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Ranganathan and the Universe of Knowledge

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Ranganathan was the first library and information scientist to recognize the role of developmental and structural studies of subjects in knowledge representation. 'Knowledge' and 'information' are used synonymously in the article. Different types of social knowledge can be distinguished and identified, applying the concept of 'subject' as formulated by Ranganathan. The Universe of Subjects is a growing universe. It is being cultivated continuously. This leads to change and growth, and consequently to new structures. This concept is illustrated by taking the case study of a specific subject namely biochemistry. The article also highlights other structural and developmental attributes of the universe of subjects as propounded by Ranganathan and points out their relevance and role in information retrieval.
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0. Introduction

B.C. Vickery has aptly remarked that "the representation of knowledge in symbolic form is a matter that has occupied the world of documentation since its origin. The problem is now relevant in many situations other than documents and indexes. The structure of records and files in databases; data structures in computer programming; the syntactic and semantic structure of natural languages; knowledge representation in Artificial Intelligence; models of human memory; in all these it is necessary to decide how knowledge may be represented so that the representation may be manipulated" (1).

The above remark by Vickery succinctly brings out that one of the main concerns in documentation, information retrieval, databases and artificial intelligence is how to represent knowledge.

Knowledge representation is the key to effective retrieval and dissemination of data, information and knowledge. Techniques like use of "predicate" and "argument" categories, Fillmore's "case grammar", Schank's and Wilks' "Semantic primitives" in linguistic analysis; "predicate logic", "frames" and "semantic nets" in artificial intelligence; and "facets", "fundamental categories", "role indicators", "operators", "see" and "see also" references, "broader terms", "narrower terms", "related terms" in the field of information retrieval, are all attempts at knowledge representation.

Knowledge is generally represented in a subject statement. A subject statement consists of terms. Terms stand for concepts and concepts combine in the statement according to a pattern of relationships. In other words, each subject has its own structure. The units, i.e. concepts or isolate ideas identified in describing a particular subject, are but points in the structure or network of relations. Structuring of component concepts in a subject plays a vital role in communication, learning and remembering. In the words of Jerome Bruner, "grasping the structure of a subject is understanding it in a way that permits many other things to be related to it meaningfully. To learn to structure, in short, is to learn how things are related. Perhaps the most basic thing that can be said about human memory after a century of intensive research, is that unless detail is placed into a structural pattern, it is rapidly forgotten" (2). Kenneth Boulding is also of the same view when he expresses that "we cannot regard knowledge as simply the accumulation of information in a stock-pile, even though all messages that are received by the brain may leave some sort of deposit there. Knowledge must itself be regarded as a structure, a very complex and frequently loose pattern, almost like an enormous molecule, with its parts connected in various ways by ties of varying degree of strength" (3).

A subject cannot be grasped meaningfully until it is studied in its structural pattern. Structure is a dynamic phenomenon. It changes in the course of time. This is why Kenneth Boulding was led to remark that "restructuring is being forced upon us by the very growth of knowledge" (4). As such, studies in the growth pattern of a subject become a prelude to its structural analysis. In other words, developmental studies are prerequisites for structural analysis.

1. Ranganathan as a Pioneer in Structural and Developmental Studies of the Universe of Subjects

Ranganathan (5) was the first library and information scientist to recognise the role of developmental and structural studies of subjects in knowledge representation as early as 1930's. Bliss (6) also stands prominently in this sphere. Consequently, Ranganathan introduced a paper entitled "Universe of Knowledge: Structure and Development" in library science courses. Later on, the nomenclature of the paper was changed to "Universe of Subjects: Structure and Development". His contributions in this field are many and varied. He was of the view that in an information system readers seek information about a subject or its constituents - concepts or ideas. As such, the methods, tools and techniques of retrieval and dissimina-

tion should be designed in such a manner as to meet each reader's need for relevant subjects, concepts and ideas efficiently, conveniently and economically. This can only be done when the methods, tools, and techniques designed are based on the attributes of subjects. In other words, a study and understanding of the attributes of subjects is a prerequisite for the proper design of any information system. The attributes of subjects considered relevant in such a study are:

1. Development of subjects
2. Structure of subjects
3. Organization in the universe of subjects as a whole

Developmental studies lead to the recognition of structures at different stages in their growth. This helps ultimately in finding out the Modes of Formation of Subjects. The recognition of modes of formation of subjects leads to the knowledge of the association among the constituents of the universe of subjects. It also helps to grasp the nature of the bond among the constituents. Once the bond among the constituents of subjects is known, an efficient information system can be designed to the satisfaction of its readers. The recognition of bonds among the constituents of subjects, eventually, leads to the finding of an absolute syntax of concepts, ideas and subjects.

Derek Langridge appears to be convinced of the views of Ranganathan when he says, "The librarian acts as an intermediary between the whole of the world's accumulated knowledge and individuals who desire to access it. To perform his act of mediation, the teacher must be expert in the technique of teaching; to perform his, the librarian must be expert in the technique of acquisition, storage and dissemination. However good his technique, the teacher cannot function effectively without appropriate knowledge of his chosen subject. Similarly, the librarian needs his appropriate knowledge: knowledge of nature, structure and development of all knowledge" (7).

2. Structural Contributions of Ranganathan

2.1 Data, Information and Knowledge

Ranganathan defines knowledge as the totality of ideas conserved by humans (8). He regards knowledge as equal to the universe of ideas. At the same time, he defines information as ideas communicated by others or obtained by personal study and investigation (8, p.81). A close look at both these definitions makes it clear that the converging point is "Idea". It is also apparent that Ranganathan has used "Information" and "Knowledge" as synonyms. He himself says that the terms "thought", "knowledge" and "information" are often used as synonyms of the term "Idea" (8, p.81). Idea, according to him, is "the product of thinking, reflecting, imagining etc., got by the intellect by integrating with the aid of logic, a selection from the apperception mass, and/or what is directly apprehended by intuition, and deposited in memory" (8, p.81). Apperception mass denotes the concepts already present in memory, to which newly received percepts and newly formed concepts are assimilated. Concepts are the formations, deposited in memory, as a result of the association of percepts - pure as well as compound - already deposited in the memory. Percepts are meaningful impressions produced by entities through the primary senses and deposited in the memory. Knowledge evolves through the formation of percepts, concepts and ideas. Percepts are sensory experiences, whereas concepts and ideas constitute intellectual experiences. In other words, percepts are sensory and perceptual phenomena, while concepts and ideas are conceptual, and therefore on the cognitive level of perception. This being so, one may conclude that knowledge is the result of sensory and intellectual experiences. It may be amplified by intuitive experiences, which are rare and occasional in nature.

Nowadays, there is a general tendency to explain this knowledge spectrum in the context of data, information and knowledge. A general consensus on these terms is as follows:

Data: Letters, numbers, lines, graphs and symbols etc., used to represent events and their state, organized according to formal rules and conventions.

Information: The cognitive state of awareness (as being informed) given representation in physical form (data). This physical representation facilitates the process of knowing.

Knowledge: The cognitive state beyond awareness. Knowledge implies an active involvement and understanding and the ability to extend the level of understanding to meet life's contingencies. Knowledge can also refer to the organized record of human experience given physical representation (books, report) (9, p.8)).

A depth analysis of the above definitions reveals that the knowledge spectrum represents a pyramid like structure in which there are three levels or stages. The movement up the pyramid, from data at the base to knowledge at the apex, entails a qualitative refining and evaluative process. While data are sensory and perceptual in nature, information and knowledge are cognitive and conceptual. Comprehension and understanding are added characteristics of knowledge. It is difficult to ascertain where the one ends and the other starts. Therefore, data, information and knowledge, though appearing different, are actually overlapping and interchangeable concepts.

2.2 Types of Knowledge

Knowledge is of two types: Personal Knowledge and Social Knowledge. As library and information scientists, our main concern is with social knowledge, which is the knowledge preserved collectively by a society or social group and is available to the members of society through its records. The characteristics of social knowledge resemble the concept of "World Three" as given by Karl Popper (10). "World Three" of Popper is the world of knowledge and information in the objective sense. It comprises the expressions of scientific, literary and artistic thoughts codified in various media and forms, together with all the records of human culture. Ziman (11) used the term "public knowledge" to distinguish social knowledge.

2.3 Concept of Subject

Our handling of social knowledge in various media, forms and manifestations indicates that there are different kinds of social knowledge. Traditionally, we have been referring to them as "disciplines". No doubt the term "discipline" may distinguish between broad areas of knowledge, but its capacity to identify and distinguish all knowledge contained in documents including electronic media and forms is questionable. The term suggested by Ranganathan is "subject". According to him, the concept of subject refers to "an organized or systematized body of ideas, whose extension and intensions are likely to fall coherently within the field of interest and comfortably within the intellectual competence and the field of inevitable specialisation of a normal person" (8, p.82). In other words, "subject" refers to a segment of knowledge whose extension and intension are limited by the interest, intellectual competence and specialisation of a normal person. Applying this concept of "subject", we can identify and distinguish all the segments of knowledge in existence and those which will come forth in the future.

2.4 Types and Structural Patterns of Subjects

A subject, according to Ranganathan, can be either a Basic Subject or a Compound Subject or a Complex Subject. A subject consists of ideas. Ideas are, primarily, of three types i.e. Basic Idea, Isolate Idea and Speciator Idea. Isolate ideas are of different varieties. His Postulate of Five Fundamental Categories with Rounds and Levels is well known in this respect. Ideas combine in a subject in various patterns. These patterns are known as Modes of Formation of Subjects.

2.5 Modes of Formation of Subjects

Modes of formation of subjects represent a typology of relations and act as guiding ideas in recognizing and formulating relations among concepts constituting a subject. Ranganathan was able to recognise twelve modes of formation of subjects. They are:

Loose Assemblage 1
Loose Assemblage 2
Loose Assemblage 3
Lamination 1
Lamination 2
Fission
Dissection
Denudation
Fusion
Distillation, Clustering/Subject Bundle and
Agglomeration/Partial Comprehension

Modes constitute a fundamental contribution by Ranganathan at the seminal level.

Loose assemblage of kind *1* represents a relation when two Basic Subjects or Compound Subjects are studied in mutual relation. This type of relationship gives birth to a Complex Subject, e.g. Mathematics for biochemists.

Loose Assemblage of kind *2* and kind *3* represent the pattern of relationship when two concepts/isolate ideas are brought into mutual relation from the same facet or array respectively. Such a relationship results in the formation of a Complex Isolate Idea, e.g., Influence of occupational pattern on rural society; Comparative study of rural and urban society.

Lamination represents the mode of relationship, giving birth either to a Compound Subject or a Compound Basic Subject or a Compound Isolate. A Compound Subject is formed by combining any number of isolate ideas with a Basic Subject, e.g., Ecology of desert plants. Such a Compound Subject is the result of Lamination 1. A Compound Basic Subject is the result of Lamination 2. It is formed by compounding two or more Basic Subjects, e.g., Ayurvedic child medicine. A Compound Isolate is the result of laminating two or more isolates from the same facet over each other, e.g., Psychology of rural abnormal female child. This phenomenon can be labelled as Lamination 3.

Fission represents the mode of relationship when an isolate or a Basic Subject is born by a fragmentation process from its parent isolate or Basic Subject. It includes *Denudation* and *Dissection.* While Denudation stands for chain relationship, Dissection denotes array relationship.

Modes of relationships representing Fusion, Distillation, Clustering and Agglomeration, though recognised so far at the Basic Subject level, have also wide potentialities for the isolate level. *Fusion* is discernible in the formation of subjects like biochemistry, geochemistry, econometrics, etc., where two subjects are fused together in such a way that each of them loses its individuality.

Distillation represents the mode covering subjects like museology, policy science, systemology, research methodology, etc., which first appear as isolate idea in various disciplines and gradually develop into independent disciplines or Basic Subjects.

Clustering is the mode necessitated by inter-disciplinary team research and observable in the formation of subjects like ocean sciences, material sciences, hydro sciences, defence sciences, space sciences, and area studies, etc. Such subjects are born when specialists from different disciplines focus attention on a phenomenon or an entity.

Agglomeration represents the formation of a subject by the process of collecting together subjects into larger masses. Examples of such subjects are: natural sciences, mathematical sciences, social sciences, etc.

2.6 Global Experiments

Global experiments on these ideas, involving the structure of a subject, have fascinating accounts in the annals of information retrieval since 1950's. Attempts on systems of concept organisation for information retrieval by the Classification Research Group (CRG) (12) Farradane (13-15), D.J. Foskett (16), Barbara Kyle (17), B.C. Vickery (18-19), Derek Austin (20), Perry and Kent (21-22), Eric de Grolier(23), Gardin (24), Soergel (25), Lancaster

(26), Perreault (27), Dahlberg (28-30), Fugmann (31), Eugene Garfield (32), and the Documentation Research and Training Centre (DRTC, India) (33-34), are significant from a structural point of view.

A departure was introduced in the Ranganathan model by Farradane, ignoring the need of Basic Subjects. Farradane was of the view that there is no need of Basic Subjects. Compound subjects are to be constructed from the universe of concepts without referring to Basic Subjects. However, the need of Basic Subjects is going to remain a valid concept till the documents are to be arranged on the shelves in some helpful order and till the prevalent tradition of referring to scientists, academicians and scholars by their broader or narrower specialisation is completely done away with. Moreover, the reaction was appreciable when, on the one hand, the demarcations among the subjects into fields of specialisation found helpful and acceptable to scholars were losing their sharpness and new divisions overlapping and criss-crossing the older boundaries were being formed and, on the other hand, a conceptual framework or theory was missing to identify new Basic Subjects and to accommodate them in a helpful and filiatory order in information retrieval tools. Thanks to the efforts of Ranganathan, today we have a conceptual framework to identify new Basic Subjects. The source of this conceptual framework lies in Ranganathan's model of Modes of Formation of Subjects, viz. Fission, Fusion, Distillation, Clustering, Lamination and Agglomeration.

3. Developmental Contributions by Ranganathan

3.1 Growth Leading to New Structures

As mentioned earlier, Ranganathan held the view that the Universe of Subjects is a growing universe. It is being cultivated continuously. This leads to change and growth, and consequently to new structures.

3.2 Case Study of Biochemistry

To illustrate, let us take the case of a young discipline like Biochemistry. It has its roots in two major scientific disciplines, biology and chemistry. There are two lineages in the birth of present day biochemistry. One lineage comes from medicine and physiology, a by-product of early inquiries into the chemical composition of blood, urine and the tissues and their variation in health and disease. The other lineage traces from organic chemistry, from early studies of the structure of naturally occuring organic compounds.

3.2.1 1770-1828: Loose Assemblage Structural Pattern

The questions which biochemistry attempts to answer today concerning man and other forms of life including the origin of life itself were asked by man as early as at the dawn of human history. However, it is only 200 years back that the methods of science began to make a dent in the chemical beliefs about biological phenomena. Discovery of oxygen by Priestley; isolation of glycerol and citric, malic, lactic and uric acids from natural resources by Scheele; isolation of urea from urine by Rouelle; discovery by Lavoisier that respiration is oxydation and alcoholic fermentation is fundamentally a chemical process; isolation of an amino acid, asparagine by Vauquelin and Robiquet; synthesis of urea by Wöhler, are some of the major events and discoveries from 1770-1828, which helped to lay the early foundations of biochemistry.

An analysis of these events reveals that the science of biochemistry was in offering during this period. However, its structure was quite hazy. It was difficult to recognise its components and identify their relationships. But it was clear that a new subject was emerging as an offshoot of a relationship between chemistry and biology. In Ranganathan's conceptual framework, it was a structural pattern of the Loose-assemblage type. Consequently, the subject was being represented in information retrieval tools as a complex subject in the form of either "Chemistry in relation to Biology" or "Biology in relation to Chemistry".

3.2.2 1829-1913: Fission Structural Pattern

The next stage of development of biochemistry can be identified as a part of physiology, chemistry, medicine and agriculture.

It was under the influence of Helmholtz and his school that increasing use of chemistry entered into nineteenth century physiology. It also came under the influence of the cell theory of Schleiden, Schwann and Virchow, which emphasised that the seat of the physiological functions was the cell. By the year 1860's physiologists had established their identity within European Universities to such an extent that physiology, as a branch of study, came to include not only anatomy but also chemistry, biological and physiological chemistry were the areas under which chemical aspects of physiology were investigated. In chemistry, the rise of organic chemistry allowed chemistry groups to study biological problems. In medicine, an area developed under the name of medical chemistry to study chemical aspects of life. Agriculture offered another area under the heading "Agricultural Chemistry", which introduced chemical studies.

Quantitative analysis techniques developed by Liebig; postulation of catalytic nature of fermentation by Berzelius; cell theory of Schleiden and Schwann; isolation of glycogen by Bernard; fermentation theory of Pasteur; Darwin' *Origin of Species;* establishment of starch as a product of photosynthesis by Sachs; crystallization of a protein-hemoglobin by Hoppe-Seyler; Mendel's theory of segregation and assortment of genes; discovery of DNA by Miescher; discovery of the term Enzyme by Kuhn; recognition of enzymes as catalysts by Ostwald; establishment of procedures for staining mitochondria by Altmann; isolation of a hormone by Takamine and Aldrich; coining of the name vitamin by Funk; discovery of dehydrogenases by Batelli and Stern; kinetic theory of enzyme action by Michaelis and Menton; isolation of chlorophyll by Wilstätter and Stolli are some of the major

contributions in the field of biochemistry from physiologists, chemists, medical scientists and agricultural scientists during the period 1829-1913.

It is evident that biochemistry progressed during this period by the process of fragmentation. In Ranganathan's framework, it will be labelled as "Fission". In other words, the structure changed from Loose Assemblage in the earlier stage to Fission. Information retrieval tools, accordingly, had provision for biochemistry under various Basic Subjects.

3.2.3 1914 —: Fusion Structural Pattern

Another vital phase in the development of biochemistry starts in 1914 when Gowland Hopkins was appointed the first professor of Biochemistry at Cambridge University. This event marks the beginning of a new structure, which can be labelled as "Fusion" in Ranganathan's terminology. Attempts started to amalgamate different strands of biochemistry into a unified discipline. In other words, a process of convergence started. An area of biochemistry which had highly successful results after 1916 is "respiration" - the way in which living cells break down the molecules of fats and carbohydrates to produce energy for the organism. Another area which saw the growth of knowledge is about the nature of proteins and in particular that class of proteins now known as "enzymes". Still another area which had a most pervasive and profound influence was the recognition that heredity has a molecular basis. As a result of this recognition, biochemistry is making exciting discoveries into a number of crucial areas of biology - the differentiation of cells and organisms, the origin of life and evolution, behaviour, and human disease. The list of contributions and their contributors from 1916 onwards is too varied and large in size to be covered by this paper.

However, varied and numerous developments in the field after 1916 have made the structure of biochemistry crystal clear. It is a science today which centers around the axiom that all life and its manifestations have a physicochemical basis. In other words, every phenomenon of life has an explanation in physico-chemical laws and every question pertaining to life must have an answer comensurate with the existing laws of chemistry and physics or to be discovered in the future.

Biochemistry today is an interdisciplinary subject. It draws on many different disciplines. Understanding the chemical make-up of life requires knowledge of organic and inorganic chemistry, because all substances present in biological systems are either organic or inorganic. Physical chemistry is required to understand the nature of metabolic transformations. An understanding of morphological structures makes biochemistry related to anatomy, histology, pathology, botany, zoology, microbiology and cytology. Need for understanding biological functions makes it closely related to physiology, genetics, immunology and endocrinology. It has also close relations with physics and mathematics. Being an experimental science, it involves measurements at every stage. Furthermore, it has enormous applications in a variety of areas. It is at the base of modern medicine, pharmacology and nutrition. Its applications in surgery and medical jurisprudence are well known. It has given rise to the science of biochemical technology. Molecular biology is another discipline which is extremely and closely related to biochemistry.

Thus, it is apparent that Biochemistry has evolved today into an independent interdisciplinary subject. Its components and relationships are easily identifiable and well recognized. As such, information retrieval tools are obliged to give it the status of a "Basic Subject", earned well by passing through various developmental stage, and a number of structural changes starting from 'Loose assemblage', through 'Fission' to 'Fusion'.

3.3 Developmental Attributes

Ranganathan by such studies was also instrumental in highlighting some of the developmental attributes of the universe of subjects, viz. turbulently dynamic, infinite and continuum. These attributes also find expression and validation in the works of Kuhn, Price, Machlup and Weiss.

The universe of subjects, in its growth, comes across revolutions which completely overthrow existing pattern and structure. When such a revolution takes place, a new or different paradigm is created. Copernicus changing the paradigm of the structure of the universe and Wegener changing the paradigm relating to the position of the continents can be cited as two illustrative examples. Kuhn's book "Structure of Scientific Revolutions" (37) is a forceful depiction of the idea of scientific revolutions and their role in the growth of the universe of subjects. Another important book is Revolution in Science (38), by I. Bernard Cohen.

The Universe of Subjects is continuously growing. It is infinite. It shows regular exponential growth, with a doubling every 10 to 15 years as presented in the works of Price (39-40). He is of the view that the size of science increases by a factor of 10 with every doubling of the world population". Machlup (41) has suggested four possible standards to quantify knowledge and its growth: documents, people, institutions and expenditure.

The Universe of Subjects is a continuum where "no subject can be developed without its calling for some development in every other subject" (8, p.373). Weiss (42) has tried to show it by comparing the growth of the universe of subjects with that of a living organism.

3.4 Spiral of Scientific Method

Another contribution by Ranganathan in developmental dimension is that of the spiral of scientific method (43). The use of the spiral has been found helpful in the studies on the modes of development of subjects.

4. Conclusion

Lastly, the words of Dahlberg that "it does indeed appear that Ranganathan's ideas and contributions have

thus far not been replaced by any better ones. In fact, they have not as yet been discussed everywhere and there has been little movement towards their adoption throughout the world" (28, p.43), though said in connection with classification, are also applicable to the study of the universe of subjects. Further, the futuristic trend suggested by Yaghmai and Maxim that "librarians could help computer scientists create systems capable of inference by end users by refining the concept of concept representation" (44) is possible only when the techniques of concept representation are continuously refined in consonance with trends and changes in the developmental and structural dimensions of subjects and the universe of subjects as a whole. Ranganathan has only shown the way for it. It rests upon us to test the validity of his ideas, refine and modify them in context of data collected from developmental and structural studies of different subjects.

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