustive set of examples would provide a very precise definition. This is, admittedly, an extensional definition by enumeration, rather than an intensional definition by essential features as had long been sought by philosophers. But as we will observe more than once in this book the practical field of knowledge organization should focus on the degree to which it can in practice reduce ambiguity rather than whether its strategies address philosophical concerns. We will find in later chapters that the sort of classification urged in this book is better able than the general classifications most used in the world to insist on logical subdivision within its classificatory hierarchies. We can note here that if hierarchy is abused by including items that are not logical subclasses then hierarchy is no longer able to serve to clarify the meaning of terminology.

In sum, the existing level of ambiguity in cross-disciplinary communication is not inevitable, but reflects the lack of a general classification that employs both a common vocabulary of basic concepts and a logical hierarchical structure throughout. This is not to say that classification is the exclusive source of or solution to ambiguity, but that careful logical classification in terms of basic concepts is perhaps the most powerful tool for reducing ambiguity.

Note here that scholarly concepts almost all refer to the phenomena studied or relations among them, the theories used to examine these, or the methods employed in their study, since these are the key elements of scholarly discourse (Wallace and Wolf 2006, 4–5; Repko 2012; Szostak 2007). It thus stands to reason that the comprehensive classifications of phenomena and relationships, theories, and methods that were urged above must of necessity alleviate some of the terminological ambiguity that plagues interdisciplinarity.[11]

[11] This argument is consistent with Stone's (2014) contention that the key to successful interdisciplinary communication is an ontological emphasis on real objects in the world that we perceive in similar ways rather than the epistemological emphasis on ways of knowing favored by disciplines.

Questions of feasibility will be addressed later in the book. But it should be noted at the outset that information scientists have often shied away from the task of alleviating conceptual ambiguity. Hjørland and Nissen Pedersen (2005, 586) advocate *only* an entirely inductive approach to classification whereby concepts are identified in use within particular scholarly domains. Such an approach, as we shall see in Chaps. 3, 6, and 7, has much merit. But to urge information science away from attempting to reduce cross-disciplinary ambiguity is unfortunate. Other information scientists have been more positive. Palmer (2001, 131), for example, notes that interdisciplinarians want information scientists to translate jargon across disciplinary boundaries.

## Disciplinary Perspective

Why is interdisciplinary conversation so difficult? One reason, conceptual ambiguity, was addressed above. But there is a second serious source of difficulty. Disciplinary researchers absorb a host of disciplinary assumptions in the course of their education: epistemological, ethical, ideological, theoretical, and methodological. They may often not be conscious of these buried assumptions. Yet they interpret what others say through the lens of these assumptions. Since scholars from other disciplines will not have grounded their utterances in the same set of assumptions, misunderstanding is common. Sometimes the misunderstanding is clear at the time. Commonly in such situations the respondent wonders how on earth the utterer could have said something so at odds with the respondent's view of how the real and/or scholarly worlds should or do work. More insidiously, the misunderstanding may not be obvious at first, and erstwhile collaborators carry on for some time under a mistaken impression of shared understanding. The solution advocated in O'Rourke et al. (2014) and elsewhere for this sort of misunderstanding is to have collaborators share and compare and discuss their assumption sets.

Moreover, in their efforts to integrate insights from different disciplines interdisciplinary researchers are urged to evaluate these insights in terms of the overarching disciplinary perspective of the discipline. This is only possible if the researcher can readily identify what constitutes a given disciplinary perspective. Repko (2012) provides brief descriptions of the perspectives of the major disciplines, but researchers will often want more detail on these and/or information on smaller fields, including emerging interdisciplines. They will thus want to be able to search for works on (elements of) the disciplinary perspective of various fields (as well as on the nature of disciplines in general). They will otherwise misunderstand much of what they hear and read.

There is little value in having ready access to works on disciplinary perspective if we do not identify the disciplinary home of the authors of works. As noted in

Chap. 1, interdisciplinarity exists in a symbiotic relationship with specialized research. It should thus not be surprising that the interdisciplinarian does not seek to erase all vestiges of disciplinarity from KOSs:

> 'Studying a thing in isolation and studying it in context are two halves of modern scholarship, and neither may be safely neglected. The structure of knowledge representation must continue to shift to reflect this balance' (Iyer 1995, 27).

Of course, diversity exists within any discipline, and interdisciplinary scholars stress the dangers of stereotyping scholars. Yet it is still useful to know a scholar's disciplinary home. Even very interdisciplinary scholars still tend to betray some of the assumptions inherent in their disciplinary training. By the same, token, however, it will also be useful to be able to signal when a work takes a genuinely interdisciplinary approach, either through the purposive efforts of a single scholar or due to collaboration.

It would indeed be useful to move beyond simply recognizing the disciplinary (or interdisciplinary) home of authors and attempt to identify also other elements of the guiding perspective of the authors of a work. We have already addressed two key elements of disciplinary perspective above: theories applied and methods applied. Many geographers feel that their discipline should be identified by map-making, and many economists would associate their discipline with rational choice theorizing. Whatever the value of these views, the point here is that identifying a work in terms of theory applied or method applied may carry more valuable insight about that work than whether it is classified as (or shelved with) economics or geography or some other discipline. And we could thus imagine further aiding both interdisciplinarians and disciplinarians in the twin tasks of identifying and evaluating literature by classifying works in terms of still other elements of disciplinary perspective such as, for example, epistemological or ideological or ethical outlook. The possibility of addressing authorial perspective in these additional sorts of ways will be addressed in Chap. 5.

## What About Disciplinarians?

Before moving on, it is worth noting that the vast bulk of disciplinary or specialized research also involves the investigation of causal links: economists worry about how changes in the money supply affect business cycles, chemists study how one chemical reacts with another to create yet another, and so on. Dahlberg (1994) thus stressed the importance of subjects and predicates in all disciplines. Causal links within disciplines are easier to search for within existing classification systems than causal links across disciplines simply because each phenomenon is generally given only one place within the disciplinary main class. Yet this solves only part of the problem. Causal links are still not generally indicated as such: the researcher may thus still have to troll through a vast literature on A and B to find works on how A influences B. Even when some attempt is made to index a work in terms of related

concepts it is not always obvious what the work addresses: does a document indexed under 'teachers,' 'students' and 'behavior' deal with the influence of teachers' behavior on students, or the reverse? (Austin 1976). And different types of influence are only rarely distinguished, so again the user may retrieve many works that are not quite what they are looking for. These problems *may* be manageable if the researcher is interested in a small set of phenomena, and/or there are a limited number of types of influence among these that have been studied. Yet the fact remains that even disciplinary scholars will benefit from more careful treatment of causal relationships.

Moreover, users of any bibliographic classification do not just have 'information needs' but often more general 'knowledge (or understanding) needs.' That is, they are usually not searching for one isolated piece of information, but rather are seeking to expand (or test) their understanding. Drawing connections among different bits of information is crucial to their success. KOSs thus need to facilitate the drawing of connections (Thellefsen et al. 2013).

Specialized disciplinary researchers also sometimes examine the internal nature or functioning of one phenomenon. Such research is easier to cope with within any classificatory approach: it will be classed (and shelved) under the phenomenon investigated. Even here, a synthetic approach which can identify which particular characteristics of a phenomenon are being investigated will be helpful.

Specialized disciplinary researchers will also benefit if works are coded in terms of theories and methods applied. Not only will such modes of classifying works help scholars to identify the works in which they are most interested but it will also expose them to, and so stimulate them to look at, alternative approaches to understanding the phenomena or relationships that they are studying.

How will disciplinarians fare if disciplinary structures are replaced by a phenomenon-based general classification? Disciplinarians will benefit from being readily acquainted with research on particular linkages performed in other disciplines. They may, though, be much more interested in works generated within their own discipline. It is, of course, quite possible to continue to code works by the disciplinary home of the author. And the desirability of doing so was urged above. Researchers can then search only within their discipline for works on a particular causal link. Palmer (1996) notes that digitization (and hypertext in particular) allows us potentially to design access to resources suited to different users: a disciplinary researcher can thus be guided exclusively to disciplinary resources if they so choose.

This solution, though, may depend on scholars from different disciplines organizing their understandings in similar ways; if not, disciplinarians may find themselves lost in a general classification that cannot cater to their particular way of seeing/organizing the world. Wesolek (2012) worries in particular that a general classification might define classes more broadly than a domain analysis would. But this is hardly inevitable. And if it were the case for some classes, Wesolek's problem might be solved by identifying sub-classes of greater interest to certain disciplines (he worries, for example that sociologists may be more interested in studying loan sharks as a financial institution than are economists).

Advocates of domain-specific classifications argue that we can only cope with the ambiguous nature of language by classifying works domain by domain: only then can users share an understanding of what the terms used to classify documents mean. One advantage, then, of a discipline-based general classification is that the terminology of each domain can be catered to (but with the result necessarily being that it is more difficult to search across domains). It is an empirical question as to how great the ambiguity problem is for a general classification. If the problem is large, the ideal solution may involve domain-specific classifications, each of which is translated into a phenomenon-based general classification (see Szostak 2010). But recall that a general classification that employs the same vocabulary and hierarchical structure throughout can itself reduce ambiguity. The cost imposed on the disciplinarian cannot be properly evaluated until the comprehensive classification is in place.

While the disciplinarian faces both challenges and opportunities in adapting to the sort of classification advocated by the León Manifesto (2007), the opportunities could well outweigh the challenges. This is especially the case once it is appreciated that the scholarly need for information science is inversely related to the degree of specialization. As already noted in Chap. 1 a very specialized scholar does not much need knowledge organization. They quickly learn which journals and conferences are most likely to yield the information that they need for their studies. As they expand their gaze beyond their narrow area of specialization knowledge organization becomes ever more important. If it is accepted that every scholar should have some appreciation of how their area of specialization fits within the broader scholarly enterprise, then the benefits of a general phenomenon-based classification far outweigh, for *all* scholars, the costs of adapting to such a classification.

## Key Points

First and foremost, we have seen that existing classification systems serve interdisciplinarity poorly. Second, interdisciplinarians need the resources offered by information science more than do disciplinary researchers. It follows that KOSs need to be developed to better serve interdisciplinarity.

In particular interdisciplinarians need to search by:

- The phenomena addressed in a work.
- The relationships among phenomena addressed in a work.
- The theory(s) applied in a work.
- The method(s) applied in a work.
- The disciplinary (or interdisciplinary) perspective of authors [Note that interdisciplinary researchers will also need easy access to general works on disciplines and interdisciplinarity.]

If information scientists could provide general classifications of these elements they would at the same time serve a further important function of clarifying concepts. This is important, for, at present interdisciplinarians struggle not just to find works but to understand these due to differences in terminology across fields.

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