KNOWLEDGE MANAGEMENT, ORGANIZATIONAL INTELLIGENCE AND LEARNING, AND COMPLEXITY

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Contents

Summary

This theme explores the topics of knowledge management, organizational learning and complexity. At the core of this theme is our knowledge of the increasing complexity of natural and human systems. The theme provides insights into emerging scientific views of the evolution of complexity in the universe. The increasing complexity of human systems is examined via a review of the implications of increasing complexity for scientific understanding and methodologies, for human institutions and for individual humans.

The growing demand for managing the knowledge resource and developing learning organizations emanates from the increasing complexity of the social realm. The management of knowledge and learning is thus integral to the creation of human organizations and institutions capable of handling modern complexity. The systems of knowledge management and learning are also essential to developing organizational constructs that employ economic models that are responsive to sustainable development and global ecosystem maintenance. Thus the importance of this theme is evidenced by the intimate connections between increasing global complexity and the human capacity both to manage knowledge and learn from that knowledge, and to develop means for

integrating complexity and human knowledge into organizational systems that respect the planet's natural resources and the requirements of sustainability.

1. Introduction

The role of humanity in maintaining the life support systems of our planet must be seen within the natural complexity that exists in our universe and within the human institutional patterns that affect the planet's life support systems. This understanding is essential to an appreciation of the theme of "Knowledge Management, Complexity and Organizational Learning." At first glance, the reader may question the linkage between the three fields grouped in the theme. While knowledge management and organizational learning concern the management and purpose of human institutions and the management of the body of human knowledge, complexity represents a larger universal process that drives much of the natural evolution of the universe. However, the linkage between these three fields of study is quite intimate. In fact, it is the tendency towards increasing complexity in natural and human systems that necessitates the need for managing the knowledge resource of humanity and for developing institutions in which learning is valued and rewarded. In short, the evolving complexity of the human condition requires that humanity better manage its knowledge resources while producing institutions capable of handling the increasing complexity of the challenges faced by individuals, nation-states, and humanity.

Considerable attention in this theme-level paper is devoted to scientific discoveries in the natural sciences. This is due to the fact that these discoveries are responsible for many of the views now emerging concerning social and organizational evolution. Furthermore, these discoveries from the natural sciences increasingly serve as a link with the social and organizational sciences that provide new insights into the commonality of natural and human processes. An improved understanding of these important linkages can aid in the process of understanding the challenges to and the prospects for sustainable development on the planet.

2. Defining Complexity

"Everything is simpler than you think and at the same time more complex than you can imagine".
(Johann Wolfgang von Goethe)

Since it is the tendency toward increasing complexity in the human realm that energizes the need for managing knowledge and for producing "learning organizations," we must first examine and define the concept of complexity. Human beings have attempted to define it throughout human history. Early efforts to understand the complexity of the natural world led to what we now view largely as mythology. For example, if we did not understand the complexity of the earth's weather, rain might be explained, as it was in early Greek mythology, as "Zeus pissing through a sieve." Or, before our recognition of the earth's spherical shape, the planet was seen as a flat plane with edges. The unfortunate soul venturing too close to an edge would suffer the fate of falling off into the unknown of a cosmic abyss.

In contemporary times, however, scientists have begun to make serious efforts to examine the nature of complexity itself. This has led to the recent development of what are now called the "sciences of complexity." These emerging sciences represent multidisciplinary and inter-disciplinary efforts to understand both the nature of complexity and how it has evolved in both natural and human systems. While there is debate as to when this modern effort to examine complexity began, it is clear that a growing number of scientists across the natural, social, and organizational sciences are devoting considerable efforts to understanding the complexity of our world. In many ways these efforts remain in an embryonic stage as scientists attempt to develop a body of knowledge about complexity that can lead to applications of these emerging sciences that can aid humanity and the life support systems of our planet.

One of the greater challenges facing those interested in the sciences of complexity involves the creation of a generally accepted definition of the concept. This has been a difficult challenge, indeed. Some scientists have suggested what is referred to as "algorithmic complexity" as a means for defining what is genuinely complex. This view holds that the length of the mathematical formula required to explain a natural or human phenomenon would serve to define its relative level of complexity (see also "Formal tools for exploring complexity"). This would mean that, for example, the mathematical formula required to define the organization the United Nations would necessarily be longer than the description of a ten-person small business organization. This method for defining complexity however fails when the relative skill of the mathematician involved is considered. In brief, two different scientists may have formulas of varying length for either the United Nations or a small business organization.

Another definition of complexity that has been offered has been labeled "computational complexity." This view holds that the time a computer takes to compute a problem determines the complexity of the system under investigation. One would naturally assume that the computer program required to define the United Nations would require more computer processing time than that required to process the description of a small business organization. This definition also fails however, since a more efficient program of the United Nations might take less computer processing time than a very inefficient and slower computer would take to process the description of a small business organization. Thus definitions of complexity have been hindered by "context dependence," meaning that the type of methodology used will result in the perceived degree of complexity of a natural or human system. Clearly, this situation creates real problems for creating a generally accepted definition of complexity.

One other definition of complexity may serve as the definition that best connects complexity with our understanding of the creation and maintenance of the earth's life support systems. This proposed definition is quite simple. Let us define complexity as the degree of human ignorance of a system. This definition means that the less we understand about how an organism, a planet, or a human being behaves the more complex the phenomenon. In short, medical doctors understand the functions of the kidneys and how they work, but the more complex human brain remains a vast mystery. This definition is critical to our understanding of the earth's life support system because it brings a sense of caution and responsibility to human interactions with the biosphere. We simply do not have a thorough and deep understanding of the intricate workings of the planetary biosphere. While we understand many of the parts of the ecosystem we are not sure how all of these parts fit together. Thus, in many ways we remain ignorant of the planet that houses humanity. This ignorance and thus the complexity of our planet require that humanity proceed with caution when we degrade the air and denude the forests. We simply do not know what might happen and when, if we continue to treat the planet as if it is immune to the excesses of industrialization and expanding human populations.

Contemporary students of the sciences of complexity have though established a set of rules that seem to define how complex systems behave (see also “General features of complex systems”). These behavioral rules are nonlinearity, emergence, and self-organization. Nonlinearity refers to the capacity of natural and human systems to generate amplified effects (see also “Mathematical structures of complexity”). This is a result of the disproportionate relationship between cause and effect, which means that seemingly small causes can generate large effects. The often used metaphor that “the flap-ping of a butterfly’s wings in China may cause a tornado in the United States” explains this point. We also know that, as Jay W. Forrester has noted, “we live in a highly nonlinear world.” In nonlinear systems the relationship between variables may not be stable, thus providing the potential for change and surprise. The nonlinearity of complex systems thus also raises a cautionary note concerning the implications of the human/environmental interaction. What might seem like a relatively small disruption to the environment could lead to large global consequences. The global AIDS pandemic is such a case in point. The pandemic has spread globally and in large proportions and represents how nonlinearity can lead to large-scale problems requiring global efforts for solutions.

The concept of emergence refers to the fact that complex systems can generate new and unique forms of behavior and structure. For example, if we consider a human organization as a complex system we know that such organizations create new forms and structure sometimes without human intent. The process of evolution creates emergent form and structure as speciation occurs, leading to the novelty that occurs in nature. Emergence thus is necessary for the creation of novelty in human and natural systems, and also suggests that surprises are a basic component of human and natural systems. Quite often, we simply cannot predict the outcomes of human actions, even if these actions are well intended. As the disproportionate effects of nonlinearity emerge, humans must often simply watch events unfold. This understanding again raises a cautionary note about humanity’s responsibility for sustaining the planet’s life support systems. We simply cannot be sure what will emerge from human interaction with the environment. The reality of our world is that this is a fundamental component of the human condition. This point also emphasizes the importance of both properly managing humanity’s knowledge resources and building human organizations and institutions that enhance learning. Only by better organizing what we know and how we produce learning can we hope to handle the complexity of the human/environmental interaction.

A final common behavioral element of complex systems is self-organization. This term refers to the ability of natural and human systems to break-up during periods of instability or crisis and reformulate into their previous structure and in some cases produce novel forms. What we see as complex systems, whether they are fisheries that have been decimated by over-fishing or human organizations that survive and are rejuvenated after crises, seem to possess the capacity to renew themselves. At the human organizational level, consider how the nation-states of Japan and Germany have managed to renew themselves after the devastation of the Second World War. Critical to this understanding is the closely aligned concept of autopoeisis. This term, first presented in 1973 by the Chilean biologists Humberto Maturana and Francesco Varela, refers to the ability of living systems to constantly renew them-selves and maintain this process such that their structure and integrity is sustained. Consider that the human body is constantly replacing cells throughout the body necessary for survival. Or, consider that an octopus after suffering a detached tentacle can grow a replacement tentacle. What becomes essential in either self-organization or autopoeisis is the "process" of self-renewal. A more detailed knowledge of these processes of self-renewal may help humanity better cope with the challenges of maintaining the earth's life support system. Knowledge of self-renewal thus has the potential to help us better handle both ecological challenges and the challenge of improving the material conditions of the great mass of humanity.

3. The Evolution of Complexity in the Natural Realm

"You cannot reverse the evolution of the universe, even theoretically. And you cannot predict its future, except in terms of scenarios that depend on never-ending series of … crossroads in the chain of causality" (Ilya Prigogine).

To fully understand the intimate connection between complexity, knowledge management and organizational learning we must trace the evolution of complexity on our planet. It is this process of evolving complexity that places humanity in its current dilemma concerning issues of sustainability and maintenance of the earth's life support system. By fully understanding this historical process of the increase of complexity on our planet we begin to appreciate not only how the need for knowledge management and organizational learning has arisen, but also why these human institutional needs are necessary for enhancing and promoting sustainability.

From the beginnings of the known universe, created by the "Big Bang," we can trace the evolution of complexity in the universe. The simple fact that the result of the Big Bang was the formation of multiple galaxies and, in our own solar system, multiple planets shows an inherent tendency toward organization in the universe (see also "Hierarchy and complexity in physical systems"). While the ancients often saw the universe as ruled by the horror of Chaos, modern science focuses on the general patterns within known systems. It is the recognition of these patterns that has also energized the contemporary sciences of complexity as scientists across a variety of disciplines search for similarities across natural and human systems. Just as the ancients wondered about their place and role in the universe, contemporary scientists wonder about what properties and principles of nature have created the amazing array of natural systems and human cultures that have evolved on our planet.

Prior to the twentieth century, Western science was largely dominated by the worldview of the remarkable genius of Sir Isaac Newton (1642–1727). Newton's scientific worldview saw the universe as predictable and orderly. His recognition that planetary motion could be tracked and planetary locations predicted with mathematical accuracy revealed to him that the universe was a rather orderly and mechanical province. For Newton the world functioned much like a clock: mechanical, predictable and stable.

This led Newton to the view the dominant force in the universe was equilibrium, or stability. In this mechanical universe change was rare and the maintenance of order the primary goal. Newton's view helped to generate the notion across all of the natural sciences that stability, order, and organization represented the known universe. The natural realm was surely a predictable one.

In the nineteenth century another important discovery profoundly shaped scientific thought. This was the discovery of the Second Law of Thermodynamics, now often referred to as the entropy law. This view holds that closed systems, those without energetic input from the external environment, will tend over time toward disorder.

Organized and closed systems, in short, will eventually decay into disorder and disorganization. This process of decay is a process embodied in time. Time becomes the enemy since time serves to denigrate living and non-living things.

The apparent universality of the Second Law of Thermodynamics would also lead to the death of the universe as it loses heat and energy and decays into a frozen lifeless mass. This tendency toward the heat and energy loss of entropy would eventuate in a static equilibrium devoid of life and form.

Scientific discoveries during the twentieth century however forced a reconsideration of both the Second Law of Thermodynamics and of the Newtonian notion that balance and order were necessary for the maintenance of our universe. What these discoveries revealed was that the Second Law and Newtonian mechanics worked well when applied to simple and closed systems.

However, when scientists began to examine more complex and open systems that were open to energetic input from the external environment, they discovered that these systems behaved in very different ways from those the Second Law or Newton's mechanics would suggest.

The human body, for example, is an open system in which humans require food, water, and oxygen from the external environment for survival. Thus, while Newton's mechanics and the Second Law helped to explain the nature of simple mechanical systems, these approaches provided little help in understanding the behavior of more complex systems.

As twentieth-century scientists began to examine complex and open phenomena such as the earth's meteorological system or the dynamics of human groups, the work of previous centuries seemed to provide little guidance.

A seminal discovery in the twentieth century that forced a rethinking of both Newtonian mechanics and the Second Law of Thermodynamics was the study by physical chemist Ilya Prigogine (1917– present; Nobel Laureate in Chemistry, 1977) of chemical systems open to their environments, which he labeled dissipative systems (see also “Complexity in chemical systems”).

Prigogine discovered that when certain chemical compounds were pushed to a state of instability or disequlibrium, both internal and external disturbances would amplify nonlinear interactions, and push the compounds to a state of disorder such that the organization and structure of the compounds broke apart.

These compounds could then evolve in varying ways, one of which was towards disorder and decay. Yet, in some cases Prigogine found that over time these compounds would reorganize into new and unique structures.

In short, what Prigogine had discovered was one of the founding principles of the concept of self-organization. Through both internal and external disruptions to the chemical compounds, these compounds would move through periods of profound instability and disorder, or cascades of chaos, but somehow reach new forms of structure and organization.

Prigogine labeled this phenomenon “order through fluctuation.” This discovery had a profound effect on students of the sciences of complexity. Prigogine showed that natural systems have the potential for profound renewal and recreation via a process of destabilization and reformulation.

Thus, the process of destabilization and disorder did not necessarily lead to decay and destruction. Instead, disequlibrium could lead to new forms of organization and structure.

A graphical method for understanding the processes Prigogine enumerated can be seen in Figure 1. This figure is referred to as a “bifurcation diagram” and is commonly used in the complexity sciences to display the evolution of complex systems. As the branches on the diagram move towards greater complexity and away from equilibrium, these branches increase.

At the nexus of each branch is a point referred to as the “bifurcation point.” At each of these bifurcation points complex systems cascade through periods of instability and disorder before new and different evolutionary pathways develop. What is also of interest in Figure 1 is that each of the curved lines between bifurcation points can be seen as periods of relative stability.

The most remarkable aspect of the diagram is that the periods of stability become shorter and shorter as complex systems evolve through the process of bifurcation. Thus complexity breeds greater complexity by increasingly short periods of stability punctuated by bifurcation points leading to instability and potential qualitative change in the complex system. The metaphor of the bifurcation diagram has profound meaning for studies of complex systems since it shows that the evolution of complexity is a continuous phenomenon generated by instability and symmetry breaks that lead to new forms of behavior and structure.

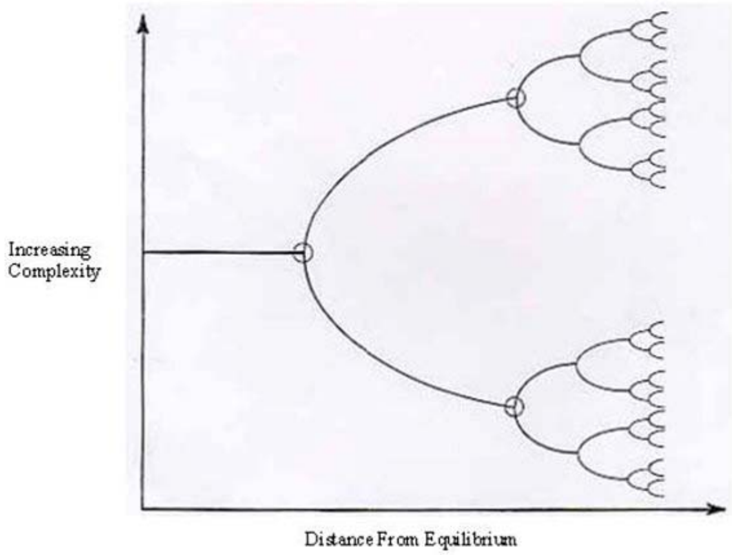

Figure 1: Bifurcation Diagram

Figure 1 thus provides a graphical means to show Prigogine's insights into the functions of instability and disorder in complex systems. Instability and disorder can thus potentially lead either to greater order and organization or towards increased decay and greater disorganization. Moreover, Prigogine's work showed that uncertainty was a critical element in the evolution of living systems. It is uncertainty that provides the multiple possibilities, the openness that generates the potential for fluctuations, bifurcations, and positive change. Yet, in an uncertain world we also lose the confidence that human action will always be for the better. This understanding has profound meaning for the sustainability of planet earth. The uncertainties inherent in the human/environmental interaction may lead to pathways of environmental stress and decay that limit the planet's capacity for sustaining life. At the same time, humanity's place as both the "conscious animal" and the "technological animal" places us in the ethical position of moving the earth toward a more complex pathway. This is a pathway that ensures that humanity properly manages the planet's resources and its capacity to sustain life.

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