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Classification Theory, Yesterday and Today[1]

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Until very recently, classification theory was held to be nothing but an expressed or unconscious knowledge framed in intuitively given reasons for the subdivision and arrangement of any universe. Today, after clarification of the elements of classification systems as well as of the basis of concept relationships it is possible to apply a number of principles in the evaluation of existing systems as well as in the construction of new ones and by this achieving relatively predictable and repeatable results. (Author)

1. A short history of classification theory

The old art of classifying, as old as mankind, has only recently acquired an adequate theoretical basis – a basis permitting us to assume that it has advanced from the status of an art to that of a science. While still only an art, classification was applied in many ways, shapes and forms as our knowledge developed. It has left its traces in all of the systematic arrangements that have gone into the composition of the works of great philosophers starting with the Indic Vedas, the Bible, the encyclopedic collections of all things known at a given point in time, as e. g. the encyclopedia of the Egyptian *Amenope* (1250 B. C.), of *Gaius Plinius Secundus* (23–79 A. D.), as well as in the great encyclopedias of the middle ages, e. g. those by *Isidor of Sevilla, Vincence of Beauvais, Bartholomaeus Anglicus, Brunetto Latini* and in the ones of the Renaissance e. g. the encyclopedias of *Georg Valla, Raphael Maffei, Johann Heinrich Alsted, Wolfgang Ratke.* All of these works were arranged systematically i. e. the knowledge they presented was ordered according to some preconceived idea. The last encyclopedia in this development was the one of *Diderot* and *d'Alembert* (1751–1780), which, however, was presented not only in a systematic but also – as a new approach – in an alphabetic arrangement. (For a detailed history see (1).)

In the early times, the systematization of knowledge was not accomplished in the schematic manner in which we know it today. Until 1491 it was not customary to elaborate systems for the classification of the sciences as an end in itself. It probably was only after 1491, when the Italian humanist and poet, *Angelo Poliziano* published his "Panepistemon" – a scheme that was not meant to be the outline of a text but rather to show schematically the relationships between the sciences or fields of knowledge – that this "movement" of designing classification systems actually got under way. After him, numerous others tried their hand at the same thing, none of them better known than *Francis Bacon,* who about 100 years later, in 1605 to be exact, published a pertinent scheme in his work "De dignitate et augmentis scientiarum". However, this art of designing schemes was not called "classification" until almost 200 years later, towards the end of the eighteenth century. From this time on only, we have evidence, especially through the bibliographies of *C. W. Shields,* (2), *R. Flint* (3), and *E. C. Richardson* (4), that the term "classification" was used in titles of books (5, p. 17) concerned with the presentation of a scheme for the classification of the sciences and of books. Especially in the 19th century the construction of such schemes became a hobby for each philosopher, as well as for some scientists, e. g. for the physicist *A.-M. Ampère* (6), and even for a statesman, as *Th. G. Mazaryk,* the later Czechoslovakian President (1886). The inspiration derived from these works of philosophers influenced librarians too, to design ever new systems for the systematization of the contents of their book collections.

This art of designing systems with some intuitive idea about divisions, priorities in arrangement, first hierarchies and subordinations and finally also "auxiliaries" was held to be *the classification theory* until fairly recent times; we still find it reflected also in the great work of the late *E. I. Šamurin,* the Russian librarian and historian of classification, who spent 20 years of his life in collecting, describing and interpreting most of the classification systems of universal character the world had known until then (1).

2. First steps toward a new approach

It was actually already in the 16th century that an Italian philosopher, *Mario Nizolio* (1498–1556) expressed his irritation at the fact that some sciences may be found under several aspects if displayed in an overall scheme of the sciences. In his 1533 treatise "Antibarbarus philosophicus" containing his own classification suggestion for knowledge fields, he would not list any sciences at all that may occur in several divisions, such as the ones we still find in the scheme of *J. Huarte* (1575), who distinguishes between "Theoretical Medicine" and "Practical Medicine", "Positive Theology" and "Scholastic Theology", "Theoretical Law" and "Practical Law", with each of these disciplines being found in a different division. However, all of 300 years had to pass before a theoretical investigation of the phenomenon was attempted by *Ampère.* In the Foreword to his classification of 1834–1843 he wrote:

> "For some time I have already been aware that, in trying to determine the distinguishing characteristics for the definition and classification of the sciences it is necessary to consider not only the nature of the objects to which they are related but also the points of view under which these objects may be seen. . ." (6, p. VII).

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The special viewpionts under which a certain area of object-related knowledge may be seen were therefore given special positions in the subdivisions of his scheme. In a similar way *I. G. de Saint-Hilaire* (1805–1861), as well as others later on, tried to display the diversity of the aspects diagrammatically as a "classification parallélique" (see 1, II, p. 73–76). The first librarian to consider this fact in the discussion of the theory underlying his scheme was *Henry Evelyn Bliss* (1870–1955). After a first publication of his ideas in 1910 he concerned himself with the philosophical background of classification and wrote his two famous books: "The organization of knowledge and the system of the sciences" (7) and "The organization of knowledge in libraries" (8). In a third volume he tried to combine the philosophical knowledge about classification with the demand of shelving books in a library. Although in his resulting classification system, first published in 1935 and revised and enlarged in 1940–1953, the different aspects for each area were also shown diagrammatically (according to the philosophy, science, history and technology/art points of view), he generally rearranged the two-dimensionally displayed fields mostly on one hierarchical level only, this for the sake of brevity of notation and of the resultant easier shelving of books.

His real contribution to classification theory consisted in the fact of having put library classification again into closer contact with the philosophical principles of classification, e. g. with the conceptual foundations of class formation, division and partition. It is also fair to state, however, that Bliss did not himself discover and formulate a great number of new concepts in classification theory. Looking back from our present-day vantage point we must even state that the real, visible contribution Bliss made with his three aforementioned books, was the most fruitful inspiration he gave to the Indian classificationist Ranganathan.

3. Ranganathan, father of modern classification theory

In his "Prolegomena to library classification" of 1937 (10) *S. R. Ranganathan* (1892–1972) describes this situation most vividly. Once he could not find sleep in the night; a friend advised him to read something for distraction. Ranganathan had the three Bliss volumes on his desk and hitherto had not found the time to look into them. So he followed the advice of the friend. But instead of finding sleep he could not stop reading until he had finished all of them. He was fascinated by the idea of writing a theoretical background for a classification system, and he was motivated at the same time to write down such a theory of his own, the theory of the Colon Classification as presented in his famous "Prolegomena...". This happend four years after the publication of the first edition of the CC, then developed on intuitive grounds only. Now, he formulated rules, and stated canons and postulates, from which he derived his principles and introduced his so-called "devices" for the formation of conceptual representations on the theoretical level.

Before becoming a librarian, Ranganathan specialized in mathematics, a subject he even taught at Madras University. Through his theoretical approach Ranganathan can perhaps be said to have mathematized classification. But he did not apply mathematics in a quantitative or statistical way. His mathematical approach was very similar to the one already aimed at by the great German philosopher *G. W. Leibniz* (1646–1716), who not only laid the foundation of both integral and differential calculus (1675) but who also had been looking all his life for a new kind of mathematics, a "qualitative" one, as he termed it. Ever since his dissertation "De arte combinatoria" (1666) Leibniz had been searching for a "characteristica universalis", a kind of concept language for the combinatory expression of any concept and subject existing in this world (12), (13), thus eventually also influencing *G. Frege's* predicate logic and "Begriffsschrift" (14) as well as most of modern logic today.

Possibly it is in the way in which Ranganathan tried to analyze subjects into their constituent elements and to subsequently formulate and formalize through his "facet formulas" the statements about subjects found in books and other kinds of documents that we find this new kind of qualitative mathematics expressed that Leibniz had been looking for. It consists in the rules for the "devices" which he introduced as general representatives of the notational elements that would have to replace the concepts of the subjects in question.

Ranganathan's approach to classification was thus entirely different from all previous ones. Although an analytical and combinatorial approach to classification may already be perceived in the systems of Dewey (especially through the generating of the UDC by *P. Otlet* and *H. LaFontaine*), of *C. A. Cutter* (1837–1903), *J. D. Brown* (1862–1914) and *H. E. Bliss*, Ranganathans system differed from the others above all in that he did not work with preestablished, ready-made classes to which titles had to be related but rather created the classes of books only at the moment at which a book was analyzed according to the conceptual elements of its subject and synthesized according to the rules of his discipline-bound facet formulas. But this also means that the number of classes generated by this system may equal the number of books in the library concerned if its holdings are diversified enough since two books can only then be said to belong to one and the same class if they yield the same synthesis.

Among all of Ranganathan's many new ideas and the multitude of new classification concepts created by him (and often most picturesquely expressed), what three things can be regarded as his major contributions to modern classification theory?

First of all he introduced the three distinct levels on which classificationists (=designers of classification systems) and "classifyers" work. These levels are

- the so -called 'idea plane', the level of ideas, concepts
- the 'verbal plane', the level of the verbal expressions of concepts (which may be varying with the language employed)
- the 'notational plane', the level of the fixation of concepts in abstract forms, such as signs (letters, numbers)

This three-level-distinction helped considerably to clarify what may be regarded as the object of the science of classification: it is the single concept and its combinability to represent the knowledge of man about the objects of his world that – ever since Ranganathan's new approach to classification – may be regarded as the characteristic

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element of classification systems. It presupposes the availability of natural language expressions for its description (verbal plane) and uses notations for its representation in a semiotic form.

Ranganathan's second contribution to modern classification theory is his *analytic-synthetic-approach* to the identification of subjects. This implies that every classing of a document requires an analysis of its title or a descriptive statement about its content in terms of the concepts forming the components of the science to which the document belongs. After this analysis and subsequent ordering of these elements into the socalled facets (which are representatives of kinds of concepts in special fields of knowledge), he was able to synthesize the elements of these facets into combinative expressions forming the analytico-synthetically constructed class of a given topic of a document. All of this had to be accomplished according to the facet-formulas mentioned above with their generalized formula, the sequence of PMEST (Personality, Matter, Energy, Space and Time). These served
a) for the representation of subjects and
b) for the ordering of the concepts of a given discipline into formal classes according to the categories occurring in that discipline.

His third major contribution may be seen in the formulation of his *18 principles for arrangement* of elements of facets in a repeatable manner, his 'arrangement rules' or 'principles for helpful sequence'. These latter very clearly outlined principles may also be regarded as one helpful tool for the evaluation of classification systems.

4. Ranganathan's influence

A fair assessment of Ranganathan's influence would have to consider much more of his work than just the contributions mentioned above, not to forget his Colon Classification (11) itself, which may be regarded today as a model for a new universal faceted classification system.

After World War II his system and the Prolegomena became more widely known in the West, particularly in England, where as of the late fifties the design of faceted classification systems for special fields of knowledge has become very common.

When in the early sixties thesaurus development started to take shape, the English contribution to the modelling of thesauri resulted in Thesaurofacet (15).

These faceted classification systems were constructed with and without facet formulas, citation formulas. In general, this contribution of Ranganathan was regarded as too inflexible a limit for the expression of subjects. *B. C. Vickery's* proposal (16) for a standard citation order allowed more flexibility and at the same time more generality. It contains the following elements:

Thing/Part/Property/Process/Operation/Agent

The discussion about these problems still has not come to an end. The questions connected with an orderly syntactical display of phrases for the expression of subject contents of documents went also in to *D. Austin's* free-language-indexing system, called PRECIS. He uses a number of Role Operators (17, p. 92) for the identification of syntactical elements of his phrases and their representation in the subject index of the British National Bibliography as well as in all the other information services which have already adopted his system.

5. Research in concept relationships

As soon as one began to consider classificatory structures from an analytical point of view – as made possible by the conscious construction of facets on the basis of concept categories – one also realized the necessity of a clarification of categorial elements in classification systems. One study must be mentioned here above all as the fundamental text for further research: *E. de Grolier's* book "A study of general categories applicable to classification and coding in documentation", Paris 1960/62 (18). It contains a detailed collection and presentation of all the general categories of the major universal classification systems as well as some special ones, either as represented in the auxiliaries or in the main classes. He also listed all the proposals for syntactical elements which had been made in recent schemes as well as kinds of representatives of categories found in natural language.

About the time of this study by de Grolier in France another Frenchman, *J. C. Gardin* and his group were working on the construction of SYNTOL, the socalled Syntagmatic Organisation Language which was to allow syntactical indexing with the help of a computer (19).

In England, *J. Farradane* had developed already in 1950 his scheme of nine operators which were to serve as relationship indicators for the expression of his socalled "analets" (two or more concepts combined together by an operator to express a more informative statement about the contents of a document than just by a single term or by unrelated terms) (20).

In the United States, especially in the former Center for Documentation and Communication Research (CDCR) in Cleveland, research in the application of rôle indicators in the WRU-system for the indexing of metallurgical literature was undertaken, and pertinent devices were developed which later on influenced also the system of links and roles propagated by the Engineers Joint Council (EJC) (21).

And again in the United States, a philosophical scheme of about 108 relators was developed by *J. M. Perreault* and published in 1965 (22). These relators were meant to serve as syntactic elements together with the elements of any classification system.

The crowning of all this development was a conference on relational factors in classification, organized by *J. M. Perreault* in Maryland, June 1966, with contributions from all the aforementioned authors, including Ranganathan (23). On this occasion, an encyclopedic study and correlation of all kinds of relationships indications was presented in a paper by *D. Soergel* (24). But no solution to the problems of conceptual relationships was found at this conference. As de Grolier stated: "We still need further research" (23, p. 396).

At most centers further research was stopped in this field, chiefly on account of the fact that computer processing of literature was becoming less expensive and faster every year and many started to believe in automatic indexing. Also, some studies, especially those by *Sinnett* (25), *Montague* (26) and *Lancaster* (27), seemed to prove that the

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use of syntactic devices was not very helpful in coordinate indexing.

However, with the masses of documented literature still growing, there is today a noticeable and increasing dissatisfaction with the poor kind of information which many large data bases are furnishing. On the basis of which theory would better retrieval results become feasible?

Thanks to the construction of documentation thesauri and the conscious determination of relationships of concepts, as well as to some new research in analytical concept theory (28), (29), we can perhaps claim to have arrived by now at a better understanding of the nature of concepts. This concept theory implies that concepts are the labelled syntheses of true statements made on objects of thought, with the statements – the predications – leading to the recognition or separation of the characteristics of concepts which may also be regarded as the elements of concepts. Relationships between concepts can thus be stated by the common possession of certain characteristics in different concepts. The well-known kinds of relationships, such as e. g. the
genus-species relation
partition relation (whole/part relation)
opposition relation
functional relation
may now be explained (that is, with the help of this theory) on account of the elements of concepts, their set of intensional characteristics. Also, the categories to which concepts belong may be determined by the very last predication possible about a given object of thought. Thus, according to the ultimate form categories of their characteristics one may distinguish between the following kinds of concepts:
– object-related concepts
– phenomenon-related concepts
– process-related concepts
– property-related concepts
– relation-related concepts
– dimension-related concepts
as well as combinations of these among each other. With these categories the intellectual tool for the organisation of concepts in a general systematization of knowledge elements as well as in any of its given subject-fields is available.

With this analytical concept theory it is also possible to explain the socalled "paradigmatic" and "syntagmatic" relationships in classification, which were introduced by *J. C. Gardin* in analogy to the understanding of these terms in modern lingusitics (30). The paradigmatic relationships were understood as those existing in classification systems, the syntagmatic ones as those occuring in the phrases composed of elements of classifications systems for the description of contents of documents.

Both of these kinds of relationships may now be understood as depending on kinds of concepts and their special kinds of relationships; the paradigmatic one occurring with concepts in genus-species, whole-part and opposition relation, the syntagmatic one occuring with concepts in functional relation.

Both kinds of relationships may occur in classification systems as well as in free or faceted kinds of classificatory phrases, they are not restricted to either one of them, a fact already noted by *D. Soergel* (31). In the following we shall give some examples of the kinds of relationships mentioned:

1) genus-species relationships:

objects	*kinds of objects*	*kinds of kinds of objects*
trees	fruit trees	apple trees, pear trees
	nut trees	walnut trees, hazelnut trees

2) whole-part relationship:

whole	*parts*
tree	roots, stem, branches, leaves etc.

3) opposition relationship:
height – depth, numeric – non-numeric,

4) functional relationship:
donation – gift – wedding
typing – paper – conference

One may easily see that these kinds of relationships have majority occurrences with special kinds of concepts, thus the *genus-species relation* usually occurs with concepts denoting objects or abstractions, although it occurs also with concepts denoting processes and properties; the *partition relation* also occurs mostly with objects, since these may be separated into their parts. Of course this relationships is also applicable in such cases as e. g. the partition of a field of knowledge into its component facets; the *opposition relation* may be detected mostly with concepts denoting properties, and the *functional relation* mostly with concepts denoting actions or processes and their necessary or facultative complements.

This latter fact, however, is also the reason why this relationship occurs more often in the syntagmatic arrangement of concepts in a phrase than in the hierarchies of the paradigmatic arrangement of a classification system. The number of complements in a given phrase, expressing the functional relation might be extended to comprise any further information necessary or possible, e. g. about special conditions, about the purpose of an action, about the reason for something, the agent, about the place and the time. Usually the necessary amount of such complements is determined by the valence of a special verb in the predication of a phrase, a statement, a subject; the facultative amount depends on the given circumstances which may be mentioned to give the information in question some more concreteness. It is therefore also possible to construct the formula for a citation order on other new grounds: it is no longer necessary anymore to demand that such a formula should start with the more concrete concept and end with the more general one, as e. g. by beginning with the objects/things and by putting "time" as the "most general concept" at the end. The concepts as they are represented consecutively in a statement about a subject of concern rather follow the pattern that is given by the structure of a passive-voice sentence with the object in the first position, the predicate in the following and the possible complements in the positions thereafter. With the indications of space and time thus in the very last positions of a statement the utmost possible concreteness and individuality of a statement or an information may be attained. Usually the overall amount of the complements of verbs is limited

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a) to the "natural" valence of the verb in the predicate in question ("the functionality" of the characteristics of its concept)
b) to the required manner of forming and extending statements to comprise the necessary details of information in a given case.

6. Necessary consequences of the concept theory outlined

On the basis of the research described above we are today in the position to apply the principles of concept organisation in varying ways in the recognition, construction and use of classification systems. To sum this up briefly we may thus say that *classification theory today* is understood to comprise

1) the recognition of the concept as the material element of classification systems
2) the application of an analytical concept theory for the explanation of concept relationships as structural elements of classification systems
3) the use of concept-based statement structures for the representation of knowledge or information

and we may at least see three consequences following from this new theoretical approach to classification, since we may use it

1) for the evaluation of existing classification systems,
2) for the construction of new systems with predictable groupings and arrangements,
3) for the formalization of statements about the contents of documents.

Such statements may also be searched consistently either manually or by computer on the basis of predeterminable sentence structures.

With the help of the theory of kinds of concepts (categories of concepts) classification systems can be elaborated in a much more objective way than ever before. There had been two approaches so far for the construction of classification systems, 1) the *deductive approach* (subdivision of a universe of knowledge into disciplines – the total approach – the approach of the general classification systems known so far) and 2) the *inductive approach* (building up systems of descriptor languages from terms and their possible broader and narrower terms/concepts – the elemental approach – the approach of the thesauri); both kinds are highly open to subjectivisms, since the way of subdividing a universe as well as the determination of broader, narrower and related terms are very much dependent on a persons knowledge and the varying purposes of an information system. A third approach, however, the *relational approach* starts from a formal aspect, from a categorial one. It is easy to construct, easy to recognize and easy to use for everybody. It is also repeatably structured and may thus be accepted much more readily. As a result this approach guarantees more objectivity than any other one (32).

7. Future research and development in classification

The actual existence of a classification theory today which is able to explain a number of previously unknown or only intuitively known factors does not mean that we are now in a position in which there is no need for any further research in classification. The opposite is true: we have now acquired the instruments which enable us to evaluate existing classification systems, to state what exactly has been wrong or right, and to recognize how classification systems could be improved.

I went through a very encouraging experience recently when, at the end of the course on classification theory held at the Brazilian Institute of Information in Science and Technology (IBICT), Rio de Janeiro, I could examine the results of the term papers. The assignment had been to make a comparative analysis of existing universal classification systems (DDC, UDC, LCC, BC, CC) in one field of knowledge (28 different fields had been investigated) (33). The analysis was to be both quantitative, regarding numbers of classes on different levels of abstraction and the location of their terms in the different systems, and qualitative, regarding the kinds of relationships found as well as the kinds of arrangement rules applied. After this analysis each student was to propose a new faceted classification for the field in question with a citation order for the sequencing of the elements of a classificatory statement (the classate). The proposed systems were – in part – worked out excellently. It may thus be assumed that with the application of the principles established and with the help of trained subject specialists it will be possible to elaborate new classification systems that will not only be more flexible, and thus rendering better service in the expression of new knowledge but also be more readily acceptable to the professional world.

New research should now be directed towards

1) analyses of concepts, especially of concept combinations
2) analyses of verb valencies in different languages and in different subject-fields, leading to the establishment of formulas for filing and citation order
3) typology of classificatory sentence structures
4) concept comparisons with the help of definitions including problems of definition structure and structuring
5) methodology for the establishment of concept correlation tables in different subject-fields; structure of intermediate lexica
6) finding forms of notations for varying fields of application ("the best system can be spoiled by a bad notation")
7) determining notational syntactic structures for the formation of expressive concept representations together with their necessary and facultative complements
8) identifying organizational and user problems in the application of classificatory elements and statements; which cases need a broader, which a more refined and which the finest possible access?

In addition to further efforts in classification research, a new general awareness of the possibilities of classification should be developed, above all for the sake of intellectual as well as of material economy. It has been stated recently as a result of research in molecular biology that the programming capacity of a complete chromosome set is not so large that every single one of the many billions of somatic cells could be pre-programmed in the genom of a germ cell, which means that cells must be generated out of each other on the basis of a hier-

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archical structure principle (34). If nature itself thus seems to use hierarchical facilities for its processes, why should these principles then be abandoned in our macroscopic world of knowledge structures? Why do many information systems still continue to use undefined and unrelated index terms for subject analysis? Should we really waste our time and capacities with such inferior tools only because of the inadequacy of the existing old classification systems? For the sake of – and thus honouring today and at this conference – the contributions to mankind by Melvil Dewey whose system has helped on a world-wide basis to improve access to knowledge, let us now strive toward a better understanding and application of the principles of classification.

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Please note that the index to volumes 1–3 of International Classification is added to this number: pp. 131–134 of this issue.

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