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On the Place and Role of Astronomy and Astrophysics in the Emerging New Model of Education

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Abstract

Developing digital technologies as an evolutionary leap, we are clearly facing a crisis in traditional education system. We are close, or are already at the bifurcation point of techno-cultural evolution. Systems Theory (Bertalanffy (1968)) and the concept of Purposeful Systems (Ackoff & Emery (2009), Ackoff et al. (2006)) focuses on the design of a new model of education. The main difficulty of education is caused by contradictions between the fuzzy logic (Zadeh (1973)) of the humanities and the clear logic of natural sciences. Lingvistic variables of fuzzy logic, reflecting and classifying the multiplicity of objects and connections, allow fuzzy interpretation of reality. The concepts of number and measure achieve convergence in the identification of objects, in their study and in the creation of new objects of reality. Problems arise in the process of combining these two logics in education. Psychology, responsible for understanding of teaching-learning processes, encounters difficulties in solving these problems. Ethology, studying the social behavior of animals and humans, firmly argue that without solving the problems of education as a form of intelligence development, we become an endangered biological species if the environment we have created will be destroyed. We will return to the primitive, animal form of social behavior, since the form of social organization are transmitted genetically and lie deep in our subconscious (Dolnik (2009), Lorenz (1963, 1971)). The digitalization and standardization of education started replacing part, or all of the intelligence with the ability to use databases of "recipes" for recognizing situations and appropriate behavior. Repetitions of each such recipe creates a fixed set of unconscious behavior (Uznadze (1995)) turning people into state of cybernetic organism. This perspective causes some blurred models of the present and gloomy forecasts and plans of social reconstruction. There is the need to clearly describe the reality in which our biological species exists and to transfer this knowledge into the process of education in the form of intellectual development.

Astronomy and astrophysics have created the most fully formulated model of the Universe, that becomes an essential part of culture and practice. The analysis of the intellectual activity of our civilization identifies astronomers and astrophysicists as a special group of purposeful and advanced carriers of intellect whith the great potential for formation of a new model of education. The development of astronomy and astrophysics can be represented as a continuous process of transforming the concepts of fuzzy logic into constructing the model the Universe as observable, measurable and clearly described system. The specificity of the subject of study, the need to constantly develop complex specific technologies for remote research and the need to use the most advanced methods for describing, interpreting and understanding the results, created conditions for specific Cerebral Sorting (Saveliev (2016)) and formation of advanced intellectual, professional and social community.

All significant results in General Psychology have been achieved in cooperation with exact and natural sciences. It is reasonable to offer astronomers and astrophysicists ideas explaining their intellectual activity and consistent with the concepts and ideas of General Psychology. This knowledge may became the part of activity technology and motivation to form a system based on astronomy and astrophysics as a model of cognition and education. Such a model based on General Psychological Theory of Set (Nadirashvili (2007), Uznadze (1995)) is proposed for discussion and use.

Keywords: *Astronomical knowledge, Astronomical Education, Uznadze Theory of Set.*

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1. Introduction

Education is a natural continuation of human scientific activity, a kind of processed product and a system for disseminating knowledge gained by science. Taking care on education, science strengthens the foundation on which it relies, on which its future state and development prospects depend. The formulation of the goals and objectives of scientific research, the determination of an adequate methodology and research tools, the systematization of the results of observations and experiments, the formulation of the discovered patterns using the language of known ideas - is an ideal plan and algorithm of scientific activity. Publication of the results for rigorous verification and confirmation by other members of the scientific community, and the practice of applying knowledge is the only criterion for the reliability and usefulness of scientific activity results. This activity should be considered only as part of the comprehension of the existing reality and its laws in order to create new reality objects. Science has become a tool for designing a new reality, first in our imagination in a certain language of ideas, then in planning and technology for creating the future.

If the process is well documented, as soon as the future becomes present, we have the opportunity to compare the result of activities with the original intent. Creating systems as formations consisting of many elements and connections between them (Bertalanffy (1968)), in most cases, a difference between the result and the intention is found. We have learned to create systems and to identify as systems many phenomena to explore them. In the first case, having discovered a discrepancy, we try redesign the system by replacing elements and reconfiguring connections. In the second case, we try to predict its behavior and try to improve its performance or prevent undesirable consequences of its functioning. If this can be done, practice shows that our identification is adequate to the phenomenon of reality.

The concept of the system turned out to be very productive. On this basis developed the concept of Purposeful systems (Ackoff & Emery (2009)) and the concept of Self-organizing systems (Kapitsa et al. (1997)). Social systems of varying complexity and scale became the subject of research in these areas. There are some results in the form of approaches to forecasting and designing their future by intervening in the system at the stage of its current development (Ackoff (1974), Ackoff et al. (2006)). These ideas began to be projected onto education as a system, and on its elements and connections (Pribram & King (1996)).

The concept of instability appeared as a systems property to behave in an unpredictable way under external influence, unforeseen destruction of elements or connections. The Catastrophe Theory was created and instability was generalized as a property of the Universe. The idea pushed determinism and made it possible to include human activity, including educational activities, in the field of study of natural science. Iinstability, unpredictability and, ultimately, time as an essential variable began to play an important role in overcoming the disunity that has always existed between social and natural sciences (Prigogine (1989)).

Self-organizing Criticality (Bak (1996), Bak et al. (1988)) belongs to the field of Catastrophe Theory. We only recently understand this phenomenon, although it has long been observed and known as flicker noise. Such systems have large number of identical elements and should be classified as stochastic. They are systems of relaxers, can be synchronized and synchronization can even be controlled (Lursmanashvili et al. (2010)). In science and education, we are dealing with a spectrum of diverse changing intellectual states of elements, which is a product of current state of education system and, as we will see below, two types of social relationships that come into conflict.

The general systems patterns found in some scientific areas can be transferred to systems of other areas. In such cases, we often observe an intellectual breakthrough in understanding the phenomena. A retrospective analysis of intellectual breakthroughs shows that the process begins in exact and natural sciences, where understanding is brought to simple primary models of phenomena easily accepted by various fields of research and activity. For example, systems and self-organization ideas (Bertalanffy (1968), Nicolis & Prigogine (1977)) have been consistently developed in natural sciences useing mathematical formulations. Authors of discoveries find the simplest formulations for the dissemination of this knowledge and projection to other areas of human activity (Prigogine (1978), Prigogine & Stengers (1997, 2018)).

If science reaches the level of understanding of phenomenon, the impact on education is reached if linguistic variables of fuzzy logic (Zadeh (1973)) are combined with clear logic of measure and number. Such case is a condition for al breakthrough as a form of instability. Some turn out to be so significant that starts self-organization changing the form of existence and activity of the entire civilization. This transformation lasts 50-100 years (Dyson (1988)). Generations change and the duration of transformation in many ways depends on the effectiveness of the impact of science on education. Sometimes breakthrough waits technology to be realized. Developing information and digital technologies as a stage in the evolutionary leap of humanity, it should not be forgotten that Boolean algebra about a century was waiting for its first

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implementation. It took about 70 more years for the technology to develop so much that we began to realize its unpredictable impact on evolution and fear our transformation into cybernetic organisms.

We are clearly facing a crisis in the traditional education system. It cannot be excluded that we are already at the bifurcation point of techno-cultural evolution, although the formulation of systems approach to education as a societal problem, was the part of breakthrough in understanding systems. The following requirements were formulated for the education of the Systems Age (Ackoff (1974)): should focus on the learning process, not the teaching process; should not be organized around rigidly scheduled quantized units of classified subject matter, but rather around development of the desire to learn and the ability to satisfy the desire; should individualize students and preserve their uniqueness by tailoring itself to fit them, not by requiring them to fit it; should be organized as a continuing, if not a continuous process; should be carried out by educational systems that can and do learn to adapt.

From these requirements follows a number of properties and objects that the system must satisfy and contain, arises a number of questions. Apparently the requirements, as well as the requirements for an ideal university (Ortega y Gasset, (1991)), were waiting for the technology of their implementation. This approach was later developed by the same author in the form of the so-called Idealized Design (Ackoff et al. (2006)). This is really good tool to design the future ideal education system. Apparently, in both cases, only a part of the necessary invariant formulations of the properties was found. The system approach clearly implies that the identification and creation of a future system is impossible without a clear formulation of both its purpose and the current state.

2. Is it possible to measure the intelligence of our civilization as a system?

Is it possible to assess current state of science and education as the complex self-organizing system, consisting of many carriers of intelligence interacting with each other by exchanging information? What should be the sample and indicators to make a conclusion about its state? It turned out that the scientific activity of universities, reflected in scientific publications, is suitable for assessing their intellectual state. For many years, author has been using data of international indices, collected and published without interpretation by the University Ranking by Academic Performance (URAP) Research Laboratory of Informatics Institute of Middle East Technical University of Turkey. Transformation of these data in the form of a diagnostic diagram allows to draw a number of significant conclusions and generalizations.

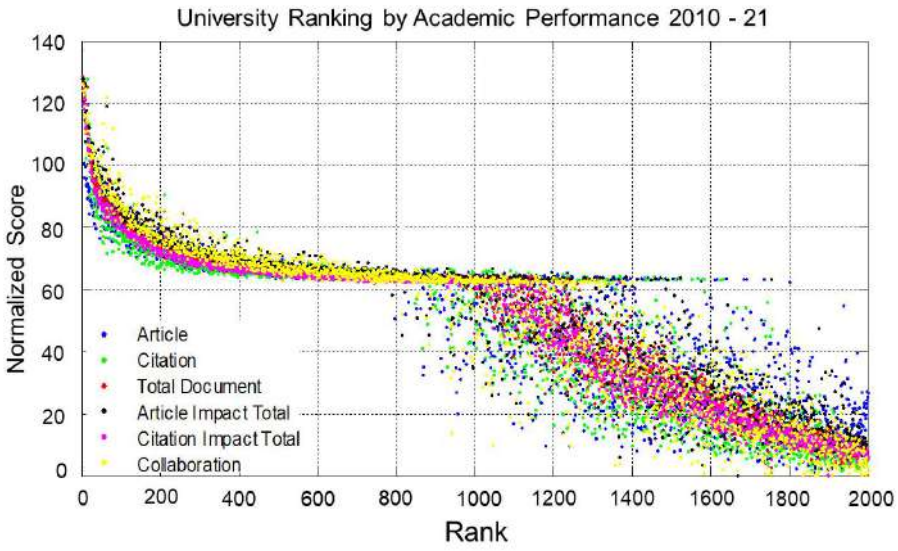

Figure 1. Diagnostic diagram.

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The curves of the ranking indices of about a thousand of first universities are in good correlation with each other. The shape of each curve corresponds to the phenomenon of self-organizing criticality. By normalizing each index in such a way that the data of the first thousand universities match as much as possible, it is possible to bring all the data into one diagram. The general view of the diagram shown in Figure 1 has not changed for 12 years. This indicates the fundamental nature of regularities.

The diagram indicates the presence of two self-organizing types of intellectual "population" - two types of universities classified by the effectiveness of scientific activity. The indices of the second group weakly correlate, create significant noise indicating a relatively low scientific, and therefore intellectual efficiency of activity. This state is traced further for the three thousand universities whose data is published. Considering that the world system of higher education is represented by approximately thirty thousand universities, we can state that we are a weakly intellectually developed civilization. This diagram is the argument confirming the existence of Cerebral Sorting mechanism as a factor of social self-organization (Saveliev (2016)).

The data on the intellectual activity of universities can be regrouped by country.The diagram is presented in Figure 2. It turns out that countries can be classified as having intelligent education systems, and countries with education systems in disaster. Diagram shows that some countries have both types of university "population", and some, mostly European, only the first type. This is another argument in favor of the Cerebral Sorting mechanism. It also becomes obvious why many perfect models of education (Ackoff et al. (2006), Ortega y Gasset, (1991)) have not been implemented for many decades.

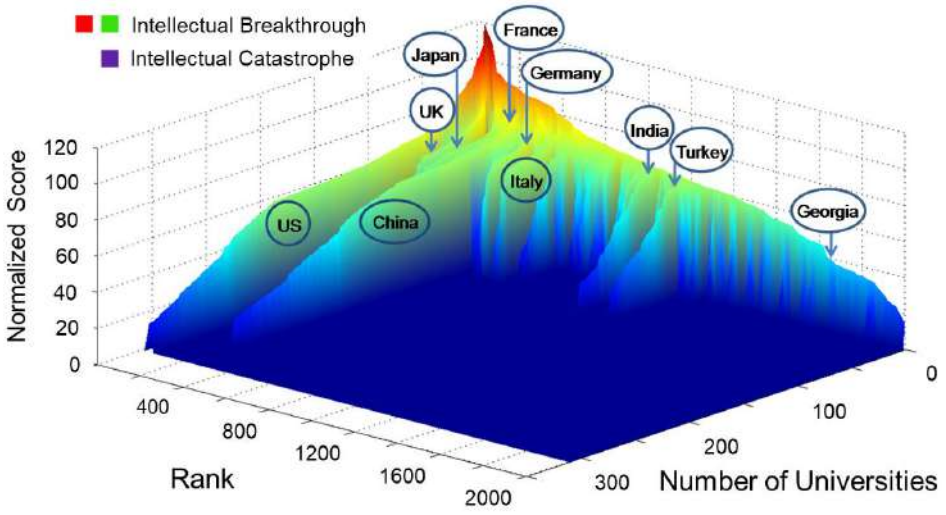

Figure 2. 3D Diagnostic diagram.

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We canl see two categories of development: ability to form attitudes of imitation and learning borrowing models from the information environment; ability to create effective attitudes of behavior in new, previously unknown situations (Nadirashvili (2007), Saveliev (2016)).

3. How to solve the problem of intellectual development

It is proposed to consider the picture of the Universe created by astronomy and astrophysics as a result of human intellectual development, which has, had, has and will have a significant impact on the development of civilization. The scientific activity accompanying this development continuously formulated and solved the most complex problems in the fields of engineering and technology using the language of clear logic. We have almost completed the construction of a model of the Universe, but have not yet fully figured out what place to assign in it to the human as a carrier of intelligence. The intellectual development of the human is a continuous process of interaction between science and education. Every achievement of science is an achievement of education, preparing the basis for an intellectual breakthrough. And every achievement of science returns to education. The system has own peculiar hysteresis of the transition from education to science and vice versa. It seems to the author that the existing knowledge about the Universe can best be transformed into new digital and systems forms of education if this process will be carried out on the basis of knowledge about human psychology and ethology.

Simplistically, education can be represented as a kind of renewable environment for storing and using information, as a library of informational messages of varying degrees of complexity. "Consumers" learn to use it and turn to it in search of recipes for their life needs. If we take into account the achievements of ethology (Dolnik (2009), Lorenz (1963, 1971, 1981)), these basic needs are the simplest needs of a biological species, the satisfaction of which has turned out to be very complicated as a result of our social and technocultural

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development. The models of social behavior necessary to satisfy these primary needs have been developed in the course of biological evolution, are part of the genetic code and are transmitted from generation to generation. This is part of our subconscious social behavior, responsible for building hierarchies in the ownership and distribution of life resources. The history of our civilization can be represented as a continuous process of growing and resolving conflicts of this subconscious behavior in a continuously developing technocultural environment (Dolnik (2009), Lorenz (1963)). Moreover, the subconscious, coming into conflict with the consciousness, builds self-organizing social hierarchies, selecting its members according to their intellectual abilities and regulating access to education (Saveliev (2016)). Such established hierarchies, as a rule, for the purpose of self-preservation, begin to hinder the development of science and its impact on education. The demand for science and education arises when there is a threat from another, more developed hierarchy.

The situation gets more complicated by two factors of this self-organization. One is the presence of significant differences in the morphological parameters of the brain that determine the intellectual potential of each person (Saveliev (2018), Zworykin (1992)). The second - childhood and adolescence is the period of deployment of subconscious programs of social behavior and at the same time the period of mastering the skills to turn on and exercise consciousness and intellect. This is that crucial period of life when the first personal library of behavior programs in the already existing techno-cultural environment is consciously formed in the memory and brought to automatic, unconscious behavior (Uznadze (1995)). Some of these programs begin to form and are fixed as a counterbalance to the primary subconscious programs, oppose fear and aggressiveness in the natural behavior of a human as a biological phenomenon. Obviously, the state of the education system and its impact on this age group can shape the fate of generations and the community as a whole. By transforming education systems in a certain way, one can create and preserve entire behavioral communities for a long time. These considerations must be taken into account when we talk about education, designing the future and a systems approach to social problem (Ackoff (1974)).

Turning over the pages of the history of science and relying on the idea of the Cerebral Sorting (Saveliev (2016)) as a factor in the self-organization of social communities, one can come to the conclusion that the Universe, as a special subject of research, has formed a special social group of its researchers. The main feature and the argument of Cerebral Sorting of this social group is intellectual activity to study phenomena and objects that are not directly a part of life resources.

Darwin's theory of the evolution of species has received significant support from ethologists who study the social behavior of animals and humans[1] (Lorenz (1963, 1971, 1981)). We have pointed that *two forms* of behavior in human social behavior. One, ancient, subconscious is successively deployed in the form of a set of programs for future adulthood during the initial development of the organism until its puberty (Dolnik (2009), Lorenz (1963)). These programs establish and maintain hierarchies of strong individuals in the possession/distribution of food and reproduction in the animal world. This is a set of physiological sorting programs. It is important that in this set of programs for enimals, there are programs for "bloodless" maintenance of subordination in the process of change and maintenance of the hierarchical rank.

The second, later form of social behavior is the product of conscious social behavior and social evolution. This set of behavioral programs includes a variety of forms of learning reduced to a simple formula - fixing in memory a set of social situations and contacts with the environment, the skills of their unconscious recognition, and unconscious response in accordance with the program (set) alredy fixed in memory by previous experience of being in situations or contacts. This is what we may call the mechanism of our psychics in accordance with the Uznadze General Psychological Theory of Set (Uznadze (1995)). It is difficult to imagine ourself as a robot learning automatically by trial and error, approaching the desired result in each new situation and fixing it in memory in order to respond if it is repeated. It is also difficult to accept the idea that the education system is only a realized way of creating attitudes of behavior not from one's own, but from someone else's experience. But there is no other theory that claims to be General Psychological, is confirmed experimentally and explains a significant part of psychological processes, and one have to come back to it again and again (Nadin (2015), Parjanadze (2015)). This second form of behavior is responsible for cerebral sorting (Saveliev (2016)). We differ significantly from each other in terms of memory capacity, speed of recognizing situations and accuracy of recognizing situations.

Both forms, interacting, competing and conflicting in different situations, explain all psychological phenomena without exception. It is very important that by developing this second form of social behavior, evolution weakened in our species the protective subconscious "bloodless" mechanisms of the first model.

[1] In 1973 Lorenz K., Frisch K. and Tinbergen N. were awarded the Nobel Prize for Physiology or Medicine for their discoveries concerning animal behavioral patterns.

As a result, our social reality and the entire history of our civilizations have turned into a bizarre conglomeration of hierarchical pyramids of various sizes being built and destroyed. It is easy to guess that we are dealing with a system and a phenomenon of self-organizing criticality (Bak (1996), Bak et al. (1988)).

Researcher experienced in systems approach and seeking in psychology a clue to his motives and incentives for research behavior, comes to conclusion that he is dealing with a poorly organized system of young, emerging field of science with the most difficult object of study. The only working definition of intelligence he will find has long been present in psychology (Piajet (1950)) and is analogous to the basic concept of Operations Research (Ackoff & Sasieni (1968)). The exact and natural sciences already understand and build in their own way what psychologists are trying to define and formulate. Every unsolved problem in psychology is a challenge for the entire scientific community.

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