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ABOUT THE SYSTEMS THEORY IN THE FIELD OF EDUCATION SCIENCES

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Abstract

The objective of this presentation is the analysis of various aspects related to the principles of holistic education from the perspective of dynamic systems theory. Starting from the definition and concepts of dynamic systems, an argument will be made that holistic education, defined in the formal sense in harmony with the real world, it can not be done without discussing the entirety of the system of education, seen from the view of a systems integrator. This problem exists from ancient times, and it is not believed that a solution will be found in current times, possibly never. This problem is largely correlated with the fundamental problem of philosophy. Besides, neither philosophy, nor science could not yet determine whether the Universe has the border,. Hence, it follows that the "whole" can not really be known. We can assume that an "object" is a whole only if we "see" this like to be isolated from its exterior. So, we are forced to apply the principle of reductionist. Otherwise, the "object" is a part of the whole which is made by the "object" and its outside.

Keywords: Dynamic systems, holistic education, reductionism, mathematics, philosophy.

1. Introduction

If one wants to imagine the above argument related to the core definition of the concept of a system, they need not look further than Bertalanffy's book 'General Systems Theory' (1969). What is

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especially interesting, with regards to the concept of systems introduced by the author, is the fact that, implicitly, this is related to other fundamental concepts, such as those of: “whole”, “entirety”, holistic, reductionism, dynamics, force, energy, complexity, etc. Similarly, it should be noted the fact that a biologist, as was Bertalanffy, felt the necessity to clarify the understanding of the world from a systems perspective, using examples of “systems” from almost all fields of scientific knowledge (biology, mathematics, physics, psychology, education, etc.), in the attempt to construct a unifying theory. Evidently, as was expected, he did not succeed, as “What is to be defined as system is not a question with an obvious or trivial answer” (Guberman, 2004).

Another “notable” approach for defining the concept of a system was made by Ghitescu (2006): “The system represents a philosophical category which establishes a finite set of material and spiritual elements with distinct functions, whose architecture, interconnection, and interaction, is determined by the predominant types of energy of those elements, which, together, finalize at least one characteristic process. As such, to highlight the entirety of the concept of a system through this definition, it must also present the concepts of intellectual energy, as a form of bioenergy, and of information, which are defining attributes of a system. This is interesting approach, compounded by the fact that the author is a fan of Forrester' s (1961) theory of the dynamics of systems, as a “ ... professional field, which combines the theory, methods, and philosophy needed to analyze the behavior of systems in not only management, but also in environmental change, politics, economic behavior, medicine, engineering, and other fields. System dynamics provides a common foundation that can be applied wherever we want to understand and influence how things change through time” (Forrester, 1993). Could this be really a path toward realizing the unity of the sciences (Cat, 2014)?

In fact, it is in the belief of this paper's author's that, this is firstly a still-unsolved problem of dialectics: whole-part, holistic-reductionism. How can a system be described, specified, and analyzed, if not all the parts, each part's actions, interconnections, etc. are known? Starting from the Aristotle’s statement that “The whole is more than the sum of its parts ...”, Gregory Mitchell (2005) wrote: “The holism is the idea that all the properties of a given system (biological, chemical, social, economic, mental, linguistic, etc.) cannot be determined or explained by the sum of its component parts alone. Instead, the system as a whole determines in an important way how the parts behave.“ and “Reductionism is the analysis of complex things into simpler constituents, a theory that all complex systems can be completely understood in terms of their components. This may be seen as the opposite of holism. On the other hand, holism and reductionism can also be regarded as complementary viewpoints, in which case they both would be helpful to get a proper understanding of a given system. The reductionist process helps to determine the parts of a mechanism or structure, but the holistic view helps to determine its purpose and potential applications.”

2. What Is a Dynamic System in the Other Sciences, Outside of Mathematics?

Before or while defining the concept of a dynamic system to fit one's field of knowledge of one science, they should ask themselves whether they really understand the concept of reductionism. The response would be a hard one to give, and it depends so greatly on who formulates it, as much as the understanding of the above concepts of dynamic systems and reductionism. This affirmation poses an

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argument, for example, for untangling research (i.e finding the definition of a dynamic system on the internet). One would be surprised of how such definitions and explanations they could find about this concept. Some would be in convergence with the scientific semantics of the concept, others far away. For example, in mathematical framework “a dynamical system is a system whose state evolves with time over a state space according to a fixed rule” (Nykamp, 2016), or “the dynamical system concept is a mathematical formalization for any fixed rule which describes the time dependence of a point’s position in its ambient space” (para. 1), etc.

On the other hand, each particular science (e.g. physics, chemistry, biology, medicine, economics, politics, etc.) has its own “logic” from which reductionism can then be applied for its “object” of study or for research, which can be named and specified as a subsystem of the real world, and such of the “entirety”. In addition, every science brings a contribution to the understanding of the “entirety” through the resulting research done over a portion of it. Alternatively, each science seeks to establish which are the fundamental elements, the basic building blocks from which the object of study is built. In other words, each science tries to establish the “monad” type of elements, in the general sense of the concept as suggested by G. W. Leibniz's in his book “Monadology” (2007), to analyze and then to establish what type of “composite” defines its object of research. On the other hand, this composite is not “constructed” randomly, as “nothing is without a reason or there is no effect without a cause”. From Leibniz’s Principle of Sufficient Reason follow (Look, 2014) that “... nothing takes place without a sufficient reason means that nothing happens in such a way that it is impossible for someone with enough information to give a reason why it is so and not otherwise”, and “most of the time these reasons cannot be known to us”. So, implicitly, Leibniz accepted absolute determinism of Newtonian mechanics, and the conceptual space which he constructs still had coordinates, although not in Decartes' strict sense. This society has allowed itself to use Leibniz's ideas, which constructed a “minimal system” of the axioms of his philosophy, just as a possible “isomorphism” between scientific and philosophical debates from his time and axioms from which this world addresses.

Is it possible for biology, for example, to correctly establish its own elements of the monad type? One of biology's study objects is named “ecosystem”, identified by the environment and the species of plant and animals that it comprises. In this example, the reductionism has already been applied, since, from the start, this was isolated from the real world by specifying the all its constitutive elements (plants, animals, geographic area, environmental conditions, etc.). If in its incipient stages biology meant medical, botanical and zoological sciences, nowadays it had to expand in order to study the “living organisms” according to the current body of knowledge. As a result, many new branches of biology have been established (genetics, embryology, bioecology, etc.), which also signifies a scale adaptation. In order to understand living organisms and to accurately define the object of study of modern biology, new technologies, instruments and research from other disciplines are employed. For a better understanding of the “system of biological sciences”, and thus of the knowledge of the “living things”, from the first philosophical-scientific opinions to a certain scientific level, a reference can be made to the works of Mayer (1985).

One of the dynamic systems often referenced in biology is the so called “predator-prey” model, with a very special case being the study on the equilibrium between the species of rabbit (prey) and fox (predator). This type of model has applicability in many other fields (virology, economy, etc.). The

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dynamics of the biological system comprised of two interacting species “predator-prey”, with some simplifying hypothesis, is best modelled by the Lotka-Volterra equations (also known as predator-prey equations). From a mathematical standpoint, a dynamic system is comprised of a set of non-linear, autonomous differential equations, and a set of initial conditions. The geometric representation of the set of its solutions phase space are extensive, and, correspondingly, the space phase, i.e. the geometric description of the state of a dynamic system.

In mathematical language, the predator-prey dynamic system is described by:

$$\frac{dx}{dt} = \alpha x - \beta xy, \quad \frac{dy}{dt} = \delta xy - \gamma y, \tag{1}$$

with the initial conditions

$$x(0) = x_0, y(0) = y_0. \tag{2}$$

In this system, x represents the number of prey individuals (e.g. rabbits), and y represents the number of predators (e.g. foxes) relative to the ecosystem selected for study. These unknown variables in the system of equations (1) are also functions dependent on time $t \in [0,+\infty)$, the independent variable of the system. So, we have the unknown functions $x = x(t)$ and $y = y(t)$. Moreover, from a mathematical perspective, these functions have the property of regularity, i.e. they are derivable in relation to time, i.e. exist the functions $\frac{dx}{dt}$ and $\frac{dy}{dt}$, respectively represents growth rates of the two populations over time, $x(t)$ and $y(t)$ represents the number of individuals in each population at a given moment in time $t > 0$, while x_0 and y_0 are the numbers of each species at the initial time (e.g. $t = 0$ represents the beginning of the experiment). The ordered pair (x, y) represents the state of the dynamic system foxes-rabbits at any given moment in time. The parameters $\alpha, \beta, \chi, \delta$ are positive real numbers describing the interaction of the two species and are either prescribed by knowledge of the real ecosystem in which the two species coexist or their values are determined by means of simulated evolutions of the equilibrium between the two species. Rather than performing an in depth analysis of the non-linear system (1), the objective is to highlight that the biologic system has an associated “system of mathematical equations”, both looking to determine the number of individuals in each competing species. The complexity of the system (1) is contrasted in mathematics against the constant slope of a system of linear equations, though the later could also model the complexity of some real life dynamic systems. The complexity of dynamic systems drove the study of deterministic chaos (Hirsch, Smale, & Devaney, 2004), bridging stochastic (Attal & Pautrat, 2006), fractals geometry (Barnsley, 1988), etc. There is a vast amount of literature written on dynamic systems theory and chaos theory, which makes difficult to recommend a specific bibliographic reference.

Within the above-mentioned framework, would it be possible to state that the two species, predator and prey, are the monad type elements for the dynamic system predator-prey? In case of an affirmative answer, it would represent that the reductionist principle was also applied, and as such, we assumed simplifying hypotheses which in turn allowed to assign the equations (1) as the governing laws

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for the dynamics of a predator-prey biological system, with only two interacting species. Are the solutions to the problem (1)-(2) useful to know understand the foxes-rabbits relationship in the real system? The statement is not always true, since by applying scientific reductionist, the monad approach neglected other factors that can influence the dynamic, hence the equilibrium of the two species: diseases affecting either one or both competing species, climate changes or other cataclysmic events, changes in the ecosystem, pollution, etc. What is, then, the usefulness of the dynamic system (1)-(2)? By altering the value of one or more of the parameters in (1), Lotka-Volterra equations allow for computer simulations and plotting possible evolution scenarios. The better the understanding, the knowledge acquired through scientific research into the interactions between the encompassing ecosystem and the two species, the higher the probability that humans can determine the means to restore the balance, preserve Earth's biodiversity and avoid the extinction of a growing list of endangered species. In the foxes-rabbits system, the first step in maintaining the equilibrium of the two species requires identifying the state of equilibrium of the system, defined as asymptotically stability, i.e. $\lim_{t\to\infty} x(t) = x^*$, $\lim_{t\to\infty} y(t) = y^*$, where both species are assured to exist, if the all exterior conditions of this foxes-rabbits system which are provided from its ecosystem are not drastically modified in the future. In the other words, if and only if all values of the constants from (1) will not be significantly modified. In this case, the number of the rabbits, $x^* > 0$ and the number of foxes, $y^* > 0$, are in equilibrium. In line with the advances in the fields of biology, ecology, etc., the differential equation (1) are to be rewritten to better approximate the true laws governing terrestrial ecosystems, while the equivalent mathematical formulation should be developed accordingly.

Newton's Mechanics – the study of the motion of bodies from a terrestrial perspective - was subsequently reformulated in pure mathematical language by Lagrange in his Analytical mechanics. One of the analytical mechanics axioms is that of isolation or liberation: a constraint can be replaced by a force called bundle or reactive force. A constraint is actually the resultant of all the external forces acting upon a rigid body. For example, in the case of an vehicle's motion the constraint is of a geometrical type: the tires must always be in direct contact with the surface of the road (tangent at its surface into o contact point). If the geometric constraint is replaced with the resultant of all reactive forces created by the wheels' contact with the pavement, then the vehicle can be considered like "material point in free motion", without constraints. The replacement of a constraint is said to be „liberation" (or „isolation") of the system from the actions of the environment in proximity of its functioning space (i.e. it is a free system, but isolated from rest). The isolation axiom makes possible to reduce the study of the movement of the vehicle to the movement of of a material, dimensionless geometrical point, assigned in practice to the "center of gravity" of the vehicle. In mechanics, this method was named „the reductionist method". In practice, the mathematical solution for the system of differential equations where the reductionist method was applied is validated by the experimental observations and measurements performed during the movement of the vehicle. Obviously, within the automotive engineering research field, the model is much more complex than the simplified ones in this document.

In essence, everything is "the same", modulo one isomorphism. The predator-prey system is observed independent, "freed" from the encompassing environment. What can be done has limitations imposed by the body of knowledge, political interests related to ecology, etc.

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3. Is an Education System a Dynamic System?

Could one approach education as a dynamic system? To begin with, it should be established what are the base monadic elements. It can be difficult to do so, and, and this is not an objective of this work. But, if one presumes that the monadic elements are already known, and their interactions are established, and in this way education could be defined as a dynamic system, then, this requires specification and boundaries in relation with the real world in which it exists. So, we would need to apply a reductionist method, But, can the real world be defined as a dynamic system integrated with that of education?

This question is not quite rhetorical, and is a problem that everyone encounters, ranging from professors, scientists, managers, politicians, economists, bankers, etc. However, they vary in opinions, theories, developments, and they push for school curriculum reforms and methods of teaching, and adjust facets based on the public budget of the education system, etc. One of the most circulated theories at the level of the base factors of political educational decisions is that formal education no longer meets the needs and the expectations of society. In consequence, the education system must develop other types of education: non-formal, informal, e-learning, blended learning, etc. This way, education as a subsystem of the world-system is already known, defined, and studied with regards to its interactions with the world-system, but some of the populous does not know. To simplify: there are not established universal rules (written in the objective language of mathematics) that govern dynamic systems attached to education, on the basis which analyses are done, scientific simulations and prognoses that assure sustainable development and durability of the human society in the context of national, global, etc. Then, how is it possible to talk about reforms, so of modifications of variables and/or parameters of the dynamic system of education in such a way to optimize the variable “states”? How can one known which states of equilibrium are stable, unstable, etc.? The formal education does not meeting any more the needs and expectations of the society. This is the most used theory at the political decision making levels. Non-formal and informal education are what the society has need, and e-learning and blended learning are new education methods that are being developed for these (Duit & Treagust, 2003).

In this context, another question arises which flows in a logical way, from a desire to clarify several scientific aspects (as morals and ethics apply to less and less people!) of the government, actually of the real social world in which everyone lives (whether at the local, national, or global level): what would be the natural link within the academic space between world-system theory, dynamic systems theory, and scientific education theory? Does there exist scientific understanding of interactions between a system of learning and real society in such a way that the next generation progresses toward “good” or toward “better”? To continue, how do we define “good”? Are some pedagogical principles and didactics enough? As these sciences are empirical and experimental, they are considered as the only ones that govern a learning and education system, but the learning and educational systems are integrated (incorporated) in the social system which, in turn, is in a continuous dynamic and unpredictable state, one may ask whether the problems of education, learning, lifelong learning, and so on are formulated correctly.

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If we accept the principles of education in the sense of moral principles, ethics, etc., we cannot or should not accept them in the sense principles of physics, chemistry, mathematics, etc. For didactic principles to have the same statute, the same consistency, the same outcomes if applied, they should be translated into mathematical language. Why was not this done before? An argument at hand is the so-called "didactic triangle" consisting of "knowledge-teacher-student". There is a lot to be discussed on this subject and there is a lot of literature related to pedagogy, didactics, education, etc. But as far as we know, in the conceptual framework of these sciences there was no attempt for this dynamic system to be specified as a complex system, in the sense of establishing, through research, non-linear laws governing the interactions between the three subsystems: student, teacher, knowledge. The order is not random, because:

1. The student is a dynamic subsystem, intellectual energy carrier that will bring intellectual progress of society in the future; "educational condition" is one that gives feedback on both school-society and on the modeling processes in school.

2. The teacher is the transfer subsystem between knowledge and student. He is withal a "whole" and a "a part", and therefore its role within the "pedagogical triangle" is very important vis à vis of the student and the society.

3. Knowledge encompasses the state of the society where the student is shaped under the resultant of all sources of education, be it formal, non-formal, informal, etc.

The resultant of all types of education experienced by the pupil is unique for each individual student, as a monad element of the society. From this perspective, the human dynamics complex description on the path to become a "human being" through successive dives in the real world is well plotted, at least in the form of existential problems, by Lakoff and Núňez (2000), or, why not, in Pink Floyd' s song The Wall. One of the components (forces, actions) acting upon the student is that of the teacher. The later transfer's knowledge accumulated through experience both in the professional field of study as well as in its applicability in the society the teacher and the student belong. Not in the least, the teacher bears the responsibility to challenge the student to reflect and imagine alternative models and methods to approach possible versions of the society where the student will live in the future.

By performing a simple analysis of the definition and principles of "holistic" education, one may be disappointed by the rather superficial "trendy" ideas so easily adopted by some researchers. For example, how can the following sequence be decoded at a scientific information level: Modern educational theory and practice are grounded in an objectivistic, reductionistic world view, particularly a "natural science" conception of human development. Holistic education is a radically non-reductionist approach based upon a person-centered, ecological, global and spiritual world view. As such, the holistic paradigm is an alternative not only to the scientific reductionism of the modern age, but also to the intellectual reductionism of post-modern thought. Holistic education is a humanistic as well as spiritual critique of the dominant culture.", (Miller, 2000). Regardless of the logical, scientific, humanistic arguments supporting the above statements, there is an obvious contradiction: there is no need to have „natural sciences" knowledge, since being holistic one knows all there is to know about everything and not have to do anything for knowing the whole. Moreover, observed from this angle, holistic education is in itself a reductionist to single monadic element, the human being. This brings into question the status of the Humanist Psychology as either a branch of the science psychology or a new science altogether.

4. In Place of Conclusions

One can agree with the fact that "Holistic education is an approach to pedagogy that can meet the needs of all types of learners, that can be a source of fulfilment and gratification for teachers, and that prepares future citizens who will contribute a concern and mindfulness for others, for their communities, and for the planet. It is compatible with both global education and environmental education, which are also based on the principles of interdependence and connectivity. Based on this interdependent perspective, holistic education seeks to create a society where we live in harmony with the surrounding environment." (Mahmoudi, Jafari, Nasrabadi, & Liaghatdar, 2012). But this affirmation is something else entirely!

Paraphrasing (Nicolescu, & Petrescu, 2013), holistic education is the same with "integrative nature of education must be like an ecosystem where" each student learns to find out his place in the real word through the all his experiences of learning and thinking.

As such, responding while reconciling Miller's ideas, one can tell them that their approach only represents the reduction of a student to a monadic element of education, but that only leads to a limited, superficial and egotistic understanding of just one of the human subsystems - the psychological one. Is this true science of education? If one could imagine for a second Leibniz being alive and among us, would he be able to sustain his anti-Cartesian ideas? This is how Leibniz would reformulate his affirmation now: "There is a continuum here from God, angels, and human beings through animals to stones and the dull monads which underlie the muck and grime of the world; and this continuum is not solely to be understood in terms of the comparative clarity of the mind's perceptions but also in terms of the kinds of mental activity possible for a particular being." (Look, 2014).

We hope that human society, in general, and education, in particular, would assure the existence and protection of the enlighten spirits such as Plato, Archimedes, Aristotle, Euclid, ..., Descartes, Newton, Leibniz, Piaget, Bertalanffy, etc., who tried to describe the real world through application, in one way or another, of reductionist, but they did not forget that this is a whole embedded in other whole, and so on. After all, an old question is still unanswered: what is a "whole" embedding in the Universe?

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