Adaptive Mechanisms of Management in Educational System Development

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Abstract
Modernization of education requires significant changes in the management of educational systems and processes, the development and implementation of new principles of educational management. The result is determined by the objective necessity of transition of educational systems in a qualitatively new state and to a higher level of functioning. It is necessary to develop such innovative methods, principles and mechanisms that would reinforce the effect of the reforms, reducing as much as possible their negative manifestations in the current time period. The aim of the article is to describe the phenomenon of controllability in educational systems, namely the problems of formalization, high dynamism and activity of managed elements in the system. The leading idea in the article is the use of information and logic simulation to improve the controllability of the educational systems that contribute to script development in the context of high uncertainty in the external and internal environment. The authors defined the specificity of the controllability of educational systems and processes, the combination of features and properties of this controllability. The adaptive mechanisms are given that determine the ratio of the organization and self-organization in the educational systems and controllability’s boundaries of educational systems. The article is intended for experts of education authorities, teachers of pedagogical and managerial specialty, managers and employees of educational organizations, researchers who are involved in the governance of educational systems and processes.

Keywords: education, educational system, management, controllability, development, adaptive mechanisms, modeling

1. Introduction
1.1 Background
Under the education system, based on the definition of D. A. Novikov & N. P. Glotova (2004), can be understood as a set of educational institutions implementing successive educational curricula of different levels and directions. The development of the education system depends on other systems - economic, political, technological and social, that is called when these systems are changed the priorities, goals, structural elements, conditions of implementation of education also are changed (Muhametzyanova, 2005; Shamova, 2005, Novikov, 2009).

Considering the controllability as a universal characteristic which is peculiar to any system or process, it is necessary to consider several aspects: the first is to define the specificity of this concept in the system of categories of sociology; the second is to describe the characteristics which are inherent to controllability, and the third is to identify properties of controllability. These aspects give to the social phenomenon some new quality
Management of educational systems, like any other object, seeks to change its current state and trajectory of development in order to achieve goals. Thus, goal setting is the point of the report and means the setting of parameters, conditions and mechanisms of governance.

1.2 Status of a Problem

The vocational education system is complex and dynamic, that is variable in time and is active when driven elements of the system can change its state independently (Novikov, 1999; Borytko & Solovtsova, 2006; Potashnik & Solozhnin, 2012; Nizhegorodtsev, 2015). Representatives of the synergetic approach formulate understanding of the problem of complex systems’ management which is based on internal analysis of trends in the self-development of the systems themselves and the detection of spatial areas and temporal moments of unpredictability and lack of control (Vasiliev et al., 1999; Prigogine, 2015). Followers of the synergetic approach recognize the importance of controllability, paying attention to the ratio of the organization and self-organization, and effects of management thinking.

At each level of education management (Federal, regional, municipal, territorial, level of educational institutions) there are a set of stakeholders that selects the kind of change in their condition while preserving their own interests (for example, learner that learns not all the necessary material, but only some part of it, which ensures him or her a satisfactory mark), there is a change of control actions within the positive impact of achieving the goal.

1.3 The Research Hypothesis

From the standpoint of the complexity of the content the category "controllability" means the maintenance and development of socially significant standards, the complexity of the management process and the qualitative transformation of the social environment. As a result of it the "controllability" is presented not as an abstract category or many everyday judgments, but as a cognitive model designed to describe the actual practice of any organization, due to economic, social, political and spiritual processes.

2. Materials and Methods

2.1 The Definition of the Specificity of Management in Educational Systems and Processes

The active entities of the educational system, which include staff, faculty, students, have the opportunity of freedom to choose the trajectories of their actions (based on their own preferences) for the implementation of the educational process, i.e. the communicative activity on transmission/reception of professionally oriented scientific, educational and organizational information, which provides the transformation of the individual student and his vital functionality. Control of professional educational system, like any active system should "take into account the activity of the managed entities" (Novikov, 1999), who measuring their own level of preferences, values and motives change management impact. Then, under these conditions, the control problem is reduced to finding optimal trajectory of control to reach its maximum efficiency.

Besides the entities of management on the installation of the types of management actions in the system of vocational education have influence stakeholders: governments, business community, social society in general. Moreover, with the increase in the share of one of the groups other interests are infringed, for example, the orientation of education to the needs of the market contradicts its humanization and development of spirituality.

The specificity of active educational systems is in:
- formalization and parameterization of processes and connections in operating system;
- high probability of random events under the influence of factors which are difficult to predict;
- absence of one of the optimum condition;
- determination of the beginning and applicability;
- the establishment of conditions of adaptability (response frequency of the system) and multifactor pedagogical cycles require the development of unique highly dynamic adaptive mechanisms and models, not allowing fully to translate the methods of management in technical systems (Bagrinovskiy, 1999; Kuropatkin, 1980).

2.2 The Simulation Stages of Management in Educational Systems Development

The optimization problem setting in educational systems’ management consists of:
1) the definition of the parameters of the control function F(x1, x2,...xn) and the optimization criterion;
2) taking into account of the restrictions (conditions) on the parameters of development’s management;
3) corridors’ identifying of parameters’ variation, which is created by an active system.
According to the theory of active systems, a model of active educational system is assigned a set of parameters:
- the totality of participants in the system (learners, their families, social and professional groups, administrative institutions and the institutions of civil society);
- a set of relationships between entities in the system (management, hierarchical, information);
- sequence of operation (focus of control and information flows);
- dynamic of functioning (length of control cycles to manage the entities of the educational system);
- the level of impact (the degree of system’s entities -stakeholders on the state of the system);
- the performance efficiency parameters of the system’s state (management criteria);
- the operation conditions (the set of acceptable states for the entities of the system);
- certainty of participants and stakeholders of the system (the level of awareness when making decisions).

These parameters define the mechanism of interaction of its elements, i.e., a possible mechanism of its functioning control from different positions.

2.3 The Controllability’s Criteria Defining of Educational Systems

Applied aspect of the study of the category "controllability", according to A. I. Prigozhin (2015), includes decisions’ capability to be implemented; consistency of purpose and action; stability of the institutional order, and each of these indicators, definitely, cannot be absolute and attainable.

As a result, the dimension of controllability takes several parameters.

First of all, consistency of purposes and action of controlling elements and entities which implement solutions. Controllability presented as the coherence of the objectives and actions is defined by purposes’ quality, namely, clarity, coherence, consistency and accessibility. Quality parameters of the objectives are: high strategic objectives (desired image of the future); long-term goals of the organization (mission and strategy); operational objectives (utility functions of departments and employees); the degree of motivation of the entities of education on the achievement of these objectives; status of educational and organizational processes. Thus, controllability, represented in the decision-making process, seen as a process of influence on the level of the individual, group, organization.

In addition, the ability to be control detects the restriction of freedom in the decision-making process personified by dominant entity. The controllability process is possible only if you can form adequate to the existing problem the personalized sociocultural "body" and create such a dominant entity, which is able to build up into a social process some adaptive mechanism of managerial type. In this dimension the specifics of controllability is that the creative nature of social processes predominates over their destructiveness, and the definition of the control boundaries and retention mechanisms of social processes within these boundaries is a more significant goal than practical results’ achieving.

Finally, the content of the category "controllability" is expressed in the intensity’s indicators of the process. It is characteristic that determines the degree of influence of relationships and connections in the organization. Controllability can be high, medium and low. The design includes not only the conceptualization and operationalization of the category "controllability", but the creation of a typology of this phenomenon depending on the type of organization (Zarubin, Nachkin, 2015).

3. Result

3.1 Definition of Educational Systems’ Management Types

Based on the classification of species (management practices) by Novikov (2004) there are:
- composition’s management - management organization of training and retraining of educational institutions;
- structure’s management - the hierarchy of subordination by type of organizational structure and technology of management decisions’ transfer;
- institutional management- webcast of the entire hierarchical structure with decrees, orders of management’s higher authorities and getting of reports on their implementation;
- motivational management- changing of subordinates’ preferences, contributing to the solution of management problems;
- informational management - as one of the least studied aspect of management from the point of view of formal models, one way or another presenting in all other methods.
In our opinion, informational management is a continuous, dynamic and changing part of the Department for granting optimally grouped data for management decisions to achieve goals with the resources available. We believe that the implementation of informational management is essential in all types of management and at all levels of the management hierarchy (Federal, regional, institutional, process).

3.2 Informational Management as an Adaptive Mechanism of Management in Educational System’s Development

Implementation of informational management is presented as sufficiently flexible, adaptive and predictive mechanism providing a comprehensive solution of multivariate problems when there are changes in the external and internal environment with the economic and social efficiency’s criteria. It should be noted that the mechanism in this context means the ability of self-determination of the system when there is an impact on its resources, i.e. the planned response of the system (the organization of its processes, and structures and methods) on the adjustable control within the selected loop (cycle). Adaptation here is a dynamic process that ensures the existence, development and effective functioning of the educational system in conditions of high turbulence of external systems (political, economic, social and technological) (Kononov, Kul'ba, Shubin, 2000; Kul'ba, Kononov, Kosyachenko, Shubin, 2004). The adaptation process is implemented (enable) in case of significant changes in the external and/or internal conditions, changing the state of the educational system and includes the support functions of the system’s balance in achieving planned goals and maintaining of compliance with the requirements of the environment (the training standards and requirements of the stakeholder groups). Then, using the cybernetic definition of adaptation as “the accumulation and use of information to achieve optimal in some sense the condition or behavior of the system at the initial uncertainty in a dynamic and changing environment”, it can be argued that informational management – there is an adaptive mechanism to manage the educational systems applied to optimize the system state with the accumulation and processing of information about the state of the external and internal environment of the system.

The adaptive mechanism’s features include: the lack of clear patterns in the system’s management, the necessity of modeling the system and its response to the operation of the adaptive mechanism in connection with the necessity to change actions at the control of variable changes of the system.

3.3 The Model of Managed Educational System

The variability of educational systems requires the use of special methods of modeling and design, when the effectiveness of the state at the current time (t) is the starting point of the report on the next time interval (t+1), and the boundaries of the variability of the objective function are in a certain range of values. That is the task to build the adaptive mechanism means to build two models: technological and adaptive. Structural informational model (includes components of the educational system and their relationship) has a high level of certainty, and dynamic informational model with a flexible and adaptive parameters and structure in specified of the corridors values (established during the goal-setting of the processes in educational systems) has the capability of functioning setting under changing of informational impact parameters. In addition, in every time of dynamic adaptive educational system’s functioning the assessing of its parameters’ values is carried out, i.e. the system’s monitoring is a mandatory element of the model of the educational system. Informational management involves a dynamic process of informational influence on the management of the educational system and includes formalized and grouped delivery of information, monitoring and the development of possible scenarios of development of the educational system. The uniqueness and characteristics of informational management of active educational system require the ability to modify the actions of the system and the coordination of its operation when there are changes in external and internal conditions without significant changes in its resources, i.e. build such prognostic model of the system which will allow to determine the necessary approvals, the optimal solution on the set of possible trade-offs, and to provide them with automation.

Search of adaptive mechanism for the management of the education system is in the formalization of functions between the management and the state of the system. At the forefront is the development of a model to manage the system which possesses the properties of adaptability and dynamism. As a rule, in such cases, a model can be used, which has parametric mapping of management and managed process, where ruling the output responses of the process we can judge about the effectiveness of control actions. And here it is necessary to emphasize the resulting uncertainty associated with the conditions of the environment’s operation and informational entropy.

Thus, the adaptive model of informational management of the educational system consists of process model describing structurally the implemented system processes and simulation - dynamic model of the process’s formation, and the "adapter" of the control system means the possibility to predict the system’s behavior under
the influence of the control action, i.e. the possible choice of controlling actions to achieve the system’s desired state.

As a structural model of the system the author proposes to use a process model of the educational system, when a set of processes’ results, inputs and outputs technologically describes its functioning. The model is based on the quality standard ISO and process approach (Levina, Kamasheva, Gazizova, Yusupova, Kuzmin, 2015). For example, the functional description of the processes of the University in our opinion, can be represented as a set of processes:

- **Training** *(goal: implementation of complex of educational curricula);*
- **Research activity** *(goal: development of innovative projects, technologies and tools);*
- **Training and methodological support** *(goal: design, development and use of educational and methodical literature and documentation that meets the requirements of the content of higher professional education);*
- **Staff training** *(goal: implementation of training, retraining and advanced training of pedagogical staff of the University);*
- **Pre-University training** *(objective: to provide assessment, training, career guidance and adaptation of students);*
- **Monitoring of educational activities in the University** *(goal: realization of measurement, analysis and improvement of educational activities’ processes; the purpose of the sub-processes is realization of measurement, analysis and improvement of all identified processes of educational activities at the University);*
- **Marketing** *(aim: evaluation of the market conditions of educational services and labor market);*
- **General management in the University** *(goal: organization and regulation of management activity (psychological, pedagogical, administrative and distribution, organizational and economic functions) at the University; development of the strategic plan and the strategic development’s ensuring).*

The absence of applicable to the educational system dynamic models of management have led to the search of such a concept of modeling, which would ensure the change of the structure and functioning of the modeled object (in the system) when there is a changing in the characteristics of the internal and external properties. The foundations of this type of modeling may be suggested conceptually a informational framework model of Helmut Krcmar describing the image of the system from the point of view of each of its participants, thereby forming an n-dimensional model, (according the number of stakeholder groups - n) in the system.

Technologically, such a description can be created using information and logic simulation used in database theory to describe the subject area. Here the characteristics of educational processes can be obtained on the base of the interaction of information flows of the educational system. The process of modeling itself is the basis, in accordance with which the system is considered as a set of processes of information processing carried out in series-parallel mode with the use of modern information technology of processing and analysis of data to identify relationships and patterns that cannot be detected with other methods of analysis. Information-logical modeling is much broader than information modeling, which describes only the structure of threads and objects’ metric.

This model is dynamic, variable in time, i.e. when converting any indicators of external and internal environment the structure’s informational description of the management flows is changed (configurable) at constant relationships and connections of model’s components that enables the parameters’ adjustment of the system’s functioning during dynamic changes of the external and internal environment and leads to the definition of scenarios and algorithms of the system's actions in spatial and temporal characteristics simultaneously, where on the basis of consideration of external and internal conditions the decision is made.

4. Discussions

The controllability process is possible only if it is possible to form adequate to the existing problem the personalized sociocultural "body" and to create such a dominant entity which is able to integrate into the social process some regulatory mechanism of the managerial type. In this dimension the specifics of controllability is that the creative nature of educational processes predominates over their destructiveness, and the definition of the boundaries of controllability and mechanisms of retention of educational processes and systems within these boundaries is a more significant goal than achieving of practical results.

The proposed informational-logical model can serve as an adaptive mechanism by setting all the parameters, actions, and structures in a turbulent external environment, while maintaining information relations of described objects, thereby ensuring the relevant parameters necessary for making managerial decisions and their variations.

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5. Conclusions
The obtained on the basis of the model and the computational experiment results should be imposed in a real teaching environment taking into account constantly emerging and complex, rapidly changing situations, system interference (noise) simultaneously fulfilling the adjustment of the model based on the experience, intuitive assessments, common sense, resource capabilities. The accuracy of the model predictions should be evaluated on the error, which in the conditions of pedagogical processes is quite high, since not all qualitative parameters of the pedagogical process reasonably can be translated into quantitative. However, despite the stochastic nature of the operation of any pedagogical process, the conditional forecast accuracy and built on the basis of their projects, the result of the process’s formalization, processing and analysis of the system’s parameters will be conducted in boundary conditions, that is, the result of informational and logic simulation will be an element of the controlling system.

Such model can be constructed for any level of management of professional educational systems. The processes’ selection of the described hierarchy’s level, the establishment of the factorial values of the parameters of the processes, information flows’ directions and the description of algorithms of functioning will ensure the implementation of the automated system of support of decision-making in educational systems.

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