

# Ranganathan and the faceted classification theory<sup>1</sup>

## *Ranganathan e a teoria da classificação facetada*

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### Abstract

The present study contextualizes Ranganathan's main theoretical contributions to the classification theory and addresses the Five Laws of Library Science. The major milestones in philosophical and bibliographic classifications are presented to show that the classification system has evolved from purely philosophical schemes, which were focused on the systematization of knowledge, into modern bibliographic classification systems. Facet analysis is considered a contribution to the classification process since it allows the use of an approach that encompasses different points of view of the same subject, as opposed to the enumerative systems. This article also discusses Ranganathan's five fundamental categories, known as Personality, Matter, Energy, Space and Time, and points out to criticism of this form of categorization in the literature. The Spiral of Scientific Method and the Spiral Model of Development of subjects are presented; the latter is the meta-model of the former. The Colon Classification, which was first published in 1933, was also discussed. Finally, the applicability of the faceted classification in today's world was addressed.

**Keywords:** Classification. Faceted classification theory. Ranganathan.

### Resumo

*Este artigo contextualiza as principais contribuições de Ranganathan para a teoria da classificação e aborda as Cinco Leis da Biblioteconomia. São apresentados os principais marcos históricos das classificações filosóficas e bibliográficas, de modo a evidenciar que estas evoluíram de esquemas puramente filosóficos, voltados à sistematização do conhecimento, para os modernos sistemas de classificação bibliográficos. A análise facetada é identificada como uma contribuição ao processo classificatório, por permitir uma abordagem que abarca diversos pontos de vista de um mesmo assunto, em contraposição aos sistemas enumerativos. O artigo também situa as cinco categorias fundamentais de Ranganathan, conhecidas como Personalidade, Matéria, Energia, Espaço e Tempo, e aponta as críticas a essa forma de categorização presentes na literatura. São apresentadas a Espiral do Universo do Conhecimento e a Espiral do Desenvolvimento de Assuntos, esta última entendida como metaespiral da primeira, bem como se destaca a Classificação de Dois Pontos (Colon Classification), publicada pela primeira vez em 1933. Ao final, são tecidas considerações acerca da aplicabilidade da classificação facetada na contemporaneidade.*

**Palavras-chave:** Classificação. Teoria da classificação facetada. Ranganathan.

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## Introduction

For a better understanding of the world, individuals organize the information they receive throughout their lives creating representations and making associations between the information gained. The term information representation can be understood as a 'sign relation' since the purpose of the sign is to represent something. In Peircean's conception, to represent also means to substitute, "to stand for, that is, to be in such a relation to another that for certain purposes it is treated by some mind as if it were that other" (KOBASHI; FERNANDES, 2009, p.2). Thus, depending on the context and the desired purpose, a building can be represented by an image, an architectural drawing, or a model, for example.

In the context of Library and Information Science, information representation presupposes a cognitive process that encompasses the stages of perception, identification, interpretation, reflection, and codification of information (ALVARENGA, 2003). These technical processes of representation are generally used to facilitate finding the accurate location of information in a given collection using different types of instruments of representation. Such instruments can be: verbal - such as thesauri, lists of subject headings, ontologies, and taxonomies - and symbolic - such as bibliographic classification systems. The present study is focused on symbolic systems of knowledge representation, in other words, bibliographic classification systems, especially in terms of the contributions of the Faceted Classification Theory.

People classify phenomena, situations, and objects all the time in order to better understand them. Classification is, therefore, an inherent element of human nature. The term classification was coined by Zedler in 1733 in his Universal Lexicon Encyclopedia; it is the combination of the Latin words *classis* (class) and *facere* (make). This term is based on the word *class*, which was used to designate an army or group of persons called to the arms, or, according to Piedade (1977), the term designates the groups into which the Roman people were divided.

The act of classifying is a mental process by

which things, beings, or thoughts are grouped together according to their similarities or differences (BARBOSA, 1969). Similarly, according to Piedade (1977), classifying means to divide into groups or classes according to differences and similarities; to arrange concepts according to their similarities and differences in a certain number of methodically distributed groups. This is also the meaning attributed to the term by Vickery (1980). Accordingly, the classification process is the action by which the subjects of documents are classified aiming at arranging them in logical order, grouping together the items of information concerning similar subjects.

It is important to distinguish the concept of classification as a process, which was discussed above, from the classification as product, which refers to the instruments of classification, *i.e.*, the systems used in the classification process. Langridge cited by Piedade (1977), one of the members of the Classification Research Group - group was formed in England in 1948 and in 1955 it had 14 members: D. J. Campell, E. J. Coates, J. E. L. Farradane, D. J. Foskett, G. Jones, J. Mills, T. S. Morgan, B. I. Palmer, O. W. Pendleton, L. G. M. Roberts, B. C. Vickery, A. J. Walford, K. E. Watkins e A. J. Wells. Much of their research was based on the Ranganathan's faceted classification theory, which was debated and modified by them (LIMA, 2004b), argued that a classification system and/or a classification table is a map of a certain area of knowledge. Accordingly, the creation of bibliographic classification systems is based on the classification theory, whose principles are related to the organization of objects (subjects) in groups according to their similarities and differences, based on a set of criteria.

The theorist Shiyali Ramamrita Ranganathan [1892-1972] greatly contributed to classification systems. His studies are another milestone in his contributions, and he is considered the father of library science of the twentieth century. Ranganathan highlighted the importance of libraries for education in India. In 1928, he formulated the Five Laws of Library Science and developed his own decimal classification system. The system proposed by him was based on the division of knowledge into multidimensional and/or faceted aspects.

## Life and work of Ranganathan

Ranganathan, Indian librarian, philosopher, and mathematician, was born on August 9, 1892, in Shiyali, Tanjavoor District, Madras State, when India was still under British rule. He earned B.A. and M.A. degrees in mathematics from Madras Christian College. Although he did not have any formal training in librarianship, he was appointed to the position of Madras University Librarian and took up the job in 1924. The following year he traveled to London to study at School of Librarianship of University College under the supervision of W.C. Berwick Sayers. After his return to India, he worked in the field of library science as a professor for forty years. He wrote more than fifty books on library science and articles and books about mathematics, mainly related to the history of mathematics. He died at the age of 80, on September 27, 1972, in Bangalore, India (VICENTINI, 1972).

Ranganathan's family belonged to the Brahmin caste, traditional Hindu hereditary system of social stratification in India. The Brahmin caste is considered the highest in Indian society since its members are believed to have come from Brahma's head, and Brahma is often credited as the creator of the universe. He lost his father very early, at the age of six, and was raised by his grandfather, who was a Brahmin and a school teacher and who taught him the values of Hinduism. Ranganathan married Sarana in 1928 and had only one child. He was very religious and highly, political, and he admired Gandhi (SEPÚLVEDA, 1996).

According to Sepúlveda (1996), Ranganathan's education was strongly influenced by the Eastern culture and the holistic vision of the universe. The Brahmin and Chinese cultures, as well as astrology had leading presence in his life. In Brahman culture, meditation is taught to young people at an early age, and it is considered an activity to purify the mind, leading to concentration and knowledge. Other important values of the Brahmin culture are discipline, religiosity, rigor, and work. The British culture also influenced Ranganathan since at that time India was under under British rule.

Srivastava (1992) compares Ranganathan to a pattern maker, a person possessed of rare combination

of talents and who reaches high standard in several different directions transcending limitations of space and time limitations of space and time. Therefore, Ranganathan is among the most influential theorists such as Dewey, Panini, Aristotle, Newton, Hegel, and Darwin, among others.

He was dissatisfied with the existing bibliographic classification systems when he worked as librarian because they were marked by hierarchical rigidity. Thus, he suggested the creation of a more flexible system, known as Colon Classification, which was first published in 1933. This classification system treats knowledge as a multidimensional structure: the interconnections of each concept are spread in many directions, and each subject is usually a synthesis of several multiple connected concepts, thus adopting an analytico-synthetic approach (NAVES, 2006). The division of knowledge is understood based on the study of its facets and subfacets, which means the representation of the same subject from various points of view.

Ranganathan authored more than fifty books and published a large number of articles in periodicals and in conference proceedings. His works cover subjects that include various fields of Library Science, such as classification, cataloging, reference service, library organization, book selection, library administration, and documentation, a field of study similar to librarianship.

The Five Laws of Library Science is a theory that deserves special attention in the field of Librarianship: (1) the books are for use; (2) every reader his/her book; (3) every book its reader; (4) save the time of the reader; (5) the library is a growing organism.

These laws appear to be simple or even naive, but they have a deep meaning and content since they propose a comprehensive philosophy for Librarianship and are considered as fundamental statements for the goals that information services should seek to achieve (NAVES, 2006, p.43).

The first edition of Ranganathan's five laws was published in 1931 and was an attempt to develop scientific guidelines for libraries whose practices were essentially empirical. These laws establish the principles that information units must follow. Garfield,

the founder of the Institute of Scientific Information of Philadelphia (ISI), cited by Figueiredo (1992), emphasized the importance of the five laws for India in the 1930s:

Today these laws seem self-evident, but they certainly were not when they were enunciated. Particularly in India, he explains, a colony during Ranganathan's days, libraries were hardly among the most progressive, and there was no public library system as such; libraries were usually associated only with universities and other academic institutions. With the laws, in fact, Ranganathan provided India and other developing countries with openness to the democratic library tradition, which was then a privilege of the United States and England after the late nineteenth century (FIGUEIREDO, 1992, p.187).

Focusing on the user and information, the Indians Rajagopalan and Rajan updated the five laws: (1) information is for use; (2) every user his/her information; (3) every piece of information his/her user; (4) save the time of the user (5) an information system is a growing organism (FIGUEIREDO, 1992). With these new statements, Ranganathan's laws were broadened and inserted into larger contexts, consistent with the current reality of modern information retrieval systems.

French researcher Alireza Noruzi, from the Department of Information Science of Paul Cézanne University, has also updated Ranganathan's five laws in order to apply the principles to the web. According to Noruzi (2005), the web is the global hypertext system providing access to documents written in a script called Hypertext Markup Language (HTML) that allows its contents to be interlinked, locally and remotely. The five web laws, updated by Noruzi are: (1) web resources are for use; (2) every user his or her web resource; (3) every web resource its user; (4) save the time of the user; (5) the web is a growing organism. Accordingly, a review of the concepts of library, reader, and book for the web, user, and information, and/or resource can be identified. Thus, Noruzi (2005) updated the principles, but the philosophy behind these concepts continued the same: democratization and easier access to information.

The faceted classification theory developed by Ranganathan is an important contribution to the

classification theory, and it has been presented in several of his works, such as *Prolegomena to Library Classification*; *Philosophy of Library Classification*, and *Colon Classification* (CAMPOS; GOMES, 2003).

## Classification theory

Classification theory has applications in all branches of knowledge, especially the biological and social sciences. Its application to mathematics is called set theory. It is a method and a process for establishing classes in a classification system of elements that share at least one common characteristic and can be organized according to a point of view or specific characteristics. For example, individuals can be grouped according to age, gender, profession, etc.

A classification cannot be permanent, accurate, and comprehensive because every different time and situation requires a specific classification. Every period of time has different characteristics, focus, thoughts, and theories which require their own classification structures. Therefore, the problem in the classification of a field of knowledge, from the Greek Dark ages to contemporary times, is the definition of the principles and postulates into which classes can be grouped to organize and represent the knowledge contained in the documents. Corroborating these ideas, Jacob and Albrechtsen (1998, p.523) argue that:

A classification scheme epitomizes Foucault's notion of a well-constructed language in that it constitutes a whole domain of empiricity as at the same time describable and orderable ordering and describing it'. In a heterogeneous environment, a controlled vocabulary facilitates the exchange of knowledge, neutralizing distortions. [...] any given point in time is characterized by a general model of knowledge, which determines what and how it can be expressed, according to what criteria and premises and what order. Reality exists independently of our effort to know it, and language is the means by which we can describe this reality in a more or less objective manner.

The origin of the art of knowledge classification probably dates back to 1491, with Angelo Poliziano, an Italian humanist and poet, with the publication of "Panepistemon", which showed, in schematic form,

the relationships between the sciences. Before then, classification was just an art, like encyclopedias, for example, which were systematically organized based on some idea as an end in themselves (DAHLBERG, 1979).

In the field of Library and Information Science, the classification theory principles are applied to the organization of knowledge, initially developed for the creation of specific classification systems. These principles are related to the organization of groups of subjects according to their similarities and differences based on a set of characteristics. This is the field of information representation, which refers to the ordering of the classes of subjects in the classification schemes. According to Araújo (2005, p.59):

[...] the essential element that characterizes the classification process is the systematic and methodical formation of groups, the organizing action of ordering a certain set of beings or things into smaller groups according to similar characteristics shared by some of them (which include them in a certain group) and not shared by the others (which do not belong to this group). In this process, a division criterion is established based on processes of differences and similarities, agreements, and validations.

Accordingly, classifying is essentially a mental process of applying divisional characteristics to a certain set of objects (phenomena, situations, information, and things) due to the addition of a characteristic and/or difference. In the practice of classification, the principles used in this division and grouping take into account the nature of what is being classified. Thus, identifying the similarities and differences between objects is an important task in the classification process. For example, plants and animals can be classified according to their genetic characteristics, and water can be classified according to its hardness (water can be soft, moderate soft, hard, or excessively hard, depending on its amount of mineral salts). Therefore, it can be said that the selection of the characteristics that will be used to classify the objects reflects the purpose of the classification being constructed. Piedade (1977) stated that there are as many classifications as there are characteristics that can be used as the basis of division. There are as many possibilities to classify as there are similarities and differences between objects or ideas to

be classified. Thus, classification systems play a key role in the representation, organization, location, retrieval, and access to knowledge and information resources in information retrieval systems.

## Classification systems

Classifications evolved from purely philosophical schemes, with no intention of ordering anything into the modern systems of bibliographic classification used in the organization of libraries and even in digital contexts. Therefore, an overview of the development of classification systems is presented, starting with the philosophical schemes that gave rise to the current classification systems.

## A brief history of classifications

Barbosa (1969) defined philosophical classifications as purely theoretical classifications constituting groupings of human knowledge according to the point of view of its idealizers. A similar definition was provided by Piedade (1977), philosophical classifications are those created by philosophers with the purpose of defining, schematizing, and hierarchizing knowledge.

Among the philosophers who studied classification theory are Aristóteles (384-322 a.C.), Greek philosopher and student of Plato (428-347 a.C.), and Porphyry ([233]-304 d.C.). Plato divided human knowledge into three sciences: physics, ethics, and logic. Since ancient times, Aristotle's studies encompassed science and he divided knowledge into three parts: theoretical, practical, and productive. He believed that every field of knowledge has its own general laws, which control its thinking and procedures that are distributed from the simplest (specific) to the more complex (general) ones (BARBOSA, 1969; PIEDADE, 1977).

Porphyry, who was also a Greek scholar, stood out by proposing a binary or dichotomous classification system with division of classes from general to specific subjects. In the division proposed by him, also known as the "Tree of Porphyry", knowledge is subdivided successively due to the inclusion of a difference and/or a characteristic. At the end, there is a term that cannot

be further divided. This classification system is based on the logical division of genus and species (BARBOSA, 1969; PIEDADE, 1977). In the book *Advancement of Learning*, Francis Bacon [1561-1626], English politician, philosopher, and essayist classified the knowledge or sciences into Memory, Imagination, and Reason based on human faculties. Such division culminated in another one: History, Poetry, and Philosophy.

French philosopher and mathematician, Auguste Comte [1798-1857], proposed the division of human knowledge according to the order of increasing complexity and decreasing generality. He divided the sciences into abstract (fundamental) and concrete (derived). The division proposed by Comte gave rise to seven disciplines, namely: Mathematics, Astronomy, Physics, Chemistry, Biology, Sociology, and Morality.

It is important to emphasize that the continuous effort of the philosophers towards the attempt to systematize knowledge was the basis for the development of bibliographical classifications, which are discussed in the next section.

### **Bibliographic classifications**

It is worth mentioning that the development of new classification systems reflects an effort to improve previously proposed schemes. A fact that can confirm such assertion is that Bibliographical classifications that originated in the classification of human knowledge, initially proposed by Plato.

In the context of Library and Information Science, according to Barbosa (1969), bibliographic classification is understood as the process of arranging books according to their subject, and a pre-established system, allowing them to be stored in a certain order in the collection, *i.e.*, they have a relative location. Thus, bibliographic classification is, in the broad sense of the term, a process of indexation since it aims to gather informational items (from collections, catalogs, and bibliographies) whose contents have similar subjects arranged based on logical principles of organization.

Bibliographic classification systems are symbolic languages of indexation that were developed based on the philosophical classifications due to the need

for systematization and organization of bibliographical collections, catalogs, and reference list or bibliography in order to group items by subject to meet the interests of the readers or library users.

The system discussed by Barbosa (1969) is composed of classes and/or group of subjects with some degree of similarity. An important characteristic in the arrangement of these classes in the classification system is the principle of useful sequence, according to which subjects are subdivided from the more general to the more specific. On the other hand, according to Piedade (1977), a classification system or classification table is a set of classes presented in a systematic order.

The first evidence of a book classification scheme was found in the Library of Alexandria, and it was inspired by the Aristotle's classification. Callimachus (310-240 a.C.), a Greek librarian, poet, grammarian, and mythographer organized a catalog called *Pinakes*, in which he listed works alphabetically by author and genre, resulting in the following division: poets (epic, comic, tragic, and dithyrambic); legislators; philosophers; historians; orators, and miscellaneous writers. The system he adopted uses chronological order and alphabetical order in the section concerning the authors (BARBOSA, 1969; PIEDADE, 1977).

In the Middle Ages, between the 5<sup>th</sup> and 15<sup>th</sup> centuries, it was common the use of large classes of subjects in the arrangement of books, and within these classes the books were arranged by size. In the 17<sup>th</sup> century, the French librarian Gabriel Naudé (1600-1653) created, in 1643, a new classification system that encompassed twelve classes: Theology, Medicine, Bibliography, Chronology, Geography, History, Military Art, Jurisprudence, Canon Law, Philosophy, Politics, and Literature (BARBOSA, 1969).

Moreover, in the seventeenth-century France, the System of the Paris Booksellers or the French System and the *Table méthodique*, developed by Jacques Charles Brunet, stood out in terms of the organization and arrangement of bibliographies. Brunet created his table based on adaptations of the French System, which served as the basis for the classification used in the National Library of France in Paris (BARBOSA, 1969).

In 1876, the first version of one of the largest bibliographic classification systems, the Dewey Decimal Classification (DDC), was first published in the United States by the librarian Melvil Dewey (1851-1931). The Dewey Decimal system was the first to use decimal numbers for classification symbols using pure notation (Arabic numerals only). Knowledge is divided into ten main classes (000 to 900), successively subdivided into ten other classes, based on the principles of division established by Francis Bacon (knowledge or sciences divided into three major groups: Memory, Imagination, and Reason). The system also has special tables, such as racial groups, language, geographical distribution, and chronological organization, which allow greater specificity in the representation of the subjects. A relative index represents the several occurrences of the same subject in the scheme, and a three-digit number represents the main class. DDC is the most widely used system in libraries, especially in public libraries. It has inspired the development of other systems, such as the Universal Decimal Classification (UDC), used mainly in specialized libraries (MENDES, 1995).

Another classification initiative, the Expansive Classification System, was developed by the American librarian Charles Cutter in 1891, in which the subjects are represented by letters. The Expansive Classification System was published fifteen years after the Dewey system and consists of seven classifications to be adopted in libraries according to the size of their collection. Cutter's classification system influenced the Library of Congress Classification (developed by the Library of Congress), which emerged at the end of the 19<sup>th</sup> century, and its first edition was published in 1901. Other important Cutter's contributions to Library and Information Science are the Rules for a Dictionary Catalog and the table for standardizing author names and geographic place notations, known as Cutter Table; still used in libraries today (BARBOSA, 1969; PIEDADE, 1977).

The Universal Decimal Classification (UDC) was created by Paul Otlet and Henri de La Fontaine. They were responsible for the organization of the Universal Bibliographic Repertory project, whose purpose was to capture the totality of the human knowledge by gathering information on every book published in

the world. The DDC was the instrument used in the organization of this repertory, and it was initially translated. Innovations were made in this system, through the inclusion of mechanisms that allowed the combination of compound subjects; it was the first semi-faceted bibliographic classification system to be developed. The first edition of the UDC was published in 1905 in French by the International Institute of Bibliography, *Manuel du Répertoire Bibliographique Universel*. The International Federation for Information and Documentation (FID) managed the UDC, from its creation around the year 1900 until the end of 1991. The UDC Consortium (UDCC), a body that brings together Standard Institutional Information from different countries, assumed ownership of UDC on 1 January 1992. In Brazil, the first partial edition of UDC in Portuguese was published in 1976 by the *Instituto Brasileiro de Informação em Ciência e Tecnologia* (IBICT, Brazilian Institute of Information in Science and Technology). The system is organized into main and auxiliary tables and uses a mixed notation (numbers, letters, and signals). The first type of tables are tables of subjects with their respective numbers, and the second are tables that show the signs and subdivisions that allow the construction of compound subjects (CLASSIFICAÇÃO DECIMAL UNIVERSAL, 1997).

In 1906, James Duff Brown (1816-1914), a British librarian, released his classification system, the Subject Classification. The last edition of this classification was published in 1939. Henry Evelyn Bliss, a librarian of the College of the City of New York, created a classification system called Bibliographic Classification, also known as Bliss Classification. Its first full volume was published in 1940; the second volume was published in 1947; and the third and fourth volumes in 1953. Bliss adopted the division of human knowledge into five major groups: "Philosophy", "Science", "History", and "Technology and Art". Each group is then subdivided into classes, grouped side by side in subordinate classes, according to their degree of similarity, which allows the coordination and subordination of the subjects. This is one of the main characteristics of this system (BARBOSA, 1969).

The last great general bibliographic classification system to emerge was Ranganathan's Colon Classification. The system was first published in 1933, and the last

edition dates from 1960. It was the first fully faceted system, which due to its importance in the field of classification theory, is presented and discussed below.

The Colon Classification is the first ever faceted classification scheme. It was developed by Ranganathan and published for the first time in 1933. Its tables were improved in the other CC editions published in 1939 (2<sup>nd</sup> edition), 1950 (3<sup>rd</sup> edition), and 1960 (6<sup>th</sup> edition). The last edition (6<sup>th</sup> edition) was reprinted in 1963. It has around 200 tables, and it is also called the analytico-synthetic classification since it involves analysis and synthesis, that is, the symbols are constructed and synthesized during document analysis.

The name "colon classification" comes from the use of colons (:) to separate facets into class numbers. The Colon Classification notation uses mixed notation: Arabic numerals, lower case and upper case letters, Greek letters, and graphic signs (period, comma, colon, semicolon, parentheses, hyphen, and apostrophe). In this classification system, Ranganathan divided knowledge into 42 broad subject classes (PIEDADE, 1977).

In the Colon Classification, the construction of class numbers follows the Personality, Matter, Energy, Space, Time (PMEST) order and the facet formula, which comes at the beginning of the class and determines how the numbers should be formed. Ranganathan also used Auxiliary Tables similar to those in the UDC. Colon Classification includes Tables for the representation of: geographic subdivisions - representation of the facet Space, such as empires, groups of countries, zones, and cardinal points; chronological subdivisions - representation of the facet Time, such as years, days, seasons, weather conditions; subdivisions of language - classes of Literature and Linguistics; and common subdivisions - to specify the document type, such as a periodical or journal, letter, treaty, statistical report, general reports, among others. Colon Classification also uses chain indexing, which specifies all contexts in which a term occurs (PIEDADE, 1977).

Based on the literature review, it is important to discuss some features of this classification. Firstly, the classifier using the Ranganathan scheme must have a comprehensive knowledge about his/her field, which

should be broader than the knowledge required for classifiers using enumerative systems, such as DDC and UDC. An example is the classification of an area such as medicine: in order to correctly use the system, the classifier must know the causes of diseases and the organs affected by them; otherwise, the classification would be incomplete.

Another important aspect is related to the fact that the unlike enumerative systems (DDC and UDC), numbers are not ready in the scheme; they are constructed during document classification. The Ranganathan system can be considered laborious due to the use of formulas to construct the classification symbols. Considering the high number of publications to be indexed in libraries and the time that would be required for the analysis of the document and the construction of the classification numbers, the adoption of Colon Classification on a daily basis in libraries is almost unfeasible. This may be one of the justifications for the low rate of adoption of Ranganathan's classification in Western libraries. However, there are indications of some libraries in India that have adopted this system in the literature.

It is worth highlighting the influence of Ranganathan's mathematical thinking on the development of the Colon Classification system, which can be seen by the use of facet formulas that provide instructions on how to construct classification symbols.

One issue to be discussed is the potential difficulty locating documents, encountered by the end user of this classification scheme. Library users often find it difficult to locate books on the shelves when traditional classification systems are adopted. Therefore, one can imagine how difficult it can be locating books classified using complicated symbols that are unfamiliar to the user, such as those in the Colon Classification.

Among the favorable aspects of the representation of knowledge identified in the Colon Classification are: the representation of the subject of the document can be very specific; the possibility to represent various aspects of the same subject, which is not possible in the enumerative systems; and the possibility of applying this scheme to broader contexts, especially digital contexts. The principles used in the development of



the Colon Classification led to the development of the Faceted Classification Theory, which stimulated studies on classification theory.

### Faceted classification: Theory and definitions

In the context of the faceted classification, the most important concept is the *facet*, which is understood as the part resulting from the application of a principle of division, *i.e.*, a difference or characteristic. The facet gathers terms that have the same type of relationship among themselves, and it can be considered as a genre (BARBOSA, 1969; PIEDADE, 1977). According to Vickery (1980), the various hierarchies involved in a subject field classification are known as facets of the subject. On the other hand, Lima (2004b) stated that facet is the collection of terms which have the same relationship with the global subject, reflecting the application of a basic principle of division.

Ranganathan also introduces other important concepts for the organization of knowledge. Among them are: array, chain, and fundamental category. The basis for structuring rows and chains is the concept. The term 'fundamental category' was used by Ranganathan to designate fundamental ideas that allow the division of the universe of knowledge into broad classes; the fundamental category is the first parameter to classify a universe of knowledge (CAMPOS; GOMES, 2003). On the other hand, arrays are classes formed from a single characteristic of division, forming horizontal series. Chains are vertical series of concepts in which each concept has one more or one less characteristic than the previous concept, depending on whether the chain is descending or ascending (CAMPOS; GOMES, 2003). The term "subfacet" is related to the groups of coordinated terms derived from the application of the same principle of division and that are mutually exclusive. The concept of "focus" refers to each term within a facet and the subdivisions of a facet; the focus corresponds to the species. The term "isolate" refers to the term lying outside the context of a facet; each division in a facet is called an isolate Focus or simply an isolate (BARBOSA, 1969).

In the Ranganathan's theory, the notions of "concept" and "isolate" are mixed up, *i.e.*, a concept is

equivalent to an isolate. Arrays and chains arise based on the set of organized concepts. When grouped, chains form the classes or facets of subjects. Several facets of the same subject grouped together are the fundamental categories. The set of fundamental categories is called "system of concepts".

One of the objectives of Ranganathan in developing the Faceted Classification Theory was the attempt to highlight the principles used in the development of the Colon Classification, which is the scheme used to organize the collection of the Library of the University of Madras, India.

Another important concept of this theory is the concept of the fundamental categories "PMEST", which is discussed below.

### Fundamental Categories: Personality, Matter, Energy, Space, Time

Ranganathan proposed a classification scheme based on fundamental categories. According to him, these categories would allow the classification of any universe of subjects. The fundamental categories are the first part of the classification of a universe of subjects (CAMPOS, 2001).

The fundamental categories defined by Ranganathan are: **Personality (P)**, **Matter (M)**, **Energy (E)**, **Space (S)**, and **Time (T)**, also known as **PMEST**. In the representation of subjects using the facet formula as proposed by him, each fundamental category corresponds to the connecting symbols, according to his book, Prolegomena. Therefore, for the category Personality the connecting symbol is a comma (,); for the category Matters, the connecting symbol is a semicolon (;); for the category Energy, the connecting symbol is a colon (:); for the categories Space and Time, the connecting symbol is the period (.). In the scheme, the facets represented by these fundamental categories are described as: [P] [M] [E] [S] [T] (BARBOSA, 1969).

Lancaster (1993, p.54) defined Ranganathan's categories as:

[...] the easiest way to describe Personality is as 'the thing in itself'. Matter is the substance

of which the thing is composed. Energy is the action performed in or by the thing. Space is where the action takes place, and Time is when it takes place.

Still regarding the PMEST, Lancaster added:

Unfortunately, the PMEST formula is rather simplistic. When indexing highly complex subjects, it is possible that a category occurs more than once (for example, the force acting on a structure can cause it to crack, indicating two different occurrences of the category energy). Some categories have to be further subdivided, for example, to indicate different types of activities. Furthermore, the PMEST formula does not clearly encompass some attributes that are important in indexing, such as the properties of materials (LANCASTER, 1993, p.54).

The category **Personality** is related to the “things” that the subject deals with. Personality represents the objects of study in a particular discipline that underlies its traditional division. In Medicine, Personality is the organs; in zoology, it is the animals; In Botany, it is the vegetables; in librarianship, it is the types of library, and so forth. Personality is a fundamental category of great difficulty to be identified. Ranganathan suggested the Method of Residues, any entity, which is not a manifestation of “Time” nor of “Space” nor of “Energy” nor of “Matter”, should be a manifestation of “Personality” (GOMES *et al.*, 2006).

Foskett, a member of the Classification Research Group, defined the concept of Personality as:

It is difficult to define Personality [P], but it is easy to understand it: it corresponds to what we have called as the primary facet, and it usually includes things, types of things, or types of actions (FOSKETT, 1973, p.266).

The category **Matter** refers to the notion of properties or characteristics of personality. Matter consists of all kinds of materials and substances of which the things are composed. Some examples in Civil Engineering are: bricks, roof tiles, and stones. The manifestations of this category includes: material and property of an object. According to Campos and Gomes (2003), the category **Matter** can be seen as the manifestation of materials in general, such as their property, and also as the material that compose all species.

On the other hand, the category **Energy** reflects the actions, reactions, activities, operations, processes, techniques, and treatments present in the areas of knowledge. For example, in librarianship, there are the following processes: cataloging and indexing.

The categories **Space** and **Time** are identified through their usual meanings, and they indicate phenomena in space and time in which subjects are conceived.

There is criticism of this form of classification in the literature, especially regarding the possibility of predicting the categories representative of any field of knowledge. Another issue concerning Ranganathan's categories refers to the inaccuracy of the concept of **Personality** as it was defined, despite the importance of this category (CAMPOS, 1978).

The PMEST also received criticism from Foskett (1973), who pointed out the advantages and disadvantages of this classification proposal:

The analysis according to the fundamental categories of Ranganathan is often useful to determine the correct citation order of subjects in other schemes; however, we must be cautious about accepting them without adequate criticism. For example, periodicals fall into the facet **Matter** in librarianship, but they fall into the facet **Personality** in bibliography. [...] In fact, PMEST does not solve the problems related to citation order; it simply transfers them to a different stage of the analysis process. [...] However, the fact that it is possible to disagree with the use of PMEST does not mean that the citation orders found in the Colon Classification are incorrect. Most of the times, they are clear and useful, and this is the only scheme in which we can verify this fact. A disadvantage is the lack of flexibility; it is not possible to select a facet order that suits a certain group of users if it conflicts with PMEST (FOSKETT, 1973, p.267).

Based on these considerations, the Classification Research Group (CRG), through cooperative studies initiated in 1952, suggested a new version of the Ranganathan PMEST, including the following categories: Types of final product, Parts, Materials, Property, Process, Operation, Agent, Space, Time, and Form of presentation (PIEDADE, 1977).

This group of researchers concluded that there were no *a priori* categories to classify subjects. They

argued that the categories are derived from the subject to be classified, in each specific context. Among the criticisms of PMEST from the CRG identified in the literature are:

With regard to the fundamental categories, the CRG stated that they should be based on the nature of the subjects to be classified and that not all subjects have fundamental categories. The CRG prefers to identify the fundamental categories by the context of the subject itself, concluding that lists of fundamental categories should not be too long or mechanically imposed on the subjects. Compared to Ranganathan's PMEST, the fundamental categories proposed by the CRG, are, due to their flexibility, appealing to classifiers, who can shape them to specific subjects thus allowing the formation of more distinct and better defined categories (LIMA, 2004a, p.65).

The fundamental categories constitute the basic and preliminary form of information organization, as previously discussed. Ranganathan also considered other relevant issues that influence the organization of knowledge; one of which is the Spiral of Scientific Method, which is discussed below.

### Spiral of Scientific Method

Ranganathan's faceted classification theory was developed based on the understanding of the importance of knowledge production and the impact of new generated knowledge on classification schemes. Accordingly, Ranganathan defined the universe of knowledge as:

[...] the sum-total, at the moment, of such accumulated knowledge. It is being continuously developed and added to. Different domains of the universe of knowledge are developed by different methods. Scientific method is one of the recognized methods of development. Scientific method is characterized by a never-ending spiral movement (CAMPOS; GOMES, 2003, p.154).

Ranganathan proposed a spiral model to represent the dynamism of knowledge production. In this model, the stages of the development of the universe of knowledge, whose characteristics are continuous, cyclic, and never ending. The concepts

included in the spiral model are: experimentation, observation, abstraction, generalization, particularization, deduction, and concreteness.

The main concepts addressed in the Spiral of Scientific Method (Figure 1) are described below to provide a better understanding of the theory:

(a) experimentation: a method that consists of observing a phenomenon under certain conditions (controlled or known) to better understand it; experience, experimental method. Systematic use of experience (LALANDE, 1993);

(b) abstraction: supposed process of forming ideas that consists of isolating what is common to different cases. An 'action of the spirit' that considers separately an element (quality or relationship) of a representation or a notion, focusing on it and neglecting others (LALANDE, 1993);

(c) generalization: an operation by which through the identification of common characteristics between several singular objects; they are included in a single concept (LALANDE, 1993);

(d) particularization: particular proposition concerning some individuals or a single individual in a class, if it is not specific. It is common to contrast the particular to the universal (LALANDE, 1993);

(e) deduction: process of reasoning in which a conclusion is drawn from a set of premises (BLACKBURN, 1997);

(f) concreteness: opposite of abstraction (BLACKBURN, 1997).



Figure 1. Spiral of Scientific Method.  
Source: Campos and Gomes (2003, p.155).

In the Spiral of Scientific Method, Ranganathan defines four cardinal points denoted by the terms: Nadir, Ascendent, Zenith, and Descendent. According to Sepúlveda (1996), this terminology shows an influence of Astrology on Ranganathan's life.

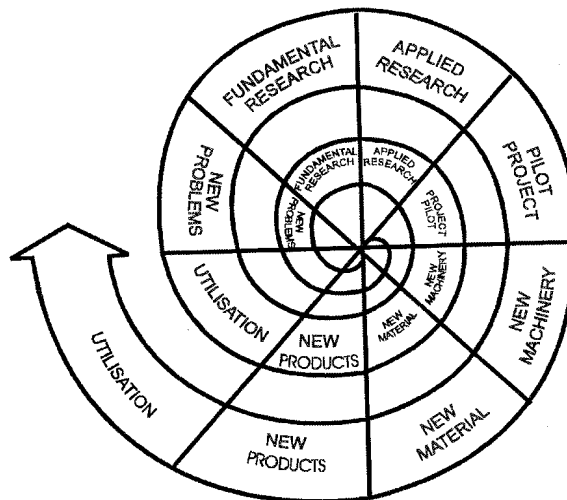
According to Ranganathan (1960), between these points are the stages of knowledge production. These cardinal points give rise to 4 quadrants in the cycle implied in the spiral. Between Descendent and Nadir is Quadrant 1, corresponds to the stage in which observable facts are found and recorded. The concepts included in this stage are: experimentation, observation, concreteness, and particularization. Between Nadir and Ascendent is Quadrant 2, which corresponds to the stage when the inducted or empirical laws are formulated and recorded. The concepts included in this stage are: induction, abstraction, and generalization. Between Ascendent and Zenith is Quadrant 3, which corresponds to the stage in which the fundamental laws are understood and recorded. The concepts included in this stage are: intuition, abstraction, and generalization. Between Zenith and Descendent is Quadrant 4, which refers to the stage in which the deduced laws are derived and recorded. The concepts included in this stage are: particularization, concreteness, and deduction (CAMPOS; GOMES, 2003).

As can be seen from this diagram, the first stage of the cycle is marked by experiments and observation of the phenomena. Since the spiral is an ongoing cycle that is constantly developing, experimentation and observation are at the same time the beginning of a cycle of knowledge (due to new scientific inquiries) and the end in another. The spiral motion, therefore, reflects the progression of scientific production.

### Spiral model of development of subjects

Ranganathan also studied the theory and nature of knowledge and the ways knowledge is produced in several subjects. Accordingly, he proposed the spiral model of development of subjects, which shows the relationship between knowledge production and organization. This spiral is characterized by the continuous and unending process of subject growth and development. This leads to the possibility of

constant changes in the universe of knowledge and subjects (CAMPOS; GOMES, 2003).



**Figure 2.** Spiral model of development of subjects.  
Source: Campos and Gomes (2003, p.156).

The Spiral Model of Development of Subjects is seen in the literature as a "meta-spiral of knowledge" since it incorporates Ranganathan's efforts to apply it to the field of documentation and librarianship. Moreover, the Spiral Model of Development of Subjects is ruled by the same laws of continuous and unending process as those in the Spiral of Scientific Method (CAMPOS; GOMES, 2003).

The diagram in Figure 2 shows that the Spiral Model of Development of Subjects includes new scientific problems in its starting point. "Scientific problems" become "fundamental research", which in turn becomes "applied research". Following, in the scientific method, "pilot projects" are developed. "New machinery", "new materials", and "new products" are then developed. Their use leads to new problems, and the cycle is restarted.

Therefore, it can be seen that the continuous spiral motion reflects the scientific investigation, resulting from everyday problems and scientists' inquiries. Scientific research is a natural result of the search for solutions to problems. Scientists are continuously faced with questions that demand answers. The products developed reflect the attempt to solve the problems encountered, and the use of such products lead to new scientific inquiries and thus science progresses.

## Current approaches to faceted classification theory

The faceted classification theory has been used in the development of hypertext systems. These systems allow structuring and manipulation of non-linear texts. Ranganathan's postulates can be applied in new contexts other than librarianship. The faceted theory can be used to represent intellectual contents in hypertext systems since it enables the representation of different points of view from which a subject can be treated. The approach to hypertext, from the faceted analysis point of view, consists in the organization of classes (facets and subfacets) and concepts, as well their interrelationships in an online hypertext environment. In addition, as a classification and indexing technique, the faceted analysis provides support to the organization of knowledge from a semantic perspective.

Vanda Broughton, a researcher at the University College London, considered the possibility of using facet analysis as a basis for organizing of digital resources in portals. She described the research carried out at the School of Library, Archive & Information Studies of the University College London in the portals "Arts and Humanities Data Service (<http://www.ahds.ac.uk>)" and "Humbul (<http://www.humbul.ac.uk>)". These portals are devoted to disseminating information in the fields of Arts and Humanities, and are soon to merge into a single Humanities portal. The objective of her research was to develop a subject tool for the management of this new portal, based on the principles of faceted classification. The author argues that the faceted structure is the most appropriate for the management of terminologies and concepts. She adds that faceted classification provides effective tools for vocabulary management and document description and retrieval. The classificatory principles developed by the CRG were applied, and the Bliss Classification (second edition) was adopted as a standard methodology for content organization (BROUGHTON, 2002).

Broughton (2006) also advocated the application of a faceted system to e-commerce sites as a navigational tool. The multifaceted navigation design provides a more sophisticated search allowing the user to browse the conceptual structure and to combine concepts from different facets (windows or menus).

An important study on this topic in Brazil is the doctoral thesis defended by Lima (2004a) in the Graduate Program of the *Escola de Ciência da Informação, Universidade Federal de Minas Gerais* (School of Information Science of UFMG, Federal University of Minas Gerais), titled *Mapa hipertextual (MHTX): um modelo para organização hipertextual de documentos* (Hypertext Map (MHTX): a model for hypertext organization of documents). The author developed a model for the hypertext organization of theses and dissertations based on the principles of facet analysis. The author combines conceptual maps - visualization tools that facilitate the graphic structuring of hypertext documents - and the analysis concept to propose a prototype for the organization of the Digital Library of Thesis and Dissertations of the Graduate Program in Science of Information of UFMG. The author concluded that the faceted analysis technique was efficient in the development of the conceptual model proposed, providing meticulous dynamics from the identification of the relevant terms to the creation of categories (LIMA, 2004a).

Maria Luiza de Almeida Campos and Hagar Espanha Gomes, researchers at the *Universidade Federal Fluminense* (Fluminense Federal University), carried out theoretical investigations on the representation of information through hyperdocuments, adopting the classification theory and its concept. The authors argue that providing the searcher with consistent and meaningful navigation is one of the great challenges in the construction of hypertexts. Considering the conception of hypertext as a network of interconnected concepts, the authors suggest that the planning of this instrument should be based on the identification of its general classes and subclasses and also on the analysis of the different types of relationships between the concepts. In the establishment of consistent and logical relationships between conceptual nodes, the types of relationships between the concepts that will be interconnected through links should also be considered by the hypertext creator (CAMPOS; GOMES, 2005).

Another possibility of the application of the faceted classification theory is related to the mapping of the scientific knowledge of a certain subject. This was

the proposal of a doctoral thesis defended in 2005 by Carlos Alberto Ávila Araújo, professor at the School of Information Science of UFMG, titled *Análise temática da produção científica em Comunicação no Brasil baseada em um sistema classificatório facetado* (Thematic analysis of the scientific production in Communication in Brazil based on a faceted classificatory system), in which a faceted classification system for the field of communication was constructed. The results allowed the mapping and thematic quantification of research on communication in Brazil. The themes and research trends in this field were identified.

Ana Maria Delazari Tristão, a researcher at the Graduate Program in Civil Engineering of the *Universidade Federal de Santa Catarina* (Federal University of Santa Catarina) carried out in 2005 a study proposing the construction of a faceted classification system for ceramic tiles in the civil construction sector. The study was based on the need for information retrieval for the selection of the most appropriate ceramic tiles for different places and different types of buildings. The system constructed aimed to classify the ceramic tiles for a specific use according to their respective technical characteristics (physical and chemical properties). Moreover, the system considered terminological standardization, coding, and classification of materials used in the construction sector. The facets were created based on the categories proposed by the Classification Research Group, according to the international standards of the International Standard Organization concerning the systematization of information in the field of civil construction. The advantages offered by the faceted classification system developed by Tristão (2005) include: identification of the different aspects in the literature on ceramic tile flooring using analysis of concepts and the detailed description of the user's information needs since the faceted system has greater flexibility in the detailed description of specific, complex, and multidimensional subjects (TRISTÃO, 2005).

Other studies on the construction of terminologies using the faceted classification theory were identified, such as the study by conducted by Moraes (2010), researcher at the *Fundação Oswaldo Cruz* (Fiocruz, Oswaldo Cruz Foundation), on the development of suicide terminology in Brazil. Moraes

(2010) developed a basic terminology on this subject based on a literature review on suicide between 1996 and 2007, which included dissertations, theses, periodicals, and books. The study had the support from two experts in the field and used the terminology used in the *Descritores em Ciência da Saúde* (DeCS, Health Science Descriptors), a controlled vocabulary for document indexing in the health field. Furthermore, the author used the Lasswell's model of communication and Ranganathan's facet theory. Based on this theoretical and methodological framework, the researcher developed a basic suicide terminology for Brazil. Facet arrangement followed the method proposed by Ranganathan. The main facets defined were: types of cases, actor, time, place, process, material, reason, suicide risk identification, prevention, treatment, professionals, presentation of cases of attempted suicide, consequences, issues (ethical, spiritual, and moral), and related areas of knowledge.

Another possibility of application of the faceted classification theory was described in the study carried out by Costa (2010), researcher at the *Universidade Estadual Paulista* (Paulista State University), who identified the theoretical and conceptual similarities among Ranganathan's fundamental categories, the principles of rhetorical discourse, and the literary narrative elements to contribute to the development of methodological procedures for reading, content analysis, and textual representation of posters for document creation.

According to Costa (2010), literary narrative is understood as a form of discourse in which a fact or an event is stated or reported, which may be an episode or an incident of life that may have real and fictitious data. The author adds that categorizations are also present in narrative theory, since narration has five structural elements: the narrator and his points of view; the action or the plot of the story; the characters that cause or perform an action; the place where the plot happens; and the time of the event (COSTA, 2010). Therefore there was an effort to combine Ranganathan's categories and the categories formed by the elements of the narrative.

Conducting a literature review, Costa (2010) identified the categories for the analysis of the structure of discourse that can also be used in the analysis of images, namely: the canons of rhetoric brought

together and organized by Roman philosopher and politician Cicero - who? (invention); what? (arrangement); how? (style); where? (memory); when? (delivery). Other possibilities of categorization to represent the image contents identified in the literature by the author are: who (identification of the object being focused); where (determine image position in space); and when (determine time of occurrence).

The literature also refers to the use of the fundamental categories as parameters for the indexation and creation of more consistent indexes. The categories facilitate text analysis and comprehension and the definition of the most adequate facets for the work in certain types of texts. Moreover, facets can be used in indexing to ensure completeness and consistency (LEISE, 2008).

Maculan (2011) also applied the principles of faceted classification to the development of a faceted taxonomy for organization of information and standardization of informational contents in the context of digital library of theses and dissertations. The author concluded that it is possible to refine the search using faceted navigation taxonomy, which allows greater visibility of the available content without overloading the user (MACULAN, 2011).

Faceted classifications have also been used in studies on modeling databases to investigate the adoption of classification schemes in digital environments (SILVA; NEVES, 2012). Faceted classification and computational systems using data modeling are aimed at knowledge structuring, through the organization of concepts and the establishment of relationships between them. This allows mapping the subject field and the inclusion of new concepts without this changing the system structure. These authors identified the benefits of using faceted classification to refine searches in digital environments.

Silva and Lima (2015) also defended the use of faceted navigation as a strategy to facilitate the use of keywords in the faceted web catalog search interface. By conducting a usability test, this type of navigation allowed web catalog users to find new terms as they navigated through the system. Therefore, it was possible to locate more specific concepts and insert them into the facets thus reducing the number of

retrieved records. The study concluded that faceted navigation and keyword search can be complementary and thus improve users' search strategies (SILVA; LIMA, 2015).

The literature review conducted enabled the identification of ways to apply faceted classification theory to contemporary contexts. The principles of this theory stand out in terms of the possibility of providing greater specificity in the representation of subjects since it allows the representation of the various facets into which the same subject can be organized.

## Conclusion

The literature review also demonstrated Ranganathan's importance regarding changes in the conception of bibliographic classification systems. The theorist proposed a new classification approach, which allows the representation of various facets of the same subject. The faceted approach also provides a more flexible way to incorporate new subjects and disciplines into the classification scheme since the subjects are not included in "a priori categories". Ranganathan, as previously mentioned, also stood out in other branches of librarianship due to publications addressing the development of libraries in general.

The Five Laws proposed by him contributed to the redefinition of the philosophy of the activities performed in a library by including a socialist and humanist view of the democratization of books and reading. Ranganathan was undoubtedly a very important figure in librarianship and research in Information Science due to his contributions to the organization of information focusing on its recovery. His theory has been incorporated into the following contexts: construction of hypertext systems; representation of digital objects in portals; terminology elaboration; representation of iconographic contents; thematic mapping of knowledge domains; and development of faceted navigation taxonomy, to name but a few.

Although the Colon Classification has not been extensively adopted in libraries around the world, with the exception of India, the theory developed

by Ranganathan goes beyond temporal and spatial boundaries since it contributed to the consolidation of theoretical principles of knowledge organization. It is well known that theories reflect ideologies, cultures, and their own historical moments. Similarly, Ranganathan was strongly influenced by Brahmin culture and Hinduism, which taught him values such as religiousness, discipline, and constant meditation.

Authors who developed faceted classification systems showed the possibility of representing complex subjects with greater specificity, directly reflecting the users' needs. This is due to the fact that facet analysis coordinates concepts and allows a subject, however complex it may be, to be represented by the synthesis of the terms belonging to more than one facet.

Furthermore, due to their flexibility, analytico-synthetic classification schemes are able to follow the pace of development of the subjects more quickly since they allow the insertion of new terms into tables without changing their structure.

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## Contributors

All authors participated in all phases of the research article.

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