A Development Plan for the New Millennium

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Abstract

This paper points out the importance of systems science as the second dimension of knowledge and introduces the yoyo model as the intuition and playground commonly useful for systems thinking and reasoning. By revealing how traditional science abstracts numbers and quantities out of objects of rich internal structures, this work shows the wide range of applicability of systems research in not only new territories created by the research but also the studies of all the age-old quests of the mankind. By detailing a careful design, this paper establishes the idea and purpose of creating educational programs at specifically undergraduate levels in order to stimulate further development of systems science.

Keywords yoyo model, social organization, systems thinking, curriculum design, calculus

1 Introduction

The breadth and diversity the vast amount of the literature of systems science and engineering covers point to a golden opportunity for the next stage development of systems movement. By comparing the origin where numbers are from and the places systems are seen, this paper establishes another reason for the 2-dimensional landscape of knowledge. By pointing to the advantage of the additional dimension, it is argued that because of the maturing development of systems research, some age-old problems that have challenged the mankind for thousands of years can now be hopefully resolved. After introducing the systemic yoyo model as the common intuition and playground for general systems thinking and reasoning, this paper looks at how even at the ground root level, the traditional science has intelligently dealt with mathematical entities without involving the internal structures of objects it studies and the impacts of the environment. That is, to successfully employ numbers and quantities, only thinghood the traditional science captures. However, the natural world consists mainly of structures and organizations, that is, systems. Hence, systems researchers should start working on improving almost all, if not all, the basic concepts and elementary procedures of the traditional science so that problems of systemhood, which are more realistic than those problems addressed by using the traditional science, can be effectively addressed.

To this end, considering the scope and magnitude modern science covers and embodies, improving the basic concepts and elementary procedures of such science from the angle of systemhood requires a steady supply of a huge amount of manpower. The number of current scholars who are interested in systems research is quite limited. It implies a severe shortage of manpower within the community of systems researchers. To help resolve this problem, this paper lays out a particular plan to establish educational programs worldwide that parallels that of mathematics education. By doing so, a steady job market for systems researchers will appear, while major advances in systems science can be achieved at the same time.

As what George Klir[1] did, let us look at the currently available knowledge as 2-dimensional. Along the first dimension, the traditional science dimension, subjects that are investigated are compartmented based on their thinghood; along the second dimension, the systems science dimension, subjects are classified according to their systemhood. With this conceptual 2-dimensionality in place, it is argued in this paper that by taking the responsibility of reshaping the traditional science, from its very bottom up, as part of the future works of systems research, one will be able to truly make systems science the second dimension of knowledge. In terms of the future development of systems research, it is argued that calculus should be employed as a reference. And it should be emphasized that when students take courses of systems science, they need be taught, along all the fundamentals, with procedures that can be loosely followed to produce some more or less definite outcomes. That is actually why calculus has been used by generations after generations. In other words, since its inception over three hundred years ago, that is how calculus has provided livelihood for millions of people, and at the same time these people had helped to create the prosperity of calculus.

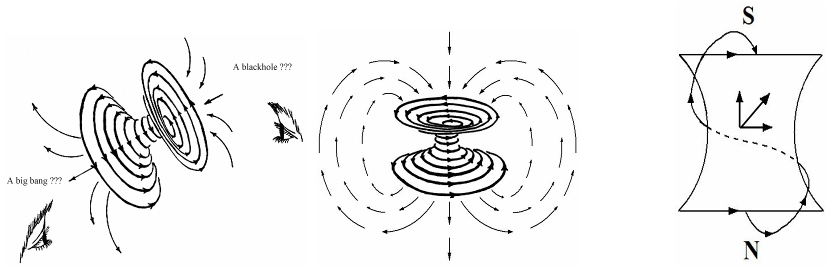
This paper is organized as follows: In Section 2, we look at the different origins of numbers and systems, and why additional dimension of knowledge is expected to bring about breakthroughs. Then the systems yoyo model is introduced for the purpose of naturally leading the reader to the conclusion of the following section: The concepts of numbers and systems really complement each other; together they will make science more useful in addressing practical problems. In Section 3, we analyse why from the root level up, the traditional science needs to be revisited from the viewpoint of systems. However, to satisfy such need of revisiting every corner of the traditional science requires more scientific manpower additional to what is currently available in the community of systems research. To resolve this problem, in Section 4, we lay out a particular idea for developing educational programs to serve the greater audience of university students in order to eventually feedback to the systems research with additional manpower and scientific progress. Section 5 concludes this paper.

2 Some Observations

Since 1924 when von Bertalanffy pointed out that the fundamental character of living things is its organization, the customary investigation of individual parts and processes cannot provide a complete explanation of the phenomenon of life, this holistic view of nature and social events has spread over all corners of science and technology[2]. Accompanying this realization of the holistic nature, in the past 80 some years, studies in systems science and systems thinking have brought forward brand new understandings and discoveries to some of the major unsettled problems in the conventional science[3-4]. Due to these studies of wholes, parts, and their relationships, a forest of interdisciplinary explorations has appeared, revealing the overall development trend in modern science and technology of synthesizing all areas of knowledge into a few major blocks, and the boundaries of conventional disciplines have become blurred (“Mathematical Sciences,” 1985). Underlying this trend, we can see the united effort of studying similar problems in different scientific fields on the basis of wholeness and parts, and of understanding the world in which we live by employing the point of view of interconnectedness. As tested in the past 80 plus years, the concept of systems has been widely accepted by the entire spectrum of science and technology[1,5].

Similar to how numbers are theoretically abstracted, systems can be seen in each and every object, event, and process. For instance, behind collections of objects, say, apples, there is a set of numbers such as 0, 1, 2, 3, ; and with each organization there is an abstract, yet very realistic, system within which the relevant whole, component parts, and the related interconnectedness are emphasized. In other words, when internal structures are out of the concern, numbers can be very useful; otherwise the world dominantly consists of systems. Historically speaking, traditional science has been developed on top of numbers and quantities; while along with systemhood comes the systems science. That gives rise of a 2-dimensional spectrum of knowledge, where the classical science, which is categorized by the thinghood of the objects it studies, constitutes the first dimension, and the systems science, which investigates structures and organization, forms the genuine second dimension[1]. That is, systems thinking focuses on those properties of systems and associated problems that emanate from the general notion of structures; the division of the classical science has been done largely on properties of particular objects. That explains why systems research naturally transcends all the disciplines of the classical science and becomes a force that unites all existing disciplines.

The importance of this supplementary second dimension of knowledge cannot be in any way over-emphasized. For example, when studying dynamics in an n-dimensional space, there are difficulties that cannot be resolved within the given space without getting help from a higher-dimensional space. In particular, when a one-dimensional flow is stopped by a blockage located over a fixed interval, the movement of the flow has to cease. However, if the flow is located in a two-dimensional space, instead of being completely stopped, the 1-dimensional blockage would only create a local (minor) irregularity in the otherwise line movement of the flow (that is how nonlinearity appears[6]). Additionally, if one desires to peek into the internal structure of the 1-dimensional blockage, he can simply take advantage of the second dimension by looking into the blockage from either above or below the blockage. That is, when an extra dimension is available, science will gain additional strength in terms of solving more problems that have been challenging the survival of the mankind.



(a) (b) (c)

Fig.1 The eddy motion model of the general system

Even though systems research holds such a great promise, the systems movement has suffered a great deal in the past 80 some years of development due to the reason that this new science does not have its own speaking language and thinking logic. Conclusions of systems research, produced in this period of time, are drawn either on ordinary language discussions or by utilizing the conventional mathematical methods, making many believe that systems-thinking is nothing but a clever way of rearranging conventional ideas. In other words, due to the lack of an adequate tool for reasoning and an appropriate language for speaking, systems research has been treated with less significance than they were thought initially since the 1970s when several publications criticized how systems enthusiasts derived their results without sufficient rigor[7-8], even though most of the criticized results turned out to be correct if seen through our 20-20 hindsight. Considering the importance of the Cartesian coordinate system in modern science[9-10] realizes that the concepts of (sizeless and volumeless) points and numbers are bridged beautifully together within the Cartesian coordinate system. That is how this Cartesian coordinate system plays the role of intuition and playground for modern science to evolve; and within this system, important concepts and results of modern mathematics and science are established. Recognizing the lack of such an intuition and playground for systems science, on the basis of the blown-up theory[10], the yoyo model in Fig.1 is formally introduced by[11] in order to establish the badly needed intuition and playground for systems science.

In particular, on the basis of the blown-up theory, which shows how the common form of motion of systems is eddy motion, and the discussion on whether or not the world can be seen from the viewpoint of systems[12], the concepts of black holes, big bangs, and converging and diverging eddy motions are coined together in the model shown in Fig.1. This model was established in[10] for each object and every system imaginable. In other words, each system or object considered in a study is a multi-dimensional entity that spins about its either visible or invisible axis. If we fathom such a spinning entity in our 3-dimensional space, we will have a structure as shown in Fig.1(a). The side of black hole sucks in all things, such as materials, information, energy, etc. After funneling through the short narrow neck, all things are spit out in the form of a big bang. Some of the materials, spit out from the end of big bang, never return to the other side while some will (Fig.1(b)). For the sake of convenience of communication, such a structure, as shown in Fig.1(a), is called a (Chinese) yoyo due to its general shape. More specifically, what this model says is that each physical entity in the universe, be it a tangible or intangible object, a living being, an organization, a culture, a civilization, etc., can all be seen as a kind of realization of a certain multi-dimensional spinning yoyo with either an invisible or visible spin field around it. It stays in a constant spinning motion as depicted in Fig.1(a). If it does stop its spinning, it will no longer exist as an identifiable system. What Fig.1(c) shows is that due to the interaction between the eddy field, which spins perpendicularly to the axis of spin, of the model, and the meridian field, which rotates parallel to axis of spin, all the materials returning to the black-hole side travel along a spiral trajectory.

Note:This yoyo model for each and every system is theoretically established on Newtons second law of motion, the concept of blown-ups existing widely in evolutions of systems, mathematical characteristics of nonlinear models, the principles of mathematical modeling, and the universal existence of eddy motions. Empirically, this model is manifested by Diracs large number hypothesis, the mystery of solar systems angular momentum, and the measurement analysis of the movement of earths atmosphere. For all the technical details, please consult with[13].

To show this yoyo model can indeed, as expected, play the role of intuition and playground for systems research[2,13], have successfully applied it to investigate Newtonian physics of motion, the concept of energy, economics, finance, history, foundations of mathematics, small-probability disastrous weather forecasting, civilization, business organizations, the mind, among others.

At this junction, let us look at how a workplace can be investigated theoretically as such a spinning structure. In fact, each social entity is an objectively existing system that is made up of objects, such as people and other physical elements, and some specific relations between the objects. It is these relations that make the objects emerge as an organic whole and a social system. For example, let us look at a university of higher education as a workplace. Without the specific setup of the organizational whole (relationships), the people, the buildings, the equipment, etc., will not emerge as a university (system). Now, what the yoyo model says is that each imaginable system, which is defined as the totality of some objects and some relationships between the objects[3], possesses the yoyo structure so that each chosen social system, as a specific system involving people, has its own specific multi-dimensional yoyo structure with a rotational field.

To this end, there are many different ways for us to see why each social entity spins about an invisible axis. In particular, let us imagine an organization, say a business entity. As it is well known in management science, each firm has its own particular organizational culture. Differences in organizational cultures lead to varied levels of productivity. Now, the basic components of an organizational culture change over time. These changes constitute the evolution of the firm and are caused by inventing and importing ideas from other organizations and consequently modifying or eliminating some of the existing customs. The concept of spin beneath the systemic yoyo structure of the firm comes from what ideas to invent, which external ideas to import, and which existing customs to eliminate. If idea A will likely make the firm more prosperous with higher level of productivity, while idea B will likely make the firm stay as it has been, then these ideas will form a spin in the organizational culture. Specifically, some members of the firm might like additional productivity so that their personal goals can be materialized in the process of creating the extra productivity, while some other members might like to keep things as they have been so that what they have occupied, such as income, prestige, social status, etc., will not be adversely affected. These two groups will fight against each other to push for their agendas so that theoretically, ideas A and B are actually spin around each other. For one moment, A is ahead; for the next moment B is leading. And at yet another moment no side is ahead when the power struggle might very well return to the initial state of the organizational affair. In this particular incidence, the abstract axis of spin is invisible, because no one is willing to openly admit his underlying purpose for pushing for a specific idea (either A or B or other ones).

As for the concept of black hole in a social organization, it can be seen relatively clearly, because each social organization is an input-output system, no matter whether the organization is seen materially, holistically, or spiritually. The input mechanism will be naturally the "black hole", while outputs of the organization the "big bang". Again, when the organization is seen from different angles, the meanings of "black hole" and "big bang" are different. But, collectively these different "black hole" and 'big bang" make the organization alive. Without the totality of "black hole" and that of "big bangs", no organization can be physically standing. Other than intuition, to this end the existing literature on civilizations, business entities, and individual humans readily does testify the conclusions used here.

From this example, a careful reader might have sensed the fact that in this yoyo model, we look at each system, be it a human organization, a physical entity, or an abstract intellectual being, as a whole that is made up of a physical body, its internal structure, and its interactions with the environment. This whole, according to the systemic yoyo model, is a high dimensional spin field. Considering the fact that the body is the carrier of all other (such as cultural, philosophical, spiritual, psychological, etc.) aspects of the system, in theory the body of the system is a pool of fluid realized through the researchers sensing organs in the three-dimensional space. The word fluid here is an abstract term totalling the flows of energy, information, materials, etc., circulating within the inside of, going into, and giving off from the body. And in all published references that we have searched these flows are studied widely in natural and social sciences using continuous functions, which in physics and mathematics mean flows of fluids and are widely known as flow functions. On the other hand, as it has been shown and concluded in[2,13] that the universe is a huge ocean of eddies, which changes and evolves constantly. That is, the totality of the physically existing world can be legitimately studied as fluids.

To make this presentation complete for the reader, let us look briefly at the justification of this yoyo model of systems. In theory, the justification for such a model of general systems is the blown-up theory[10]. It can also be seen as a practical background for the law of conservation of informational infrastructures. More specifically, the blown-up theory establishes that in the evolution of a system, what are commonly observed are transitional changes, known as blown-ups, so that it supports the input-output structure of the yoyo model. And based on empirical data, the following law of conservation is proposed[14]: For each given system, there must be a positive number α such that

$$AT \times BS \times CM \times DE = \alpha \tag{1}$$

where A, B, C, and D are some constants determined by the structure and attributes of the system of concern, and T stands for the time as measured within the system, S the space occupied by the system, M and E the total mass and energy contained in the system.

Because M (mass) and E (energy) can exchange into each other and the total of them is conserved, if the system is a closed one, equ. (1) implies that when time T evolves to a certain (large) value, space S has to be very small. That is, in a limited space, the density of mass and energy becomes extremely high. So, an explosion (a big bang) is expected. Following the explosion, space S starts to expand, while time T starts to travel backward or to shrink. This end gives rise of the well-known model for the universe as derived from Einsteins relativity theory[15-16]. In terms of systems, what this law of conservation implies is: Each system goes through such cycles as: $\ldots \to$ expanding$\to$shrinking$\to$expanding$\to$shrinking $\to \ldots$ Now, the geometry of this model of universe established from Einsteins relativity theory is given in Fig.1.

Empirically, the multi-dimensional yoyo model in Fig.1 is manifested in different areas of life. For example, each human being, as we now see it, is a 3-dimensional realization of such a spinning yoyo structure of a higher dimension. To this end, consider two simple and easy-to-repeat experiences. For the first one, imagine we go to a swim meet. As soon as we enter the pool area, we immediately fall into a boiling pot of screaming and jumping spectators, cheering for their favorite swimmers competing in the pool. Now, let us pick a person standing or walking on the pool deck for whatever reason, either for her beauty or for his strange look or body posture. Magically enough, in a brief moment, the person from quite a good distance will feel our stare and she/he will be able to locate us instantly out of the reasonably sized and boiling audience. The reason for the existence of such a miracle and silent communication is that each side is a high dimensional spinning yoyo. Even though we are separated by space and possibly by informational noise, the stare of one side on the other has directed that side′s spin field of the yoyo structure into the spin field of the yoyo structure of the other side. That is the underlying mechanism for the silent communication to be established.

As the second example, let us look at the situation of human relationship. Two individuals are said to be in a congruent position when compared to each other, if none of them is in a more powerfully authoritative height over the other. For example, in a typical marriage relationship the husband and wide in general are in a congruent position, where no one has much authoritative control of the other. However, the relationship between a parent and a child is different, where the parent to a degree and in certain sense has an overarching control of the child. For individuals A and B in a congruent position, all clinic trials in family psychology have shown that when A has a good impression about B[17], magically, individual B also has a similar and almost identical impression about A. When A does not like B and describes B as a dishonest person with various undesirable traits, it has been clinically proven in family psychology that what A describes about B is exactly who A is himself. Once again, the underlying mechanism for such a quiet and unspoken evaluation of each other is that each human being stands for a spinning yoyo and its rotational field. Our feelings about other people are formed through the interactions of our invisible yoyo structures and their spin fields. On the other hand, when individual A possesses an authoritative control over individual B, it simply means that the yoyo field of A is more powerful than that of B. In this case, deviations in their mutual evaluations of each other appear, for more details, see[13].

Historically, although the word system was never emphasized in science, we can still find many similar concepts. For example, Nicholas of Cusa, that profound thinker of the fifteenth century, linking Medieval mysticism with the first beginning of modern science, introduced the notion of *coincidentia oppositorum*, the opposition or indeed fight among the parts within a whole which nevertheless forms a unity of higher order. Leibnizs hierarchy of monads looks quite like that of modern systems; his *mathesis universalis* presages an expanded mathematics. That is not limited to either quantitative or numerical expressions and is able to formulate much conceptual thought. Hegel and Marx emphasized the dialectic structure of thought and of the universe it produces: the deep insight that no proposition can exhaust reality but only approaches its coincidence of opposites by the dialectic process of thesis, antithesis, and synthesis. Gustav Fechner, known as the author of the psychophysical law, elaborated, in the way of the natural philosophers of the nineteenth century, supraindividual organizations of higher order than the usual objects of observation C for example, communities of life and the entire earth, thus romantically anticipating the ecosystems of modern parlance, for a more comprehensive study of history along this line, please consult with[18]. In other words, various theories of systems had been considered throughout history. However, for one reason or another, each of these theories came and gone without leaving much trace and impact.

In this section, after realizing the difficulty of not having its own particular speaking language and thinking logic for systems research, we introduced the badly needed systemic yoyo model. On the basis of this model, the next section shows vividly how such fundamental concepts of modern science as numbers are introduced cleverly with internal structures taken out of concern, and how the yoyo model can help to resolve this problem of the missing internal structures. That in turn establishes the need to develop systems science, the second dimension of knowledge, with the added responsibility of reshaping the traditional science from its bottom up. That is the underlying rationale for why we need to develop a comprehensive curriculum of systems science at all levels of formal education.

3 Problems Investigated Using Systems Thinking and Methodology

Because of the availability of the yoyo model, we now have an intuition and playground that is commonly available for systems theorists and practitioners to house their abstract reasoning and thinking, just as what people are accustomed to do with the Cartesian coordinate system when they think about how to resolve a problem in the classical science. Now, one of the most important problems of systems research is what kinds of problems systems science could and should attack and attempt to resolve. Historically speaking, the importance of this question is that only when systems science can provide new and powerful means to resolve at least some of the age-old whys which have challenged the mankind since the dawn of the recorded history, systems science will have a chance to become firmly recognized as a legitimate branch and the second dimension of knowledge. The never-fading effort of the man invested in studying these forever important whys fundamentally signals the relevance of these endeavours to the very survival of the human race.

Here is a common belief currently existing in the community of systems researchers about what kinds of problems systems science could and should attempt to address[19]: Systems science resolves problems that are related to systemhood instead of thinghood. In other words, systems science is good at addressing such a problem that when one looks at one aspect, he realizes that several other aspects of the issue should be addressed first. That is, the issue seems to be messy with neither any beginning nor an ending and is surely not a linear causality. Many factors influence the outcome, while the outcome simultaneously affects the influencing factors.

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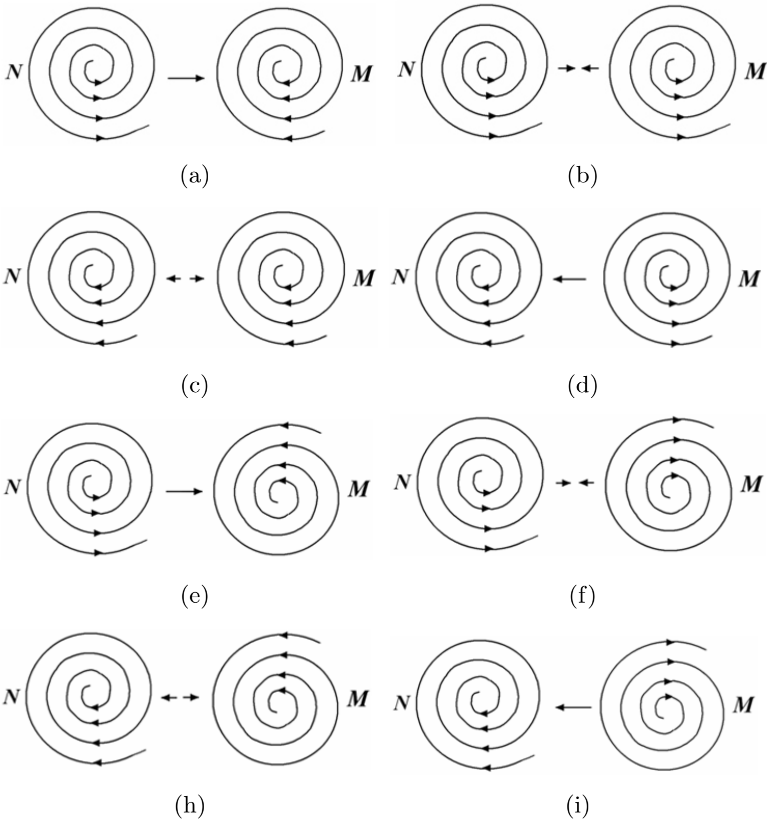
Although such a belief is in line with how systems science has been perceived historically, it has also been quite misleading. In fact, based on this belief, it should be readily recognized that the limitation of modern science is that it takes all structure related aspects of issues out of concern. For instance, for the very basic arithmetic fact that $1 + 1 = 2$ to hold true, modern science has purposefully give away many structural characteristics of the issue of concern. In particular, if 1 + 1 = 2 stands for the fact that when one object is placed together with another object, there will be two objects totally, then the internal structures of the objects have been ignored. It is because when the internal structures of the objects are concerned with, the togetherness of the objects can be zero, or one, or two, or any other possible natural number. To illustrate this fact, let us assume that 1 + 1 = 2 represent placing two systems together. (That is, the objects we put together now have their individual internal structures.) Does that mean consequently we will have two systems totally? The answer is: Not necessarily. In particular, each system now is a spin field, as what we have seen in the previous section. When we place two spin fields together, what do we have? Do we really have two spinning fields?

To answer this question, let us consider all possibilities when two spin fields N and M are placed alongside of each other, Fig.2. Considering their directions of spin and their divergence and convergence of the fields N and M, Fig.2 (a) will produce the outcome of two systems. The spin fields N and M in Fig.2 (b) will remain separate while creating a joint rotational field. Due to their convergence, the fields N and M in Fig.2 (c) will merge together to become one bigger field. If we look back at Fig.2 (b), then they are simply the "big-bang" sides of the convergent fields in Fig.2 (c). So, if the fields N and M do combine with each other, then there will be only one rotational field resulted. If these fields do not combine into a greater field, then while they stay separate from each other, they also create many smaller fields in the areas between them. Similar to the situation in Fig.2 (a), the fields N and M in Fig.2 (d) will stay separate without creating any small field.

Similar analysis indicates that the fields N and M in Fig.2 (e, i) will either destroy each other so that no more rotational field is resulted, or if they stay separate, they will create many smaller fields in the zones between N and M. For the fields N and M in Fig.2 (f, h), they either destroy each other or simply stay separate. In short, 1 + 1 = 2 is a very special case among all the eight possibilities as depicted in Fig.2. As a matter of fact, we can conclude the same fact that 1 + 1 = 2 is a very special case as follows: When one positron is placed together with an electron, the outcome is nothing; that is 1 + 1 = 0. When a woman and man combine into a family, the outcome can be (in theory) any number of people. In comparison, of course, the previous spin-fields analysis is more systemically and scientifically significant than this short version of modelling.

Now, let us look at how modern science resolves problems by analysing the following basic algebraic scenario: Suppose that John and Ed together can finish doing a job in 2 hours, John and Paul together can do the same job in 3 hours, while Ed and Paul together can complete the job in 4 hours. The question that needs to be resolved is: If John, Ed, and Paul work together, how long do they need to finish the job?



(a) (b)

(c) (d)

(e) (f)

(h) (i)

Fig.2 The internal structure of a two-body system

The standard method of solving this algebraic problem is first assume that John can do the job alone in x hours, Ed alone in y hours, and Paul alone in z hours. Then, the following system is established to describe the relationship among the quantities x, y, and z.

$$\begin{cases} \frac{1}{x}+\frac{1}{y}=\frac{1}{2} \\ \frac{1}{x}+\frac{1}{z}=\frac{1}{3} \\ \frac{1}{y}+\frac{1}{z}=\frac{1}{4} \end{cases}$$

Next step is to solve this system mathematically, producing the answer that in $24/13 \approx 1.85$ hours John, Ed, and Paul can complete the job.

To confirm the answer is correct, one is required to go back to the original problem to check the validity of his answer. Here is one way to do just that: Because John and Ed can finish the job in 2 hours together, with Paul added, the additional manpower should make complete the job quicker. So, 24/13 is the correct answer.

Now, if we look at the resolution of the previous problem from the angle of systems thinking, we can see at least two problems: One is that the job might have a structure so that extra hand may not help at all. The other is that if each of the three workers is seen righteously as a living system, then when they are put together, they will surely interact with each other so that instead of speeding up the work progress, the interaction may also very well slow down the progress. Although a greatly simplified version of the first problem has been addressed in operations research, the second problem represents an extremely difficult issue for modern science, known as the three-body problem. For more detailed discussion about this end, please consult with[13].

What these two examples are intended for is that by simply holding onto the thinking of systemhood, almost all, if not all, basic concepts and methods of modern science can be either generalized or improved or both. For example, the following are some of the success stories among many others of thinking and doing just along this line:

(1) By applying the yoyo model to the forecasting of near-zero probability disastrous weather conditions, the current prediction accuracy that is commercially available has been greatly improved[13,20].

(2) By employing the rotation structure of the yoyo model and the observational facts of the dishpan experiment, we are led to the discovery of the fourth crisis in the foundations of mathematics[13].

(3) By relying on the yoyo model as a road map, a sufficient and necessary condition is established for when Beckers rotten kid theorem can hold true, where the theorem is widely used in the research of economics.

Note:Whats listed above represents some of the most difficult, unsettled problems in modern science with which recent progress has been made only through applications of systems thinking. As for other examples of how systems science can address the important whys that have plagued the mankind for centuries, let us look at medicine. In particular, Chinese traditional medicine is a well-developed systems theory about the human body. On the basis of four basic, not defined concepts C blood, qi, yin, and yang, the entire Chinese traditional medical theory has been developed since nearly 5 thousand years ago along with a whole set of practical procedures of how various ailments can be treated, for details see[2] and references listed there. To this end, one specific example is that if a fetus is not positioned right inside its mother at the time of birth, the newborn will most likely suffer from physical disabilities due to birth related injury. A Chinese medical claim is that by needling a specific acupuncture point on the mothers feet, the fetus will reposition itself to the desired position. This ancient mystery (claim) is only reconfirmed recently by researchers from Oxford University, England, while why the needle works as it does is still not known in terms of modern medical theory[21].

In short, what the discussion in this section teaches us is that by bringing organization, structure, and systemhood into modern science as they should be naturally in the first place, the entire spectrum of science will be enriched and become more useful in terms of how well it could resolve real-life problems. On the other hand, by taking the responsibility of reshaping and enriching modern science with the previously unconcerned structures and systemhoods from its very bottom up as part of the future works of systems research, we will be able to truly make systems science the second dimension of knowledge, where the first dimension, the traditional science, considers less or no internal structures.

To this end, a natural question arises: To accomplish this task of reshaping and enriching modern science plus those systems researchers are currently working on, the community of systems scientists does not seem to have the adequate manpower.

4 Educational Programs in Systems Science

One proven effective way to solve the problem of manpower is to follow the disciplinary development of mathematics, which, as an educational program, has been offered to every level of schooling. That of course has provided livelihood and good living for millions of people from around the world. These millions of people surely provide an abundant supply of manpower, with which one can expect to have systems science developed at a rapid speed. For the community of systems scientists to achieve this goal, it will surely be a long and difficult journey. And no matter how long and how difficult this journey can be, we have to start with the first step, the initial planning. Here are some of the details of our idea, which is empirically developed in reference to how programs of mathematics from around the world at different educational levels are offered.

We first start at the undergraduate level by

(1) Offering service courses of systems thinking to all majors in a similar manner as how basic mathematics and science courses are offered currently;

(2) Providing major specific courses to those students who are currently required to learn such materials;

If these imagined courses can be offered successfully, there will be thousands of college-teaching positions suddenly become available worldwide. After talking to many colleagues from around the world, this idea seems to have the potential of success.

Practically, to make this idea work, one needs to secure the financial backing for these positions. Here is one way to get around this problem. If a full time professor teaching X students can provide enough revenue for the university, then the initial step to create the very first teaching position for systems science is to secure at least a steady stream of X students per semester. Then gradually increase this number to 2X, 3X, ..., by adding additionally required systems science courses in as many majors as possible. Based on the current landscape of systems science education, the first service courses could be readily offered to business majors and engineering majors, creating the initial momentum of our planned large-scale programs. In most universities, these two areas represent about 50% or more of the student body. The next in line will be social science and humanity majors, and then followed by the traditional science majors.

As an example, let us imagine a small university of 8,000 undergraduate students, more than 1/8 of which are in the business school with about 300 freshmen each year. If these students are required to take courses in methods, which are most likely the case for many universities from around the world, then we can readily make one of the method courses to contain two parts: the first consists of an examination of the main concepts of quantitative thinking, and the second an introduction to systems science and methodology. If each class section contains a maximum of 30 students, then we are talking about 20 sections for both parts of the sequel. If the teaching load of each instructor is 3 sections per semester, then we have an independent systems science program of about 3.5 faculty members. A similar calculation also indicates an impressive course offering opportunity for engineering majors. So, counting on either the business school or the engineering school, the imagined program in systems science can be started without any trouble. If a systems science major is created accordingly, that of course also translate into additional faculty positions.

This idea of building up educational programs of systems science by focusing on providing service courses is more practical than that of using external research funds. The latter method has been tried during the systems movement in the past decades. One problem with this approach is that the systems science programs established in such a way tends to be limited in size; and when external funds dwindle, the established educational programs also die out consequently, creating an undesirable aftermath for the next round of rapid development of systems science. At the same time, the previous idea of offering service courses can of course be combined with research funding opportunities, because the teaching faculty can surely engage in joint research on various applied topics. By doing so, the teaching load can be accordingly lessened, producing additional faculty positions.

When enough teaching positions at the undergraduate level become available, corresponding graduate programs in systems science will consequently flourish, because graduate assistantships will be more widely attainable and there is a well-established job market for the graduates of the graduate programs. At the same time, to make the students majoring in systems science more marketable in the job place, we can again follow what programs in mathematics do for their students: Each student has to have a special interest area in traditional disciplines, which generally help mathematics majors to locate their future jobs.

In terms of the curriculum, there is a strong and desperate need to develop a whole set of courses of systems science to be taught to systems science major and non-major students. First of all, these courses collectively need to cover all the main blocks of the relevant knowledge. Not only so, the curriculum should be designed in such a way that they form an organic whole and satisfy the following four criteria of a glorious and long-lasting scientific theory[13] in order to bring about historical success for systems science:

A. The basic theories must be readable by as many people as possible;

B. The theoretical conclusions must coincide with peoples intuition;

C. Each course of the curriculum must possess a certain kind of beauty, which can be easily felt;

D. The theories must be capable of producing meaningful results and insights that excite the population.

The first three criteria guarantee a wide-range acceptance of systems thinking and methodology by both the scientific and non-scientific population; and the last criterion provides the livelihood of the discipline of systems science, and the “milk and bread” for all those scholars who pursue a career in systems science. This last criterion also means that systems researchers have to, without any choice, put in their efforts to resolve at least some of the age-old challenges that have faced science and the mankind.

As a side note, to see why what is stated in the previous paragraph is important, let us look at the following fact among many other similar ones: Although systems science and engineering consider various theoretical and practical systems, these systems do not really have much in common even at the level of abstract thinking. This end constitutes a real challenge to the community of systems researchers. Specifically, when a systems project or idea needs public support, such as locating reputable reviewers for a research grant application, the principal investigator or the funding agency in general has a hard time to crystalize the base of supporters other than a few possible personal contacts. Due to this reason, it generally takes a long time, if it ever happens, for a new rising star in systems research to be recognized even within areas of systems science and engineering. In particular, most rising stars, based on my professional contacts, in systems research have experienced difficulties in getting their research projects funded and in obtaining their well-deserved promotions. As a consequence, most of these young scholars have turned away from systems research in order to acquire a professional safe harbor. Without a steady supply of new blood, the effort of systems research will surely stay on the sideline and as secondary to the traditional sciences, as it is currently the case, instead of being complementary to the traditional sciences.

Comparing this state of systems science to that of, for instance, calculus as the core of the traditional science, one can see the clear contrast. In particular, calculus possesses the following characteristics:

(1). It gives one the feeling of a holistic body of thoughts where each concept is tightly developed on the previous ones in a well-accepted playground, the Cartesian coordinate system.

(2). It possesses a high level of theoretical beauty.

(3). It contains a large reservoir of procedures scientific practitioners can follow to obtain their desired consequences. That is, calculus provides solutions to practical problems of different disciplines.

That is, by either further developing calculus and related theories or using these theories, thousands of people from around the world in the generations both before us and after us in the foreseeable future have made and will continue to make their satisfactory living. That in turn feeds back to the livelihood and prosperity of calculus.

On the other hand, systems science does not have a tightly developed system of theory and methods, which new comers can firstly feel excited about and consequently identify themselves strongly with, and scientific practitioners can simply follow established procedures to produce their needed results. In other words,

(1). There is a definite need for the community of systems researchers to develop a cohesive spectrum of systems theories that underlies all methods of systems technology;

(2). To accomplish line 1 above, a speaking language and logic of reasoning particular to systems research have to be established so that currently seemingly unrelated publications could be unified on the same foundation;

(3). Each and every practically applicable methods of systems science has to be theoretically established on the cohesive theoretical spectrum so that conclusions of the methods are scientifically sound and more readily acceptable by the greater community of science; and

(4). Theoretical beauty and practical applicability of systems research have to be established in order to produce a steady follow of new blood for the community of systems scientists.

The most urgent of these tasks of systems research is develop a specific speaking language and logic of reasoning for systems research so that new scientific progresses can be authentically and convincingly shown to be fruits of systems thinking. The current practice of identifying various new theories from various traditional disciplines as new progresses in systems research just wont make systems research a science that truly complements the traditional science as it promises. This end has been well witnessed by the recent and fast disappearance of systems programs from around the U.S.A. Considering the historical successes of calculus for our purpose, the community of systems research should really use all the activities around the development of calculus as its reference to design its relevant courses of action. In particular, we need to develop a curriculum of systems science and methodology to be offered to all levels of formal and informal education, because as we have shown earlier in this paper, in any corner of knowledge that involves basic operations of the traditional scientific thinking, the corresponding systemic reasoning should also be involved.

In the rest of this section, let us discuss more specific course contents to be used in the imagined curriculum. To this end, due to the fact that the field of systems science, the topics of systems research, and the interpretations of the basic terms, such as system, systems methodology, systems thinking, etc., are both broad and diverse, our discussion here will be naturally in principle only. All the specific details will be figured out and improved later when particular course contents are concerned with. What follows next in this section is based on[22] and is intended to be a starting point for future thinking and efforts. It does not aim to be definitive or authoritative. It represents only a partial account of the vast literature existing in systems science.

(1) General systems theory C the foundation: It seeks to establish studies of systems as a discipline in its own right. It aspires to uncover from different scientific disciplines concepts, laws, and models that are applicable to systems of all types. As what is shown in[13], one needs to be reminded that some of the laws of nature are not expressible in the language of mathematics. Considering the diverse audience of our imagined educational program, several versions of this theory should be made available for teaching to different majors of undergraduate students in order to be more readily accessible by these students. At the same time, at this foundation level, the basics of systems science and engineering should be laid out firmly so that on these basics all other courses of the curriculum will be established.

(2) Organizations as systems: Studies in this direction seek to understand different levels of human organization through interactions of subsystems and relationships with the environment. Courses along this line will mainly target students in management and social sciences.

(3) Hard systems approach: It investigates the general systems thinking by using the traditional natural scientific methods. All real-world systems of con-

cern are modelled by using mathematical systems and then these systems are optimized in order to pursue some predefined goals. Theories and methods established here should be well organized into an organic whole so that all students who pursue careers in science and technology could benefit from this course.

(4) Cybernetic thoughts: It stands for the science of communication and control among the elements of a system and is about effective organization. Some of the laws established in this area are considered to be as important to managers as Einsteins law of relativity is to physicists. Similar to line 1) above, several versions of the textbook should be prepared for this area in order to be useful to students with different academic backgrounds.

(5) Systems dynamics: It concerns with continuous processes and the dynamic behaviours of feedback loops or processes, and covers model formulation, equation writing, approaches of validation, and policy analysis. Computer simulation techniques are established. Courses along this line should be designed for students who are more science and technology inclined.

(6) Soft systems: It seeks to apply systems ideas and laws to situations where objectives are not well-defined, and the systems of concern are too complex to be modelled by using mathematics. The complexity arises partially because human beings and ethical concerns are involved. Courses on soft systems thinking should be made available to all students because methods and conclusions learned here can be useful in day-to-day lives.

(7) Emancipatory systems thinking: Studies in this area attempt to provide help to groups in disadvantageous situations by applying systems approaches. So one course should be designed for this area along with the teaching of strategies developed and well tested throughout the history of various conflicts.

(8) Critical systems thinking: As the name suggests, studies in this area attempt to bring unity to the vast number of different systems approaches so that the issue at hand, which might be characterized with seemingly unmanageable large scale, unfathomable complexity, uncontrollable uncertainty, impermanence, and imperfection, can be resolved successfully. This subject matter can be arranged for graduating seniors to take.

Because calculus is surely one of the few scientific theories that has enjoyed a long-lasting glory, in order to make systems science as recognized and as widely accepted as it seems to promise, we should employ calculus as our reference when we compose the materials of the imagined courses in order to satisfy the four criteria of a glorious and scientific theory as listed above. Another important insight we learned from calculus is that when students take courses of systems science, they need be taught, along all other fundamentals, with procedures that can be loosely followed to produce some more or less definite outcomes, which of course depends on which systems area is involved. This end actually explains why calculus has been used by generations after generations. In other words, that is how calculus has provided livelihood for millions of people since its inception over three hundred years ago.

To conclude this section, let us look at how specifically one can get started with our imagined curriculum in systems science by looking at a typical university in the U.S.A. Assume that a systems scientist teaches in an engineering school. Other than what he does already in teaching and research, to succeed with his offering of a new course in systems methodology, he would normally go through the following steps:

(1). Chooses a book on systems methodology that is available in the marketplace, and that is good enough to be used as a textbook for all engineering majors. If no such book is available, then he can readily write one to fill the market need.

(2). Fill out some particularly designed forms for creating a new course. Here what is presented earlier in this paper can be modified for the new course proposal for explaining why such a new course is needed.

(3). Get approvals of the departmental, college, and university curriculum committees;

(4). Advertise on campus to attract at least the minimum required number of students to take the course; and

(5). Actually teach the class.

If the said systems scientist is in the department of philosophy instead of the engineering school as mentioned above, then he can more readily offer the course of systems science that is more philosophical in nature as the first class. If the systems scientist is in the department of mathematics, he can then conveniently offer a course like systems analysis that is more mathematically oriented.

In short, as we discussed in this paper, systems research had popped up as a fad once in a while at different times in various languages throughout the history. However, when compared to the successes of mathematics and natural science, none of these fads lasted very long. On the contrary, the current wave of systems research has been quite long lasting, about one hundred years old, wide spread and accepted throughout the entire spectrum of learning. That is the scientific history has presented us a golden opportunity to make the past short-lived fads into a prominent dimension of knowledge. So, let us hold hands together and make our impacts in the history.

5 Some Final Words

As analyzed in this paper, the golden opportunity, which appears along with the breadth and diversity the vast amount of the literature of systems science and engineering represents, for the next stage development of the systems movement could be more effective if a little purposeful planning is first given. By referencing back to the development history of calculus, it is expected that as long as a worldwide undergraduate education program in systems science can be initiated, a 2-dimensional landscape of knowledge will be formally established, where many of the important whys the mankind has been asking for thousands of years will be ultimately answered. So, let us join hands to collectively make the world in which we live a better place for everyone.

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