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Facet analysis: The logical approach to knowledge organization

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ABSTRACT

The facet-analytic paradigm is probably the most distinct approach to knowledge organization within Library and Information Science, and in many ways it has dominated what has be termed "modern classification theory". It was mainly developed by S.R. Ranganathan and the British Classification Research Group, but it is mostly based on principles of logical division developed more than two millennia ago. Colon Classification (CC) and Bliss 2 (BC2) are among the most important systems developed on this theoretical basis, but it has also influenced the development of other systems, such as the Dewey Decimal Classification (DDC) and is also applied in many websites. It still has a strong position in the field and it is the most explicit and "pure" theoretical approach to knowledge organization (KO) (but it is not by implication necessarily also the most important one). The strength of this approach is its logical principles and the way it provides structures in knowledge organization systems (KOS). The main weaknesses are (1) its lack of empirical basis and (2) its speculative ordering of knowledge without basis in the development or influence of theories and socio-historical studies. It seems to be based on the problematic assumption that relations between concepts are a priori and not established by the development of models, theories and laws.

1. Introduction

Knowledge organization (KO) or information organization is a subfield of library and information science (LIS) with different approaches and research traditions. Hjørland (2008) mentioned the facet-analytical approach, the information retrieval tradition, user oriented and cognitive views, bibliometric approaches and the domain analytic approach. The theoretical assumptions underlying these different approaches have not been thoroughly examined in the literature and papers are planned about each of these traditions. The purpose of the present article is to examine the theoretical foundations of the facet-analytic tradition. A deeper understanding of each theoretical position will, of course, be possible when all approaches have been examined, but here the foundation of the facet-analytic tradition is analyzed.

2. Historical developments

The basic idea of faceted classification (FC) goes – according to Schulte-Albert (1974) – more than 300 years back in time. In the 20th century the *Universal Decimal Classification* (1905–1907) was an early manifestation of facet classification. It was not, however, until the work of W.C. Berwick Sayers (1881–1960) that FC became a research-based approach within the field of knowledge organization. Sayers was an English librarian and researcher who wrote, among other works, *An Introduction to Library Classification* (Sayers, 1918), a book that went through nine editions by 1954. Francis Miksa writes about him:

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"For the first time library classification had been given a clear and strong methodology that was both understandable and teachable. The methodology clearly insisted that library classification was nothing if it wasn't logical, where logical referred to classical approaches to definition and delineating of classes and class hierarchies. Further, by clearly identifying library classification with logic defined in this way, Sayers was able to structure the methodology of library classification in terms of canons and axioms. The emphasis is important, especially for its impact on the thinking of Sayers' most notable student, S.R. Ranganathan" (Miksa, 1998, p. 64).

S.R. Ranganathan (*1892–1972*) was an Indian mathematician and library scholar, and, as we saw above, a student of Sayers. Ranganathan also attacked the problems of library classification in an axiomatic way, i.e. to develop a set of basic principles and then to apply these rigorously to the problem at hand. From his background in mathematics (and also his influence from Hindu thought) he was able to develop the axiomatic approach much broader and deeper compared to Sayers.

The British Classification Research Group (CRG) developed Ranganathan's work further. The Bliss Bibliographic Classification, 2nd edition (BC2), is also an important product by this group of researchers and it is probably the most theoretically advanced system based on this approach. A member of CRG, B.C. Vickery, wrote:

"The essence of facet analysis is the sorting of terms in a given field of knowledge into homogeneous, mutually exclusive facets, each derived from the parent universe by a single characteristic of division. We may look upon these facets as groups of terms derived by taking each term and defining it, *per genus et differentiam*, with respect to its parent class ... Facet analysis is therefore partly analogous to the traditional rules of logical division, on which classification has always been based ..." (Vickery, 1960, p. 12).

In this quote Vickery connects FC with the principles of logical division developed more than two millennia ago and thus put forward very old ancestors. However, the principles of FA as developed in the tradition of Sayers, Ranganathan and CRG came to be almost synonymous with "modern classification theory" within LIS.

During the 1980s the interest in FA seemed to be decreasing, but at the turn of the 20th century and the beginning of the 21st there seems to have been a revival of interest in the facet-analytic tradition. The philosophical journal Axiomathes published in 2008 (vol. 18, #2) a thematic issue about facet analysis edited by Claudio Gnoli. Frické (2011, 2012) is a new serious researcher in the field, and La Barre (2006) found that faceted techniques are increasingly being used in the design of web pages. A specific format, XFML, a simple XML format for exchanging metadata in the form of faceted hierarchies, has been developed (Van Dijck, 2003). The technique is thus alive and in use. In this connection the distinction between the older systems such as Colon and Bliss designed for shelving books and the kind of systems developed for purely electronic retrieval should be emphasized. Among the newer systems not restricted by shelving purposes are *the Art and Architecture Thesaurus* developed since the late 1970s, the MeSH developed by the National Library of Medicine (see Tang, 2007) and the current attempt of the Library of Congress to develop its subject headings into a faceted system termed FAST.

3. Basic principles of facet analysis

The relation between FC and logic[1] is already evident by Sayers as indicated by Miksa:

"it may be reasonably concluded that his [Sayers'] teaching and texts on the topic contributed more than any other source to equating the library classificatory process not only with logic, but also, and more specifically, with that branch of logic that ultimately had its origin in an Aristotelian approach to categorization. The most striking correlation that he made in this respect was to adopt definitions, relationships, and operations that arose from Aristotle's five predicables – i.e., genus, species, difference, property, and accident. Sayers' use of these ideas included describing the process of classificatory division as that of 'genus et differentiam'" (Miksa, 1998, p. 64).

Ranganathan continued the logical approach and worked from the rationalist idea that he could:

"discover the very nature and order of things, an order based on principles which are eternal, unchanging, and all-encompassing. There is virtually no area of Ranganathan's work and personal life in which this quest for discovering the inner or essential order behind the visible world is absent" (Miksa, 1998, p. 67).

This quote expresses clearly a basic assumption of rationalism: underneath the confusing empirical reality is a clear order, which can be discovered by research. Ranganathan developed a theory of *the universe of subjects* inspired by the mathematical works of Georg Cantor (1845–1918) in relation to the idea of infinity. Ranganathan always used mathematical concepts and theories *as analogies* rather than working directly as a mathematician. His theory of the universe of subjects was that subjects exist in a multidimensional space. Ranganathan's theory of facet analysis appeared in *Prolegomena to Library*

[1] Logic, the principles of valid reasoning, is sometimes confused with psychology and cognitive science (the study of how the mind works) and this also seems to be the case with Sayers (Miksa, 1998, p. 63): "[Sayers] suggested [...] descriptions of how the mind works so that library classification can be approached with some sort of reasonable consistent methodology". However, in this article we discuss classification in relation to logic understood as the study of the principles of valid inference and correct reasoning, and in Hjørland (in press) we discuss classification in relation to psychology and cognitive science (the cognitive view in information science).

Classification in 1937 and was reissued in a second edition in 1957 and a third edition in 1967 (his work is, however, difficult to read and perhaps even unclear and obscure).[2] Ranganathan referred to such infinite sets of subjects by the term *facets* and he described two kinds of facets:

1. *Basic subjects:* Subjects which do not have isolate ideas as a component are basic subjects. Example: Mathematics (Ranganathan, 1967, 83).
2. Qualifications of basic subjects, which he termed *isolates*. They are, for example, space and time (In the example "Indian 20th Century Mathematics," *India* and *20th Century* are respectively space and time isolates).

Ranganathan found that five kinds of isolate facets were necessary and sufficient to characterize all existing or future produced documents:

- **P**ersonality is the distinguishing characteristic of a subject.
- **M**atter is the physical material of which a subject may be composed.
- **E**nergy is any action that occurs with respect to the subject.
- **S**pace is the geographic component of the location of a subject.
- **T**ime is the period associated with a subject.

This is Ranganathan's well-known PMEST formula: **P**ersonality, **M**atter, **E**nergy, **S**pace and **T**ime, consisting of *five fundamental categories*, the arrangement of which is used to establish the so-called facet order, i.e. a ranking of the importance of the five dimensions of each subject according to decreasing concreteness.

The best way to explain the facet-analytic approach is probably to explain its *analytico-synthetic* methodology.

- "Analysis": breaking down each subject into its basic concepts.
- "Synthesis": combining the relevant units and concepts to describe the subject matter of the information package in hand.[3]

In the example above, books about mathematics in different periods and countries may be analyzed:

- *Basic subject: Mathematics.*
- *Isolates*: Periods and countries.

For each isolate a separate classification is constructed (e.g. one of all countries, another of all periods). To identify classes from such classifications of isolates is the analytic part of the process. To construct a subject descriptor by combining isolate classes is the synthetic part of the process, hence analytic-synthetic classification. The resulting synthetic notation is composed of sections, each of which stands for a special aspect of the combined notations (somewhat analogous to chemical notations where the notation for water is H_2O, thus informing about the components of water[4]).

The difference between the traditional kinds of classification systems, the enumerated kinds and the facet-analytic schemes is that in the enumerative kinds all classes are listed (for example all countries and all periods). In the faceted classification, by contrast, classes are constructed when needed by combinations of building blocks, much like building objects out of Meccano parts. Ranganathan himself derived inspiration for his Colon Classification from Meccano, which he came across in a London toy shop whilst studying at University College London (UCL) in 1924 (Broughton, 2007).

S.R. Ranganathan wrote in his *Philosophy of Library Classification* (1951): "An enumerative scheme with a superficial foundation can be suitable and even economical for a closed system of knowledge ... What distinguishes the universe of current knowledge is that it is a dynamical continuum. It is ever growing; new branches may stem from any of its infinity of points at any time; they are unknowable at present. They cannot therefore be enumerated here and now; nor can they be anticipated, their filiations can be determined only after they appear" (Ranganathan, 1951).

[2] "The semantic and syntactic structure of Ranganathan's language may serve to hinder easy comprehension of his principles of facet analysis. Sentences such as 'The denotation of a term ... should be determined in the light of the different classes or ranked isolates of lower order (upper links) belonging to the same primary chain as the class or the ranked isolate denoted by the term in question' (Ranganathan, 1967, 208) tend to leave some doubt as to what Ranganathan is trying to say (i.e. that a term's meaning and context depend upon its location in the classification schedules). It is often necessary to read such sentences several times before they can be understood, and even then, one may not be certain that full comprehension has occurred" (Spiteri, 1998).

[3] Fugmann (1993, p. 176): "[The analytico-synthetic classification] is one in which: – In the first step the analysis is performed which yields the constituent, monocategorial components and – in the second step, the synthetical one, these components are brought into a predictable sequence in order to display the particular kind of syntactical relation in which they are encountered in a document or in a search. In several variations, this basic idea has proven extremely useful in computerized information systems of the faceted type, too".

[4] Broughton (2007) also found that molecular modeling provides a useful modern equivalent to Ranganathan's Meccano analogy.

Ranganathan thus expresses the views:

1. That enumerative systems have a superficial foundation.[5]
2. That the discovery of new knowledge implies the need for new classes, which cannot be anticipated by an enumerative system.
3. That newly discovered knowledge can be expressed in FC designed before the discovery is made by combinations of pre-established categories.

These views reveal some basic assumptions in the facet-analytic approach. One might question this view and ask whether the difference between the theoretical foundations of enumerative systems and faceted systems is that the former have a superficial foundation while the latter have a profound foundation? Could it rather be that the basic questions in knowledge organization are shared by both approaches? While it is correct that it may be easier to combine existing elements to form new classes and thus easier to place new subjects in faceted systems, it does not follow that it is possible for FC to represent all new subjects as combinations of existing elements. This is in disagreement with the development of scientific concepts according to the theory of Thomas Kuhn, who introduced the concept of incommensurability, which asserts that successive theories employ different conceptual systems and that, consequently, some of the terms that may seem to be shared by the competing theories may differ in meaning (cf. Andersen, Barker, & Chen, 2006, p. 196). The concept cannot, according to this theory, be understood or defined just by a set of necessary and sufficient conditions or attributes that define the objects falling under the concept, as the "classical theory of concepts" assumed (Andersen et al., 2006, p. 6). New conceptual structures therefore require new concepts and classification systems, and this is true for enumerative classification as well as FC.

Kathryn La Barre summarized the facet-analytic approach in this way:

> "FA is a form of conceptual analysis that collects commonly used terms in a given domain and uses these terms as raw material for analysis [Vickery, 1960, pp. 12–13]. During analysis, each term is examined and a series of questions asked: What concept does this represent? In what conceptual category should this concept be included? What are the class relations between this concept and other concepts included in the same category? In sum, a faceted classification schedule consists of a set of clearly defined, terminologically expressed concepts along with their semantic relations that have been defined and identified through the process of facet analysis [Vickery, 1966]" (La Barre, 2010, p. 249).

Vickery (1960)[6] also found that a longer list of fundamental categories has proved helpful in science and technology and proposed the following list for classifying scientific domains:

- Substance (product)
- Organ
- Constituent
- Structure
- Shape
- Property
- Object of action (patient, raw material)
- Action
- Operation
- Process
- Agent
- Space
- Time

One of the editors of BC2, Vanda Broughton, said:

> "These fundamental 13 categories have been found to be sufficient for the analysis of vocabulary in almost all areas of knowledge. It is, however, quite likely that other general categories exist; it is certainly the case that there are some domain-specific categories, such as those of form and genre in the field of literature"[7] (2001, 79–80).

The terms in Vickery's 13 categories may be combined in complex ways:

> "As well as these, in any scientific classification there may occur a number of terms applicable at several points in the combination formula. For example, any property or process may itself have a general property: rate, variation, and so on" (Vickery, 1960, pp. 23–24).

[5] Perhaps Ranganathan did not directly express in the quote presented that enumerative systems have a superficial foundation , but based on a broader knowledge of his work and the tradition of FC it is reasonable to conclude that he considered enumerative systems like DDC lacking a theoretical basis.

[6] Vickery (1966, p. 24) compiled other lists of fundamental categories. See also La Barre (2010, p. 251) for an updated listing.

[7] Consider, however, that Ranganathan found five categories sufficient for the analysis of vocabulary in all areas of knowledge. This may indicate that categories are not "discovered" but pragmatically "constructed". This line of reasoning may also provoke the question: Are Vickery's categories equally good for all scientific fields? Are they something that he and other researchers in the same tradition think that they "discover", while in reality they force a discipline into a particular form, while being blind to other categories and forms?

Vickery's expansion of the number of fundamental categories may imply that there is not a fixed set of categories in the world.[8] This represents a loosening of the rationalist view. It is however, still unclear whether categories are discovered or constructed and how, precisely, they are identified, and how their identification can be verified by other scholars.

4. Construction principles for facet classification schemes

The construction principles have been developed in, among other texts, Mills & Broughton, 1977 and Vickery (1960, 1966), and subject-specific descriptions in each volume of the BC2 system (e.g. Physics in Class B, published 1999). The following six points are based on La Barre (2010, pp. 249–250), but have been modified here:

Facet analysis

1. Define the subject field. This may be accomplished by first asking "(i) what things or entities are of interest to the user group envisaged; (ii) what aspects of those entities are of interest" (Vickery, 1966, pp. 43–44).
2. *Facet formulation:* Examine a representative range of material that directly expresses the interests of the user group: their own reports and papers, supplemented by comprehensive texts, glossaries, subject heading lists, etc. This provides a list of candidate terms to use. Sort these terms into "homogeneous groups of terms ['facets'], derived by taking each term and defining it with respect to the entities that are the center of interest in the classification" (Vickery, 1966, p. 45).

Facet analysis and faceted classification

3. *Facet amplification and structuring:* It is helpful at this stage to construct a hierarchical order of the terms collected within each facet. Even if no well-developed hierarchy results, the procedure helps to coalesce synonyms, eliminate terms that are collated with the wrong facet, and to indicate gaps in the system.
4. *Creation of scope notes:* These notes will define terms that are unclear and provide instructions to users and indexers as to the meaning and use of each facet.
5. *Facet arrangement:* Decide how the facets are to be arranged among themselves. This is use-dependent, i.e. for post-coordinate use (as in a thesaurus), arrange in categories, for pre-coordinate use (in a catalog), more thought must be given to the sequence of facets in the schedule and placing them in citation order. The chosen order should be that of greatest utility to the person using the system.

Faceted classification

6. Add notation (Vickery, 1960) devotes 13 pages to this problem.

Mills (2004, p. 550) lists "the six fundamental steps in design":

1. Division of the subject into broad facets (categories).
2. Division of each facet into specific subfacets (usually called "arrays", following Ranganathan).
3. Deciding the citation order between facets and between arrays.
4. Deciding the filing order between facets and between arrays and the order of classes within each array.[9]
5. Adding a notation.
6. Adding an A/Z index.

Below, the principles are discussed, but not all Mills's steps are considered, because they do not exhibit the same theoretical importance. The first two steps are governed by the principles of logical division, which were developed more than two millennia ago:

- Only one characteristic of division should be applied at a time.
- Division should not make a leap: steps should be proximate.
- Division should be exhaustive.

Mills writes: "Assigning terms to categories is a deductive approach to concept organization, and it may be noted that one member of the CGR [Classification Research Group] advocated and developed an inductive approach (Farradane, 1950).[10]

[8] See further: Wardy (1998), Section 4: Are categories universal?

[9] As Broughton (2007) stated the sequence or order of concepts in combination is less vital in a digital context, but is still important where any sort of linear order or display is needed.

[10] This quote is important for the theoretical perspectives in this article because I assume that FA is based on deductive (top-down), not inductive (bottom-up), principles – and that inductive (empirical) principles produce different classifications compared to those classified by deductive (rationalist) methods.

[...] classifications resulting from Farradane's system proved to be remarkably similar to those of faceted classification" (Mills, 2004, p. 551[11]).

Example: Medicine
"'Medicine' may be defined as the technology concerned with the actions taken by the human person to maintain their health and treat their sickness. The definition of the subject leads directly to the primary category (the defining entity, the person), and all the other categories are realized in their relation to this. The categories disclosed are:

- Kinds of human persons (females, males, young, old ...).
- Parts of the person (anatomical and regional, and physiologically functional subsystems – trunk, circulatory, neurological ...).
- Processes in the person (normal physiology, pathology).
- Operations acting on the person (health maintaining or preventative, diagnostic, therapeutic).
- Agents of operations (medical personnel, instruments, institutions – hospitals, health services ...).

So a particular document entitled 'Rehabilitation Following Fracture of the Femoral Neck [in old persons]' would get the index description: Old persons (geriatrics) – Bone – Femur – Neck of femur – Fracture – Therapy – Rehabilitation" (Mills, 2004, pp. 552–553).

In steps 3 and 4 the concepts of citation order and filing order are introduced. Mills illustrates these concepts with a telephone directory in which:

- **The citation order** is analogous to the order of constituents in a telephone directory entry – surname, forename, designation (Dr., Sir, etc., perhaps), whereas
- **The filing order** is analogous to the A/Z arrangement.

In the bibliographical contexts citation order and filing order are not independent (as in a telephone directory), however, a general principle in FC is to reverse the filing order in relation to the citation order. This is termed "inversion" and the purpose is to maintain a consistent general-before-special filing order of all classes.[12] In the medical example above,

- **The citation order** (order of division): Old persons – Bone – Femur – Neck of femur – Fracture –Therapy – Rehabilitation.
- **The filing order** (reverse): Rehabilitation – Therapy – Fracture – Neck of femur – Femur – Bone – Old persons (Rehabilitation in general files before, for example, rehabilitation of old people).

Step 3 and 4 are considered "extralogical" by Mills and are thus not dependent on logical division. Deciding the citation order (step 3) consists primarily of deciding which classification criterion should be the primary, which should be the secondary, etc. Should a historical classification system, for example, classify primarily by countries or by periods? Two principles are considered fundamental for deciding the citation order: (1) the predictability in locating classes (2) "helpful order". Mills finds that the number of different ways of classifying a subject is so huge that it would be rash to say that one order is better than all the others. But the one decided upon should be one of which it cannot be said that another is better (i.e. admitting some degree of arbitrariness in the decision). Ranganathan's choice was, as we saw, to arrange according to decreasing concreteness in the PMEST formula; we have also seen Vickery's (1960) list of facets. Mills (2004, p. 557) has a modified version beginning with the defining system or entity which he (and CRG) came to see as reflecting the end product of the subject in that the other categories are features of it or actions directed at producing or sustaining it. "The production of this end product, whether by natural forces or by human actions, is seen as reflecting the general principle of the subordination of means to ends."

Even if Mills introduces the pragmatic concept of "helpful order" and writes that the third step in FC is "extralogical" we can see that he is searching for some specific and *general* rules to be followed in determining citation order (although it should be admitted that he argues for the use of alternative citation orders). There is no suggestion on how empirically to determine what citation order is "helpful" in relation to a given target group, a given task or a given perspective. Mainly based on what is not said, we may conclude that FC is a clear example of a rationalist epistemology operating in KO.

As already said FC has got a renaissance with the Internet, and many people find that this new medium at last provided the full utilization of the strength of this approach. There is no doubt that many sites provide faceted facilities today. La Barre (2010, p. 246) provides, for example, a figure of the Circuit City e-commerce website, www.circuitcity.com, demonstrating camera facets: resolution, camera style, brand and price. But to what degree are such sites inspired by research in LIS? Could it be that they are often spontaneously developed without knowledge of the facet analytic tradition? The close connection

[11] I have not been able to identify any empirical evidence for Mills' claim that Farradane's inductive approach provided results similar to the deductive approach of FA.

[12] The drawback is that users have to remember a different filing order and citation order and it is therefore not followed by all classifications. http://www.icis.org/siteadmin/rtdocs/images/5.pdf.

between FC and logical division (described later in the article) supports this hypothesis: The basic principles in FC are probably used far beyond the influence of the facet analytic community.

5. Relations to Aristotelian and other kinds of logic

What are the relations between facet analysis and logic? We saw above that Sayers' view had its origin in an Aristotelian approach to categorization (and ignored newer theories of logic and classification). Aristotelian logic is also termed traditional logic and is by many seen as a rival and incompatible with new mathematical notions of logic developed by Gottlob Frege (1848–1925) and later developments (Smith, 2011). The status of traditional logic today is evaluated differently by different researchers. Frické (2012, p.171) found that "Aristotelian classification is a worthy model: it is exemplary in its clarity, and it can do most everything that seems desirable. Other schemes are often not as good; indeed, many can be improved by being modified so as to approach the Aristotelian ideal"[13]. There are other forms of logic, however, as also indicated in the quotes by Miksa above. The discussion of the relations between different schools of logic and their relevance for classification in information science is outside the frame of the present article, in which only the foundation of FC is examined.

Is FC just the application of traditional logic, or has it contributed new important insights of its own? Vickery (1966, pp. 45–50) notes that FC is "partly analogous to the traditional rules of logical division on which classification has always been based."[14] It is necessary here to ask whether this is correct: has classification always been based on logical division? Parry and Hacker (1991, 136–139) write:

> "In logical division, one starts with a class (genus) and divides it into subclasses (but not into individuals). In classification, one starts with individuals or classes, and groups them into classes on the basis of properties they share" (p. 136).

> "As a process of knowledge, division is characteristically an a priori process based on meaning. Classification, however, is primarily inductive, and may require empirical knowledge" (Parry & Hacker, 1991, 137).

In the light of Parry & Hacker's quote it looks like not just Vickery but the whole facet-analytic tradition has confused logical division and classification. Logical division is one kind of classification, but mostly not the most important kind, which has been known for a long time:

> "Aristotle had argued that logical division was an inappropriate tool for the classification of organized beings" (Stevens, 1998).

The main characteristic of FC is the use of logical division at the expense of other methods of classification (in particular the empirical methods). As we shall see below, this is a very important objection to the whole tradition and approach of FA. Here, however, we return to considering the relations between FC and logic. The first observation is that several kinds of logic exist, and that the Aristotelian branch seems to have been out of favor among philosophers for a long time. A reviewer wrote the following about Parry and Hacker's (1991) book *Aristotelian Logic*:

> "[Aristotelian logic . . .] has been out of favour for about a century now. The hegemony of Fregian first order predicate logic has left little room for traditional logic to have more than a tenuous toe-hold on the field. [. . .] But the fact is that Frege's new world is not paradise. An increasing number of philosophers are recognizing this fact. A logic built initially to account for inferences made in the medium of mathematical language has turned out to be a poor fit for inferences made in the medium of ordinary language. [. . .] For all its shortcomings traditional logic was at least *natural* (i.e. a logic of natural language). And that old logic, in spite of the awesome power and prestige of the new logic now in place, still has friends" (Englebretsen, 1992, p. 75).

Based on this quote, we may conclude that issues in the field of logic are still open to different views, including the "traditional" or "Aristotelian" tradition.

Parry and Hacker (1991, 138–139) found that there are six rules of classification, four formal rules and two informal rules. The first three formal rules correspond in their opinion exactly to the first three rules of logical division:

A: Formal rules:

1. Coordinate classes in the classification must be *mutually exclusive*.
2. The coordinate classes must be jointly *coextensive* with the class immediately superordinate (their proximate genus).

[13] Frické (2012, p. 175) also discusses the relation between Aristotlean logic and the DDC under the label "Librarian Aristotelian".

[14] According to Vickery, FA results in a classification system which differs in three important ways from "the traditional rules of logical division on which classification has always been based": (1) by its strict application of rules and analysis during system construction such that: "every distinctive logical category should be isolated, every new characteristic of division should be clearly formulated, every new relation should be recognized, even though at a later stage it may be possible and advisable to present a less refined analysis" (Vickery, 1966, p. 46); (2) the categories in an FC are not locked into "rigid enumerative schedules, but are left free to combine with each other in fullest freedom, so that every type of relation between terms and between subjects may be expressed"; (3) from the theoretical point of view, "faceted classification breaks free from the restriction of traditional classification to the hierarchical, genus-species relation. By combining terms in compound subjects it introduces new logical relations between them, thus better reflecting the complexity of knowledge" (Vickery, 1966, p. 46).

3. Each stage of a classification should be based on one *principle of classification*.
4. Other things being equal, the classification using the *fewest principles* of classification is preferred. This is the criterion of logical *simplicity*.

B: Informal rules:

5. The classification should serve the purpose for which it was constructed.
6. Unless the classification is constructed to serve one specific function, it is desirable that it be as *fruitful* as possible.[15]

Parry and Hacker's descriptions of the rules of classification seem to be related to those of FC, although, as we saw, they considered logical division to be based on a priori knowledge but classification mostly on empirical knowledge (it seems therefore strange that their three first principles of classification correspond to those of logical division). There is, moreover, in their book a discussion of the distinction between *artificial* and *natural classification* taken from Mill's (1872) classic book *A System of Logic*, which seems to be ignored in the rules quoted above (and thus also important to FC because it is based on the same rules). Other parts of Parry and Hacker's book (1991) seem to better reflect the limitations of artificial classification: for example, the book argued that logical division and a priori classifications are generally of limited value in the social and natural sciences:

> "In mathematics, it is usually not difficult to make a priori divisions into suitable subclasses that are mutually exclusive and jointly coextensive. For example, one may divide plane rectilinear figures into triangles, quadrilaterals, pentagons, and polygons of more than five sides. Outside mathematics, one can usually make quantitative divisions of some sort. For example, one may divide rocks – or even animals – into those weighing less than ten grams, those weighing at least ten but less than twenty grams, and so on; but this is likely to be of little use, except perhaps for knowing what it would cost to mail them. [...]
> In the social and natural sciences, a priori divisions are generally of relatively limited value. For example, there are various ways in which the class of mammals may be subdivided. The principal way for zoologists is to subdivide into the orders of monotremes, marsupials, rodents, and so on. The concepts of these orders are obtained by empirical and inductive procedures of classification (6D) rather than division, though the result may be presented in the form of a division" (Parry & Hacker, 1991, p. 133).

John Stuart Mill wrote about artificial versus natural classification:

> "The Linnæan arrangement answers the purpose of making us think together of all those kinds of plants, which possess the same number of stamens and pistils; but to think of them in that manner is of little use, since we seldom have anything to affirm in common of the plants which have a given number of stamens and pistils" (Mill, 1872, p. 498). And further:
> "The ends of scientific classification are best answered, when the objects are formed into groups respecting which a greater number of general propositions can be made, and those propositions more important, than could be made respecting any other groups into which the same things could be distributed [...]
> "A classification thus formed is properly scientific or philosophical, and is commonly called a Natural, in contradistinction to a Technical or Artificial, classification or arrangement" (Mill, 1872, p. 499).

The concept of natural classification is related to the concept of natural kinds, which is still much discussed; cf. Hjørland (2011) and the following quote:

> "Scientific theorization is associated with the development of classification schemes. It is not a coincidence that Kuhn (2000) in his later works tended to replace the idea of paradigm with the notion of lexical taxonomy, i.e. the taxonomic structure projected by scientific theories upon the world. The debate about natural kinds is a central topic of the philosophy of many scientific disciplines, chemistry included" (Mazzocchi, 2011, p. 398).

This whole debate about natural classification and scientific theories seems not to have found its way into the facet-analytic approach. And the conclusions that Miksa draws about Sayers' contributions to library classification – that its base is too narrow – may also be relevant for FA as a whole:

> "The negative side effect of Sayers' approach to library classification theory was that it effectively narrowed the base for investigating the process of library classification. This is the case because the 'logic' that Sayers identified as basic to library classification in reality provided only a relatively narrow range of approaches to the thinking process and, therefore, to the process of categorization useful for information-bearing entities. For example, by the time Sayers was writing his principles, investigations by George Boole, Augustus De Morgan, and others, when combined with the work of the

[15] "A classification is fruitful to the extent that it suggests new hypothesis, explanations, and theories concerning its subject matter. For example, the periodic table—the classification of the elements—proved extremely fruitful, since it suggested the existence of hitherto unknown elements and even suggested what physical properties they would have. It should be noted that natural classifications, by definition, are more fruitful than artificial ones" Parry and Hacker (1991, p. 139).

German mathematician Georg Cantor, were already yielding the entire field of axiomatic set theory. But Sayers never included such developments in his considerations of library classification theory. [...] Nor did Sayers take into account later work in statistics (for example discriminant analysis and clustering) and many-valued logics. And this is to say nothing at all about classification principles and work which have arisen in linguistics, psychology, and anthropology under the general label of the processes of human mental categorization. When one follows out the implications of alternative methodologies such as these, the very idea of classificatory principles will expand significantly from its narrow base in the kind of logic Sayers saw as essential to it " (Miksa, 1998, p. 65).

We may conclude with Miksa than FC seems to be based on traditional logic and that the both the relation to that basis and the limitations by relying on that foundation has not been properly examined within LIS.

6. Reception and criticism

It is rare in the literature of FC to find discussions of the limitations of its approach or comparisons with other approaches. It is far more often stated that FA is the only or the best way to classify documents or to make them findable. In 1955 the CRG issued a manifesto, *The need for a faceted classification as the basis for all methods of information retrieval*, rejecting all "existing classification schemes as unsatisfactory, in one way or another, for the demands of modern documentation" (Classification Research group, 1955, p. 263). Another example is Mills (2004, p. 541), who writes that he does not see faceted classification "as a particular kind of library classification but as the only viable form enabling the locating and relating of information to be optimally predictable".

An exception to the rule that it is difficult in the literature of FC to find discussions of its limitation is Vickery (1966, pp. 17–18), who listed the following disadvantages of the method (here shortened):

1. They require more effort to initiate and cannot as readily incorporate marginal topics that become of interest.
2. The use of notational symbols instead of natural language may lengthen both indexing and searching processes. They cannot so simply introduce new indexing terms.
3. Relative to more structured systems, they cannot provide such flexible facilities for generic search.

In general, Vickery concludes, being intermediate in degree of structure, faceted schemes introduce more constraints than verbal indexes but have fewer search facilities than more structured codes. This conclusion may indicate that Vickery failed to anticipate the power of faceted search.

Vickery also presents results from the first Cranfield experiments (see Table 1) and interprets them in this way:

"Performance [of FC] was poorer than for the other systems tested [...] A supplementary test, in which multiple entries were made in the classified file for each topic, improved the success rate of Facet to 83 percent [...] I consider that these results support the claim that faceted schemes, as improved in the ways described in this paper, are no less efficient in retrieval than other systems" (Vickery, 1966, pp. 86–87).

In spite of Vickery's positive evaluation of the efficiency of FC, the general trend following the Cranfield experiments was to downgrade all kinds of classifications and other forms of controlled vocabularies in the information retrieval (IR) tradition. The general attitude has been that such systems were not efficient for information retrieval, were not worth the high expenses, or would by the improvement of retrieval technologies be made superfluous in the near future. A split was made between IR on the one side and KO on the other, with the IR field being far the most prestigious and influential. Leading IR researcher Gerard Salton expressed his view this way:

"Acting as if we were stuck in the nineteenth century with controlled vocabularies, thesaurus control, and all the attendant miseries, will surely not contribute to a proper understanding and appreciation of the modern information science field" (Salton, 1996, p. 333).

That quote is now 16 years old. Although recent research in IR has recognized the importance of KO – as evidence by faceted search and newer (semantic) IR approaches taking advantage of ontologies – the overall picture seems still to be a disconnection of KO with IR. The following books, for example, do not mention facet analysis or the researchers in this tradition: Büttcher, Clarke, and Cormack (2010), Goh and Foo (2008), Hersh (2003), Kowalski and Maybury (2000) and Manning, Raghavan, and Schütze (2008). Göker and Davies (2009) mentions facet analysis, but does not really draw on the research

Table 1
Aslib Cranfield Research Project (Warburton & Cleverdon, 1961; after Vickery, 1966, pp. 86–87).

	Original test (%)	Supplementary test
Facet	73.8 ± 2.5	83%
UDC	75.6 ± 2.5	–
Alphabetical	81.5 ± 2.5	–
Uniterm	82.0 ± 2.5	–

tradition. An indication is also that facet analysis or researchers in this tradition is absent in references on information retrieval in bibliometric searches.[16] There is thus clear evidence that the facet analytic tradition is not influential in contemporary research in information retrieval today.

Ranganathan has had many followers in library and information science (LIS) and his name occurs in most textbooks about bibliographic classification and knowledge organization. He, as well as other classification researchers (except Vickery), is not, however, much cited in the research literature, and does not appear on White and McCain's (1998, p. 343 + p. 350) maps of information science.[17] It has, moreover, been extremely difficult to trace critical examinations of this approach. Lancaster, Zeter, and Metzler (1992) wrote about the way Ranganathan is quoted in the literature:

> "Nevertheless, it is also necessary to point out that many of the references are very superficial ones, acknowledging some intellectual debt to Ranganathan without actually explicating Ranganathan's work or even explaining in detail the nature of the debt. A few authors seem to make such non-substantive references to Ranganathan in more or less every article they write" (Lancaster et al., 1992, p. 276).

Only very few researchers have had a broader knowledge which enabled them to consider the facet-analytic approach in relation to fields like philosophy and linguistics. Among the few who have done this is Moss (1964), who found that Ranganathan based his system of five categories on that of Aristotle without recognizing this. In this way FC seems to have isolated itself from more established fields, in which related problems have been discussed, and which may be considered foundational. It is also a sign of an insufficient level of scholarship in KO. Another critical voice is Francis Miksa,[18] who, for example, wrote:

> "In the end, there is strong indication that Ranganathan's use of faceted structure of subjects may well have represented his need to find more order and regularity, in the realm of subjects, than actually exist" (Miksa, 1998, p. 73).

The Danish linguist and information scientist Henning Spang-Hanssen (1974, p. 39) found that Ranganathan's distinction between idea plane and verbal plane is problematic because the description of the two planes will lead to one and the same structure; for this reason there can be no motivation to speak about the two planes.

Hjørland (2007, 382–384) related the basic philosophy of facet analysis to the philosophy of semantic primitives and to a broader theory of semantics. He provided the example of chemical nomenclature. Chemical elements are given symbols (e.g. H for hydrogen; O for oxygen). In the chemical language, H and O are semantic primitives, and chemical compounds are expressed by a combination of names of the elements (e.g. H_2O). But the composition of water is something discovered by chemists (not given by logic), and the chemical formulae are constructed as models of the reality described by chemistry. In antiquity earth, air, fire and water were considered the chemical elements. In 1661, Robert Boyle showed that there were more than just the four classical elements and the first modern list of chemical elements was given by Antoine Lavoisier in 1789, and because new elements are still discovered the research is still going on. When a set of elements are discovered or theoretically constructed, they are named in languages, and these languages may subsequently be subject to logical analysis. The important conclusion is that *semantic primitives are not something given by a natural language, they are models constructed by specialists in specific domains*.

It is problematic if FA is based on the view that meanings are given in a language, and that subjects can be constructed by a universal set of semantic primitives given by natural languages. The decomposing of complex concepts into primitive concepts (and the synthesis of primitive concepts into complex concepts) cannot be done without considering the specific subject knowledge (as was also done, for example, by Szostak, 2011[19]). The decomposing of complex concepts into primitive concepts cannot simply be done by a priori, conceptual analysis. But when a given set of elements is provided from outside, it may be used in classification, and new discoveries may be classified as new combinations of elements from the set– as long as the set is considered in accordance with the scientific theory on which it is based (often there are conflicting scientific views). The elements in classification are not given by the logical analysis of the philosopher or the information specialists, but are given by scientific discoveries and theories. This is again the question of the differences between logical divisions and scientific classifications as discussed by Mill (1872). In faceted classification a given document is classified by taking one or more symbols from the appropriate facets and combining them according to certain rules. This combination is called "notational synthesis". The idea is that the same building blocks can be used for all purposes (cf. Meccano). *The underlying philosophical assumption is that elements do not change their meaning in different contexts.* According to modern theories of meaning, this is a rather problematic assumption.

[16] A search in SciSearch and SocialSciSearch on CR = RIJSBERGEN? OR CR = VANRIJSB? OR CR = SALTON? OR CR = ROBERTSON S,? OR INFORMATION(W)RETRIEVAL on 2012-09-22 gave a total of 22102 references of which 1207 unique references were from 2011. Of these 0 (zero) contained the word facet analysis or facet classification and only 1 cited S.R.Ranganathan and 1 cited BF Vickery.

[17] Ranganathan's absence from the bibliometric maps constructed by White and McCain (1998) is partly due to the elimination of journals in which Ranganathan is highly cited, such as *Libri* (14.8% of references to Ranganathan); *Aslib Proceedings* (14.3%) and *International Classification* (09.7 + 07.6% = 17.3%) in the period until and including 1995 (more journals citing Ranganathan not included here). Much more than 46.4.7% of the citations to Ranganathan were thus eliminated by White and McCain, although these references were in the database.

[18] Francis Miksa's father was a mathematician and this is the reason that Miksa was able to read Ranganathan critically. It is somewhat disturbing that such coincidences determine whether core issues in a field like LIS are seriously considered or not.

[19] See Fox (2012) for a comparison of Szostak's and Hjørland's views.

It is worth mentioning that FC was developed at a time when Boolean searches were not yet introduced in LIS, and since then it has developed without much interaction with the online searching community in which Boolean searching is everyday practice. For example, the concept of facets was used by Stephen P. Harter in the context of online searching; he wrote:

> "A *facet* is a group of concepts that, for a given search, will be considered to be equivalent by the searcher [i.e. synonymous]. There may be several facets in a search, but usually there are no more than three or four" (Harter, 1986, p. 172; italics in original).

Example: In a search for "Gross national products of European countries". One facet would be "European countries OR Denmark OR Germany OR Spain OR . . ." That facet should be combined with Boolean AND with another facet like this: "Gross national product OR GNP OR . . ."

Vickery (1966, p. 15) suggested that FC might be used as an aid in formulating search queries. This idea was also independently suggested by Hjørland (1988), who found that the facets constructed in faceted classification systems like BC2 may in fact be used to construct facets in online searching as a heuristic tool; he exemplified this with a concrete example from psychology. Curiously enough there has been extremely little exchange of knowledge between the online searching community and the knowledge organization community in relation to facets and facet analysis (although the concept of faceted search has lately evolved, cf., Tunkelang, 2009). It also has been found that a thorough faceted analysis applied in query formulation is conducive to favorable results (Drabenstott, 2001; Kekäläinen & Järvelin, 1998; Soergel, 1985; Vakkari, Jones, MacFarlane, & Sormunen, 2004). The strength of facet analysis is its possibility to remind the indexer of the different aspects by which a document can be represented, as well as the searcher to articulate different aspects of the topic they are exploring. Yet it remains an open question how facets constructed by the indexers are able to correspond to the facets needed by users.

7. Discussion

Facet analysis is primarily a logical approach to classification and knowledge organization. Although the methodological principles also sometimes mention empirical elements (such as examining a representative sample of texts) and pragmatic criteria (such as producing the most helpful classification), these elements are so vaguely peripherally described that they do not change the general conclusion of FA as a rationalist approach based on a priori knowledge, not on empirical knowledge or on historical or pragmatic methods.[20] When concrete classifications are produced (such as the single volumes in the BC2 system) the classifiers do, of course, consult libraries and terminology lists. This part of the methodology is not well described, however. It is not described what differences it makes whether the empirical work is done one way or another. There are in the tradition clear assumptions about "discover the very nature and order of things, an order based on principles which are eternal, unchanging, and all-encompassing" (cf., the above quote from Miksa, 1998).

The classical opposition to rationalism is empiricism. When electronic databases were new, long lists of terms were extracted in order to serve as descriptors in thesauri. Such empirical material is in itself confusing (as the classic rationalist argues against the empiricist). By ordering the material in logical categories it becomes much easier to evaluate the empirical material, e.g. to orient oneself and to evaluate the term base, for example by finding missing terms and aspects. Therefore the rationalist approach and FA has its justification, but our conclusion is that it cannot stand alone: rationalist methods have to be supplemented with empirical, historicist and pragmatic approaches (to be covered by other articles).

There is another important conclusion to draw. Miksa (1998, p. 73) wrote: "Ranganathan vigorously pursued the goal of finding one best subject classification system". Again: although, for example, the BC2 system often recommends alternative citation orders for different purposes, it has never been outlined how to design and evaluate classification for different purposes. It is also the case that different views have much wider implications than just alternative orderings of sets of preestablished classes. In mainstream KO it has always been a tendency to standardize classifications rather than to construct systems that are optimized to certain collections, users or points of view.

Finally, we may ask: Does the value of a classification system depend on the value of its intellectual foundation? Francis Miksa writes:

> "I for one am also tempted to conclude that Ranganathan's faceted universe of subjects has been adopted as much for what appears to be some sort of intuitive correctness as for any other reason, but a claim of this sort is little more than unsupported speculation. Still, one cannot easily miss how nicely his formulation of the facet idea seems to fit certain subject areas, and this may be reason enough to adopt it as a standard approach, regardless of whether it has any sound scientific basis or whether it always serves well" (Miksa, 1998, p. 75, footnote 35).

[20] It should be said, however, that Vickery (1959, p. 23) recognizes the need of literary warrant when he wrote: "our grouping of terms in a newly approached field cannot b carried out a *priori*. New associations are continually being discovered and recorded in the literature, and we cannot too rigidly lay down in advance what *kinds* of term – i.e. what categories – will be associated. So, in order to formulate categories, out first step must be a concrete examination of the literature of the given subject. Classification must be based – as far as its raw material is concerned – on literary warrant" (italics in original). Vickery does not say how to identify categories in the literature of a subject. The view of the present author is that this is implied by the scientific theories, and that this perspective is totally absent in the tradition of FC.

Miksa's thought is important. It is somewhat tricky because the aim of scientific theory is to improve action potentials: there should not be a conflict between having a proper scholarly basis on one side and serving its purpose on the other. The question is also whether Ranganathan's formula really fits certain subject areas well? How could we say unless we have something to compare with? In order to do so we need comparative studies of classifications designed from the alternative methodologies such as, for example, bibliometrics, algorithmic approaches or domain analysis.

References

Andersen, H., Barker, P., & Chen, X. (2006). *The cognitive structure of scientific revolutions*. Cambridge: Cambridge University Press.

Broughton, V. (2001). Faceted classification as a basis for knowledge organization in a digital environment: The Bliss Bibliographic Classification as a model for vocabulary management and the creation of multi-dimensional knowledge structures. *The New Review of Hypermedia and Multimedia, 7*(1), 67–102.

Broughton, V. (2007). Meccano, molecules, and the organization of knowledge: The continuing contribution of S.R. Ranganathan. In *(Proceedings) ISKO UK event Ranganathan revisited: Facets for the future*. University College, London, November 5, 2007. <http://www.iskouk.org/presentations/vanda_broughton.pdf> Retrieved 12.05.11.

Büttcher, S., Clarke, C. L. A., & Cormack, G. V. (2010). *Information retrieval. Implementing and evaluating search engines*. Cambridge, MA: The MIT Press.

Classification Research Group (1955). The need for a faceted classification as the basis for all methods of information retrieval. *Library Association Record, 57*(7), 262–268.

Drabenstott, K. M. (2001). Web search strategy development. *Online, 25*(4), 18–27.

Englebretsen, G. (1992). Book review of Parry & Hacker (1991): Aristotelian logic. *Informal Logic, XIV*(1), 75–82.

Farradane, J. E. L. (1950). A scientific theory of classification and indexing. *Journal of Documentation, 6*, 83–99.

Fox, M. J. (2012). Book review of two books by Rick Szostak. *Knowledge Organization, 39*(4), 300–303.

Frické, M. (2011). Faceted classification: Orthogonal facets and graphs of foci? *Knowledge Organization, 38*(6), 491–502.

Frické, M. (2012). *Logic and the organization of information*. New York: Springer.

Fugmann, R. (1993). *Subject analysis and indexing. Theoretical foundation and practical advice*. Frankfurt/Main: Index Verlag.

Goh, D., & Foo, S. (2008). *Social information retrieval systems: Emerging technologies and applications for searching the web effectively*. New York: Information Science Reference.

Göker, A., & Davies, J. (Eds.). (2009). *Information retrieval. Searching in the 21st century*. Chichester, UK: John Wiley & Sons.

Harter, S. P. (1986). *Online information retrieval: Concepts, principles and techniques*. New York: Academic Press, Inc.

Hersh, W. R. (2003). *Information retrieval: A health and biomedical perspective* (2nd ed.). New York: Springer.

Hjørland, B. (1988). Information retrieval in psychology. *Behavioral and Social Sciences Librarian, 6*(3/4), 39–64.

Hjørland, B. (2007). Semantics and knowledge organization. *Annual Review of Information Science and Technology, 41*, 367–405.

Hjørland, Birger (2008). What is knowledge organization (KO)? *Knowledge Organization, 35*(2/3), 86–101.

Hjørland, B. (2011). The periodic table and the philosophy of classification. *Knowledge Organization, 38*(1), 9–21.

Hjørland, B. (in press). User-based and cognitive approaches to knowledge organization: A theoretical analysis of the research literature. *Knowledge Organization*, 40(2013) No. 1, x-xx.

Kekäläinen, J., & Järvelin, K. (1998). The impact of query structure and query expansion on retrieval performance. In W.B. Croft, A. Moffat, C.J. van Rijsbergen, R. Wilkinson, & J. Zobel (Eds.), *Proceedings of the 21th annual international ACM SIGIR conference on research and development in information retrieval* (pp. 130–137). New York: ACM.

Kowalski, G. J., & Maybury, M. T. (2000). *Information storage and retrieval systems. Theory and implementation* (2nd ed.). Dordrecht: Klüver Academic Publishers.

La Barre, K. (2006). *The use of faceted analytico-synthetic theory as revealed in the practice of website construction and design*. Unpublished doctoral dissertation. Indiana University, Bloomington.

La Barre, K. (2010). Facet analysis. *Annual Review of Information Science and Technology, 44*, 243–284.

Lancaster, F. W., Zeter, M. J., & Metzler, L. (1992). Ranganathan's influence examined bibliometrically. *Libri, 42*(3), 268–281.

Manning, C. D., Raghavan, P., & Schütze, H. (2008). *An introduction to information retrieval*. Cambridge: Cambridge University Press.

Mazzocchi, F. (2011). Kinds, classification and realism. *Knowledge Organization, 38*(5), 398–404.

Miksa, F. L. (1998). *The DDC, the universe of knowledge, and the post-modern library*. Albany, NY: Forest Press.

Mill, J. S. (1872). *A system of logic, ratiocinative and inductive: Being a connected view of the principles of evidence and the methods of scientific investigation*. In two volumes. 8th ed. London: Longmans, Green, Reader, and Dyer (1st ed. 1843). <http://www.archive.org/download/systemoflogicrat00milluoft/systemoflogicrat00milluoft.pdf> Retrieved 23.06.12.

Mills, J. (2004). Faceted classification and logical division in information retrieval. *Library Trends, 52*(3), 541–570.

Mills, J., & Broughton, V. (1977). *Bliss bibliographic classification* (2nd ed.). Introduction and auxiliary schedules. London: Butterworth.

Moss, R. (1964). Categories and relations: Origins of two classification theories. *American Documentation, 15*(4), 296–301.

Parry, W. T., & Hacker, E. A. (1991). *Aristotelian logic*. Albany, NY: State University of New York Press.

Ranganathan, S. R. (1951). *Philosophy of library classification*. Copenhagen: Munksgaard.

Ranganathan, S. R. (1967). Prolegomena to library classification, 2nd ed. 1957, 3rd ed. 1967. London: Asia Publishing House. Digital version. <http://arizona.openrepository.com/arizona/handle/10150/106370>.

Salton, G. (1996). Letter to the editor. A new horizon for information science. Journal of the American Journal for Information Science, 47(4), 333.

Sayers, W. C. B. (1918). *An introduction to library classification*. London: Grafton and Co.

Schulte-Albert, H. G. (1974). Cyprian Kinner and the idea of a faceted classification. *Libri, 24*(4), 324–337.

Smith, R. (2011). Aristotle's logic. In *Stanford encyclopedia of philosophy*. <http://plato.stanford.edu/entries/aristotle-logic/> Retrieved 25.09.12.

Soergel, D. (1985). *Organizing information: Principles of data base and retrieval systems*. San Diego, CA: Academic Press Professional.

Spang-Hanssen, H. (1974). Kunnskapsorganisasjon, informasjonsgjenfinning, automatisering og språk. In *Kunnskapsorganisasjon og informasjonsgjenfinning* (pp. 11–61). Oslo: Riksbibliotektjenesten.

Spiteri, L. (1998). A simplified model for facet analysis: Ranganathan 101. *Canadian Journal of Information and Library Science – Revue Canadienne des Sciences de l'Information et de Bibliotheconomie* 23(1–2), 1–30. <http://iainstitute.org/en/learn/research/a_simplified_model_for_facet_analysis.php> Retrieved 23.06.12.

Stevens, P. F. (1998). Linnaeus, Carl von (1707–78). In *Routledge encyclopedia of philosophy*, Version 1.0. London: Routledge.

Szostak, R. (2011). Complex concepts into basic concepts. *Journal of the American Society for Information Science and Technology, 62*(11), 2247–2265.

Tang, M.-C. (2007). Browsing and searching in a faceted information space: A naturalistic study of PubMed users' interaction with a display tool. *Journal of the American Society for Information Science and Technology, 58*(13), 1998–2006.

Tunkelang, D. (2009). *Faceted Search*. San Rafael, CA: Morgan and Claypool Publishers (Synthesis Lectures on Information Concepts, Retrieval, and Services).

Vakkari, P., Jones, S., MacFarlane, A., & Sormunen, E. (2004). Query exhaustivity, relevance feedback and search success in automatic and interactive query expansion. *Journal of Documentation, 60*(2), 109–127.

Van Dijck, P. (2003). Xml.com: Introduction to XFML. <http://www.xml.com/lpt/a/2003/01/22/xfml.html> Retrieved 23.06.12.

Vickery, B. C. (1959). *Classification and indexing in science* (2nd ed.). London: Butterworths Scientific Publications.

Vickery, B. C. (1960). *Faceted classification: A guide to the construction and use of special schemes*. London: ASLIB.

Vickery, B. C. (1966). *Faceted classification schemes*. New Brunswick, NJ: Graduate School of Library Science at Rutgers University (Rutgers series on systems for the intellectual organization of information, edited by S. Artandi, Vol. 5).
Warburton, B., & Cleverdon, C. (1961). *Report on the first stage of a test on the library catalogue of the English Electric Co. Ltd*. Whetstone. Cranfield, England: College of Aeronautics.
Wardy, Robert (1998). Categories. Routledge encyclopedia of philosophy, Version 1.0. London: Routledge.
White, H. D., & McCain, K. W. (1998). Visualizing a discipline. An author co-citation analysis of information science, 1972–1995. *Journal of the American Society for Information Science, 49*(4), 327–355.