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HOMEOSTATIC APPROACH TO EDUCATION

Dzyatkovskaya Elena Nikolaevna (a)*, Saraeva Nadezhda Mihailovna (b), Mamchenko Anna Alexandrovna (c), Pustovalova Vega Vadimovna (d)
*Corresponding author

- (a) 103062, the Makarenko street, 5/16, Federal state scientific institution " Institute for the Development Strategy of Education of the Russian Academy of Education", leading researcher, Moscow, Russia, dziatkov@mail.ru
(b) 672039, Alexandro-Zavodskaya St.30, FSBEI HE "TSU" (Federal State Budgetary Educational Institution of Higher Education "Transbaikal State University"), Professor, Chita, Russia, saraiewa@mail.ru
(c) 103062, the Makarenko street, 5/16, Federal state scientific institution " Institute for the Development Strategy of Education of the Russian Academy of Education", Senior Researcher, Moscow, Russia, anna-priv@yandex.ru
(d) 634012 Tomsk, Matrosova street, 8, Information and Methodical Center of Tomsk, Director, Tomsk, Russia, vega_2005_11@mail.ru

Abstract

The problem of accessibility of education is caused by the contradiction between the tasks of training and the real possibilities of learning students, including their health. We examined the problem of accessibility of education from the standpoint of the homeostatic approach: as a relation of the management of student learning and universal laws of homeostatic regulation. Previously, we have shown that the reason for the learning difficulties may be hidden in the immaturity of the cognitive regulation connected with the perinatal period. However, this could not explain all the cases of low availability of various teaching systems for diverse children. We suggested that the reasons may be connected with the specifics of the child's learning management: its inconsistency with the laws of natural regulation. The structure and principles of the homeostat - regulation system in self-regulating systems - served as an analogue for the construction of a nature-like teaching system. We investigated the features of training, mental development and the state of health of children studying in experimental and control groups. The groups differed in the use / non-use of a homeostatic approach to the design of teaching systems. It is proved that the homeostatic approach reduces the dependence of the learning success on the individual cognitive features of children, their state of health and the ecological situation in the place of residence. It optimizes the mental development of children and prevents their psychosomatic disorders. It is proposed to develop a homeostatic method for verifying didactic developments.

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Keywords: Teaching system, accessibility of training, homeostatic approach.



1. Introduction

The didactic principle of accessibility of education was put forward by Komensky (1998) in the 17th century. He formulated the rules of access to training, which are relevant to the present day: from known to unknown, from easy to difficult, from simple to complex, from close to distant. Subsequently, the concept of "accessibility of training" was expanded and became interdisciplinary. Today it is a complex problem, the research of which is occupied by specialists of many branches of science: hygiene, physiology, psychology, and ergonomics. The principle of accessibility has become an obligatory criterion for selecting the content of the training material. The urgency of the problem of accessibility of training is not diminishing, but is increasing in global information society (Scholz, 2015; Sudakov et al., 2013).

It is proved that the accessibility of training is determined by the correspondence of its content, volume, methods, tools, forms, time devoted to study, relationships "student - teacher" with the level of knowledge and skills of students, their age, the development of their cognitive abilities, individual characteristics, motivation, etc. The problem of accessibility reflects the main contradiction between the tasks of training and the real possibilities of pupils' learning, including the problem of educational safety for health. The accessibility of training expresses as a measure of learning difficulties, which are overcome by rationally organized activity in the "zone of the nearest development of a particular student" with a help of teacher (Dehaene, 2017; Ishalin, 2003; McNamara, 2006; Talkhabi & Nouri, 2012).

Homeostatic approach allows to approach the problem of accessibility of education by cybernetic laws of self-regulating systems. The theory of homeostatics was developed by a Russian scientist Gorsky (1990). He revealed new facets of the philosophical law of unity and struggle of opposites - the purposeful regulation of contradictions in homeostatic structures that provides them ultra-stability, operational reliability, adaptability to disturbing effects, complex autoregulation and self-adjustment to an effective mode of operation, survivability, certain invariance in relation to aging elements, noise, pathology of individual elements. The regulation of contradictions is traced in the structural, functional and dynamic organizations of the homeostatic system (Gorsky, 1990).

The system of regulation of internal functioning, indicators, rhythms, development trends and self-organization of the system is called homeostat. All homeostats, regardless of their material carrier, have a similar structure and functioning principles. The universal principles of homeostatic regulation are the following: regulation of contradictions, expansion of the field of diversity, combination of rigid and flexible principles management, the dynamic nature of the regulation of contradictions, the "stock" of movements, and others (Glaserfeld, 2002; Gorsky, Stepanov, Teslinov, 2000; Scott, Shurville, Maclean, Cong, 2007).

Homeostatics allows to model the behavior of systems of any nature - natural, social, technical, ecological, to predict the stability of their development under the influence of both internal regulation and management influences from the outside. It allows to foresee the development of pathologies in the homeostatic system, to understand their nature, the causes and ways of preventing conflict management. For our research, the following homeostatic problems are in sight: what can and should be managed in dealing with self-organizing systems; how to choose the optimal direction of development; where the boundaries of external management of a self-developing system are.

The homeostatic approach refers to cybernetics of the second and third order. Today it is considered proven that homeostasis manifests itself not only in living organisms, but also in natural systems, in social

phenomena and in large artificial systems. Homeostatic laws are necessary to take into account in the economy, in the creation of artificial intelligence systems and in other spheres, where topics of survivability or competition are explored. Applied homeostatics deals with areas of management, adaptology, medicine, biology, sociology, aviation, astronautics, and economics. For example, in the socio-psychological field, the homeostatic approach was used to study the effectiveness of joint activity of crews under extreme conditions; qualimetry of group activity of operators of complex control systems; corporate object management system and decision-making methods. The application of a homeostatic approach to the study of biosphere processes led to the development of noospheric cybernetics.

It was proved that a deep analogy exists between the mechanisms of effective management in human collectives and the homeostasis of living organisms (Gorsky, 1990; Kolesnikova, Dzyatkovskaya, Dolgih, 2015). This gave reason to believe that an educational and upbringing process in which the mechanisms of managing the child's studies are based on the fundamental laws of regulation in natural systems is possible. In such system, management does not contradict the laws of the neuropsychological regulation.

2. Problem Statement

According homeostatics (branch of cybernetics), teaching can be considered as management of learning, which is simultaneously influenced by involuntary neuropsychological regulation. The paper shows the possibility of optimizing the teaching system managing in accordance with the regulation laws of homeostatic systems. The article proves that the homeostatic approach can be useful in solving the problem of the accessibility of education and its safety for psychosomatic health of students.

3. Research Questions

Is it possible to assess a teaching system by comparing its management function with homeostatic regulation? Can we use a homeostatic approach to the verification of teaching systems?

4. Purpose of the Study

The purpose of this article is to investigate the possibility of optimizing the teaching system managing in accordance with the regulation laws of homeostatic systems.

5. Research Methods

Neuropsychological complex (Simernitskaya, "Luria-90") - necessary to assess the maturity of neuropsychological regulation, methods of cognitive psychology (Holodnaya, 2008) - required to assess the maturity of cognitive regulation, Torrance Creativity test - necessary to evaluate search activity, neurological anamnesis and diagnosis - important for assessing neurological health and, therefore, the state of neuropsychic regulation, basic vegetative tone (Belokon & Kuberger, 1987) - to assess the dysregulation of the autonomic nervous system, biochemical studies of lipid peroxidation and antioxidant protection (Menshikova & Zenkov, 1993) - to assess the physiological "price" of training, a complex of functional

physiological and ergonomic tests (Dzyatkovskaya, 1998) - for a comprehensive assessment of the conflict of neuropsychic regulation of studies and its external management

6. Findings

6.1. Facts about the conflict of management and regulation

Earlier we applied the homeostatic approach for interdisciplinary medical-psychological-pedagogical research (Kolesnikova, Dzyatkovskaya, & Dolgih, 2015). The phenomenon of qualitative information stress was discovered - a "collision" of the external management of student learning and its regulation. Groups of students' risk of conflict management – regulation were described. It was shown that these groups includes children with immaturity of neuropsychological regulation of cognitive processes caused by problems of the perinatal period. Many children of this group had neurological diagnosis and increased risk of development of educational difficulties and psychosomatic disorders. Immaturity of their neuropsychological regulation led to difficulties of adapting to learning, formation of unproductive methods of educational activity, and on this basis - the psychosomatic status of the child.

At the same time, we noted that some children had a high physiological and psychological "price" of learning in some teaching systems but they successfully studied in other systems, while subjective interpersonal factors being insignificant. More than 80% of cases of deterioration of psychosomatic health were observed in children with a figurative type of coding in the traditional teaching system and with a sensory type of coding in the developing teaching system. It is also interesting to note that the characteristics given by teachers to children with the same neuropsychological profile were often diametrically opposed in various teaching systems. So, in the traditional system teachers noticed low initiative of boys with a leading left eye and right ear. In the classes, trained in the Zankov's system, the same children were clear leaders.

So we suggested that we were faced with the conflict between the pedagogical management of the learning and individual characteristics of the neuro-psyche regulation of healthy children.

Probably we have to bring the structure and principles of teaching system management in line with homeostatic regulation to reduce the number of children "uncomfortable" for a particular teaching system, rather, on the contrary (!), to increase the adaptability of children with different cognitive personality to any teaching system.

6.2. Design of the didactic system on principles of self-regulation and openness

System of teaching was considered as an ordered set of goals and tasks; content, methods, means, forms of organization of teaching and results (Maheshwari, 2016). We transformed teaching systems as close as possible to the characteristics of open and self-regulating systems (Gorsky, Stepanov, & Teslinov, 2000; Yang & Song, 2014).

Giving to the system of openness inevitably led to consideration of its external environment - a set of factors that affect its functioning and, in turn, are affected by the teaching system itself.

The openness of teaching system is closely connected with transdisciplinary of education: the integration of science and practice, the cooperation of science, education and society, the transparency of school boundaries for society, the emergence of learning meanings that go beyond the fundamentals of

science and deal with complex social problems. Problems of sustainable development are priority here; they correlate knowledge and values of the scientific and non-scientific world, human wisdom and the analytical rigor of science and academic methodology (Bazhanov, Scholz, 2015; Scholz et al., 2015).

The idea of sustainability concerns a general mode of management. The sustainable development of society is ensured by its transition to "nature-like" management technologies. This means that the sciences of stability, based on the homeostatic theory of the management of self-organizing systems, become a social didactics of the study of stability (Ko, Sammons, &Bakkum, 2016).

An open teaching system declares the importance, but the inadequacy of traditional school subjects, because there are knowledge, concepts, skills, attitudes and actions that go beyond their boundaries. To be truly educated, the student must be able to establish links between scientific disciplines, find ways to integrate the knowledge of individual subjects and correlate them with what they learn in life.

This is equivalent to the homeostatic principle of expanding the field of diversity. In our experiment, one of the means of its implementation was a metalanguage, understood not only by students, but also by their families, employers, specialists. We proposed didactic metaphors about sustainable development - "carts" for the transport of meanings between school subjects, between theory and real life, the world of childhood and the adult world, culture and personal experience.

Another homeostatic principle - the combination of rigid and flexible management principles - was realized through the combination of changing scientific knowledge and congenital archetypal codes of conduct by including cultural concepts of national mentality into the education for sustainable development.

According to the theory of homeostatics, an open system receives the property of self-regulation due to the peculiarities of its structural and functional organization. All such systems, based on natural intelligence, have three regulatory circuits - the basic, adaptive and protective (Gorsky, Stepanov, &Teslinov, 2000).

The basic circuit ensures the functioning of the system by means of an internal network of direct, reverse, cross links between the "leader" (goal of training), "executors" (content, methods, means and organizational forms of instruction) and "managed object" (the subject of culture sustainable development). These are neutral, allied, partner, stabilizing, competitive, conflictual and other links (more than 100 variants of their combination), which are realized in a variety of educational, project and social situations.

The more diverse the network of links (except conflict ones) - the more stable the system becomes. In our study, a crosscutting vector of education for sustainable development provided the diversity and integrity of the system's links. It was formulated at the pre-objective level of constructing content and was implemented with the help of trans-subject technology of greening through all the academic subjects consistently: understanding - interpretation - the semantic setting of activity - the product of meaningful activity.

The adaptive circuit gives the system the ability to self-development. It solves the contradictions that arise within it and with the environment based on the feedback "goal-result". In teaching, the circuit is represented by student and public reflection of the results obtained - subject, meta-subject, personal; and by the education about and for sustainable development (Keestra, 2015).

The protective circuit, or self-preservation circuit, protects the system from conflicts (failures, crisis states) that threaten the achievement of the goal. It provides it with operational reliability and sustainability

of development. The circuit redistributes the voltage in the network of interactions of the main circuit, changes the load on the various links of the additional circuit, and regulates the rhythm of the entire system. Thus, it gives the system a margin of safety in relation to internal and external conflicts caused by natural fluctuations in the parameters of the system and environment, the uneven development of their various components or various force majeure circumstances. In education it is implemented as whole-institution approaches to sustainable development proclaimed by the Road Map of the UNESCO Global Action Program (Scholz, 2015; Ko, Sammons, & Bakkum, 2016). It implements the principles of safe management: multiple overlapping of each functional block of the system, flexible planning taking into account resources (the main educational program of the school is presented in the form of a roadmap), strategic forecasting (school forecast service), etc. The whole-institution approach is aimed at creating the way of school life that models sustainability in the region, the country, the world based on transdisciplinarity.

The consequence of getting the system the properties of self-regulation is the realization of the principle of regulating contradictions in all its functions.

At the level of the teaching goal, the regulation of contradictions was presented as: necessity - opportunity, social - personal, present - future, etc. At the level of teaching methods, the regulation of contradictions was presented as: traditional - innovation, quantity-quality, balancing by modalities of perception, first and second signal systems, training rhythms and rates; controlled introduction of cognitive dissonance in dialogues, case studies, etc. (Dehaene, 2017; Metcalfe & Kornell, 2007).

At the level of content selection, scientific and everyday concepts; concepts and sensual images; theoretical, sensual-emotional and mythological thinking were used as well as teaching the principles of environmental management in order to increase the literacy of the society in the field of the environment, and build up the potential for sustainable development in it. In general, the teaching system appears as a transdisciplinary system of learning sustainability on the principles of sustainable management (Scholz et al., 2015).

6.3. Biochemical, psychophysiological, cognitive changes in children. The state of their health

More than 2,000 children from Moscow, the Irkutsk Region, and the Ust-Ordyn Buryat District were participated in interdisciplinary research by the Institute of Content and Methods of Education of the Russian Academy of Education in conjunction with the East Siberian Branch of the Russian Academy of Medical Sciences. Children did not have neurological diagnoses in the present and in the anamnesis as well as immature profiles of cognitive regulation. Special psychological and medical support for students in the experimental classes was excluded. The method of natural experiment was used. Physiological, biochemical, psychological as well as clinical and laboratory research methods were applied. The experimental and control classes differed in the use / nonuse of the homeostatic approach in the teaching system at the stage of constructing its content: selection of sources, principles, criteria, and selection of teaching methods. Specialists dealt with encoded student numbers, without knowing whether they belonged to experimental or control classes. Biochemical studies was carried out at the Cambridge Technical University.

Statistically significant differences have been revealed in the indices of antioxidant protection of children in experimental and control classes (the ratio of alpha-tocopherol and dienic conjugates in the blood serum), indicating the influence of learning management on deep homeostatic biochemical processes.

Correlative galaxies between the vegetative accompaniment of the child's study, ways of coding information, and styles of emotional, volitional and communicative regulation were investigated. It was shown that they are regularly changing with the age of children. These changes were especially significant in the period of primary school age, when the improvement of biological regulatory mechanisms and the formation of individual styles of cognitive, motivational-volitional and social-communicative regulations are taking place. In the experimental group, the tightness of the connections between these indicators decreased more rapidly than in the control group (Fig. 1).

At the same time, the tension in the system of psychophysiological regulations of schoolchildren decreased. This means that the combination of ways of obtaining, processing, coding information and styles of their regulation has become multiplied, that indicated an increase in the options for responding the system to external influences, that is, an increase its adaptability as a whole.

Teachers, psychologists and physicians have confirmed optimization of cognitive regulation under a homeostatic approach to teaching management. The quality of teaching children in the experimental classes was higher than in the control. The dependence of the indices of mental development on the ecological status of the place of residence, as well as on individual cognitive features, was statistically insignificant, and the number of children with learning difficulties was significantly lower in the experimental classes than in the control classes.

It was established that 87% of students in the experiment (compared to 14% in control classes) did not worsen the state of neurological health. 13% of cases of deterioration of the neurological health indicators of children in the experimental classes were neuroendocrine diseases of pubertal age, revealed genetic pathologies, brain traumas, infectious diseases of the nervous system.

The accentuations of the basic vegetative tone were noted in 60% of cases in the control group, whereas in the experimental group it was more than twice as rare. In the experimental group, the number of children with cognitive "accentuations" decreased from 28 to 2.5% in the first five years of education, and in the control group it increased from 27 to 35% (Table 1).

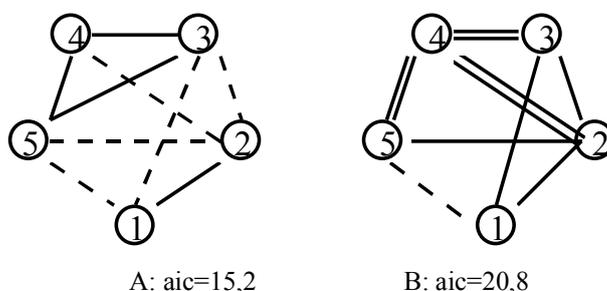


Figure 01. Correlation of the methods of coding (3), vegetative (1), emotional (2), motivational-volitional (4), communicative regulation of cognitive activity. Reliability of communications: double line - $p < 0,01$; one continuous line - $p < 0,05$; intermittent - $p < 0,1$ A - for teenagers of experimental classes, B - for teenagers of control classes; aic - amount of internal connections.

Table 01. The results of the homeostatic approach application to teaching systems

Index	Experiment	Control
Sufficient level of general skills (grade 9)	94.0%±1.8%	64.0%±6.7%
Sufficient level of creativity (grade 11)	72.0%±3,5%	14.0%±4,1%
Number of children with accentuated regulation profiles of cognitive activity (grade 11)	2.5%±0,6%	35.0%±5,2%
Number of children with learning difficulties (primary school)	15.0%	48.0%
High level of educational motivation (grade 9)	78.0%±3,2%	28.0%±3,0%
Dependence of learning outcomes on the environmental situation in the place of residence and individual cognitive features (4, 9, 11 class)	0.29 (very low)	0.63 (middle)
Number of children who did not worsen the state of mental health from grades 1 to 11	87.0%±2,7%	34.0%±3,9%
The occurrence of psychosomatic disorders (grade 4 / grade 11)	32.0%±2,7%	

7. Conclusion

Accessibility of training is increasing and the risk of developing psychosomatic disorders in students is reducing when teaching system is based on homeostatic approach. Studies have revealed the possibility of applying a homeostatic approach to verifying didactic developments. The conducted studies are useful to develop pedagogical support for children in complex therapy of psychosomatic disorders at school and in clinic.

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