System-holistic modeling and evaluation of project-cluster management of regional educational space

Alina Borzenko-Miroshnichenko

Volodymyr Dahl East-Ukrainian National University
Molodizhny bl., 20a, Lugansk, 91034, Ukraine, e-mail: bmalina@i.ua

S u m m a r y . Based on models of economic tetrad and its improvements has been shown that within a regional education cluster development processes are implemented through projects. The system-holistic model of project-cluster management of regional educational space has been constructed. To form the projects portfolio of regional education cluster evaluation index system of the level of sustainable region development has been adapted, taking into account three metrics: development of cluster objects, connections between them and regional educational space as a whole.

K e y   w o r d s . Project, management, model, education, cluster, space, region, system, evaluation, index, development.

INTRODUCTION

Today at the state level in the national strategy of education development in Ukraine to the 2012-2021 years the need for modernization of the network of different types educational institutions, their reorganization and cooperation has been proclaimed in order to increase the efficiency of material and technical, human, financial and managerial resources for providing availability and quality of education [14]. Partially processes defined in the strategy have been already started through the forcible union of higher education institutions. However, force is not a rational way because of the loss of strong institutional memory of united educational institutions and opposition from the direct participants [15].

RESEARCH ANALYSIS

Taking into account the need of streamlining the existing network of high educational institutions in Ukraine management actions should be directed to creation of conditions for the adaptation and introduction of world model that provides mobility of student, teachers, resources and quality of educational service.

The basis of the modern perspective management models is strengthening the role of regions, new production systems based on network structures – innovation clusters [3].

Clusters have several advantages [23]:
- help fill the gap between business, researches and resources, thus faster giving knowledge to the market,
- provide intense competition simultaneously with cooperation,
- increase productivity, attract investments, stimulate researches and strengthen the industrial base.

One of the cluster disadvantages is the inability of obtaining quick results. International scientific researches of the clustering process have proved that cluster creating is a long and costly process. However, a cluster management model in any field of activity, including educational, is an effective tool for long-term development [4].

But development processes are advisable to carry through the projects implementing [20].

The combination of cluster and project management methodologies in the plane of the regional educational space development is one of the most promising models for solving problems of modernization of the educational system in way that does not include destruction, but directed on regional education development in polymeric space of its potential opportunities.

RESEARCH OBJECT

The development basis of the necessary models and methods of project-cluster management of regional educational space includes existing researches in certain directions, which have been received by the following scientists:

- in the direction of foundations of cluster management – R. Trion, P.V. Terent'ev, R. Luis, E. Fix, J. Hedges,

- in the direction of cluster management at the regional level – M. Porter, S.I. Sokolenko,

- in the direction of educational project management – Russian scientific school (D.A. Novikov, V.N. Burkov), Luhansk scientific school (V.A. Rach), Mykolaiv scientific school (K.V. Koshkin, V.S. Blintsov), Odessa scientific school (V.D. Gogunsky),

- in the direction of regional educational space management – A.A. Biloschytskiy, O.I. Sharov, K.M. Mikhailov.

System-holistic combination of these results will allow scientifically proving the methodological foundations of project-cluster management of regional educational space as integrity.

RESULTS OF RESEARCH

The study of systemic economic organization contains a definition of system in work [7] as the insular in space and relatively stable through time part of the environment, which is characterized by the properties of both: external wholeness and internal versatility. Kleiner G.B. (the author of the work outlined above) distinguishes four main types of systems: object, environment, process and project. Each of the selected systems is characterized by the limitations in spatial and temporal indicators.

Based on the model of economic tetrad entered by Kleiner G.B. in work [8] he has also proved that the cluster is a pronounced example of multifunctional and multidi-mensional economic system that has the properties of all four types of systems: object, environment, process and project (Fig. 1).

Projection of system-holistic organization model on the unfolded dual axis "space-time" executed in work [19] has allowed revealing the nature of the activity, development and existence processes (Fig. 2).

The possibility of development within project-cluster management of regional educational space will have been investigated in this research.

Suppose that there was a need in the performance of certain processes in the regional educational space. These processes can be implemented by several actors of cluster – such as organizations.

According to the model shown in Fig. 2, the functional connection between these elements is carried out due to the projects, which key feature is the innovative transformation.

If we consider the project as a collection of interconnected processes, for its implementation exist:

- a possibility of involving different actors for implementing different processes (activities),

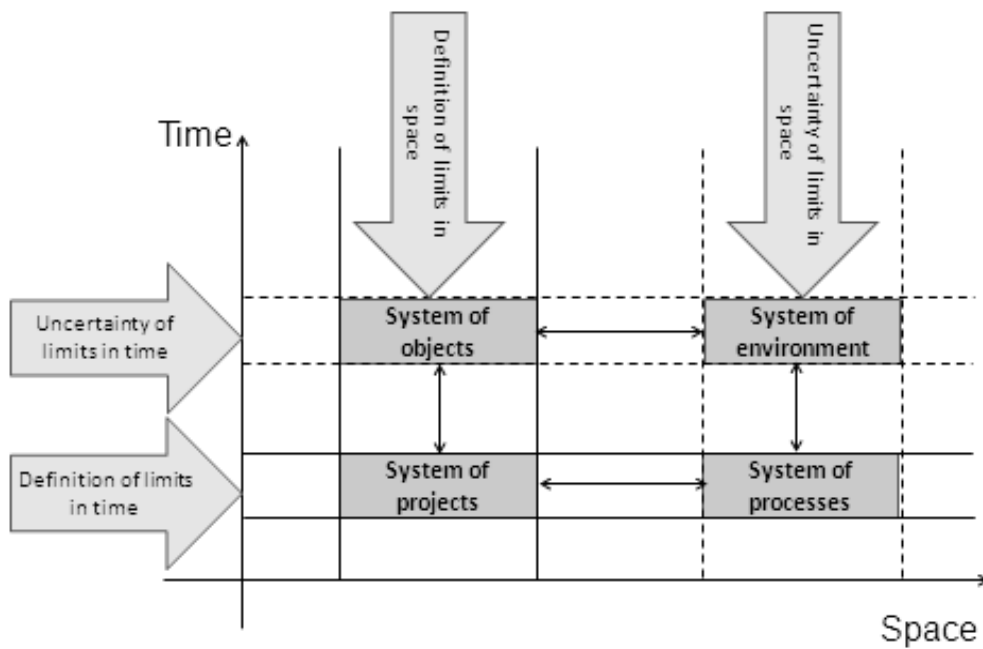- a possibility of choosing among cluster actors to perform the processes (activities) (Fig. 3).
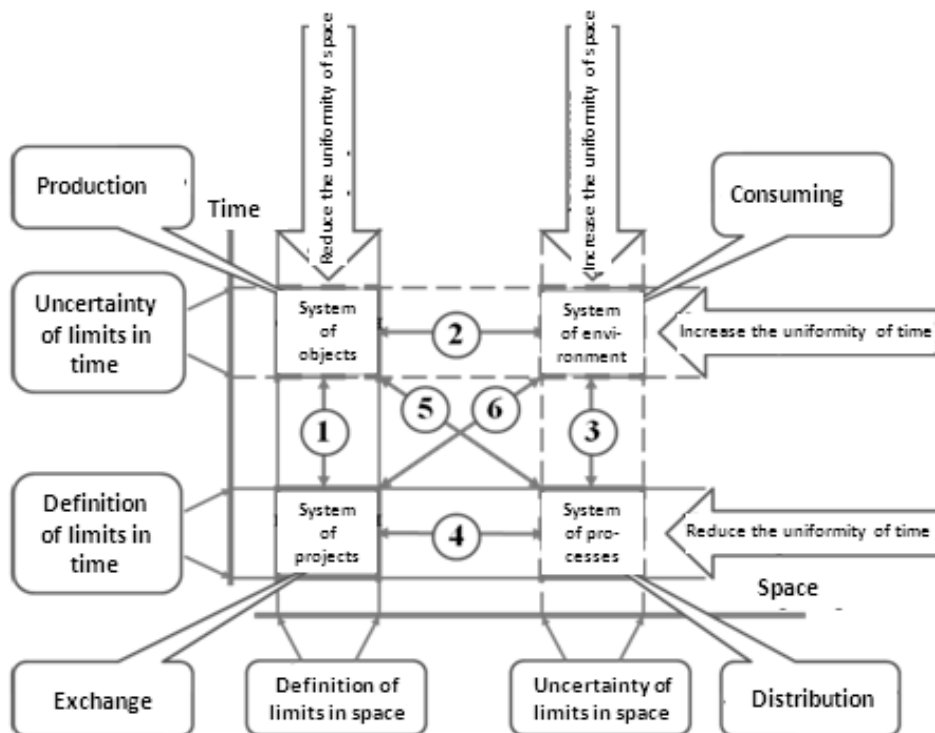
Fig. 1. Model of economic tetrad [8]

Fig. 2. The projection of the system-holistic organization model on the unfolded dual axis "Space-Time" [19]

Thus mutually sustainable relationship is implemented between project activities and educational space. It means that development is implementing (Fig. 4).

Thus, it is proved that within the regional educational space, in which the cluster has been created, the development processes are implementing through the projects.
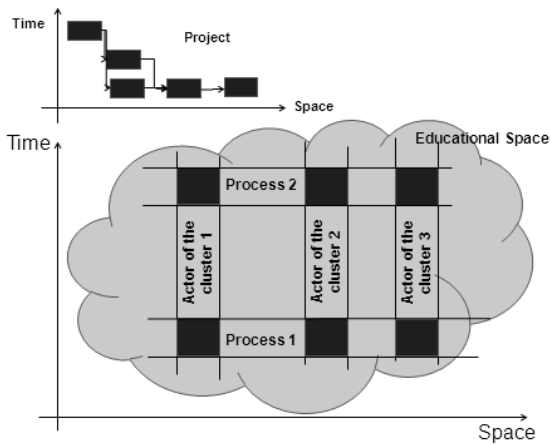
Fig. 3. Step 1 of constructing the system-holistic model of the project-cluster management of regional educational space
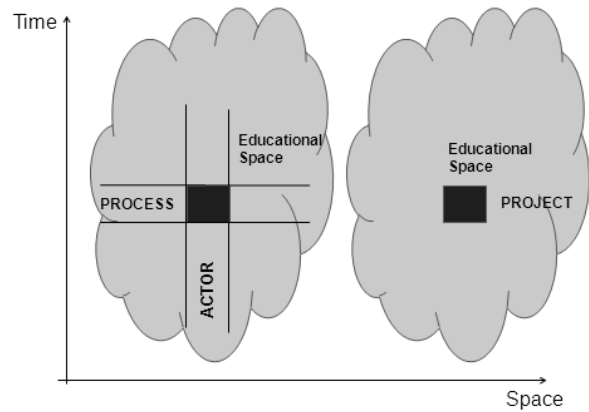

Fig. 4. Step 2 of constructing the system-holistic model of the project-cluster management of regional educational space

A set of activities components of educational institutions has been defined in work [9], which is limited by four main components: scientific, methodical, educational and business. This proves that, within the cluster activities of its actors aimed at implementing scientific, methodical, educational and business processes. These processes are realizing due to selected in work [2] types of educational projects: training, scientific, methodical, advanced training, material and technical, information, licensing, accreditation, etc.

Several projects can be simultaneously implemented to achieve the goals within the particular component of the regional educational cluster. Different actors of the cluster can be involved for the implementation of these projects. So, the set of projects is formed, which reflect all components of the activity that make the project portfolio of regional educational space. Fig. 5 shows the proposed system-holistic model of project-cluster management of regional educational space.
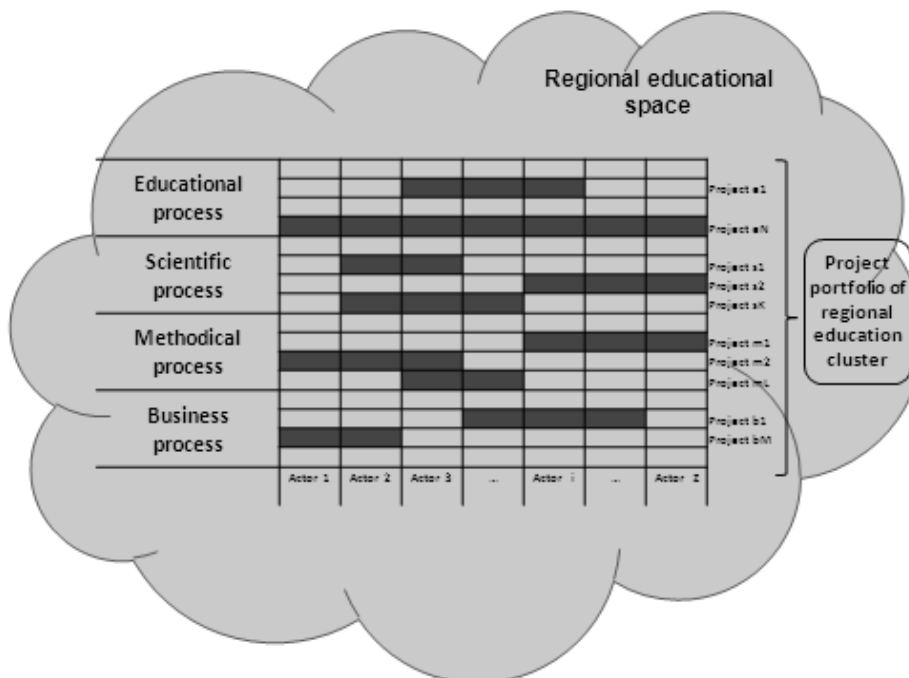

Fig. 5. The system-holistic model of the project-cluster management of regional educational space

According to the definition, given in work [5], essence of management function, as part of the six major activity functions, described in work [18]: management means the process of making decisions and implementation of coordinated actions that led the system to the desired state.

Desired state of educational cluster is an achieving of strategic development goals by its actors. Task of project-cluster management of regional educational space is to form a rational project portfolio of regional educational cluster to achieve the individual goals of its actors and the cluster as a whole. Forming of the project portfolio of regional educational cluster should be based on positions of identified and formalized strategic goals. Without this it is not possible to implement the function of the project-cluster management of regional educational space.

So, the next step of research is to develop a method of evaluating the development of regional educational cluster.

Regional educational space will be considered from the position set out in work [6].The educational space is understood as a set of objects between which the connections are established. Educational space is characterized by a dynamic unity of the actors and system of relations between them.

The global goal of regional educational space creation is the development of regional economy due to the formation of human capacity.

The importance of certain goal is confirmed by researches of several leading scholars, who claim that in the era of knowledge economy, regional development is not possible without creative, competent professionals [22].

Specific goal of cluster combination is the providing of competitiveness of regional education system through high quality of education service. The mentioned goals have been identified in the work [1].

Thus, three interacted elements of the regional educational space can be distinguished: high education institutions, enterprises and the labor market (Fig. 6).
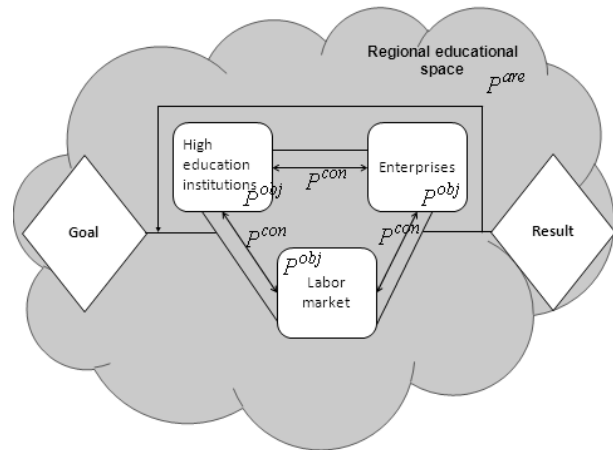

Fig. 6. System model of regional educational cluster

Project management of relationships between selected objects of cluster must ensure sustainable development of regional educational space.

Sustainability [10, 11, 12,21] is accepted to estimate by the six (or more) metrics: harmony of development, stability of development, balanced development, development equability, competitiveness of development, development security. Synthesis of defined metrics provides insight into the integrated assessment of sustainable development.

Methodic of evaluation the sustainable development level involves the following steps, pronounced in work [17]:

1) selection of the initial evaluation indicators,

2) normalization of the selected indicators,

3) analysis of the development level by field of activity,

4) analysis of sustainable development level for compliance with sustainability attributes,

5) integrated assessment of sustainable development level.

So the initial evaluation indicators should be provided at the first step for carrying out such assessment within a regional educational space. Their totality is determined by the regional educational space goals. Changing the values of the selected indicators depends on the projects implemented by the actors of regional educational cluster. In this case the

totality of parameters ($P = \{p_1, p_2, ..., p_n\}$) should be divided into two groups:

- indicators of individual cluster object ($P^{obj} = \{p_1^{obj}, p_2^{obj}, ..., p_m^{obj}\}$),

- connection indicators between cluster objects ($P^{con} = \{p_1^{con}, p_2^{con}, ..., p_l^{con}\}$),

- education space indicators ($P^{are} = \{p_1^{are}, p_2^{are}, ..., p_k^{are}\}$).

The recommendations set out in the methodology of calculation of integrated regional economic development indices [13] are appropriate to apply for the indicators normalization. However, other methods that allow to transfer natural values of the initial indicators to the interval [0;1] can be used. So totality of normalized indicators is being got for:

- object ($NP^{obj} = \{np_1^{obj}, np_2^{obj}, ..., np_m^{obj}\}$),

- connection ($NP^{con} = \{np_1^{con}, np_2^{con}, ..., np_l^{con}\}$),

- space ($NP^{are} = \{np_1^{are}, np_2^{are}, ..., np_k^{are}\}$).

If we have values of normalized indicators we should proceed to assess the region development level by selected metrics: object, connection, space.

Indexes of the object (INP^{obj}), connections (INP^{con}) and space (INP^{are}) development will have been calculated, using the formula of arithmetic mean:

$$INP^{obj} = \frac{\sum_{i=1}^{m} NP_i^{obj}}{m}, \qquad (1)$$

$$INP^{con} = \frac{\sum_{i=1}^{l} NP_i^{con}}{l}, \qquad (2)$$

$$INP^{are} = \frac{\sum_{i=1}^{k} NP_i^{are}}{k}. \qquad (3)$$

All of the indexes take values in the interval [0;1].

To perform the analysis of the regional development level of the educational space for compliance with sustainability attributes we shall use complex indexes: harmony, stability, balancing, equability, competitiveness, security of development.

Calculation of the harmony development index (I^g) is based on mathematical understanding of harmony. Harmony is a proportionality of part and the whole, merging the various components of an object into a single organic integrity [24]. The mathematical expression of harmony, which is called the "golden section", is used to calculate this indicator. It is calculated based on Fibonacci hyperbolic sinus. The formula for calculating is as follows:

$$I^g = \frac{\tau^{2(INP^{obj} \cdot INP^{con} \cdot INP^{are})} - \tau^{-2(INP^{obj} \cdot INP^{con} \cdot INP^{are})}}{\sqrt{5}}, \quad (4)$$

where: τ – the constant "golden section", which is equal to 1,618.

Stability of development is the characteristic of immutability of development character, its stability during studied period [16]. In other words, stability of development is a maintenance of positive parameters of the system as longer term as possible. This indicates that calculated index of stability must take into account the dynamics of processes.

To describe the stability of development it is advisable to use exponential-degree dependency [17].

Stability development index (I^s) of regional educational space is calculated as follows:

$$I^s = \left(\frac{INP^{obj} + INP^{con} + INP^{are}}{3} \right)^{1,471e}, \quad (5)$$

where: e – mathematical constant, which is equal to 2,718.

Balanced development allows estimating development processes by separate metrics as the integral space.

The basis of calculating the balanced development index (I^z) is the finding the medians of the triangle.

For regional educational space paired indices of sustainable development by separate metrics are calculated by the formulas:

$$I_{obj-con}^z = \sqrt{\left(INP^{are}\right)^2 + \frac{\left(INP^{obj}\right)^2}{2} + \frac{\left(INP^{con}\right)^2}{2}} \text{ , (6)}$$

$$I_{obj-are}^z = \sqrt{\left(INP^{con}\right)^2 + \frac{\left(INP^{obj}\right)^2}{2} + \frac{\left(INP^{are}\right)^2}{2}} \text{ , (7)}$$

$$I_{con-are}^z = \sqrt{\left(INP^{obj}\right)^2 + \frac{\left(INP^{con}\right)^2}{2} + \frac{\left(INP^{are}\right)^2}{2}} \text{ . (8)}$$

If the equality is executed:

$$\frac{2}{3}I_{obj-con}^z = \frac{2}{3}I_{obj-are}^z = \frac{2}{3}I_{con-are}^z = I^z = 1 \text{, (9)}$$

then the state of balanced development is reached in the region by separate metrics as parts of the whole.

So, the balanced development index is calculated by the formula:

$$I^z = \frac{\frac{2}{3}\left(I_{obj-con}^z + I_{obj-are}^z + I_{con-are}^z\right)}{3} . \quad (10)$$

Development equability is defined by Pareto as optimality. It means that increasing of the usefulness of one element does not reduce the usefulness of others [17].

In mathematical terms equability is estimated by the sum of corrected development indexes of objects, connections and space, that equal to one.

So, the equability development index (I^r) is calculated by the formula:

$$I^r = k_r INP^{obj} + k_r INP^{con} + k_r INP^{are} , \quad (11)$$

where: k_r – coefficient of equability, which is equal to 0,333.

The competitiveness development of the region is understood as the growth and effective using of competitive advantages over all metrics to ensure sustainable development [17].

Competitiveness development index (I^k) of regional educational space development is calculated as the geometric mean by the formula:

$$I^k = \sqrt[3]{INP^{obj} \cdot INP^{con} \cdot INP^{are}} . \quad (12)$$

Security of sustainable regional development involves the using of the region's potential, prevention of destabilizing factors acts [17].

Security development index (I^b) of the regional educational space is calculated by the formula:

$$I^b = \sqrt{\frac{\left(INP^{obj}\right)^2 + \left(INP^{con}\right)^2 + \left(INP^{are}\right)^2}{3}} . \quad (13)$$

The final step of evaluation is to calculate the integral indicator of sustainable development level.

Integral index (I) assuming equal importance of all metrics (objects, connections, space) of sustainable regional educational space development is calculated by the formula:

$$I = \frac{I^g + I^s + I^z + I^r + I^k + I^b}{p} , \quad (14)$$

where: p – total number of complex indexes.

To form conclusions about the implementation of management actions concerning expediency of inclusion separate projects into the portfolio of regional educational cluster should be used the data in Table 1. It contains the calculated limit values of evaluative indexes.

Table 1. The limiting values of evaluative indexes

Index	Value		
INP^{obj} INP^{con} INP^{are}	0,000	0,500	1,000
I^g	0,000	0,108	1,000
I^s	0,000	0,063	1,000
I^z	0,000	0,471	0,943
I^r	0,000	0,500	0,999
I^k	0,000	0,500	1,000
I^b	0,000	0,500	1,000
I	0,000	0,357	0,990

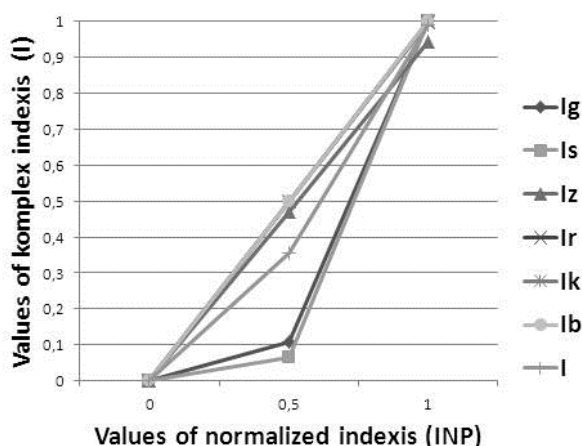Graphically the limit values of evaluation indexes are shown on Fig. 7.

Fig. 7. Graphic of the limiting values of evaluative indexes

Shown character of changes is not the same. This determines the development peculiarities of management decisions concerning project portfolio of regional educational space. This is one of the directions for further research.

It should be noted that the chosen set of evaluation indicators is not exhaustive. Additionally, in theory and on practice, the following parameters are being used [16]:
- the scale of development,
- the speed of development,
- the density of development,
- the power of development,
- the effectiveness of development,
- the capacity development.

The calculation of these indicators also refers to destinations for further research.

Also, it is appropriate to develop evaluation tool for development of regional educational cluster by individual metrics: objects, connections, space.

To perform such evaluation it is necessary to identify specific indicators which have natural expression. The basis for formalizing set of indicators is totality of projects implemented in the regional educational space. Such research has already started by the author. Basic set of projects that may be included in the portfolio has been selected.

So, for example, traditionally high education institutions implement such projects:
- methodical,
- scientific,
- business,
- human resources,
- training ordered by enterprises,
- training ordered by the state,
- advanced training,
- licensing,
- accreditation,
- information,
- international, etc.

Classification of projects has been executed based on project product. Tables 2-3 include example of a set of projects, its products and initial quantitative indicators.

Among this list of projects can be distinguished the projects that lead to the development of high education institutions as members of the cluster. This set of projects includes: methodical, business and human resources projects.

The human resources projects are included in this group, because principles of manning labor resources require special attention to implement the project portfolio based on qualification, managerial and administrative capacities of all members of the cluster in the cluster organization conditions of regional educational space.

Table 2. Projects of regional educational cluster for actor

Object	Type of educational project	Product	Indicator
High education institutions	Metodical	Methodical support	Share of fully secured disciplines
	Business	Property and equipment, elements of infrastructure	cost
	Human resources	Teaching staff	The amount of human resources

Informatization projects can be considered as belonging to the business type. However, this point requires further formalization of the essence of such projects.

Table 3. Projects of regional educational cluster for connection between actors

Connection	Type of educational project	Product	Indicator
High education institutions - enterprise	Training on order	Specialist	The volume of orders
	Scientific	Innovative product	Quantity of scientific research on order
	Advanced training	Trained staff	The volume of the orders (number of trained staff or tuition costs)
High education institutions - the labor market	State Training	Specialist	The volume of orders
	Licensing	Speciality	The range of specialties
	Accreditation	Speciality	The range of specialties

The next group of projects reflects the connection between actors of regional educational space (Fig. 6). Thus, the connection between high education institutions and enterprises is being implemented through projects: training ordered by enterprises, scientific, advanced training. The connection between high education institutions and the labor market is defined by projects: training ordered by the state, licensing and accreditation.

The place of international education projects is not defined. The product of such projects is the competent foreign students [25]. But in most cases his training is ordered by the student or by the country in which he resides constantly. Therefore, typification of such projects requires refinement.

Also, there is no example of projects that are directly focused on development of regional educational space. This question is under investigation.

Listed characteristics and tasks determine the range of further researches.

CONCLUSIONS

Results of this investigation consist of the following:

1. The results of analysis of the tetrad economic model and its components allow proving that within a regional educational space, in which the cluster has been created, projects are the tool of development processes implementation.

2. System-holistic model of project-cluster management of regional educational space has been constructed.

3. Assumptions for modeling the rational project portfolio of regional education cluster have been formulated.

4. Evaluative indexes system of the level of sustainable region development is adapted to assess changes in level of regional education space development, depending on the set of potential projects of the regional education cluster portfolio.

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СИСТЕМНО-ЦЕЛОСТНОЕ МОДЕЛИРОВАНИЕ И ОЦЕНИВАНИЕ ПРОЕКТНО-КЛАСТЕРНОГО УПРАВЛЕНИЯ РЕГИОНАЛЬНЫМ ОБРАЗОВАТЕЛЬНЫМ ПРОСТРАНСТВОМ

Алина Борзенко-Мирошниченко

Аннотация. На основе модели экономической тетради и ее усовершенствований доказано, что в пределах регионального образовательного кластера процессы развития реализуются через проекты. Построена системно-целостная модель проектно-кластерного управления региональным образовательным пространством. Для формирования портфеля проектов регионального образовательного кластера адаптирована система оценочных индексов уровня устойчивого развития региона с учетом трех метрик: развития объектов кластера, связей между ними и регионального образовательного пространства в целом.

Ключевые слова: проект, управление, модель, образование, кластер, пространство, регион, система, оценивание, индекс, развитие.