

The Properties and Regularities of the Educational System Development

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Abstract

The paper examines the ways to increase the intellectual potential of a university, which functions as an element of the national education system. The purpose of the paper is to study the properties and patterns of the functioning and development of the university as the main element of the national educational system. The methodological basis of the article is the powerful platform of the systems' theory and the system analysis. The methodology is applied to the study of an educational system at different hierarchical levels. Our major finding is the set of regularities in the functioning of the educational system. There are indicators that the management effectiveness of the educational system and higher educational institutions can be enhanced by increasing the professionalism and the qualifications of the research and teaching staff of the university. A qualitative enhancement stems from the increase of unification and standardization of organizational processes.

Keywords: Intellectual potential of a university; National education system; Management effectiveness.



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1. Introduction

There is much evidence that modern trends in the development of society, due to the characteristics of the postindustrial economy, suggest appropriate changes in the approaches to the university training of specialists. These changes encompass not only the rise of universities' effectiveness describing them as socio-economic systems, but also the implementation of qualitatively new teaching technologies and methods. It is possible to accomplish this goal only if universities optimize all kinds of available resources. According to [Naidenko et al. \(2017\)](#), "one of the key resources of the educational organization is human capital, which acts as the most significant and valuable economic resource, a source of competitive advantages. The receipt of additional revenues through unique advantages is increasingly becoming the object of attention of modern organizations. It helps shape their development strategies" ([Naidenko et al., 2017](#)).

K. Shchurin, describing the legacy of M. Porter ([Shchurin, 2005](#)), defined the competitive advantage of an organization or economic system as "the ability to earn a bigger return from the investment compared with other organizations, considering average in the industry". In this case, competitiveness emerges as an economic category reflecting the economic efficiency of an organization, i.e., the ratio of the revenues received in relation to the amount of resources spent on obtaining them. In the scientific literature there are many definitions of "the competitive advantage of universities". Therefore, I.V. Borisova defines the competitive advantage of a university as "the set of characteristics, the properties of the trademark or educational products and services obtaining which an educational institution acquires a certain superiority over its direct competitors" ([Borisova and Tikhomirova, 2002](#)). In this case, there is a value approach to the definition

of the category under discussion. However, the competitive advantage given as a value does not stem from the availability of raw materials, technologies and the economies of scale. Undoubtedly, a university competitive advantage emerges from a resource approach to the analysis of the organization's activities. It depends on the possession of valuable, rare and difficult to copy resources. As far as higher education institutions are concerned, some researchers consider labor potential, intellectual capacities, human resources to be the most important competitive resources ([Ekshikeev, 2009](#)).

T. Stuart refers this type of resources to nonmaterial assets. Human capital, as part of the intellectual capital of the university, includes resources and opportunities that are valuable, rare, poorly imitated and weakly interchangeable.

It is a common knowledge that labor resources relate to the intangible organizational assets. In current conditions economic organizations' development depends on this form of assets. It is of much importance while analyzing the competitive features of an enterprise. The economic efficiency of an organization depends equally on

both material and nonmaterial resources. Different types of resources closely interrelate. Organizational and financial resources make it possible to invest in the development of intellectual capital. Intellectual capital directly affects the formation and the development of human capital. Therefore, human capital development strategies stem from the formation, organization and optimization of the use of intellectual capital. This pattern plays a pivotal role as a resource component of the organization's innovative development.

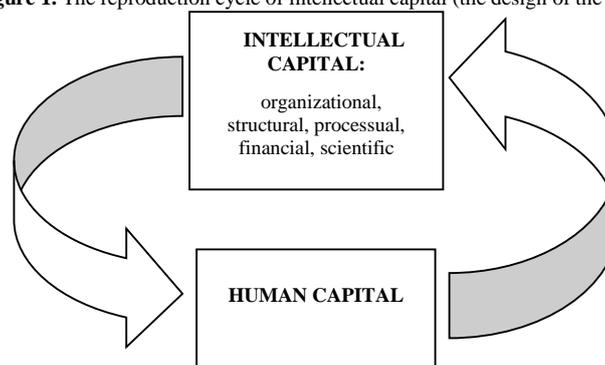
2. Methods

Methodologically the analysis and research of intellectual capital stem from the theory of organizational resource management, considering the specifics of its activities. It is obvious that the conceptual and organizational models of intellectual capital of various organizations are unique, because of the specifics and peculiar properties of not only the organizational processes, but also the characteristics of human capital. Nevertheless, by now science experts have developed certain common approaches to the structuring of intangible intellectual and labor assets.

Experts divide intellectual capital, focused on the characteristics of subjects of organizational relations, into human, organizational, client, managerial, etc. The terms that characterize the specifics and diversity of intangible assets encompass such notions as a brand, intellectual property, efficiency of research and advanced development, etc.

Intellectual capital in the modern theory of resource capitalization emerges in the forms of three components: human, organizational and client capital. It seems that the set of intellectual capital components must be expanded, eliminating human capital. This is since an organization that possesses considerable human capital may not have intellectual capital in general. It is obvious that the relationships among the structural components of intellectual capital can be explored with the help of different model designs. At the same time, with relative independence, intellectual and human capital closely interrelate. Therefore, human capital, possessing the appropriate properties or characteristics, can reproduce intellectual capital, which, in turn, activates the development and reproduction of human capital. It is a model of a closed reproduction cycle (See Figure 1).

Figure 1. The reproduction cycle of intellectual capital (the design of the authors)



Therefore, the content of human capital determines the characteristics and parameters of all other components of intellectual capital. It is human capital that determines the qualities and characteristics of organizational, scientific and other types of intellectual capital. For example, the educational structure of the university staff, the level of its competence affect the formation of innovative capital (patents, inventions, projects, etc.), as well as the capital of processes and structural capital.

A significant role in the formation of intellectual capital belongs to the design of the organization's processual structure. In this case, the functional process content of the organizational system affects the diversity and parameters of intellectual capital. In turn, the organizational system precedes the design of the management system, which is a set of functional cycles, integrated in accordance with the organization's management methodology. The processes implemented within the boundaries of the organization will be effective depending on the rationality and quality of the organization's management system.

The university, as a part of an educational system, participates directly in the reproduction processes of human capital. In this connection, experts have been studying the human capital of educational organizations, firstly, from the angle of its influence on the processes of formation of the human capital. Human capital is necessary for enterprises, regions and the country. Of much importance is the formation of graduates' competencies, knowledge and skills required by the modern sectors of material and nonmaterial production (Roberts, 1978). Experts explore the institutions of higher education as the main developers of specialists who present human capital. There is a growing body of literature developed by native and foreign scientists which describes innovative economy and the role of human capital in it.

The specificity of the university as the main element of the national education system is that its human capital determines not only the level of the intellectual capital of the educational organization itself. It also directly influences the qualitative and quantitative characteristics of the human and the intellectual capital of regions. It has significant impact on the country through the formation of competencies, knowledge and the skills of graduates. The place and role of higher educational institutions in the processes of human capital formation and its impact on innovative processes in the economy are quite fully represented in native and foreign scientific literature (Roberts,

1978). However, there is a gap in the description of the issues related to the organization of the procedure and instrumental and methodological guidance of the integrated assessment of the university human capital. This assessment should emerge from a system approach in the context of implementing its strategic priorities. V. Vladimirov argues that “the study of the interaction between the education system and society is a serious problem that does not lose its relevance and requires a systematic approach for its solution. Both the education system and the society are complex systems. They function both at an individual level and in combination” (Vladimirov *et al.*, 2006). This view is supported by V.N. Volkova who described the properties and regularities of the functioning and development of complex systems (Volkova and Denisov, 2003). Consequently, the experts describe the following main common factors which are as follows: the interaction of the parts and the “whole”, a hierarchical order, the regularities of functioning and development, manageability, goal setting.

3. Results

Considering the specifics of the national education system, the patterns of interaction between parts and the “whole” manifest themselves in the different characteristics of the functioning of the university. These characteristics depend on the model of the “whole”. Therefore, the models of the “whole” in relation to the university, can be either the entire national education system or the network of universities selected by some reason. The first model of the interaction between higher education institutions and the national educational system has to do with the rigid nature of connections, the strict formalization of organizational, financial and planning decisions. Universities have a direct strict responsibility to the state in the sphere of higher educational activities. Within the second “whole” model, universities receive more independence in making decisions in the sphere of using resources to achieve their goals.

The regularity of hierarchical ordering is evident in the fact that any complex system can be represented as a hierarchical structure. In this structural formation, higher hierarchical levels directly influence the underlying subordinate levels. Consequently, the subordinate levels acquire new properties that they did not previously possess. Therefore, the decisions, projects, orders, etc., worked out at the level of the Ministry of Education, determine universities’ new or changed functions, the revision of strategic goals, the use of new management methods, etc. At the same time, the regularity of hierarchical ordering implies the possibility of studying complex systems that have a high degree of uncertainty. In this case, it becomes possible to divide large systems into smaller ones. This subordination makes it possible to reduce the degree of uncertainty in the processes of solving management problems. For example, the task of managing the higher educational system is much more effective if the set of subordinate higher education institutions function as smaller groups selected on the principles of the number of students, location, organizational and legal status, etc.

The management of the educational system should encompass such aspects as the time and adaptation factors in the processes of system change. As far as the patterns of development are concerned it is important to single out such key factors as historicity and self-organization. Historicity in the development of systems presupposes the need to consider the stages of the life cycle of an object during the formation and the management of an organization. These stages allow the timely implementation of control actions resulting in the modernization and reforming of systems.

There is much evidence that the pattern of self-organization relates to the property of the system to withstand entropic tendencies. This principle is evident from the fact that in crisis conditions an active system can either move to a higher level of organization or be at a lower level (Ivakhnenko, 1981).

The patterns of feasibility of systems are manifested in the ability of the system to reach the final state irrespective of time and initial conditions (equifinality), as well as the action of the law of “necessary diversity ...” formulated by Ashby (2006). According to L. von Bertalanffy’s research, the system reaches a certain final state only due to the presence of internal resources, characteristics and regardless of time and initial conditions (Bertalanffy, 1969). As far as the functioning of the university is concerned, this means that, for example, the level of innovation, its intellectual potential can be changed only because of the changes in its internal parameters, i.e., the characteristics of the human potential of the university. In accordance with the law of necessary diversity, the effectiveness of the management of the education system and higher education institutions can be enhanced both by the increasing professionalism and the improved qualifications of the scientific and teaching staff of the university. Of much importance is the rise of unification and standardization of organizational processes. It is our belief that of primary importance is the reduction of the number of controlled internal parameters determining the educational organization.

4. Discussion

Scientific research of the processes of target formation in complex systems made it possible to derive several regularities that were inherent both in the formulation of systemic goals and in the development of the organizational structure of goals. The understanding and application of these laws allowed us to form not only a set of realistically achievable guidelines for the development of the organization, but also to understand their structural and functional cohesion and dependence.

Higher education institutions and university associations belong to super complex systems. Paradoxically, but now the structure, functions, criteria for the functioning of both a separate institution and the community of higher education institutions, overall, are not clearly defined. Data on their functioning are unstable, highly noisy, have a high degree of subjectivity. Currently, universities, strictly speaking, are not integrated into either a system or a network organization. However, in various scientific materials and normative documents we often come across the

phrases describing “the unified university system of the country”, “the network organization of universities”, etc. A clear (complete and consistent) mathematical understanding behind these phrases is absent. Obviously, the study should be conducted from a systemic perspective. Proceeding from the applied aspect of the system approach, we utilized the method of system analysis in this paper. We applied the fundamental methodological foundations of system analysis, and universal laws, i.e., the first and the second principles of thermodynamics.

The first principle postulates the law of the energy conservation. We used the human capital of the university, its students as an energy equivalent. The second law of thermodynamics characterizes the scattering of energy circulating in the system. Mathematically, this process is modeled by partial differential equations.

Education and society are complex fragile systems. The managerial outcomes in such systems are not always predictable. Therefore, a “fullscale experiment” over them is highly undesirable. As a rule, such experiments are expensive, require a long time, can be dangerous. The consequences of defective managerial decisions are tragic. In this connection, in the current study of higher education institutions and higher educational communities we tried to understand, explain, and describe their managerial strategies. We developed the model of anticipating and forecasting the possible ways of their evolution, managing them or adapting them to a changing environment. To achieve this goal, it is desirable to premodel, simulate the structure and the behavior of a real complex system.

There is much evidence that the basic property of the system is emergence. In this study it encompasses the process when the system acquires special properties that are not inherent in its elements. Emergence allows the system to get the sum of elements that are not connected with specific links. In the case of emergence, the system properties are not narrowed down to the properties of its components. The synonym for emergence is the “systemic effect” (Gainutdinova, 2010). In this connection, the investigation of a complex object by its decomposition into separate elements is the way to the loss of system properties of the object. Interestingly, the system elements become visible, easy to study, but in this case, they represent the generating system only in part. The methodology of scientific research develops approaches that avoid decomposition of the system. And one of these methods is the projective approach (Kuizheva *et al.*, 2015).

It is necessary to distinguish a project and projective management. As a basic theoretical impulse of the projective approach, there is a refusal to apply the decomposition property of the system to subsystems. Decomposition results in the loss of the integral perception of the research object. The object in the decomposition loses its properties, determined by the systemic union of elements.

Simplification in this case can be represented as the study of an integral object, but from different points of view. This approach gives us the set of simplified descriptions of the object under study which we call projections. Each projection is evaluated by its ability to reflect system properties, provide opportunities for setting and solving management tasks. The whole object is represented in the form of interconnected concepts-projections, and the links reflect the influence of some concepts on others. By increasing the number of projections, it is possible to increase the degree of adequacy of object research. It should be noted that the ideas of the projective approach have been used in one form or another, but they were not updated, and, therefore, the capacities and problems are not systematized, the corresponding range of tools is not developed.

In accordance with the requirements of the system approach, the necessary condition for its implementation is the integrity of the object under study. In a sense, while studying a system we sometimes must artificially separate it from the functional environment. It is necessary to break important functional connections to investigate the system. In relation to the university and the educational system, in general, this provision cannot be fully implemented, since there are numerous interactions and connections of the elements of the control object with the external environment.

Nowadays, many mathematical models have been developed to reflect certain aspects of the education system and the functioning of its subsystems. But, as a rule, they reflect only the fragments of the education system and processes occurring in the sphere of education. They do not indicate educational institutions in their integrity and, therefore, do not reflect the patterns of interaction of the system parts and the whole. The consequence of this is that at present there is no general methodology for studying the education system and, most importantly, researching it in interaction with the society, i.e., the external environment.

And, although the question of the fundamental possibility of building a unified methodology for studying the education system in its interaction with the society remains open, the action in this direction is possible. The correct attempt is the application of complex systems’ cognitive modeling (Verba *et al.*, 2004).

5. Conclusion

In this paper we highlighted universities and their communities as the objects of system analysis.

Our major finding is that a specific university systematically manifests itself as a dialectical unity of five components:

- the process of preparing an innovative researcher;
- the process of preparing an innovative teacher;
- the process of training innovative specialists;
- an innovative teacher;
- an innovative specialist.

The first three processes relate to the categories of the means of achieving the goal, the latter two to the target categories of the university. The results of these processes are integrated in the implementation of the complex goal of managing the innovation development of a university (the first stage of the system analysis). The management stages are as follows:

- the efficiency improvement of the process of preparing an innovative teacher;
- the improvement of teaching quality;
- the improving of training of an innovative specialist;
- the improving of the quality of an innovative specialist.

At the second stage of the system analysis, we discussed the impact of the external environment on the effectiveness of the national educational system and a separate university.

The third stage of system analysis consists in a formal description of the development of the processes of the university community, as an economic value, as a key system of economic reality.

Another important finding is that the systematic approach to the study of the system of higher education manifests itself in the aspects which are as follows:

1. The problems of university development. They should be considered in the context of management levels. The most common and instrumentally developed in the scientific and methodological literature are the following levels: macro, meso and micro levels. The specific formulation of the problem may require another selection of levels (increasing or decreasing their number, extending the restriction of their functional operation, etc.). This situation can arise in the formation of the necessary diversity of the management system, the classification of higher education institutions.

The macro level involves examining the university system of the country in the context of its inclusion in the world educational and scientific environment. This level describes the university's impact on the socio-economic development of macro regions, i.e., the totality of countries united by unified political, economic, social and other problems and the socioeconomic development of the countries. The meso level is represented by the problems of the regions of the country and the branches of the national economy. The micro-level includes the description and the research of university activities and the units of a separate institution.

2. The functional activity of the university. It emerges not only in the solution of educational problems of the country, region, enterprise, specific person, but also in solving scientific problems of transition to the 5th and the 6th technological orders. It should be noted that the main scientific forces of the country are concentrated in universities, but their influence on large science is complicated by various reasons. Higher educational institutions also solve numerous social problems, i.e., the career development of the employees and the students of the university, as well as the labor market regulation in the region. Universities must compensate the shifts and unevenness of demographic development in the country.

3. Motivation systems. They both improve the efficiency of current activities, and the development at all levels. Motivation in our research is given from the perspective of the theory of active systems. At present, the criteria introduced in the system of university performance indicators are designed to ensure the development of the country's university system in the currently relevant directions. However, the incentive system is not prescribed. Basically, two management modes are used, i.e., the dismantling and the merger of universities. These processes weakly stimulate the effective work of a university, and lead to the path of earning credit points to the detriment of the main mission of higher education.

4. The monitoring of universities. It is proposed to be carried out from the position of combined use of the pricing theory and the cognitive analysis (CA). CA reveals the concept-signs, which form the basis of the pricing analysis. In our case, the signs are as follows:

- the age of the faculty of the university. The change of generations of teachers and researchers is ensured by the evolutionary processes of arrival and departure of members of the corresponding community.
- the level of academic degree holders' rate, which should have some optimal value. Indeed, there are no departments where only assistants work. But the department where only professors are employed will also work ineffectively. In different segments of the educational sphere, the optimal level of academic degree holders' rate may be different.
- the size of the university. As in the economy, in general, in the educational sphere, large and small organizations are needed to provide educational and scientific services.
- the levels of educational services provided by universities (secondary specialized education, bachelor's, master's, postgraduate, doctoral), etc.

5. The formation of the educational system of Russia. It is seen in the implementation of the systemwide law of the necessary diversity. Excessive simplification of the system, its unification (the way of restructuring the higher education) will make it visible for "manual guidance". However, this will lead to the loss of the properties of self organization, that is, automatic adjustment to the changing conditions of the functioning environment.

6. The system of higher educational institutions. This system when interacting with other economic entities is a historically established artificial system with weak ties. However, it develops sustainably. It is impossible to clearly identify cause effect relationships among the elements of this system. New institutions of higher education are emerging in the system, while others are disappearing or merging. Some structures may be replaced by others, etc. Independent development occurs because of the spread of institutional, scientific, technical, economic or other decisions. With more adequacy, this is already a network model for the interaction of parts of the whole.

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