

Analysis of Knowledge Organization Systems as Complex Systems: A New Approach to Deal With Changes in the Web*

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ABSTRACT: Knowledge can be understood as the axis of a complex system in which human beings must make decisions. Since the Web has become the tool to channel knowledge organization and management, new elements, rules, aims, processes, and ways to interact come into play. The result is the emergence of a new reality that involves the adaptability of human beings. The new tasks that knowledge organization has to face are the identification of changes, the problems that those changes cause, and pointing out possible solutions for that. Turning to the theories of complex systems and the theory of organizations could be very useful to be able to make predictions and prescriptions in the scientific research about knowledge organization.

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1.0 Knowledge, organizations and decision making

Knowledge organization is a field that brings together contributions from different scientific disciplines, and for this reason it can be analyzed from various perspectives. From diverse thematic fields, both theoretical and practical knowledge are received to design systems to process information, and these contributions could be structured in three different levels: a) those oriented to achieve goals, b) those related to the selection of the most appropriate processes, and c) those connected with the criteria to be applied to the evaluation of the results (Gonzalez

2007). Within the various thematic areas involved in knowledge organization, most of the research focuses on the first two aspects mentioned. That is, the largest research effort is concentrated in the design and development of more efficient processes aimed at representing, processing, and spreading knowledge on a large scale. Furthermore, as far as technology progresses, the objectives to be reached are expanded to make them more and more ambitious.

Nevertheless, once the desired results have been achieved through more and more sophisticated processes, the task of evaluating the consequences of all that effort has to be resolved. And to do that, an

overall revision has to be made from a holistic perspective that would make it possible to distinguish if the new way in which knowledge is organized merely gives access to any kind of document or, as it seems, goes farther and causes considerable changes in different aspects of human beings. Social, political, and financial criteria applied to determine the necessary lines of research in that field will be derived from the evaluation of such results.

This paper is intended to highlight the role that knowledge organization plays in the operation of a wider system in which all kinds of interactions among three main elements take place: knowledge, human beings, and automated systems. The result that develops from that dynamic relation will be interesting to predict. From this approach, and considering knowledge organization as an activity aimed at a purpose, the result of such an activity could be defined as a set of elements that allows human beings to carry out a function that is essential for them: to make decisions.

In this way, the activity of organizing knowledge constitutes a basic part integrated in a complex system in which three main issues can be mentioned: a) the object that gives content to these activities—knowledge, b) the context that constitutes the frame of reference—organizations, and c) the aim to which the result of this activity is applied—decision making. Any of these three components could be considered as individually complex. But if we also consider all of them as a set of elements that interact with one another in a dynamic way, as the components of a system, then the level of complexity increases to levels that are difficult to predict.

1.1 Knowledge as an object

In practice, knowledge can be understood in several different ways. First, it is primarily considered as the cognitive process (neuronal) that takes place in the human brain that allows people to assimilate to new information. The mechanism consists of interpreting that new information from the cognitive contents previously acquired. Secondly, the word knowledge is used to represent that information that has been assimilated by a person and that he or she has given expression to in some way. Finally, the third kind of distinction refers to the different nature of scientific knowledge (as the objective representation of the reality) and subjective knowledge (which comes from the interpretation that people make of the information they are given from their culture, beliefs, etc.).

Among the changes that are taking place in relation to knowledge, and that are relevant to our purposes, two could be mentioned. On the one hand, the task that professionals from the information science field have been developing traditionally was that of taking documents at user disposal, whatever the kind of document, information or knowledge. Nevertheless, the development of communication and information technologies, together with the design of new processes to represent, process, and retrieve information, has led to the prosecution of a more ambitious aim: to have the capacity to intervene directly in the processes that cause cognitive changes in people. As an example, we can mention the development of intelligent interfaces that are able to identify the mood of users and modify it. On the other hand, before the existence of the Web, scientific knowledge was processed and managed separately from other types of knowledge, and by means of different channels. Nowadays, attempts to develop a system for semantic content retrieval requires that the knowledge contributed by individuals from the so-called “social networks” are integrated with those that occur as a result of scientific activity.

1.2 Organizations as context

The second element mentioned previously is related to the environment in which knowledge is generated. Organizations are the conditioning framework for human beings in the acquisition of knowledge and decision-making, because organizations provide the context in which individuals shape and develop their qualities and habits. It is indeed in the social environment where people grow, live, and work, where they acquire their knowledge, preferences, and loyalties. Therefore, it is not unusual to see that the values and objectives that guide people's decisions coincide to some extent with the goals of the organizations in which they take part (Simon 1997a). The behavior of each person and the effect this will have on others are functions of their position within an organization—family, social, occupational, cultural, religious, etc. (Simon 1997a). Needless to say, one organizational structure is often integrated into another, which integrates with others, resulting in a complex network of interactions.

It is precisely this configuration of groups which creates aspects where it is most difficult to predict the changes that are taking place in the system we are defining. With communication through the Internet, traditional organizational structures are giving way

to new forms of identification and, therefore, to new forms of interaction that are channeled through social networks. In these networks, people share values, criteria, and knowledge, bringing about major questions for the future.

Furthermore, the size of the organizations to which a person belongs—family, company, social group, etc.—has allowed him or her to be responsible for the assignment of a role within each group and the imposition of behavioral standards. The extension of a collective to an almost global scale exceeds the capacity of an organization to impose standards or rules on the group. In this new context, some concepts such as space, time, freedom, competition, collaboration, and authority acquire new shades and dimensions as they have never been seen before.

1.3 Decision making as a goal

The third outstanding aspect to consider within this complex system is decision making, the process to which the results of knowledge organization are applied. Human beings certainly try to achieve wider knowledge to be able to make higher quality choices, and those decisions are usually aimed towards an action. Therefore, it can be said that organizing knowledge is a first step within the system in which people try to aim their actions, both on individual and social levels.

One of the most important contributions to decision making theory was the one made by Herbert A. Simon—Nobel Prize winner in economics in 1978, and one of the pioneers in artificial intelligence together with Allen Newell. Before decision making, Simon said that, as human beings, we fail to optimize our choices because our rationality is bounded. For this author, the choices we make are determined not only by the fixed goal, but also by the knowledge of the world that those who are going to decide have or have not, for their ability or inability to remember that knowledge in the moment it is relevant, for their capacity to take into account the different possibilities of action, as well as the capacity to cope with uncertainty (including the uncertainty arising from the possible responses of other people), and for the possibility of achieving harmony among multiple desires in competition (Simon 2000).

Therefore, there are cognitive boundaries, although we could also consider the motivating limitations that are mentioned by Reinhard Selten (Bonomo 2009). Precisely, in this definition of human boundaries for making decisions we can identify a list of tasks that

are being assumed by automated systems to process information: storing, organizing, analysis, and retrieval of relevant knowledge. These tasks are aimed to face up to decision-making in a situation of human uncertainty.

Because of technological and computational advances that have been developed in recent decades, some of the problems posed have been solved, but, certainly, some other more complex problems have been generated. As Simon himself anticipated (1997), interest in improving the operation of organizations and information systems is no longer a matter of having more information available, but of being able to attract the scarce capacity of attention of human beings so that they can focus on the most relevant information related to the decisions they have made (Simon 1997c). Computers increase computing power, but human beings still have the same capacity to assimilate knowledge.

At the present time, we are still learning how to recognize the new problems that are being dynamically generated. Changes in the three levels mentioned above (the new ways in which knowledge is being generated, the different organizational context in which humans develop, and the widening of the capacity to cope with decision making by artificial means) are making up a new reality that needs to be analyzed as a whole. To do so, I think it could be useful to turn to approaches provided by the science of complexity and organizational theory.

2.0 Contributions from complexity theory to the study of dynamical systems

Analyzing the way a complex system behaves is not an easy task. In fact, not long ago, those systems whose behavior it was not possible to predict were considered “chaotic.” It was about 30 years ago when chaos theory moved to theories of complexity, a set of postulates that, under the name of science of complexity, try to describe those systems whose behavior seems not to comply with rules. There are two key terms to understand complexity: i) interaction, and ii) evolution. Here, interaction means that the relation between two variables could be modified by the value of a third one. In this sense, within this kind of phenomena there exists a complex causality, because the results are not determined by simple causes but by means of complex reasons, and these reasons do frequently interact in a non-additive way. In relation to the concept “evolutionary,” it refers to the fact that we are dealing with processes that are fundamentally

historical: they are not reversible or capable of being repeated in time (Byrne 1998). With the new perspective proposed by theories of complexity, life is seen as an evolution taking place by means of a continuous tension between competition and cooperation. Competition, itself, is not enough to guide complex systems to success. From this point of view, a bigger exit could be reached when cooperation among the different elements takes place (Axelrod 1997).

In the description of the system aimed at decision-making, we are dealing with the interaction of two kind of elements: a) artificial—designed to give answers to practical questions, and b) social—users mediated by knowledge. In this sense, the operation of design artifacts is easier to understand, precisely because it is an elaborated complexity. In the case of social components, we have to face situations where description is extremely difficult to carry out. On the one hand, instability is practically the rule in its operation and, on the other hand, situations are usually different, so it is very difficult—if not impossible—to determine regularities or laws in terms of natural sciences (Bertuglia and Vaio 2005).

In addition, there are other aspects to consider related to communication that could help us to increase our understanding of the complexity of the system. On the one hand, communication is carried out through the Internet, a highly complex net of computers, build by means of autonomous nodes that self-organize without a central mechanism of control. On the other hand, human communication is not limited to information, but also intuition and implied feelings and emotions, and they have to be considered as sources of complexity in relation to human beings (Mainzer 2007).

In my view, within the realm of knowledge organization there are several kinds of complexity, some belonging to the inner sphere and some others belonging to the outer. In the first case, there are complexities related to information systems: a) complexity about information itself—or knowledge in some cases—(information science deals with it); b) complexity in relation to the design of informative systems (in this case, computer sciences has a main role); and c) complexity about the feedback taking place due to the interaction between users and systems (here, disciplines about visual design, usability and accessibility intervene) (Bonomo 2011).

On the other side, within the outer sphere, complexity coming from the interaction between some users and others is generated; human beings could be exposed to continuous changes in their circumstances,

needs, and interactions. As users share acquired knowledge and their experiences in decision-making with each other, they generate new aims, new needs, and new circumstances, and those are turned into different ways to use knowledge, to identify with a group or diverse criteria to accept and share rules.

Therefore, we are talking about a system whose dynamical behavior causes emerging features which could not be understood without a reference to the relations that take place among their components. The approach of research in complexity deals with the ways in which systems change and evolve with time due to the interaction of their constitute parts.

I think that the description of how those changes happen from the approach of adaptive complexity shows very skillfully the evolution observed in matters related to knowledge organization into the Web. A complex system of such nature is continually changing, and it mainly does it through self-organization, which is a property that allows it to change its inner structure for a better interaction with its environment.

Those changes could be carried out according to three different kinds of transitions: 1) Sometimes, self-organizing allows the system to learn through gradual and little systematic changes in its inner structure. 2) Occasionally, outer strengths or inner disruptions move a system that was previously about to become more organized towards a considerable lack of organization. 3) In other cases, some systems are capable of balancing randomness and stagnation. Instead of generating a crisis from time to time, a system can reach a critical point where its inner structure is on the edge of collapse but without getting to that end. Here the speed of inner reorganization is too fast for the system to adapt, but necessary to its consequent survival (Manson 2001).

Defining the boundaries and the components of a complex system is problematic, but also necessary. The combination of this approach with other perspectives focused in questions, like social and cultural organization, could bring light to the study of the evolution of the system we are dealing with here.

3.0 Theory of organizations as a frame to interpret the new context of knowledge

Understanding the complexity of a system involves analyzing how that system organizes itself. Herbert A. Simon and James March are two authors that made important contributions to the theory of organization. In fact, their book titled *Organizations* was first published in 1958 and had a second edition

35 years later, in 1993. Herbert Simon was interested in procedures to increase information within organizations, but also how to get organizations more and more adapted to an increasingly complex world (Simon 1971). It is supposed that organizations are adaptive nets (Dow 1990), so they have an evolutionary component. Therefore, we are dealing with a basic structure through which human beings develop their interactions. Organizations are responsible for storing and passing on both information and knowledge, so that human beings can fill their informative gaps and reduce their uncertainty (Simon 1997a).

When Simon tackles the boundaries of rationality in decisions made within organizations, one of the aspects he considers most relevant is communication. In fact, without communication, there would not be organization, because it forms from people interacting to share goals. But, for this transmission mechanism to work properly, some questions related not only to the design of communication forms, but also to the behavior of individuals that comprise the group, have to be considered.

From my point of view, the analysis he makes regarding communication forming within organizations is an interesting starting point to study the changes that new ways of accessing knowledge through the Web are bringing about. Revising Simon's description of the functioning of organizations helps to identify a group of key elements and behavior guidelines whose evolution could explain the organizational trends in the new technological context (Simon 1997a).

On the one hand, Simon distinguishes between two communication systems within organizations: formal communication and informal communication. Formal communication is the result of a conscious and deliberate organizational design, and its aim is to control the social division of knowledge so as to coordinate decision-making from the highest positions in an organizational hierarchy. Nevertheless, informal communication generates in a spontaneous and natural way in social relations among individuals that are influenced by their own personal goals. It is precisely because of the people in the origin of informal communication channels that these channels could reach an essential relevance with time. Thus, together with cognitive factors, there are motivational and emotional elements that influence both the emission and reception of transmitted communications. Personal motives could induce the members of an organization to try to modify the communications systems to their own interests.

Authority is another of the key concepts that is evolving in the new context of knowledge organiza-

tion, because the role of authority within organizations is essential to explain the running of communication processes and decision making. From the point of view of practice, authority could be understood in two different ways: as the one that people recognize in a person by his/her condition (*uctoritas*) or as the power that has been given to a person and allows him/her to impose his/her criterion on those that the others have (*potestas*) (Bonomo 2009).

A person who does not hold the status of expert or who has not been recognized as an expert in some specific knowledge domain by the members of an organization would have more difficulty trying to convince an interlocutor about recommendations than someone holding "expert" credentials. Recommendations are judged not only based on the merit of their content, but also partly on the basis of the merits of people who make the recommendations. This is one of the reasons that explain why—on traditional organizations—those recommendations coming from the outside of authority hierarchy or being transmitted from different channels than the usual ones are not easily accepted. But due to the new ways of accessing knowledge through the Web, this is one of the aspects whose evolution is causing major uncertainties when one considers the future.

Besides, together with the problem of authority, another relevant element could be mentioned: the problem of coordination. Simon and March define organizations as systems aimed to coordinated action between individuals and groups where preferences, information, interest, or knowledge differ. Theories of organization describe the delicate conversion of conflict into cooperation, the mobilization of resources, and the effort of coordination that make easier the survivor of an organization and their members as a whole (Simon and March 1993). This need for coordination is given in practical terms: people act by being guided by their expectations about the behavior of the other members of the group. That is, coordination is necessary on those situations where the proper action for a person depends on what other people decide to do (Simon 1997b). Thus, coordination emerges as a practical necessity, aimed to render the behavior of people as stable as possible and, therefore, predictable. Within the framework of the World Wide Web, this need of coordination becomes even more obvious, since the boundaries that organizations establish have been largely overcome.

Turning again to the holistic approach, it could be said that, in addition to the way in which information is processed, the cooperation of people involved

in organizations will contribute greatly in determining the decision-making process. The fact that Herbert Simon had been witness to technological developments related to the processing of natural languages and that he contributed to the application of cognitive psychology to artificial intelligence help to bring about his broad vision of the role of knowledge management within organizations. On the one hand, he considers that there is a part concerning the human condition that basically has not changed. But, on the other hand, he warns that nowadays it is at a different level because now humans must calculate the consequences of their own actions in a more direct way, and it is precisely because of the huge amount of information to which they now have access. As a consequence, we have to learn how to deal with this new responsibility (Simon 1997a).

4.0 Conclusions

To give an answer to the questions arising within knowledge organization, it has a special interest to study the evolution of the system in which it is integrated through time. This interest is justified by the fact that when we are able to identify repeated behaviors, it is possible to make predictions about the behavior of the system in the future. From this knowledge about the future, we could generate new patterns of action to be able to solve set out problems or, even, to anticipate the ones that could arise later. This is the task of prescription (Gonzalez 2007).

The various disciplinary fields that make contributions to organizing knowledge converge in the realm of sciences of design. And although every one of the different scientific aspects has an individual development, there is a closer relation between them that brings about shared tasks. This means that, for instance, the design of technological tools and systems to process information draw specific limits about what is possible to reach. In this sense, prediction is feasible to some extent.

Nevertheless, the human component involves a more difficult predictive task. Knowledge organization takes place in a social context, and uncertainty is one of the inherent characteristics of modern, open society. Uncertainty not only has its origin in the absence of information or in the lack of knowledge, but it also occurs from the strategic and institutional features of networks that articulate and process problems (Koppenjan and Klijn 2004).

With the advent of the Web, the outlines of organizations are being blurred, giving way to new forms of

identification and grouping. Although the organization within the knowledge management systems—mainly the Web—and the interaction between users does not follow a preconceived scheme, it could be said that, within that digital space, they try to self-organize. In that way, they try to reproduce the same organizational structure they have in their social lives. If we are able to make predictions and prescriptions about the behavior of human beings in specific contexts, perhaps we could do the same within this new environment in which knowledge is shared.

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