Annals of Library and Information Studies
Vol. 71, March 2024, pp. 113-120
DOI: 10.56042/alis.v71i1.8996

Ranganathan's principles and a fully "freely faceted" classification

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Received 05 February 2024; Accepted 20 February 2024

Among Ranganathan's outstanding contributions to library and information science are the principles of faceted classification. He implemented them in his Colon Classification (CC), an advanced system bringing many innovations though still based on disciplines. The Integrative Levels Classification (ILC) breaks the barriers between disciplines and follows the alternative approach, phenomenon-based classification, which Ranganathan considered to be unsuitable. To express the facets of phenomena, ILC adopts a set of ten fundamental categories – quality, quantity, part, property, transformation, opposition, agent, place, time, perspective – that have some correspondences with Ranganathan's PMEST. It is a "freely faceted classification" in the sense that any phenomenon class can be used as an isolate and combined with any other by means of free facets: these are not available in CC, although similar functionalities are provided by phase relationships and by subject device. ILC notation also adopts some solutions inspired by Ranganathan, such as emptying digit (*z*) and favoured host class (*T*). Expressive notation as in CC and ILC is especially useful, although underused, to control browsing and searching in our era of computer-based information.

Keywords: phenomenon-based classification, faceted classification, freely faceted classification, phase relationships, Integrative Levels Classification, Colon Classification

1. Meeting Ranganathan's work and subject indexing

While being a young new collaborator at the public library of Mariano Comense (Italy), I heard of Ranganathan and his Five Laws from my colleague Ernesto Frigerio. That humanistic approach to library service sounded intriguing to me and would lead me to write an early paper. In subsequent years I met Eugenio Gatto, a deep connoisseur of Ranganathan's work, although one reluctant to write: he preferred to directly apply the principles of our Indian master to his home library, by marking book spines with Colon codes elegantly handwritten by an ink pen!

Realising that I was very interested in subject indexing, I borrowed A.C. Foskett's excellent book on this topic[1], as well as Ranganathan's *Prolegomena*[2]. By this time, I worked in a university library where I noticed the confusing coexistence in the card catalogue of disciplinary headings (*vegetal pathology*) and corresponding phenomenon-based headings (*plant diseases*) for basically the same subject matter. In a few years, my thoughts would lead to the first drafts of the Integrative Levels Classification (ILC), a general faceted system I gradually developed with several collaborators.

2. Disciplines, phenomena, and faceted classification

ILC applies the principles of facet analysis as identified by Ranganathan and the Classification Research Group (CRG), including a set of fundamental categories, a standard citation order, and an expressive notation. Its most original feature is that its main classes are not disciplines, such as vegetal pathology, but directly types of the phenomena discussed in documents, such as plant diseases.

This approach to classification is not completely new, as it was the object of experimentation especially by Barbara Kyle, Douglas Foskett, and Derek Austin, although their draft system[3] was never completed. The phenomenon approach may have pros and cons, and ILC is conceived as an alternative system by which it can be tested and evaluated. It is well known that in a traditional disciplinary classification system, including Dewey Decimal Classification (DDC), Universal Decimal Classification (UDC) and also Ranganathan's Colon Classification (CC), one and the same phenomenon, such as "iron" or "eyes", is scattered in many places depending on the different disciplinary perspectives from which it is discussed. In phenomenon-based

classifications, the opposite is the case, as documents focusing on eyes are grouped together, irrespective of their disciplinary perspective[4].

At the Dorking conference in 1957 and on other occasions, Ranganathan met members of the CRG who supported the new idea of phenomenon-based classification, including Foskett and Kyle; the latter even composed a poem about him, "with whom she participated in a long-drawn out but highly civilized argument about the specialist technical topics of zone analysis and Colon Classification"[5] and Ranganathan later acknowledged her as an important author[6].

Despite his deep structural innovations in classification[7], however, Ranganathan was traditionalist in his adherence to the disciplinary approach: indeed he assumed that any subject must start with a "basic class" (BC) consisting of a discipline, and only this basic class can then be specified by the "isolates" (I) for the objects of study as expressed in the categories of personality, matter, energy, space, and time:

the (BC) 'L Medicine' is a subject by itself. But the (I) '185 Eye' is not a subject by itself. It must be attached to "Medicine" or to 'Zoology' or to 'Animal husbandry' or to 'Sociology' or to some other basic class to yield a subject[8].

In other words, book subjects represented in a classification are assumed to be part of some discipline, and there is no class for the phenomenon of eyes as such; there only are classes for medicine of eyes, or zoology of eyes, etc. The facets that can specify a disciplinary class necessarily are facets of that discipline, not facets of the phenomena studied. For example, the energy facet of class *E* "Chemistry" includes such isolates as *E:3* "chemistry, by analysis", *E:5* "chemistry, by extraction" and *E:8* "chemistry, by manipulation": these clearly are facets of chemistry, not of chemical substances, as chemical substances alone do not perform any extraction or manipulation. Chemical substances such as acids are expressed as another facet of chemistry, specifically the personality facet that immediately follows the discipline letter *E*. From this, one can get such faceted compounds as *E3:3* "chemistry of acids, by analysis".

In contrast to this, the phenomenon-based approach allows the definition of facets of phenomena[9]. Acids themselves are a class in their own right (*fc* in ILC), and do not belong to any particular discipline. They may have such facets as *-65g* "gaseous" or *-5n* "acid-base reaction", giving e.g. *fc65g5n* "acids, gaseous, acid-base reaction". As for human operations such as chemical analysis, in ILC they are expressed elsewhere as a facet of sciences: *ys5*. (In this paper we use the notation of the developing third edition of the system, which differs in various details from those of ILC1 and ILC2[10].)

3. Freely faceted classification

As it can be seen from the examples above, the combination mechanism of facets in ILC is much the same as it is in CC: in both cases, any facet is appended to the basic class according to a citation order of categories. In this respect, ILC is indebted to Ranganathan and such other pioneers of synthetic indexing as Otlet, Brown, or Kaiser. Facets are (usually) cited in the inverted order of schedules: "gaseous" precedes "acid-base reaction" in the compound classmark while following it in the schedules, according to the inversion principle for the sake of effective ordering. We will later examine some differences in the list of facet categories (PMEST), but from the structural viewpoint the principle is the same.

We may then consider the structural difference between a disciplinary classification like CC and a phenomenon-based one like ILC. Is defining classes and their facets in terms of phenomena different from defining them in terms of disciplines?

Ranganathan developed various versions of his faceted classification. In its original idea, every class provided for a fixed list of facets: that is, any subject in chemistry was expected to have a personality facet, a matter facet, an energy facet, a space facet and a time facet. Of course, not all such facets always need to be expressed when indexing a particular document. For example, a document on acid analysis only has a personality facet (acid) and an energy one (analysis), while matter, space, and time are not specified. To deal with this, Ranganathan improved CC notation by indicating each facet with a different symbol (the facet indicator, being a punctuation mark in the case of CC and a numeral in the case of ILC), instead of the colon originally used for all facets. He claims to have thus moved from a "rigidly-faceted classification", where all facets should "compulsorily be used" by at least writing a colon, to a "freely faceted classification" where non-occurring facets could simply be omitted in the compound classmark[11].

Such faceted structure is indeed quite flexible, although this flexibility is only internal to a specific disciplinary class. As observed by Austin[12]:

The main classes which are a feature of existing schemes also regulate citation order to a considerable extent, even in classifications which claim to be freely faceted [...] the classifier cannot in practice decide which concept should be assigned to the fundamental category Personality, and therefore cited as the first element in a subject statement, until the subject as a whole has been assigned in his mind to some appropriate class.

Although a very big number of different combinations are allowed within the disciplinary class, its "facet formula" forces the involved concepts into predetermined roles, nor does it allow for combination with concepts from other disciplines. For the latter purpose, Ranganathan created two additional mechanisms: subject device and phase relationships.

Suppose that we want to specify that the acids being the base theme of a document are acids of soils. Now, soils are listed under a different discipline, that is agriculture, as *J:1*. How can we combine the concept of acids with that of soils? Subject device allows specifying one concept with another by appending the latter in brackets: *E3(J:1)*. This is a solution that can be adopted when indexing with CC. What is the literal meaning of such a combination? Notice that notation is always dominated by the initial letters of disciplines, *E* and *J*. So the meaning of this combination is something like "chemistry of the acids of agriculture by soil". There is no way to express the concept of acids and that of soils without reference to these disciplines.

On the other hand, the general classification drafted by CRG and the ILC it inspired get rid of disciplines. In the CRG the most advanced experiments were performed by Austin, who described their system as "a totally synthetic and freely-faceted general classification"[13]. Here, the phrase "freely faceted" acquires a different sense, as free combination of concepts does not need to be done in the context of any discipline. For example, in ILC one can combine acids and soils in *fc90nyo* "acids, of soils", where acids are simply a subclass of *f* substances and soils are a subclass of *ny* ecosystems. Note that here, neither "acids" nor "soils" are subordinated to any any particular discipline: "acids" just means acids, and "soils" just means soils. It thus seems that freely faceted structures reach a more complete implementation in phenomenon-based classifications.

ILC freely faceted notation also allows the specification of different relationships that may occur between acids and soils, with *fc20nyo* meaning "acids being 'in' soils" or *fc30nyo* meaning "acids produced 'by' soils". By contrast, CC usually has fixed roles for a concept within the framework of a discipline, although combinations may be effected by the subject device as we have seen.

4. Phase relationships as facets

Ranganathan's second method of combining concepts in different disciplines is by phase relationships. These are general relationships holding between two concepts that may be in different disciplinary classes, or in the same facet, or even in the same array within a facet. The same relationship is expressed by different digits in each of the three cases, which again suggests that the discipline is a basic reference in the structure of CC. For the purposes of our discussion, here we only consider the notation for phase relationships between different classes:

0a general
0b bias
0c comparison
0d difference
0g influencing

By these one can construct e.g. *E0aJ* "chemistry and agriculture", *E0dJ* "chemistry as different from agriculture" or *J0gE* "agriculture influenced by chemistry". More specific concepts can also be combined, but again in the default context of a discipline: *J0gE3* "agriculture influenced by chemistry of acids".

How are phase relationships implemented in a phenomenon-based classification? Well, one can say that many relationships in a phenomenon-based classification are phase relationships by their nature! Indeed, the influence of something on something else is expressed in ILC by a regular facet connecting another class, called a free facet: for example, *nyo30fc* means soils affected by acids (for any reason).

This consideration suggests that the nature of phase relationships is not very different from the nature of PMEST facets after all. In CC, the categories that occur most often in the specification of subjects within a discipline are expressed by regular facets, while the categories that occur most often between different subjects, such as bias or influence, are expressed by phase relationships. But the notion of influence basically is cognate to the notion of agent,

which is usually expressed in CC as a second-round personality (2P) and is even a fundamental category in faceted classifications developed by the CRG[14]. Indeed, both influence and agent are subsumed in ILC under category *3*.

ILC has the set of fundamental categories shown in the left column below, covering both facets and phase relationships in CC as shown in the right column:

0	perspective	*0b*	bias or general
1	position; time	*‘*	time [T]
2	context; place	*.*	space [S]
3	agent	*0g*	influencing or 2nd personality [2P]
4	opposition	*0d*	difference or comparison
5	transformation	*:*	energy [E]
6	property	*;*	matter-property [M]
7	part	*;*	matter-property [M]
8	quantity		-
9	quality	*,*	personality [P2] or subject device
a-y	phenomenon	*1-9*	personality [P1]
-		*A-Z*	discipline

As we have mentioned above, the idea of a set of fundamental categories in ILC (like in the systems developed by CRG members) is inherited from Ranganathan. Their standard citation order is also similar, as it can be seen in the right column of our table that the inverted sequence T, S, E, M, P is kept. The basic idea is that the temporal and spatial contexts of a subject are its “lighter” attributes, while its dynamic aspects are more relevant in determining it, and its properties are even more. As the last facets are cited first in the inverted order of a classmark, documents will get ordered in the most convenient sequence in a catalogue or on shelves. Also, the construction of a faceted subject basically follows the order of the passive sentence in common speech, that is the information that something (the personality or basic phenomenon) is affected (energy) by something else (the second personality or agent or influencing phase). The use of numerals rather than punctuation marks as facet indicators is just a technical detail (see below) that does not affect the structure of the system.

ILC’s set of ten categories thus is a generalisation of categories occurring in analytico-synthetic classifications that is used to cover both “phase relationships” and facets of a specific class. They can be used in various syntactical forms, according to the needs of each compound subject. In our examples until now, we have seen *free facets* where the category digit is followed by a *-0*. This in ILC3 means that the class following the *0* can be taken from anywhere in the schedules, thus implementing the idea of freely faceted classification. On the other hand, there are also *parallel facets* where foci are taken from a specific class and applied in a different, semantically related class: these are expressed in ILC3 by multi-digit facet indicators. For example, the class *w* “customs” has the parallel facet *w75 [mq]* “with *ritual animal*” taking its foci from *mq* “animals”: thus from *mqUh* “horses” one can get *w75Uh* “customs, with horses”. Finally, ILC also has *bound facets* that are defined within the class itself, and are expressed by single numerals *1* to *9* (or other numerals ending by *-9*).

ILC parallel and bound facets resemble the syntax of most CC facets, while ILC free facets resemble the syntax of CC phase relationships. That is, ILC generalises the notion of facet to cover both Ranganathan’s facets and phase relationships. This generalised notion of facet is also equivalent to what is called “properties” in ontologies: indeed, the object of a property can be either an attribute of the subject (a bound facet) or a different class (a parallel facet or a free facet); that is, the “property” can have various “ranges”. Interestingly, ILC’s set of ten categories, and the subcategories that can be obtained by combining two or more of them, permit the expression of all the mentioned cases, suggesting that their meanings are general enough for covering any subject relationships (a review of relationship categories is provided by Veltman[15]).

Furthermore, facets can also be described as either common or special. Common facets may be a specification of any class, while special facets are only defined in the schedules of a specific class. Like in CC, most place and time facets in ILC are common. Quantity facets are also usually common: *-86u* “much” can be appended to any class. While in CC the facet “domain” – either common or special – is specified in the facet formula for each class, in ILC this is done through the general principle of cascading facets: that is, if a facet is defined at the most general rank, like in the case of *86*, then it is a common facet valid for all the lower ranks; otherwise, its meaning and foci are marked as *[X]* at the most general rank and need to be assessed for every different class of subsequent ranks: *n77* “populations, *age class*” has a different meaning and different foci from *r77*

"production, exploiting *resource*", although in both cases the indicator *77* conveys the general sense of part of a part.

5. The power of an expressive faceted notation

Another feature common to both CC and ILC is their expressive notation. The main function of notation in classification is to control the sequential order of classes. According to the principle of positional notation also used in decimal numbers, classes with a shorter notation are meant to be more general, and are listed before more specific classes with a longer notation: *E* "chemistry" is listed before *E3* "chemistry of acids". At each rank, classes are listed according to what Ranganathan[16] called a "helpful sequence": *E3* "chemistry of acids" precedes *E4* "chemistry of salts".

Ranganathan extended such principles to facets, by prescribing that facets be listed in the inverted order of their relevance in the PMEST formula, as mentioned above. Thus *E:3* "chemistry, by analysis", as an energy facet, precedes *E3* "chemistry of acids", as a personality facet. The application of this principle throughout all compound classmarks produces a most convenient linear order of multifaceted subjects.

Ranganathan developed CC before the computer age. Still, his expressive notation is extremely suitable to be leveraged by computer applications, as implemented by Bianchini at the Natural History Museum of Udine[17], thanks to its consistent logical structure. Computers automatically sort literals and numerals in the same way as Indian librarians did manually in the mid-20th century.

Concerning this, some details are worth considering. In the ASCII code that grounds most computer applications, numerals precede literals; as for punctuation marks, some of them precede numerals and/or literals, while others follow them. This situation makes it necessary to provide additional coding in order to exploit CC punctuation marks properly, that is to display CC facets in their correct order. On the other hand, ILC has been conceived well into the computer age, which has allowed it to take ASCII into account while designing notation. Indeed, ILC facet indicators are expressed by numerals, so that they are automatically sorted before subclasses – as prescribed by the theory of faceted classification – and in reversed "PMEST" order: *1* time precedes *2* space, *3* agent and so on.

Unfortunately, digital applications of such clever principles of faceted classification are far from widespread, probably because most application developers have been distracted by the power of search engines based on word matching. More recently, ontologies have been developed widely, which treat word meaning but rarely include any mechanism to sort complex concepts into meaningful orders. This makes it hard to browse classes intellectually and use them as a conceptual guide to contents, as concepts in an array are usually listed in alphabetical order only. Faceted classifications do allow for the meaningful ordering of concepts, but are ignored by most people. Austin[18,19] estimated that freely faceted systems like his PRECIS would be suitable for computer retrieval, while ordering for book shelving could still need traditional systems. Our own experience gives us greater optimism about joining both functions with just some adaptations, such as shortening long classmarks in shelving.

A demo application of ILC faceted classmarks has recently been developed, in order to show its functionalities[20]. It is called Traditional Europe (TradEU) as it offers a gateway to a selection of YouTube videos documenting traditional feasts and other events in European countries. It can be freely accessed and tested at http://www.iskoi.org/ilc/tradeu/ (Figure 1).

Users are shown five facets of the ILC class "customs" (*w*): customs themselves, region, symbols, rites, and instruments. A short list of frequently-occurring foci is shown for each facet. By clicking on a focus in one, two or three facets, the user can build a faceted query, then run it. The next page directly shows the resulting set of playable videos that document the phenomena in the selected foci, sorted according to ILC faceted classmarks.

The TradEU application neatly demonstrates several features of a faceted classification having an expressive notation. Suppose that a user selects the custom type "games" (*wg*) and the symbol focus "clothes" (*7c*). This produces the query *wg%7c%*, where the percent signs are jolly characters – being part of SQL language, not of ILC notation – allowing for the interposition of any other string. In terms of the expressive notation, this means that what is searched are games or any subclass of it, the focus clothes or any subdivision of it, and whatever other facet before or after the symbol facet *7*. Results include (Figure 2):

– *wg92bo7c5c53nq53d* "games, typical of Scotland, clothes, procession, with bagpipes, with

Fig. 1 — Homepage of TradEU

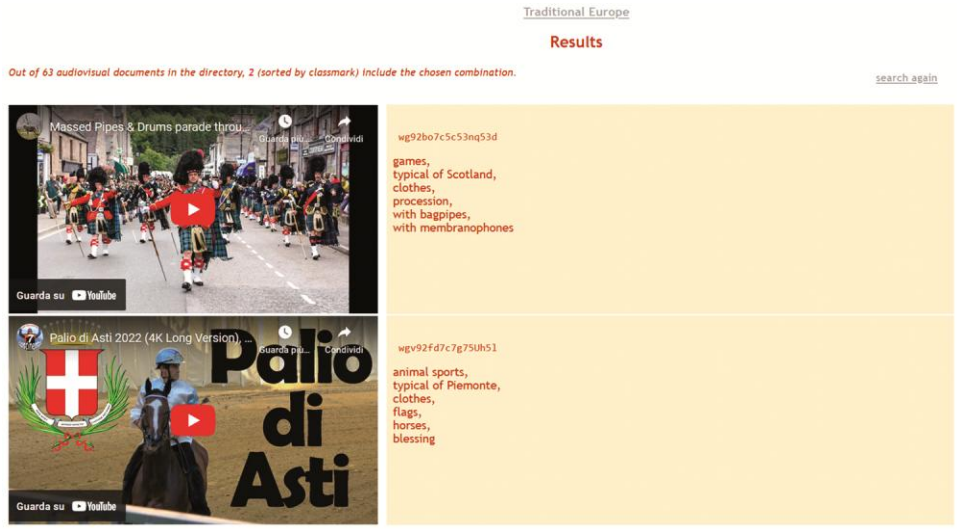

Fig. 2 — Results of the query “games” and “clothes”

membranophones” for a playable video entitled *Massed pipes & drums parade through Deeside town to start the Ballater Highland Games 2018*;

– *wgv92fd7c7g75Uh5l* “animal sports, typical of Piemonte, clothes, flags, horses, blessing” for a playable video entitled *Palio di Asti 2022*.

Note that:

– the second item is about *wgv* “animal sports”, a subclass of “games” that has been retrieved thanks to truncation after *wg* “games”;

– both items include the requested focus *7c* “clothes”;

– facets *92bo* “typical of Scotland” and *92fd* “typical of Piemonte” respectively are interposed before the symbol facet *7c*;

– more facets follow *7c* in both items;

– items are automatically sorted with the more general class (“games”) preceding the more specific one (“animal sports”). In case the basic class were the same, the next facet would be considered for sorting, e.g. by listing Scotland, before Piedmont because *92b* “typical of Britain” precedes *92f* “typical of Italy”;

– in compound classmarks, facets are cited in the inverted order of their numeral indicators, e.g. *92*, *7*, *75*, *5*. That is, the quality-place facet *92* “typical of” is considered to be more relevant for determining the subject than the part facets *7*- and the process facets *5*-.

6. Emptying digit and favoured host class

ILC notation also has taken inspiration from some clever devices introduced by Ranganathan, including emptying digit and favoured host class.

Emptying digit[21] can be used in classification schedules where arrays of many classes are needed. "Emptying digit is a digit with its usual ordinal value and also semantic value, and further having the power to deprive the depriving rich digit of the power of representing an idea".

Taking the example of world countries, all countries in ILC belong to one and the same array, but there are about 200 countries while standard notation, which runs from *-a* to *-y*, does not allow listing more than 25 of them. To deal with this problem, the letter *-z-* is used in ILC as an emptying digit, in the same way as *X*, *U* and other capital letters are used in CC (e.g. *44* India, *44U2 Bhutan*, *45* Iran). This means that more countries can be expressed by appending *-z-* plus a further letter. While the biggest or more internationally relevant countries are expressed by a single letter, like *-e* "Spain", further countries with a *-z-* such as *-ezp* "Portugal" are considered to be part of the same array. We can thus have:

wg92b "games, typical of Britain"
wg92e "games, typical of Spain"
wg92ezp "games, typical of Portugal"
wg92f "games, typical of Italy" etc.

This, however, produced a problem in an initial version of TradEU: if users selected "Spain", results also included "Portugal" because *-92ezp-* was retrieved by queries including *92e%*. This result was not intended – and was particularly unwelcome for proudly Portuguese users including a member of ILC research staff, because of Portugal's historical rivalry with Spain! In order to avoid it, we needed to improve the interface code by adding an instruction prescribing that subdivisions with *-z-* are not included in the query results. In this way, Portuguese games do not get included among Spanish games, and a query matching *-92ezp-* can only be generated by voluntarily selecting "Portugal". This experience shows how expressive notation works in most cases, and exceptions can still be managed by treating them adequately.

Another ILC device inspired by Ranganathan is favoured host class[22] . This is a class that is of primary concern to a specific collection, like the class of whales in a bibliography about whales. Favoured host class can be expressed by a special digit (*0* in CC, *T* in ILC3) chosen in such a way to:

– be listed before ordinary classes;

– be shorter than the standard notation for the same concept.

The same digit can also be appended to a class in order to express a favoured subclass.

By the same principle, ILC has also introduced *typical* class or subclass (*-U*), to express concepts that would have a long notation but are of common concern in most collections. For example, horses would be *mqvtteuf* according to the hierarchy of all animals, but are commonly expressed as *mqUh*, a subclass of *mqU* "the typical animals" also including such frequently discussed animals as bees, chickens, dogs etc.; because capital letters precede lowercase ones in ASCII, *mqU* is listed before all other classes of organisms. In the example above, the parallel facet *75Uh* "with horses" comes indeed from *w75 [mq]* "ritual animal" and *mqUh* "horses", as previously explained.

7. Conclusions

Ranganathan introduced many important structural innovations in classification. The advent of computer science led many to forget them, as research was focused on other directions. However, faceted classification still has great potential, especially when an expressive notation is applied to computers.

The ILC project has resumed research on phenomenon-based faceted classification, as started by the CRG. This looks like a further advancement resting on Ranganathan's shoulders. Indeed, the phenomenon-based approach makes it possible to implement the idea of a "freely faceted classification" in a more complete way. When the definition of classes is bound to disciplines, their facets cannot be entirely free from a specific context. Ranganathan's subject device and phase relationships are ways to enable combination of concepts from different main classes, for which he identified the need; but they still keep a trace of disciplinary meaning: e.g., soil can only be understood as an object of agriculture, rather than behave freely as an independent concept.

It seems that only a classification grounded on phenomena can be a truly freely faceted classification in Austin's sense. At this point, classmarks do not start anymore with a disciplinary class followed by facets in a fixed order. Rather, any concept can in turn take the leading position according to what is the focus of the indexed document, as wished by Austin. A document focusing on traditional games and mentioning horses can be expressed as "games, with horses"; but if horses are instead the base theme of the document[23], one can well reverse the order and get "horses, used in games" so that the entry will be listed

together with others about horses. This is not possible with a discipline-based classification, where both cases should be forced into the fixed order of a single discipline (say, ethnography). Such ability to shift the focused concepts also answers caricatural critiques of phenomenon-based classification[24], as explained by Gnoli et al.[25].

Phenomenon-based freely faceted classifications lend themselves to be applied to any knowledge source, not just written documents. Indeed, one can hardly decide whether a horse shown in a museum or a zoological garden is so more in a biological or in an ethnographical perspective: it is just a horse, and is best represented by the "horses" class of a phenomenon-based classification. The possibility of using the same classification to index books, video contents, museum specimens, or any other knowledge source has a great potential for data interoperability between all different kinds of collection.

Acknowledgement

I am grateful to both editors for their invitation and knowledgeable suggestions to improve the first manuscript.

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