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The Need for System Thinkers: Steps on Creating Awareness

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Abstract
Development of systems theory has changed the framework for looking at the real world. The entire entities of the observable world, according to this view, are conceptualized as systems, organizations, and wholes with interconnected parts, environment and mechanisms for growth and change. This great development in the way of thinking, understanding and dealing with things has popularized the key concepts of systems thinking, such as open and closed systems, inputs and outputs, feedback, linear and non-linear, causal relationship, etc., which describe the characteristic features of the actual world. Understanding fundamentals of systems theory, therefore, is increasingly becoming necessary for practical purposes. Systems thinking is a holistic view that conceptualizes entities of the real world, concrete or abstract, as 'organized wholes' composed of structure, function, and interconnected parts which work for a common goal of the whole. This holistic view of things is increasingly becoming dominant in various fields of the scientific enterprise. Adaptation to systems thinking can be built gradually upon three basic steps: first, the awareness on importance of systems thinking as an effective approach for learning and management. The second step is to understand the fundamentals and the conceptual framework of systems theory. The third step is to employ systems thinking as a method and framework for analysing and understanding the characteristic behaviours of the complex phenomenon. This article focuses on the first two stages. It briefly presents fundamentals of the General Systems Theory (GST), its principles and basic assumptions. The article, also, highlights some key concepts of systems theory and explains the different types of systems in a simple manner. An example for successful stories of recent applications of systems theory is indicated in the concluding part. The method adopted for presentation and discussion is theoretical and analytic.
Keywords: *systems thinking, organized whole, general systems theory, complexity, analytical thinking, open systems, Bertalanffy.*

Abstrak
Pembangunan teori sistem telah mengubah rangka kerja untuk mencari perkataan sebenar. Untuk keseluruhan entiti yang boleh diamati, kini, ia dikonsepkan sebagai sistem, organisasi, dan keseluruhan yang saling hubung dengan bahagian, persekitaran dan mekanisme yang saling berkaitan untuk pertumbuhan dan perubahan. Perkembangan hebat dalam cara berfikir, memahami dan menangani perkara ini telah mempopularkan konsep utama pemikiran sistem, seperti sistem terbuka dan tertutup, input dan output, maklum balas, hubungan linear dan bukan linear, perkaitan bersebab, yang menerangkan ciri-ciri tingkah laku dunia sebenar. Dengan memahami asas teori sistem, maka, semakin meningkat keperluan untuk tujuan praktikal. Pemikiran sistem boleh ditakrifkan sebagai pandangan holistik yang mengkonseptualisasikan entiti dunia sebenar, konkrit atau abstrak, sebagai 'keseluruhan tersusun' yang terdiri daripada struktur, fungsi, dan bahagian yang saling berkaitan yang berfungsi untuk matlamat bersama keseluruhan. Pandangan holistik tentang perkara ini semakin menjadi dominan dalam semua bidang perusahaan saintifik. Walau bagaimanapun, penyesuaian kepada pemikiran sistem boleh dibina secara beransur-ansur berdasarkan tiga langkah asas: pertama, kesedaran tentang kepentingan terhadap pemikiran sistem sebagai pendekatan yang berkesan untuk pembelajaran dan pengurusan. Kedua, memahami asas dan kerangka konsep teori sistem. Langkah ketiga

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ialah menggunakan pemikiran sistem sebagai rangka kerja untuk menganalisis dan memahami tingkah laku ciri fenomena kompleks. Artikel ini memberi tumpuan kepada dua peringkat. Ia secara ringkas membentangkan asas kepada Teori Sistem Am (General Systems Theory, GST), mengenai prinsip dan andaian asasnya. Artikel itu juga, menyerlahkan beberapa konsep utama teori sistem dan menerangkan pelbagai jenis sistem dengan cara yang mudah. Sebagai contoh kejayaan aplikasi terbaru bagi teori sistem ditunjukkan di bahagian kesimpulan. Kaedah yang digunakan untuk pembentangan dan perbincangan adalah secara teori dan analitik.

Katakunci: *Pemikiran sistem, Keseluruhan tersusun, Organisasi, Persekitaran sistem terbuka dan tertutup, Ludwig von Bertalanffy*

1.0. Introduction

The desire for understanding the complex systems of the natural phenomena has been the terminal goal of the human intellect across the history. Thus, the term ‘system’ now is becoming a key concept of scientific enterprise which plays a crucial role in conceptualizing the real world at its various levels of complexity. The founding author of ‘*General Systems Theory*’ (GST)[1], emphasizes that “in one way or another we are forced to deal with complexities with ‘*wholes*’[2] or ‘systems’ in all fields of knowledge; and this implies a basic reorientation in scientific thinking.” The reorientation, indicated by the author here, has led to the formulation of systems thinking as a new approach to understand the complex systems of the actual world. More efforts, however, are still needed to create awareness on this theory among the leading groups of knowledge inquiry, i.e., academicians, researchers and higher learning students, to be acquainted with the new thinking approach. To make such awareness is possible, the present article presents the core idea of this theory in a simple manner, avoiding as much as possible the technical terms, mathematical concepts and models of GTS. In the following sections, this article explains briefly fundamentals of systems thinking, i.e., the basic assumptions and principles of systems thinking. The article also aims to highlight the basic principles of the prevailing analytical method of scientific research.

Systemic thinking is the holistic approach that aims to understand how parts can influence one another to achieve the common goal of the ‘whole’ within a specific environment[3]. The word ‘*system*’ is primarily used for self-regulating orders of the natural phenomenon, especially living creatures (organisms). According to Mario Bunge, systems are complex objects whose parts or components are held together by bonds of some kind of mechanisms. These bonds are logical (abstract) in the case of conceptual systems, such as logical thoughts and theories; and they are material in the case of concrete systems, such as atoms and cells in the natural phenomena (physical and biological world), and family and hospitals in social phenomena. (Bunge 2004).

The holistic approach which aims at formulating a unified method for understanding the complex behaviors of the natural and social phenomena is known as ‘*General Systems Theory*’ (GST). This theory classifies the entire body of the observable world, based on its complexity, into four basic domains which are physical, biological, behavioral and social phenomena. This is in addition to systems of abstract concepts, such as a set of logical ideas and mathematical formulas. The key terms of systems theory are such as whole, parts, environment, organization, mechanism, self-organization, change, non-linear, etc. Systems thinking as a holistic view provide effective mechanisms of thought and analytical tools to understand the actual world which enables to communicate and integrate facts of various entities for proper management; i.e., the ability to influence or control[4] to make change[5]. These three factors constitute the ultimate goal of scientific endeavor.

Acquiring the suitable learning platforms and the relevant methods of inquiry is necessary to face the practical obstacles to understanding the complex world. The advanced thinking skills, such as creative and critical thinking, holistic approach and awareness on systems thinking must be acquired and be acquainted with. Searching for key concepts and the underlying principles which are valid throughout the entire body of knowledge is essential in such situation to guide the dedicated effort for knowledge production and knowledge sharing. This would enable to produce systems thinkers, or ‘science generalists’ in the term of Bertalanffy (1968). The progress in understanding the complex systems, such as the socio-cultural phenomenon, can be significantly enhanced by systems awareness and applying methods that enable the intellect to approach such complexity in a systematic manner.

The proceeding sections of this article explain the two basic methods of scientific inquiry, i.e., the analytic method that is currently dominating the scientific enterprise and the emerging holistic approach of system thinking. This will be followed by a brief explanation of basic assumption of systems theory and types of systems.

1.1. The need for systems thinkers

Production of systems thinkers, or scientific generalists, who are imbued with a holistic view and analytic skills, should be the core objective of the new learning environment. Systems thinkers, according Thomas S. Kuhn (1962)[6] are those who propose new revolutionary ideas, create new paradigms of science and point out to new directions for scientific progress. He named such thinkers as '*trail blazers*'. In fact, Kuhn differentiates between two groups of scientists, the first group is systems thinkers, as described above, who are seeking not only to know *how* a system works, but also to understand *why* it works the way it does?[7]. The second group, according to Kuhn, is those who follow the new directions of scientific thought and carry out careful experimentations and research within the established paradigm to formulate precise theories in a particular domain of knowledge.

Kuhn`s classification implies that every academician, researcher or administrator, needs to identify himself, according to the above two groups, to which group he/she belongs? The new education environment should be capable to upgrade majority of the second group to the level of 'systems thinkers'. The method of making systems thinkers should be guided by the principle that unity of science is necessary to understand the various forms of complexity of the real world. The modern philosophy of science has made it clear that why systems thinkers are needed in different fields of scientific enterprise. Academicians in various fields of learning, scientists, philosophers, theologians and sociologists, should be acquainted with principles of systems thinking, its basic assumptions and objectives. Systems thinking provides tools and mechanisms for analysis and understanding, methodological insights for research and learning, and guidelines for effective decision making. The method of systems thinking, as noted by Bertalanffy, L., (1968), retains its value even without mathematical modelling. It remains as guiding principle and mechanism for systematic thinking and understanding.

1.2. Challenges and obstacles

Although systems thinking is essential for understanding and management of the complex world, especially the biological and social phenomena, however, there is a real challenge on understanding principles of the general systems theory (GST), besides the problem of application which depends on understanding. These challenges can generally be observed in the literature on this topic. Lack of awareness on importance of systems theory can be for various factors such as educational curriculum, methods of instruction and lack of training; but it also can be attributed to the technical terms and mathematical models used by (GST).

Based on a critical review of Sautkina et al. (2014) who conducted an empirical study on this topic as applied in healthcare, Carey, G. et al. (2015) have cited that "Despite an explicit effort to introduce systems thinking in particular settings, there was little evidence of an understanding of specific systems science approaches and very little evidence of its application among practitioners and policymakers". Seeking to uncover the basic factors behind the problems, the authors observe that "It was concluded that the policy narrative was not very clear about what a systems-based approach meant, and thus, there was no clear direction in how this could be implemented. In the absence of clear guidance, local teams reverted to past experience." (Carey G, et al., 2015).

This problem, according to the authors "was noted as a symptom of the literature, where there is a considerable focus on developing systems-thinking concepts, but very little attention on the attributes of a system-level intervention (practice), and how it could be delivered and evaluated". The authors, here, are specifically talking about systems thinking as applied in healthcare, thus, they farther elaborate that "when assessing the quality of practice in a range of settings, success was generally defined as the presence of systems-thinking practice, irrespective of the quality of this practice, although it was noted that efforts at increasing systems-thinking capacity were required to improve practice." (Carey G, et al., 2015).

1.3. Needs of the new learning environment

Focusing on principles and basic concepts should be the basic strategy of the emerging environment for knowledge inquiry and learning. Focusing on detailed information might be irrelevant in such environment. Emphasizing the necessity of the holistic approach to produce systems thinkers, Bertalanffy (1968) reports that Professor Mather, in a symposium of the Foundation for Integrated Education, stated that one of the criticisms of general education is based upon the fact that it may easily degenerate into the mere presentation of information picked up in as many fields of enquiry as there is time to survey during a semester or a year..., if you were to overhear several senior students talking, you might hear one of them saying: our professors have stuffed us full, but what does it all mean? (Bertalanffy, L., 1968).

In fact, if we also overheard our students today we will discover that we are 'stuffing them full' but may without real meaning. Therefore, the more important in the process of teaching and learning is searching for basic concepts and underlying principles that may be valid throughout the various fields of knowledge inquiry. In answer to what these basic concepts could be, Mather stated that they are the similar general concepts have been independently developed by investigators who have been working in widely different fields. Thus, Mather concludes that integrative studies should be an essential part of the quest for an understanding of reality. The author of GST is confident that systems thinking approach provides principles and common grounds for integrative studies.

2.0. Understanding the actual world

Understanding the real world, i.e., the totality of the observable entities has been a central aim of mankind across the history of systematic inquiry. Philosophers, theologians and scientists have made great efforts to unfold the structural and functional complexity of the natural world and sources of its dynamic processes. The complex systems[8] of the world are initially reflected by the basic domains of modern science[9]. This tireless effort aimed at obtaining the true knowledge, as well as the effective methods of inquiry to obtain such a true knowledge. The basic epistemological premise which has been triggering the intellectual effort is that understanding everything is the key factor for its effective management. In other words, controlling and the relevant decision making are always guided by the true knowledge. Thus, the question of method of inquiry has been an essential element of scientific research.

Systemization of inquiry is necessary to approach the various levels of the complex world. In other words, the only meaningful way to understand the actual world is to study it as a system. Systemic analysis treats component of the actual world, physical, biological or social, as organizations or systems of an organized whole with interdependent variables, rather than independent ones.

2.1. The objective

The scientific inquiry, i.e., the empirical study of the observable world, aims to understand how the natural phenomena behave and what are causes of such behaviors? Scientific research aims to uncover what are the effective methods to understand such natural processes, either simple or complex. Systems thinking approach considers every entity as an organized whole, consists of structure, function and dynamic processes. Obtaining the true knowledge of the observable world enables man to predict, control, and manage. This is the ultimate goal of scientific research which enables to design, make change and develop. The critical review of scientific approaches, methods of inquiry, conceptual schemes, and examining the theoretical matters of science constitute the subject matter of philosophy of science.

The revolution against the prevailing modes of scientific thinking, i.e., the conventional thoughts and paradigms that dominating the method of inquiry in specific periods of time, is necessary for scientific progress. Based on criticizing the dominating approaches and introducing new relevant methods, philosophy of science contributes in a proper growth of scientific knowledge. The basic epistemological challenge to achieve the noble goal of true knowledge, however, is that the real world displays itself in various ways: simple and complex, visible and invisible, systematic and chaotic, etc. Therefore, we need the holistic approach, the method of thinking which allows seeing the order through the chaotic view of the phenomena. It also, allows to understanding the complexity of systems that lies behind the simple view of the rapidly changing world. (Jamshid, 2011).

2.2. The basic methods of inquiry

Aiming at unfolding the structural complexity and functional mechanisms of the natural phenomena, modern science has adopted two major approaches of inquiry to understand the visible world, which are the analytical thinking approach and holistic thinking approach. The two approaches are complementary rather than contradictory. The first approach, that is currently dominating scientific research enterprise, is the analytical thinking method of inquiry which conceptualizes the natural world as a machine that works with regularities dictated by its internal structure and the causal laws. Regularities and causal laws are detectable by careful observation and study of the parts, which leads to understand the 'whole'. This approach is guided by the principle that knowledge of the '*whole*' depends on knowledge of its constituent parts. Accordingly, investigating parts in isolation, as samples, is the most relevant method to obtain the true empirical knowledge which leads to general theories. (Gharajedaghi and Ackoff, 1984). This mechanical model is mainly based on the method of inductive reasoning, i.e., individual observations leading to general conclusions.

The analytical thinking is also known as mechanical model or 'reductionist approach', because it reduces the entire phenomena, nonphysical fields, to the method of physical phenomena. This approach is effective in understanding the closed systems, i.e., mechanical processes of physical entities. However, the challenge is always posted by nonphysical world, i.e., open systems of the complex domains, such as biological and social phenomena. The mechanical approach does not provide effective tools to understand the complex systems. Systems thinkers believe that understanding parts of the complex systems does not necessarily lead to the understanding of the whole. Thus, they propose the second approach, i.e., systems thinking, as a holistic and an effective method to understand the entire phenomena: the physical, biological and social. Fundamentals, principles and the basic assumptions of this approach were formulated by Ludwig von Bertalanffy in his renounced work '*General Systems Theory'* (GST).

3.0. What is systems thinking?

To understand the phrase 'systems thinking' we need to explain briefly its two components: '*system*' and '*thinking*'.

3.1.System

According to Ackoff (1971), '*system*' is a 'set of interrelated elements.' Bertalanffy (1968) defines system as a 'set of elements standing in interaction'. This set of interconnected elements can be concrete entities, observable events, or abstract concepts. Thus, the word 'system' is semantically used in different contexts, including organized behaviors of things, set of things work together as an interconnected prats of a complex whole, and finally, a set of principles or procedures according to which something is done. All these meanings are applicable to 'systems thinking'. For example, human body is a complex whole, formed by various systems, such as the skeletal system, blood circulatory system, nervous system, etc.; all these systems work in collaboration to achieve the common goal of the body, which is to maintain human life. (Johnson, Richard A. et al., 1964). All subsystems are functioning for and interconnected with each other to serve the final goal of the whole. Everything, according to system thinkers, is regarded as a system of a whole that consist of parts, or subsystems. To understand the whole, we need to understand its parts, their interconnected relations, and the whole as related to its environment. (Ackoff, Russell L., 1971).

3.1.1. Historical reflection on systems

Although the systematic processes of nature are observable and easily detectable[10], the systems thinking and systematic inquiry of such orderly behaviors of the natural phenomena have been the major challenge to human intellect, especially understanding the complex systems of biological phenomena. The attempt to solve this problem, however, is deeply rooted in human history. The beautiful designs of Egyptian pyramids, preservations of mummies, and abstract ideas of Greek philosophers may stand for this. In the ancient history of science, Aristotle assumed that the true knowledge is derived only from the 'whole' not from its individual parts. Many eminent thinkers along the history of science, classical and modern, including Ibn Khaldun[11], have held this view and made their efforts for the discovery of systems in both natural and human phenomena.

3.1.2. The biological model of social systems

The word '*system*' in its modern context was emerged in the field of social science. This indicates that management of social phenomena necessitates looking at social entities and organizations as 'systems' equally with living organisms. According to Kurt W. Back (1971), biologists distinguish between various types of biological mechanisms which can be benefited in social systems. Some of these mechanisms maintain equilibrium under changing conditions, some of which create change in the system, and some others are indicators of breakdown of adaptation. Back (1971) maintains that study of the essential characteristics of these processes can help sociologists in understanding stability and change in social systems. According to him, there are several ways in which the model of the biological open system can be related to models of society.

Early, the term '*system*' in sociology was used by Émile Durkheim and later by other sociologists, such as Talcott Parsons and other philosophers of social science who applied the method of biological systems on the social systems. The full version of systems theory, however, was proposed by Ludwig von Bertalanffy in series of works and finally developed in his 'General Systems Theory'. Other philosophers of science who contributed in developing systems theory are such as F. E. Emery[12], C. W. Churchman[13], R. L. Ackoff[14], and many more who articulated the idea and principles of systems thinking and its application.

3.2. Thinking

The term '*thinking*' is a well investigated concept in modern educational enterprise. Thinking modes, according to the cognitive studies, are mainly three types: analytic, holistic and integrative. Mankind naturally develops the analytic and holistic modes of thinking, or integrates between the two which is known as integrative mode. According to the theory of mental self-government proposes, there are several styles under each mode, such as legislative, hierarchical and judicial. However, thinking styles, according to (Zhang, 2002) can be categorized broadly into two basic types. The first type, including the legislative, judicial, global, and liberal styles, is creativity generating mode which requires complex information processing. People who use this type of thinking style are tend to be norm challenging and risk taking. The second type, including the executive, local, and conservative styles, requires simplistic information processing. People who use this type of thinking styles tend to be norm favouring and authority oriented. (Zhang, 2002). Although there is no clear boundary between the two categories, observation of the different thinking modes in children, and generally in education, is important in teaching and learning process.

Unlike thinking modes, which are naturally develop in human intellect, systems thinking is an approach, i.e., a model of viewing things, rather than a method of inquiry. It can be naturally gained as embedded in holistic and integrative modes of thinking, but it always can be enhanced by education and training. Although, it is not a research method, system thinking plays a crucial role to enhance the method of inquiry. It provides a holistic view and united platform to deal with the basic domains of scientific enterprise, especially the complex systems. It also provides a suitable ground for effective decision making. In addition to that, systems thinking provides conceptual framework, methodological insights, tools for analysis and mechanisms for understanding of the complex behaviours of the natural world. Academicians, researchers, physicians and administrators need to be acquainted with the fundamentals and principles of systems thinking and its basic assumptions.

4.0. Systems thinking: the parts, the whole and the environment

The core idea of systems thinking is to view everything, i.e., entity, object or event, as an '*organized whole*' composted of three basic elements: the parts, the whole and the environment. Every entity, according to this view, has structure, function and goal. So, there is an organized whole, which known as '*system*' or '*organization*' composted of interconnected parts which interactively work to achieve the common goal of the whole. Citing the above example, human body is a 'system' or an 'organized whole' which compost of many interconnected parts, such as heart, kidney and lever. All these parts work in harmony to achieve the terminal goal of the whole body which is a healthy life. The external world constitutes the 'environment' for human body. Another example, is family which composted from its individual members: father, mother and children. It is regarded as an organized whole 'system', its parts, i.e., the individual members, work in harmony to make a meaningful family life within a community as an 'environment'. The former example is a biological phenomenon, while the latter is a social phenomenon. Both of these examples are natural systems, but also there are artificial systems or organizations, such as engineering systems, educational institutions, companies and social organization which are created and managed by human being for specific purposes. Accordingly, to obtain a holistic view of a fact, we need to understand all the three components of the system, which are the parts, the whole and the environment[15]. (Bertalanffy, L., 1968).

Systems thinkers hold that to understand any system, we need to understand not only the parts but also the whole as related to the environment. They stress that understanding components of a system does not necessarily lead to understanding the whole, as held by analytical approach, especially in the complex systems. They insist that the 'whole' is always greater than the sum of its parts. This principle simply emphasizes that the constitutive characteristics of the whole are not explainable from the characteristics of isolated parts[16].

Components of a system are inherently involved in dynamic processes to achieve the common goal of the whole. To understand the whole, it is necessary to understand the structure, the interrelationship of the parts, as well as the whole as related to its environment. This means systems thinking does not deny the analytical method of mechanical approach, it rather extends the analytical understanding of the parts to the whole; therefore, these two approaches are interdependent and indispensable. Jashmid & Ackoff (1984), hold that structure of a system can be understood only if observed in the functioning process of the system. Thus, Jashmid (2011) observes that the analysis which reveals only the structure of a system, not its functioning, cannot provide understanding but only knowledge[17].

4.1. The basic assumptions of systems theory

Systems theory is based on certain premises which guide the process of thinking to approach the complex phenomena systematically.

- The first basic assumption is that the actual world behaves in reasonably systematic orders which are understandable to the intellect, not runs in total chaos[18]. The chaotic behaviors and unorganized complexity of the natural world, according systems thinkers, are features of our perceptions rather than true characteristics of the reality. (Jamshid, 2011).
- The second basic assumption is that the component parts of the world, in fact, are systems formed by interconnected parts which serve a common goal of the whole.
- The third presupposition is that systems are different types with various levels of complexity and hierarchal orders.
- The fourth assumption is that the whole is always greater than the sum of its parts. This denotes that a system (whole) is not understandable by investigation of its parts in isolation. Therefore, to understand the whole, we need to understand not only the parts, but also the environment which influence the whole. In fact, this is the basic difference between the Reductionism and the Holism. Reductionists view variables of the dynamic process as isolated facts; thus, they investigate characteristics of the parts independently without due consideration to their relationships to each other or to the whole. Meanwhile Holism focuses on the interconnected relationship of the parts, as well as the relationship of the whole with its environment.

Based on the above assumptions, systems thinkers hold that systems approach provides principles for unity of science, i.e., the unified method to understand the entire phenomena, physical and nonphysical. This is well expressed by the author of general systems theory, as following "So far, the unification of science has been seen in the reduction of all sciences to physics, the final resolution of all phenomena into physical events. From our point of view, unity of science gains a more realistic aspect. A unitary conception of the world may be based, not upon the possibly futile and certainly farfetched hope finally to reduce all levels of reality to the level of physics, but rather on the *isomorphy* (similarity) of laws in different fields" (Bertalanffy, 1968).

4.2. Types of systems

The modern biological theory investigates mechanisms by which the change occurs in adaptive systems. It identifies the basic biological mechanisms for adaptation at varying ranges. Kurt W. Back (1971) explains these mechanisms, which are also regarded as basic characteristics of biological phenomena (open systems). As categorised from short to long, they are: *perception*, *learning*, *immunity*, *maturation*, *heredity*, and *evolution*. By identifying the essential properties of each process, these mechanisms can be used to understand the different problems of change within any open system, including the social systems. According to (Kurt W. Back, 1971), the ways in which mechanisms of this kind could work in social systems can help in locating and understanding processes in social change.

Based on their structural and functional characteristics, systems can be divided into various types, such as abstract and concrete (soft & hard), simple and complex, open and closed, physical and nonphysical, static and dynamic systems, etc. An extended explanation of all these types and concepts will be conducted by the author in another work. However, a brief reflection on some of these types here is necessary, especially the division into closed and open systems.

4.3. Closed and open systems

According to Ackoff (1971), a '*closed system*' is one that has no environment; while an '*open system*' is one that has an environment. The term '*environment*' in this context is used for any external factor influences the '*system*'. Thus, a closed system is one which is conceptualized as that which has no interaction with any element not contained within it; or it is completely self-contained. The physical systems, i.e., mechanical processes, are mainly closed, while systems of living creatures (organisms), i.e., biological phenomena, are open. (Ackoff, Russell L., 1971). According to Allport (1960) there are four conditions for an open system, which are (i) input and output[19] of matter and energy (feedback)[20], (ii) maintenance of steady states[21], (iii) increase in complexity, and (iv) active interaction with the environment. The first two conditions are related to the maintenance of the system, while the last two are related to the change of the system. These two sets of characteristics of open systems, which seems to be contradictory, are necessary for stability and change. (Back, Kurt W., 1971).

The basic characteristic of an open system is that it is a self-organized, especially in living creatures. However, 'openness' and 'closedness' are relative, no clear boundaries between the two. The artificial (man-made) systems, such as sophisticated machines and social organizations can be closed or open, based on its purpose of making (the goal). Systems may or may not change over time (Ackoff, Russell L., 1971).

4.4. Abstract and concrete systems

Abstract (soft) systems are logical and based on human thought, such as designing, especially by computer, mathematical models, and set of logical ideas. Artificial systems are generally abstract ideas before they are turned to concrete. A concrete (hard) system, according to Ackoff (1971) is the system which at least two of its elements are objects. In fact, the term '*system*' is usually stands for concrete system, unless there is a clear indication to otherwise. Ackoff explains that in concrete systems establishment of the existence and properties of elements and the nature of the relationships between them requires research with an empirical component in it. Such systems, therefore, are the subject of study of the so-called 'non-formal sciences' (Ackoff, Russell L., 1971).

5. The key concepts of systems theory

Systems Theory has employed many key concepts, as well as scientific terminologies some of which are highly technical. A careful study and understanding terms used by this theory is essential to be acquainted with systems thinking. Some of these concepts, such as 'system' 'whole' 'closed and open systems' are explained in the previous sections of this article; some others will be briefly explained in the proceeding part. More inclusive version of these terms will be explained in other work by the author.

The key concepts of systems thinking can be generally divided into two basic types, which might be named as '*constructive*' and '*descriptive*'. The constructive concepts are such as 'system' 'part' 'whole' 'organization' 'element', 'organism', 'component', 'event' 'complex' 'environment' and other terms of the same nature, which denote the structure of the system. The descriptive concepts, on the other hand, are that which focus on function of the system or the process or the mechanisms. This set of concepts is more technical and difficult to be familiarize with, but they are necessary to be acquainted with systems thinking. This set includes terms such as mechanism, equilibrium, self-organization, adaptation, non-linear, goal-guided, open and closed, static or dynamic, homeostatic, causal relationships, feedback loops, equifinality[22], synergy[23], etc.

6. The application

Systems thinking is an approach rather than a method of inquiry. It provides an organized thoughts, insights, mechanisms and tools for thinking, analyzing and understanding. Therefore, systems thinking is necessary in all fields of inquiry, as well as in education, medicine, business management and in administration as a tool for effective decision making. There are many good examples of systems thinking application in all fields. The most important field for systems application, however, are social organizations due to the complexity of the social phenomena. There, also, good examples for application in other fields, such systems engineering, systems biology, and systems medicine. In their work, entitled "*Systems Science and Systems Thinking for Public Health: a Systematic Review of the field*" Carey, G. et al. (2015), have summarized application of systems thinking on this topic in three basic modes, as cited from K. H. Lich, et al. (2013). The first mode is Social Network Analysis (SNA), which focuses on organizational management; the second is System Dynamics (SD); and the third, is Agent-Based Modelling (ABM)[24]. These modes of application were in the field of public healthcare, but it is applicable to other fields of medicine as well as to social sciences.

7. Conclusion

'System' and 'order' in the behaviours of diverse parts of created world are signs of unity of the Creator. This is a basic argument of the theologians to prove existence of God and His unity. Scientists and philosophers of science, as well, have been utilizing the observable orders and the systematic processes of the natural world to develop principles of the scientific research method for epistemological purposes, i.e., to obtain a validated and reliable knowledge of the natural world. The major challenge of scientific inquiry, however, is that the natural phenomena is too complex and sometime displays itself in chaotic behaviours. To solve this critical problem, modern science adopted first the analytical thinking approach which aims to understanding the individual parts of the entity to make generalization for the whole. Although the analytical approach has successfully explained the physical phenomena, however, I was challenged by the nonphysical world, i.e., biological and social phenomena. These fields are too complex for analytical thinking (linear method) to explain, in the sense that the same causes may produce different effects, while the different causes may produce the same effects (non-linear or a state of seemingly lawlessness).

The attempt to reduce such a complex behaviour to the method of physical science (reductionism) was unsuccessful. Therefore, the General Systems Theory (GST) was formulated to deal with both the physical and nonphysical fields. The major difference between the analytic thinking and systems thing is that the analytic approach focusses on knowledge of parts to understand the whole, while systems thinking acquires knowledge of both the parts and the whole as related to its environment. In fact, they address two different systems: the analytical thinking (reductionism) is concerned with the physical systems which are mainly closed; while systems thinking focuses on the nonphysical systems which are open. In other words, the analytic approach investigates dependent variable (linear), while the holistic approach investigates independent variables (non-linear).

The need for systems thinking, i.e., holistic approach, is urgent and necessary. Nevertheless, the application of systems thinking has made successful stories on understanding the complex systems in last few decades. The latest successful story which proves effectiveness of systems thinking to approach the complex behaviors of nature, is given the Nobel Prize for physics in year 2021. It received by two physicists who immensely contributed in modeling the complex and chaotic behaviors in two different fields of physics, namely climate change due to human activities on earth and chaotic atomic behavior in certain magnetic alloys. The successful modelling of these two fields is a particularly vivid indication of the increasing recognition and impact of the systems thinking approach. Nevertheless, it may enable to predict future occurrences and even controlling of the phenomenon. These scientific breakthroughs also emphasize that systems thinking has great potential to lead the way for understanding the complex systems of biological and social phenomena for better management.

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[1] The basic structure of GST was developed by the biologist Ludwig von Bertalanffy (1901-1972). He proposed the theory in a series of article which formulated finally in his prominent work "*General System Theory: Foundations, Development, Applications*' published in 1968. The theory aims to develop a unified research method to approach the entire phenomena of the observable world, as presented by the different scientific fields.

[2] The term '***whole***' in the context of systems theory is very general. It stands for every organized entity or event, either natural, such as living organisms and physical processes, or artificial such as the sophisticated machines and social organizations. '*Holism*' is the theory that all the properties of a given system, biological, chemical, social, economic, logical, linguistic, etc., *cannot* be determined or explained by its component parts alone; instead, the system as a whole determines how the parts should behave. The general principle of 'holism' was concisely developed by Aristotle in his '*Metaphysics*' where he held that "The whole is more than the sum of its parts". Based on this idea, Aristotle viewed the world and each being in the world as mutually interrelated part of a goal-guided organized whole. Study more about this in "*the New World Encyclopedia*"; also found at website: http://www.newworldencyclopedia.org/entry/Holism

[3] The term '*environment*' in systems thinking is used for the external factors which influence or affect the whole in one way or another.

[4] 'Control' means that an action or the cause is both necessary and sufficient to produce the intended effect / outcome. While 'influence' means that the action is not sufficient, it only a coproducer of the effect. (Ackoff 1971, Jamshid, 2011, p 31)

[5] The holy Qur`an says: "*God does not change affairs of people until they change what is in themselves*" (Q: 13:11, 8:53). These Qur`anic verses are explicitly asserting that the initiative for social change must come from people. However, the proper change must be based on knowledge, i.e., understanding of systems of the entity.

[6] Thomas Samuel Kuhn (1922–1996) was an American philosopher of science and author of '*The Structure of Scientific Revolutions*' the renounced book which presents the notion of 'Paradigm Shift' which published in 1962 by The University of Chicago, USA.

[7] Philosophers of science differentiate between *how* and *why* questions in one side and between knowledge and understanding on the other.

[8] The phrase 'complex system' is used for interconnected elements in which the behaviors and characteristics of the whole are hardly predictable or cannot be anticipated.

[9] The basic domains of modern science, according to systems thinking approach, are the physical, biological, behavioral and social phenomena. This is a hierarchical classification of sciences that is based mainly on level of complexity of the phenomenon. The application of systems thinking, however, has extended to the manmade systems, either concrete systems, such as social organizations, or abstract systems such as a logical set of ideas.

[10] The Qur`an uses the systematic orders of nature to trigger the human intellect for inquiry and systematic investigation. It has employed various term which describe the systematic orders of nature and human phenomena. Term used by the holy Qur`an for systematic orders are such as '*Ayah*' '*Sunnatullah*' and '*Qadar*'.

[11] Perhaps Ibnu Khaldun was the first Muslim scholar who held the holistic view on investigation of social phenomena. Likely, he was envisioned by the method of Holy Qur`an on presenting the social phenomena.

[12] Frederick Edmund Emery (1925 –1997) was an Australian psychologist and author of '*Systems Thinking*'.

[13] Charles West Churchman (1913 –2004) was an American philosopher of science. He is the author of '*The Systems Approach*', published by Delacorte Press, New York.

[14] Russell Lincoln Ackoff (1919 –2009) was an American philosopher of science and author of series of works on systems thinking, the most fundamental of which is his work '*Towards a Systems of Systems*' published by (*Management Science*. Vol. 17. No. 11, July 1971.) Ackoff was a pioneer in the field of 'Operations Research' (OR), systems thinking and management science.

[15] 'Environment' is an external factor to the whole, but in one way or another the whole is influenced or affected by the environment.

[16] According to the principle of synergy, the function of the system cannot be understood from the sum of the elements that compose it, but from the interaction between these elements which generates qualitatively different results

[17] The basic deference between 'knowledge' and 'understanding' according Jamshid, is that knowledge is to know *how* a system functions, while understanding is to know *why* it functions in such a way. 'Understanding' enables to control while 'knowledge' is not.

[18] The core of this assumption was embedded in 'deterministic' view of the world as reflected by the classical mechanics, i.e., Newtonian physics.

[19] Terms 'input' and 'output' are used for energy or information exchanged by an open system with its environment. In the dynamic relationship of a system with its environment, it receives various inputs and transforms. These inputs in some way or other export outputs.

[20] The term 'feedback' refers to information that reflects the outcomes of an act or series of acts (processes) by an individual, group or organizations.

[21] The concept of 'steady state' is closely related to that of negative entropy. An open system, can attain a steady state where the system remains in dynamic equilibrium through a continuous inflow of materials, energy, and information. A closed system, however, eventually must attain an equilibrium state with maximum entropy, which leads to disorganization or death or of the system.

[22] The term 'equifinality' refers to the principle that the same goal in open systems can be reached by different ways. (https://www.definitions.net/definition/Equifinality

[23] The term 'synergy' is used for the interaction or cooperation of two or more organizations, substances, or other agents to produce a combined effect greater than the sum of their separate effects; e.g., the synergy between artist and record company.

[24] Lich, K.H, et al. (2013). *A call to address complexity in prevention science research*. (Prev Sci 2013; 14:279–89.