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Taxonomies in knowledge organisation — Need, description and benefits

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This paper is an expression about historical background, current trends and applications of taxonomies. It is based on the published literature discussing various aspects of taxonomies. The survey is based on free text search for the terms: Taxonomy, Knowledge organisation, Knowledge organisation systems, and Knowledge organisation tools in various online databases (Emerald, Taylor & Francis, Wilson web, Science Direct, Wiley online), and Google. Besides online databases some articles were identified from conventional journals and books. A number of periodicals across disciplines cover the subject. After analysis the relevant articles coinciding with the scope of the paper are presented under three categories: need, description, and benefits. The review reveals that the use of taxonomies is being highly advocated by the scholars for the efficient knowledge organization and retrieval of information in the digital environment due to the expeditious and compounded growth of information on the web and the failure of search engines to retrieve the relevant information. The ability of the taxonomies to retrieve the digital information with high precision and recall is unanimously accepted and established beyond doubt. It is also revealed that taxonomies are being implemented in various organizations/web portals across the globe.

Keywords: Taxonomies; Knowledge Organisation; Knowledge Organisation Systems; Knowledge Organisation Tools

Introduction

The organisation of knowledge is hardly a novel activity. The principles for organizing library material have been discussed in the literature at least since the middle of the nineteenth century (Panizzi 1848) and some of the basic principles that are still valid today were formulated in the late nineteenth century (e.g. Cutter 1876). The foundation for classification theory was laid in the first part of the twentieth century with the work of Sayers (1915), Bliss (1929), and Richardson (1935), among others. In the middle of the twentieth century a new bibliographic classification theory and new principles were introduced by Ranganathan (1962; 1967) that further added new principles to the organization of information. The British Classification Research Group further developed Ranganathan's ideas (e.g. Vickery 1960; Classification Research Group 1957) and added to them. The principles for the construction of bibliographic classification schemes laid down by these authors are often used and referred to as the foundation for bibliographic classification theory[1].

The various tools that are being employed in organizing knowledge include: taxonomies, ontologies, schemes for subject classification, thesauri, wordnets, semantic nets, self-organizing systems, etc. These are useful in formulating search expressions and retrieval from databases (including online web-enabled databases) and also in organizing information resources (e.g. documents, non-documentary materials) and their surrogates (e.g. entries in catalogues and bibliographies) in a helpful sequence[2].

Taxonomy is as old as the language skill of mankind. It has always been essential to know the names of edible as well as poisonous plants in order to communicate acquired experiences to other members of the family and the tribe[3]. Although the art of taxonomy and the resulting forms of taxonomic structures are rooted in the works of Aristotle, Linnaeus, and Darwin, the meaning of the term taxonomy has been expanded to cover new purposes. We now use taxonomies for creating metadata, or common words to describe an object, for information

retrieval, categories supporting browse navigation, schemas governing Web page layout and structure, and data control lists used in support of data mining (searching thousands of data records to uncover patterns and relationships contained within the activity and history store to fulfill a reporting request). Examples of these classification systems and the resulting taxonomies vary in structure, composition, and purpose, but they are all organized according to defined principles[4].

Objective of the Study

The objective of this study is to survey different aspects of taxonomies viz., need, description, and benefits, using a literature review.

Methodology and Scope

This paper is based on the published literature discussing various aspects of taxonomies. The survey is based on free text search for the terms: Taxonomy, Knowledge organisation, Knowledge organisation systems, and Knowledge organisation tools in various online databases (Emerald, Taylor & Francis, Wilson web, Science Direct, Wiley online), and Google. Besides online databases some articles were identified from conventional journals and books. A number of periodicals across disciplines cover the subject. Prominent among these are Journal of Documentation, Cataloging and classification Quarterly, Journal of the American Society for Information Science and Technology, Econtent, Online, Information Management Journal, Legal Information Management, Journal of Internet Cataloging, etc. After analysis the relevant articles coinciding with the scope of the paper are presented using three categories: need, description, and benefits.

Need (Why Taxonomies)

The experience of difficulties with cataloguing and retrieving unstructured information effectively is an eternal problem. Not only it has become a pressing issue for generations, there is also evidence to believe that we will always seek better, more efficient approaches towards the ultimate goal of perfect recall and keen precision[5]. An IDC study[6] estimated that the "the digital universe" equals approximately three million times the information in all the books ever written - or the equivalent of 12 stacks of books, each extending more than 93 million miles from the earth to the sun. The study predicts that the amount of information created and copied in 2010 will surge more than six fold, from 161 to 988 Exabyte's, a compound annual growth rate of 57%, nearly 70% of which will be generated by individuals. Taking into account the exponential growth of information and knowledge, in the digital and Internet domains, it is necessary to classify content in some order so that search and retrieval becomes manageable[7, 8] . Art Group's research as reported by Cheung, Lee & Wang[9] has revealed that 80 to 98 percent of all data in all computers are unstructured knowledge such as e-mails, office documents, PDF-files and many other text-based documents. According to IDC Research, 15% to 30% of an employee's time is spent looking for information, and they find it only 50% of the time[10]. Williamson[11] therefore stresses the need for more user friendly interfaces and greater emphasis on human computer interaction to aid the user in achieving successful searches on Internet. Patkar[12] observes that as the Web technology is entering in its next stage called Semantic Web, automatic processing of information to represent semantic relationship between entities or objects in the given context becomes critical. However feasible and sustainable solutions for WWW coverage have been mostly based on pure technological devices with a very low level of semantic processing[13]. Park[14] apprehends that dramatic environment change resulting from the production and exchange of tremendous amounts of Information nearly instantaneously via web has raised concerns regarding the maintenance of precision and recall in the retrieval of information. Although the indexing capability of search engines increases with each passing year- 76% for Google, 69% for Yahoo, 62% for MSN and 58% for ASK/Teoma in 2005[15], the search results are often cluttered with a huge amount of irrelevant information[16]. Riccio[17] believes that even very sophisticated intranet search engines, there is still a need to categorize information and to aid the user in finding the most relevant information. It is reported[18] that the most powerful search engines are able to retrieve only 20% of relevant information from what is available on the web due to lack of organized data and failure to express the inter relationship of ideas. These search engines search for text strings, not concepts, as they do not understand meaning[19]. This has brought in to light the potential of discovery over search. A search engine's main

function is to locate documents based on the user's keywords. A discovery engine on the other hand attempts to extract relevant textual data from a corpus of text and then provides a graphical, dynamic and navigable index[20].

Belkin, Oddy, & Brooks[21] while concentrating on cognitive aspects, describe the constructive process of information seeking in terms of ASK (anomalous state of knowledge) hypothesis. According to them the search for information begins with the user's problem. The gap between the user's knowledge about the problem and what the user needs to know to solve this problem is the information need. The user's ability to articulate requests to the information system can change according to his/ her level of understanding of the problem. According to Eerola & Vakkari[22] the users' habits of expressing their information needs as short queries considerably limit the success of searches, and stress the need of terminological aid to searchers in expressing their information needs for query formulation. The average users only have a vague notion of what they are looking for when initializing a search[23]. Users provide keywords for what they believe a concept might be about when searching digital collections and hope it will match the term used in the subject field of the metadata. The informational queries constitute less than 50% of web searches[24]. The intent behind a web search is often not informational - it might be navigational (show me the URL of the site I want to reach) or transactional (show me sites where I can perform a certain transaction, e.g., shop, download a file, or find a map). The ability to accommodate different users who may approach the same information from different perspectives is an essential feature for a successful information retrieval[25].

Miller[26] therefore stresses the need of controlled vocabularies for resource discovery in networked environments, as controlled vocabularies are typically generated with less controversy, have reduced management burdens and often have greater longevity within the domain[27]. For that reason faceted approaches are now increasingly being applied in web-based applications[28], and have become the de facto standard for e-commerce[29]. Bates[30], drawing on studies of information searching behaviour over several years recommends that information be facet indexed and the searcher helped to use the facets in the interface. According to Holm, Pino, Hughes, Prahst, Jackson, et al.[31] a contextual framework helps to overcome language complexities thus improving such effectiveness. Research has shown that using natural language for defined metadata fields or a controlled vocabulary, result in superior knowledge retrieval and re-use in a classified or clustered knowledge base[32,33,34]. Tudhope, Binding, Jeffrey, May, & Vlachidis[35] believe that controlled vocabularies reduce ambiguity by defining the scope of terms and possibly providing synonyms. Nowick & Mering[36] suggest that for efficient retrieval of information non-subject resource descriptors should be incorporated into the metadata records and thesaurus should be made available to users with many cross-references, broad terms, and narrow terms included. O'leary[37] suggests that for an appropriate level of precision, knowledge management systems need to unambiguously determine what topics reside in particular knowledge bases. According to Chen, Yim, Fye, & Schatz[38], development of effective online information retrieval systems must consider the vocabulary association characteristics of the users. While information systems may change to achieve greater success, they must continue to meet two fundamental requirements of information seekers: to permit users to locate information on a subject directly and to allow them to browse so as to familiarize themselves with a domain or to refine a request[39]. Lai & Taylor[40] point out that searching in the Knowledge Management system can retrieve good results, only if the knowledge is organized and placed in the correct category.

Harper & Tillett[41] point out that various controlled vocabularies, classification schemes, and thesauri can serve as some of the building blocks of the Semantic Web and can be put to great use in the development of robust Web services and Semantic Web technologies, on the other hand. Semantic Web efforts provide an approach to constructing flexible, intelligent information systems[42], as it shifts the emphasis from documents to data[43]. Haravu & Neelameghan[44] conclude that the products of text mining and data mining could be made more useful if the features of a faceted scheme for subject classification are incorporated into text mining techniques and products. Shiri & Molberg[45] surveyed 33 Canadian Digital Library collections to investigate how knowledge organization systems have incorporated into their search interfaces and found that Thesauri, subject heading lists and classification schemes were

the widely used knowledge organization systems in the surveyed Canadian digital library collections. Koch, Golub, & Ardo[46] explored the navigation behaviour of all users of a large web service, Renardus, using web log analysis and found that browsing as an information-seeking activity is highly used (about 80% of all activities in Renardus). Faceted approaches are now increasingly being applied in web-based applications[47]. Uddin & Janecek[48] compared the Faceted Classification System (FCS) interfaces to the existing single-classification system to evaluate the usability of the facets in typical navigation and searching tasks and found that performance and usability are significantly better with the FCS in the areas of efficient access, search success, flexibility, understanding of content, relevant search result, and satisfaction.

The researchers have put forth various approaches/tools for organizing information to achieve improved resources discovery in the digital environment. One such tool that is instrumental for managing increasing records volume is taxonomy: a structured, often hierarchical, classification system of topics or subject categories[49].

Description (What are Taxonomies?)

There is no generally accepted definition of what taxonomies are, though the word is usually used to refer to alphabetico-classed schemes of subject headings. These are built on fundamental principles, which have been more fully developed in their application to thesauri and classifications[50]. Taxonomy originally was developed as a tool for classifying biological organisms. In biology, the assumption is that more homologies two organisms share, closer they must be in terms of evolutionary distance[51]. Chandra & Tumanyan[52] state that Taxonomy as a tool is applied for information conceptualization, organization, and structuring; not only in biological science, but also in Chemistry, Organizational Science, Manufacturing Systems, and many other fields of study. To some it is a hierarchical arrangement of topics[53] and to others it is the science of classification and labeling, or more simply-a law for categorizing information[54].

Taxonomy is associated in one way or another with thesaurus, ontology, classification scheme, controlled vocabulary, or even a dictionary[55]. Miskin[56] observes that taxonomy is very closely related to classification and the terms can be used almost interchangeably, although some ideological bells and whistles are becoming attached to the term 'taxonomy' and it is growing to embrace areas outside the traditional classification of knowledge. However Gilchrist[57] points out that taxonomies, classification schemes and thesauri are different in scope and roles and thus possess different features, though classification schemes have properties that enable the representation of entities and relationships in structures[58]. A taxonomy bears a closer tie to an ontology than a classification scheme[59]. According to Daconta, Obrst, and Smith[60] the basic taxonomic sub-class of hierarchies acts as the skeleton of ontologies, but ontologies add additional muscle and organs – in the form of elaborate relations, properties/attributes, or property values. A folksonomy on the other hand is most notably contrasted from a taxonomy in that the authors of the labeling system are often the main users (and sometimes originators) of the content to which the labels are applied[61]. An examination of the systemic properties and forms of interaction that characterize classification and categorization by Jacob[62] reveals fundamental syntactic differences between the structure of classification systems and the structure of categorization systems. According to Doty and Glick[63] taxonomy is unfortunately used in the literature as a synonym for classification when it has broader implications. In fact taxonomy relates to a process that includes a specific type of classification as a key-defining characteristic. A taxonomic classification focuses on the general laws or principles that describe or characterize the phenomena or system of interest[64]. While discussing the features of taxonomies Bruno & Richmond[65] point out that taxonomies support inferring of additional and related information by users through the placement of resources in context. Reamy[66] categorizes taxonomies into three types: browse taxonomies, formal taxonomies, and a new form of taxonomy/metadata application, and faceted taxonomies, whereas Conway & Sligar[67] categorize them into two types: descriptive and navigational. The definitions of taxonomy, put forth by various authors are given in Table 1.

Taxonomy therefore is a knowledge structure system that is similar to classification scheme and a thesaurus of indexing terms, constructed using the principles of classification, and often used to provide a structured navigational path to information. According to Lambe[83] an effective taxonomy has three key

Table 1—Definitions of taxonomies

Author/s	Definitions
Graef[68]	Taxonomy is a system for naming and organizing things into groups that share similar characteristics.
Woods[69]	Taxonomy is a hierarchy of categories used to classify documents and other information.
Boeri[70]	Taxonomy is a logical organization of information categories.
Zhang & Lee[71]	Taxonomy is a division of a set of objects (documents, images, products, goods, services, etc.) into a set of categories.
Gilchirst and Kibby [72]	Taxonomy is the arrangement and labeling of metadata to allow primary data or information to be systematically managed and manipulated.
Roberts[73]	Taxonomy is a structure that provides users with guidance showing groupings that can emerge from information in many different patterns.
Hedden[74]	Taxonomy is a kind of controlled vocabulary that has a hierarchy (broader term/narrower terms), but not necessarily the related-term relationships and other requirements of a standard thesaurus.
Hanley[75]	Taxonomy is a collection of relevant topics and subtopics arranged in a hierarchical or networked structure.
Corcoran[76]	Taxonomy is a form of categorization that is a hierarchically ordered, systematic list of the subject matter of data, information, and knowledge organized by keyword or term.
Riesland[77]	Taxonomies are controlled vocabularies with more complex structures. Their structures are traditionally built as hierarchical trees and are useful for navigation and browsing because they direct users to a general area.
Chosky[78]	Taxonomy is a high level, hierarchical classification for documents and records that facilitates the management.
Ainsbury[79]	Taxonomy is the division of documents into ordered groups or categories.
Gokhale[80]	Taxonomy in modern parlance, applies to a system or software designed to organize information, so that it may be stored, maintained-and retrieved. It is often, created by referring to thesauri, classification schemes, or indexes, combining the software programme with human intellectual efforts thus providing a means for identifying, locating and retrieving the desired information.
Keshet[81]	The practice and science of modern, formal and institutionalized classification is termed taxonomy. As a classification system, taxonomy generally organizes the knowledge of the world as a tree-like hierarchical structure of broader-narrower, inclusive-included, superclass-subclass, or dominant-dominated relations between concepts.
Chaudhry & Saeed[82]	Taxonomies are composed of same elements of classification schemes and thesauri, but use the two elements in organizational context and for supporting the navigation.

attributes; a form of classification scheme, semantics and a knowledge map.

Benefits of taxonomies

Taxonomies have been used for information modelling, decision making, and performance measuring in different fields. Plosker[84] argues that Taxonomies are based on the long-established world of controlled vocabularies, perhaps the core of information science. While taxonomies are nothing new for librarians, who have been developing and using classification systems to describe the subject matter of their collections for years, taxonomies are now recognized at a higher and broader level[85]. Using taxonomy in the Web search has been proved to be useful to improve the search precision[86]. Samler & Lewellen[87] argue that Taxonomies rationalize the search process and allow users to achieve a greater level of precision and recall. Combined with a superior classification system, a good taxonomy will produce precise accurate results and eliminate the need for users to weed through irrelevant content. Efforts made to organize information into subject classifications, or taxonomies, offer users the opportunity to substantially improve the effectiveness of their search and retrieval activities[88]. According to Corcoran[89] Taxonomies advance information search and retrieval by providing powerful browsing capabilities based on structured content organization and access via point-and-click directories or menu selections. Their hierarchical data relationships allow users to easily broaden or narrow searches as well as to look for related information. Woods[90] puts forth three key drivers for the current level of interest in taxonomies: Information overload, rise of the Web and growing use of unstructured information management technologies. The benefits include: Improved quality, easier navigation, more efficient search, improved information sharing, better user experience, and support for interoperability and integration[91]. Noy and McGiness[92] explain that taxonomies are particularly useful: (a) to share common understanding of the structure of information

among people or software agents; (b) to enable reuse of domain knowledge; (c) to make domain assumptions explicit; (d) to separate domain knowledge from the operational knowledge; and (e) to analyze domain knowledge. According to McCarthy & Keith[93] taxonomy is mainly motivated by two objectives: To introduce structure into a body of facts and to build a unified and homogeneous view of the domain of interest. Hedden[94] contends that taxonomies help bring users and content together, and the many structures and displays of taxonomies help serve different users' needs. Samler & Lewellen[95] argue that taxonomy enables users to discover answers to questions they didn't think to ask.

Trippe[96] believes that the path to improved information retrieval on the Web lies in intelligently applied taxonomies. The need for taxonomy is becoming more and more important with the massive growth of Web sites and intranets, and the constant complaints from both librarians and their customers of information overload[97]. Further incoherent information architecture hinders a web user's ability to access and use corporate information[98]. Adams[99] points out that taxonomies are an important part of what makes the Semantic Web "intelligent." Vocabularies and the relationships that exist between selected terms help machines to understand conceptual relationships as humans do. Woods[100] believes that taxonomies are an important tool in balancing the contradictory forces of information overload and the need for instant access to the right information. According to Holgate[101] by using a taxonomic approach, search precision performance is enhanced in that more efficient organization of content allows for more intuitive searches and only relevant responses are returned. According to Plosker[102] taxonomies are devices that can be used to organize information, thus making it quicker and easier to access. Often these efficiencies can turn into revenue-generating opportunities. Research suggests that Web content can be most effectively served up in a user-responsive way using custom multi-faceted taxonomies[103]. Cisco & Jackson[104] explain that Taxonomies speed up the process of retrieving records because end users can select from subject categories or topics, enabling them to narrow the search field and find relevant information rather than relying solely on the blank text search field and their ability to construct an effective query. Lederman[105] argues that taxonomy allows access to information that is not possible through simple or complex keyword searches, as it brings together common material by relating word relationships and gathering the results in a common bucket. Cisco & Jackson[106] points out that Taxonomies also provide "serendipitous guidance." Samler & Lewellen[107] argue that powerful taxonomy makes searching easier by assigning documents to a category and defining relationships between categories. Pahlevi & Kitagawa[108] demonstrate that taxonomy-based search services can provide a great help for better information searching on the Web search services/interfaces. As it can ensure that the content of the site is categorised and indexed uniformly[109]. Taxonomies are also useful for navigation and browsing because they direct users to a general area[110]. Hlava & Eman[111] present ten reasons for organizations to create taxonomy and conclude that a good taxonomy can save staff time, organization time and money. Earley[112] believes that Taxonomies need to evolve and grow with the changing needs of the organization and the changing information and technology landscape. According to Chosky[113] taxonomy can further a wide range of corporate objectives, such as enabling business processes, protecting intellectual property, and building the foundation for compliance. Bridges[114] argues that with out a well developed and constantly evolving taxonomy, including a thesaurus and predefined metadata capture, the best Enterprise Content Management technology is useless. Reamy[115] advocates, combination of taxonomy and Enterprise Content Management (ECM) together as it can get greater value out of each and the synergy creates even more value. Hlava & Eman[116] believes that enterprise taxonomy can get everyone in the office searching via the same language, even if they don't speak it the same way all the time. As it becomes the common language upon which the content management and architecture rests, regardless of the organization's intended venue, whether it's intranet, extranet, open Web, or portal[117]. Taxonomies can also be used to group together terms in separate languages so a search for an English topic, could also retrieve all material on the French/other equivalents of the term[118].

Hunt[119] believes that information professionals have skills that can be adapted and applied to help organizations that are desperate to find their information assets (paper, digital, knowledge) in

information overload reality. LIS professionals can serve as business consultants in identifying the appropriate practice of organizing corporate knowledge[120]. However it is depressing to note from the TFPL corporate taxonomy research results of 2000 that librarians are not always consulted over the development of taxonomies[121]. Corcoran[122] argues that as the corporate library doors have closed for information professionals, the taxonomy (or content management) window has opened. Lin & Chan[123] explain that information storage and retrieval methods used by library professionals over the last century have much to offer in the digital environment. However Jansen & Pooch[124] caution that simple comparisons between traditional library services and the performance of Web search services can be misleading and is of little use because the Web is a new search environment requiring its own metrics and methodologies, independent from traditional information retrieval and OPACs

Conclusion

This paper is based on a literature review on taxonomies using free text search. The review reveals that the use of taxonomies is being highly advocated by the scholars for the efficient knowledge organization and retrieval of information in the digital environment due to the expeditious and compounded growth of information on the web and the failure of search engines to retrieve the relevant information. The ability of the taxonomies to retrieve the digital information with high precision and recall is unanimously accepted and established beyond doubt. It is also revealed that taxonomies are being implemented in various organizations/web portals across the globe. In business organisations taxonomies are believed to advance a wide range of corporate objectives. The involvement of users and the role of librarian's in the taxonomy design is highly advocated.

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