

Neural network information management model for a large educational complex

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Abstract

Effective management of the national educational system is a strategically important direction for further development of the entire state [1]. Management of educational processes is the most difficult direction in the theory and practice of management because of their multiplicity and formalization [2]. In connection with the reorganization of the Russian educational system, large educational complexes (LEC) have appeared [3], which are a new structural unit in the national education system.

The object of this article is the system connections and processes of functioning of a large educational complex.

The subject of the research is algorithms, methods and models of rating evaluation of LEC activities for managing its effectiveness.

The practical significance of the work is as follows:

- new criteria for evaluating the quality of education in LEC – individual educational programs of students are proposed;
- an information model of rating evaluation of the LEC activity based on the method of integral assessment of the quality of education is proposed, which allows for reliable ranking of the main indicators not by expert means, but by calculating the value of its entropy;
- the project of an information system for forming the LEC rating is proposed, which allows the management bodies to monitor the effectiveness of the educational system, carry out operational, tactical and strategic planning, and apply control actions in a timely manner to improve the efficiency of the main activity;
- a neural network model is proposed for selecting the control effect on the LEC.

Practical use. The obtained scientific results are of applied nature, and their application is confirmed by the results of work in Management of education of administration of Sosnovsky municipal district of the Chelyabinsk region in public-professional Association – on the Board of Directors of the educational organizations of the city of Moscow No. 10 and GBOU School No. 1389.

Keywords

management, methods, rating evaluation models, efficiency

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1. Introduction

The functioning of a large educational complex is characterized by a variety of functions, levels of educational activity, adaptability, flexibility, and dynamism, which creates difficulties for effective management [4]. The search for effective management options leads to the need to use formalized, unified methods and mathematical models. In this regard, there is a need to use information tools that automate the implementation and use of models in making effective decisions at all stages of management [5].

The development of models and methods for assessing the quality of education and educational activities in educational complexes, as well as effective management of the functioning of such complex socio-economic systems, is becoming an *extremely urgent task* [6].

Purpose and objectives of scientific research. The purpose of the study is to improve the effectiveness of the LEC management by creating a set of models, methods, algorithms and tools for rating the activities of educational organizations.

To achieve the goal of scientific research, the following tasks were solved:

- an information model of LEC management is built [7];
- criteria and indicators for a comprehensive assessment of LEC management effectiveness have been developed [8];
- a management information system has been designed to automate rating evaluation of educational organizations in accordance with the developed methodology, algorithms and models [9];
- a neural network model is proposed to support the management decision-making of heads of educational organizations [10].

The scientific novelty of the study is that:

- criteria (quality of education, accessibility of education, efficiency of resource use) and indicators have been developed to determine the criteria for a comprehensive assessment of the effectiveness of LEC management, taking into account current trends in the development of the education system [11];
- an information system for automating rating evaluation and monitoring the activities of educational organizations is proposed [12];
- a neural network model is proposed for the system of support for management decision-making of heads of educational organizations [13].

2. Theoretical Research

The effectiveness of managing the education system in Russia is determined by the structure of the system itself, which consists of regional, sub-regional, territorial, inter-municipal and municipal educational systems, as well as educational organizations and their associations [14]. Therefore, one of the important tasks is a formalized description of the system model and a unified approach to solving the problem of effective management of all components of the system.

The activities of education management bodies are aimed at ensuring Federal programs for the development of education, state educational standards, and the functioning of the education system at the level of state standards [15].

Organizational structure of education system management (Figure 1) reflects the composition and subordination of various elements, links and levels of management that function to achieve certain goals [16]. The functions and structure of management are two components of a single whole—the organization of the management system of the education system and act, respectively, as the content and form of the management process [17]. Certain management issues are within the competence and responsibility of the educational organization.

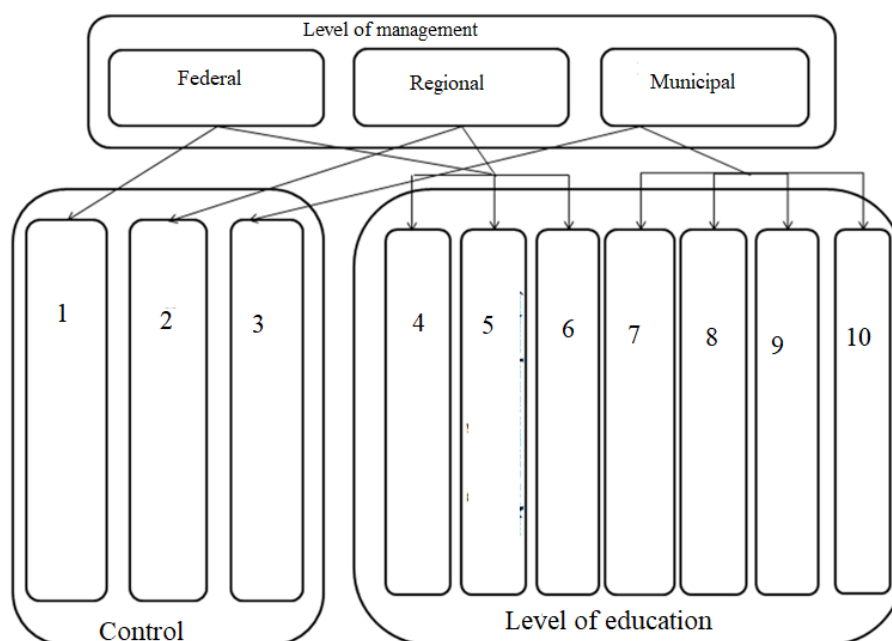


Figure 1: Organizational structure of education management Russian Federation

Designations for Figure 1:

1. Ministry of education;
2. Department of education;
3. Municipal government;
4. Secondary professional education;
5. Higher education (bachelor's degree, specialty, master's degree, training of highly qualified personnel);
6. Additional education;
7. Preschool;
8. National General;
9. Basic General;
10. Average total.

In this study, managed systems (management objects) are divided into groups [18]:

1. An education system consisting of education management bodies and the infrastructure of the education system (scientific and methodological centers, resource centers, repair and supply services, and so on).
2. Educational system — a set of educational organizations and educational programs (EP) implemented by them.

The educational system (ES) includes not only educational organization (EO) and EP, but also the infrastructure (educational and methodological offices, resource centers, etc.), as well as education management bodies of the appropriate level. Within this definition, the “minimum” educational system is a separate educational organization.

In the most General form, the management process in the education system can be divided into three components, mutually dependent and interrelated forms of its implementation [19] (Figure 2):

- administrative, whose task is to develop and define policies;
- economic, which determines the material and financial resources, motives and financial results of the management system;
- operational, providing operational, Executive, aimed primarily at the technological organization of the control object.

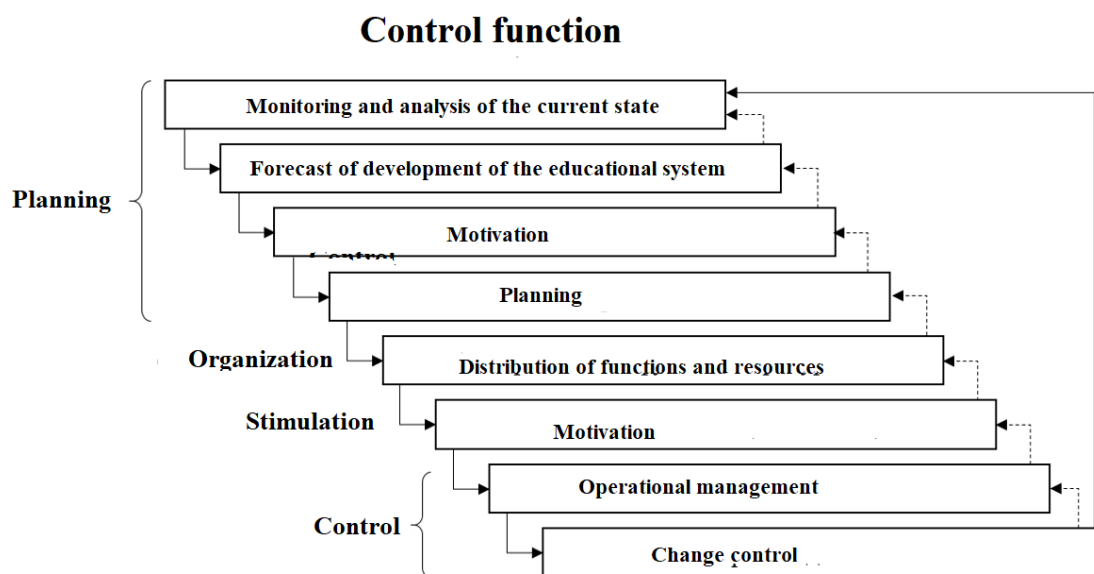


Figure 2: Control function

Any ES is defined by setting [20] the following parameters:

- the composition of the ES (participants-people, their groups and collectives that are part of the ES, that is, its elements and the composition of the ES implemented in the OP);

- ES structures (sets of information, management, technological, and other relationships between ES participants);
- restrictions and norms of activity of ES participants, reflecting, among other things, institutional, technological and other restrictions (conditions) and norms of their joint activity. In particular, the demand and supply for educational services and for graduates (taking into account the criteria of both quantity and quality) of the ES can be considered as a managed (including self-managed) restriction of the ES activity;
- preferences of the ES participants;
- awareness – the information about the essential parameters that the ES participants have at the time of their decision-making.

Restrictions on the activities of ES participants are, in particular, their powers.

List of business processes of the regional educational system:

1. Business management processes:
 - development and implementation of regional education development programs taking into account regional socio-economic, environmental, demographic, ethno-cultural and other features;
 - planning and development of the regional educational system;
 - distribution of responsibilities and powers;
 - analysis of the quality system of the regional educational system.
2. Main business processes:
 - creation, reorganization, liquidation of educational organizations, implementation of functions and powers of founders of educational organizations;
 - ensuring state guarantees of the rights to receive public preschool education, primary General education, basic General education, and secondary General education;
 - organizing the provision of secondary vocational education, including ensuring state guarantees of the right to receive public and free secondary vocational education;
 - organization of additional education for children;
 - organization of additional professional education.
3. Enabling business processes:
 - material support of the regional education system (including textbooks in accordance with the established Federal list, and textbooks approved for use in the implementation of these educational programs);
 - financial support for the regional education system;
 - staffing of the regional education system;
 - information support for the regional education system;
 - normative and methodological support of the regional education system;
 - social security of the regional education system (including the organization of providing psychological and pedagogical, medical and social assistance to students who are experiencing difficulties in mastering basic General education programs, their development and social adaptation);

- subcontracting processes.
4. Business processes for monitoring, measuring, evaluating, and developing:
- monitoring, measurement, and quality control of the regional educational system (including creating conditions for organizing an independent assessment of the quality of educational activities of organizations engaged in educational activities;
 - internal audits and self-assessment;
 - managing monitoring and measurement devices;
 - assessment of satisfaction of consumers of educational services of the regional educational system.

The diagram of business processes of the educational system is shown in Figure 3.

The criteria for effective management of the educational complex can be presented using Figure 4 [21].

3. Research Methods and Tools

One of the most popular and popular tools for managing and informing consumers of educational services is the rating of educational organizations. To build a rating of General education organizations in the Ulyanovsk region on the quality of education, the following areas have been identified:

- learning outcome;
- participation of students in procedures for independent assessment of the quality of knowledge;
- ensuring a systematic approach in the procedures for independent assessment of the quality of knowledge;
- the effectiveness of the internal monitoring;
- compliance of the educational organization's activities with accreditation indicators.

The following data types are used to calculate indicator values [22]:

- data from monitoring conducted by the Committee for supervision and control of education in the Ulyanovsk region;
- data of monitoring conducted by the regional state Autonomous institution Ulyanovsk regional center for information, methodological, organizational and technical support of supervision and control procedures in the field of education;
- data of educational organizations.

The rating of educational organizations is formed for each direction separately and as a whole (summary rating). The algorithm that reflects the main stages of rating formation is shown in Figure 5.

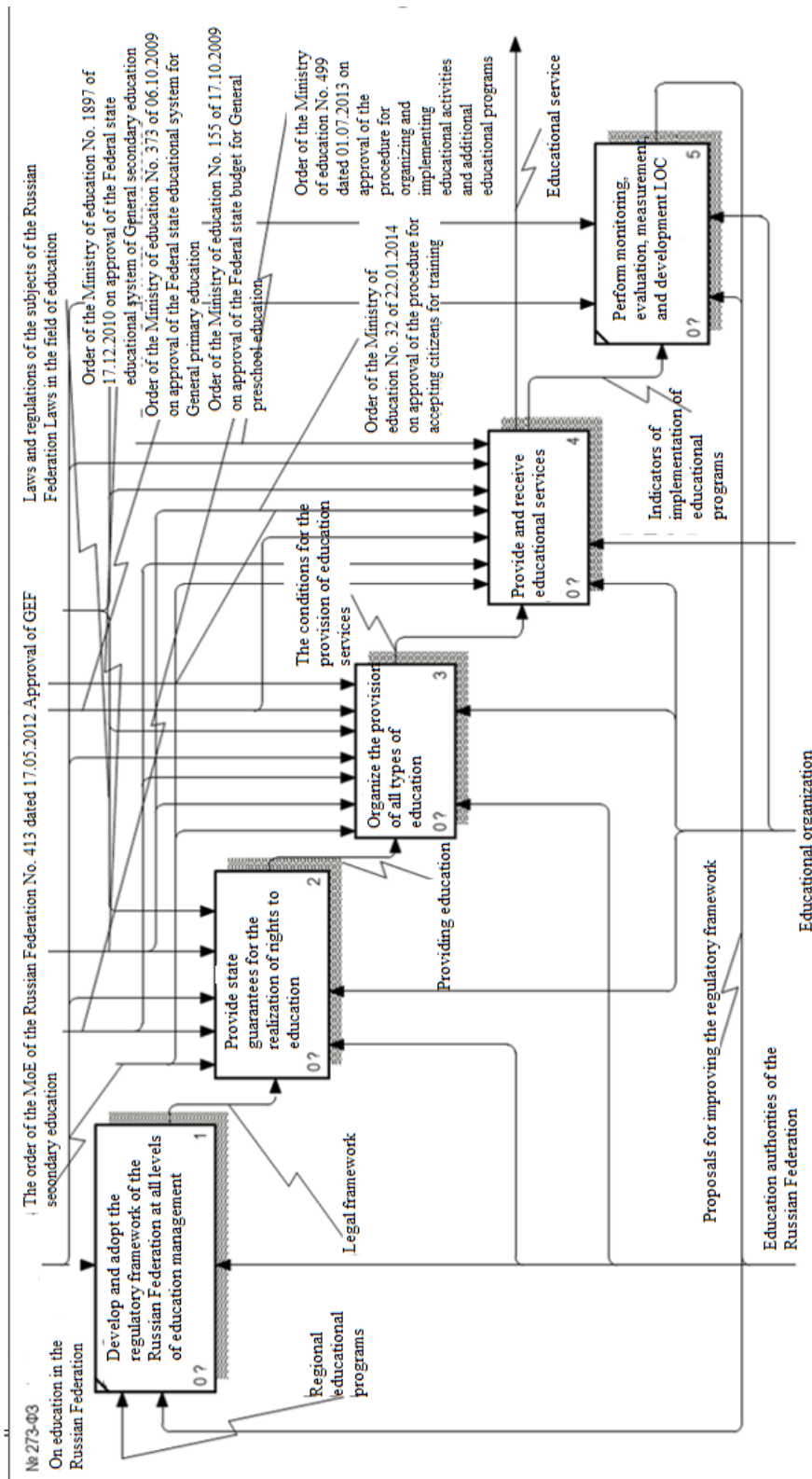


Figure 3: Business process diagram of the educational system

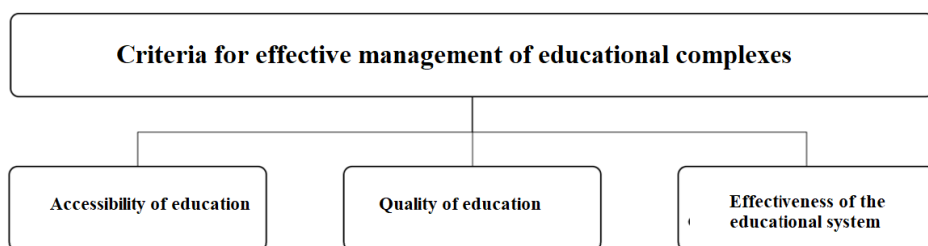


Figure 4: Efficiency of educational complex management

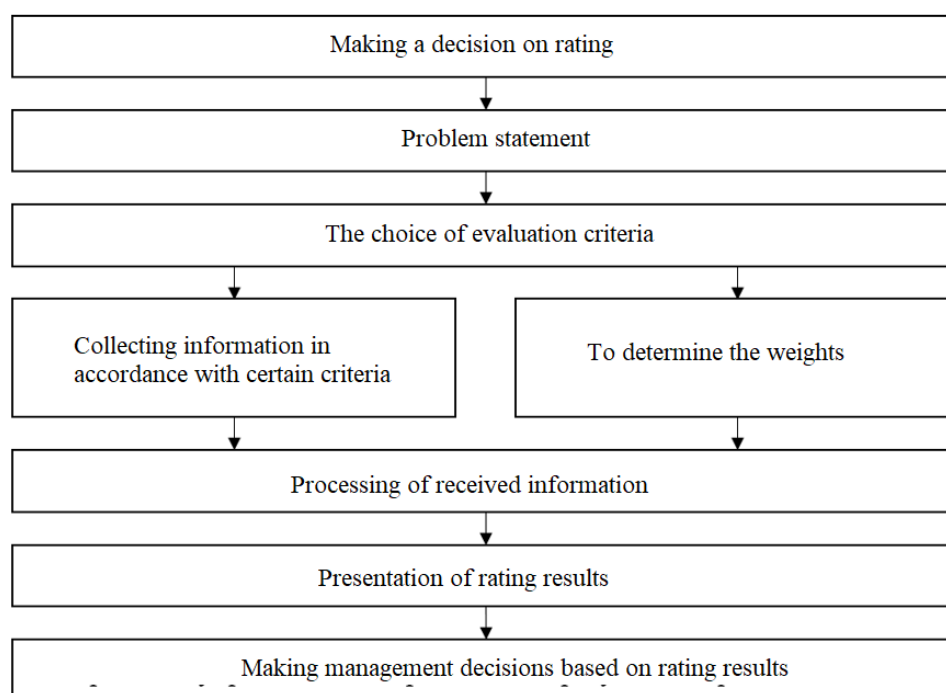


Figure 5: Algorithm for forming the rating of the educational complex

The effectiveness of management has two aspects: the effectiveness of the functioning of the managed system itself and / or the effectiveness of the actual management activity.

The main tool for optimizing decision-making in this study was mathematical methods. The technological process of functioning of the rating evaluation model of educational organizations for managing the educational system is shown in Figure 6.

For effective management of educational organizations, information about the final rating is not enough. This indicator allows you to get a General idea of the situation in educational complexes and draw appropriate conclusions. To make specific management decisions to improve performance, it is necessary to analyze the rating for each criterion.

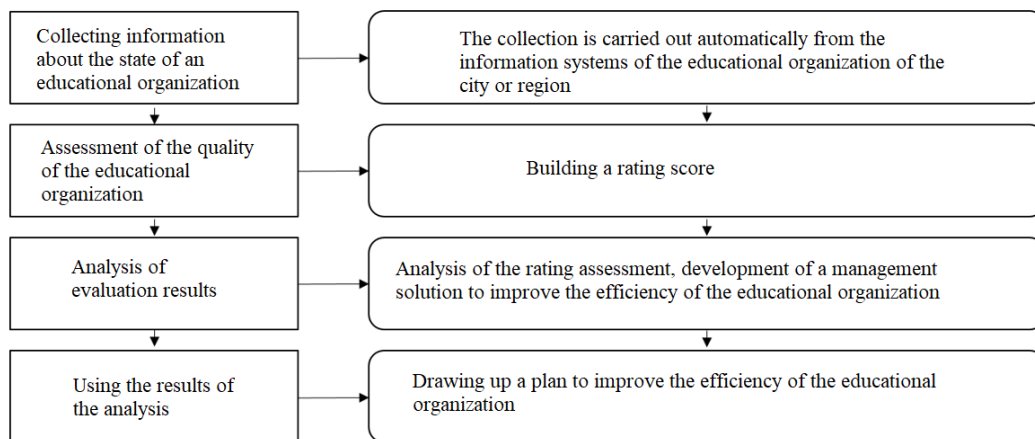


Figure 6: Technological process of functioning of the model of rating evaluation of educational organizations for the management of the educational system

Evaluating the management of a large regional educational system is a multi-component process that involves a detailed analysis of the functioning of each component of the object under study. Based on the above material, we can conclude that in order to organize a qualitative assessment of the management of a large regional educational system, it is necessary to develop an appropriate model.

The authors propose a model that allows us to evaluate each component of the management of an educational organization (Figure 7). The model represents a directed graph. Each criterion is a composite criterion.

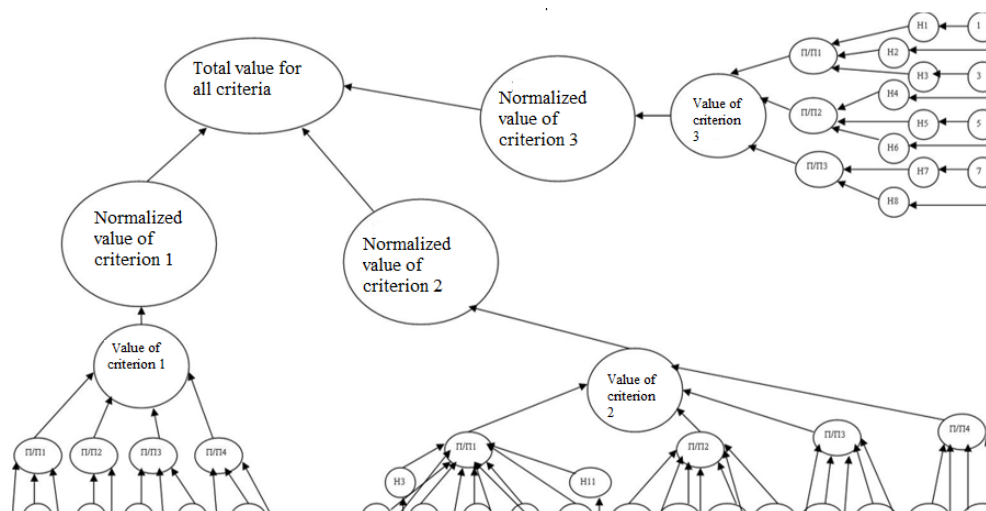


Figure 7: A fragment of a mathematical model for calculating the rating of each evaluation criterion for an educational complex

The criterion for managing the quality of education (criterion 1) consists of four groups of indicators:

- indicators of individual educational results-allow you to characterize the learning dynamics of each individual student;
- indicators of the overall level of academic performance-aimed at creating a holistic picture of learning material by students;
- indicators of high educational achievements-help to get information about the number of winners of Olympiads and various competitions at various levels;
- the performance of graduates.

The criterion for managing the availability of education (criterion 2) is also divided into three groups of indicators, which will allow us to summarize the data obtained on the functioning of the management system of an individual organization:

- indicators of overall access to education for children of appropriate ages;
- indicators of access to continuing education-create an idea of the effectiveness of the education system as a whole, and therefore allow you to assess the quality of management of this system;
- indicators of access to education for children with special needs.

The third component of the model (criterion 3) is a criterion for managing the efficiency of resource use. This component is a financial indicator of the functioning of the educational system, since most educational institutions in Russia are fully supported by the state. This component is also divided into components:

- indicators of effective use of financial resources;
- indicators for creating appropriate conditions for students;
- indicators of effective use of school premises;
- indicators of effective work of teachers.

4. Research Result

Let's consider the application of this mathematical model on the example of calculating the final value for three criteria for 4 educational organizations that are combined in an educational complex [23]. The data is presented in Table 1.

Based on the selected indicators and the final assessment of the educational institutions of the complex, a neural network model was built that allows making a forecast of the final rating value of the entire complex as a whole (Figure 8).

Table 1
Final rating of educational organizations

Educational organization	Standard values for criteria			Normalized values by criteria			Sum of normalized values by criteria	Final rating
	Criterion 1	Criterion 2	Criterion 3	Criterion 1	Criterion 2	Criterion 3		
EO No 1	2,60	3,5	16,42	0	0	0,15	0,15	4
EO No 2	7,07	5,12	15,07	0,70	1	0	1,7	2
EO No 3	8,99	3,56	15,58	1	0,04	0,06	1,09	3
EO No 4	7,23	4,37	23,99	0,723	0,54	1	2,26	1
EO No 4	7,23	4,37	23,99	0,723	0,54	1	2,26	1

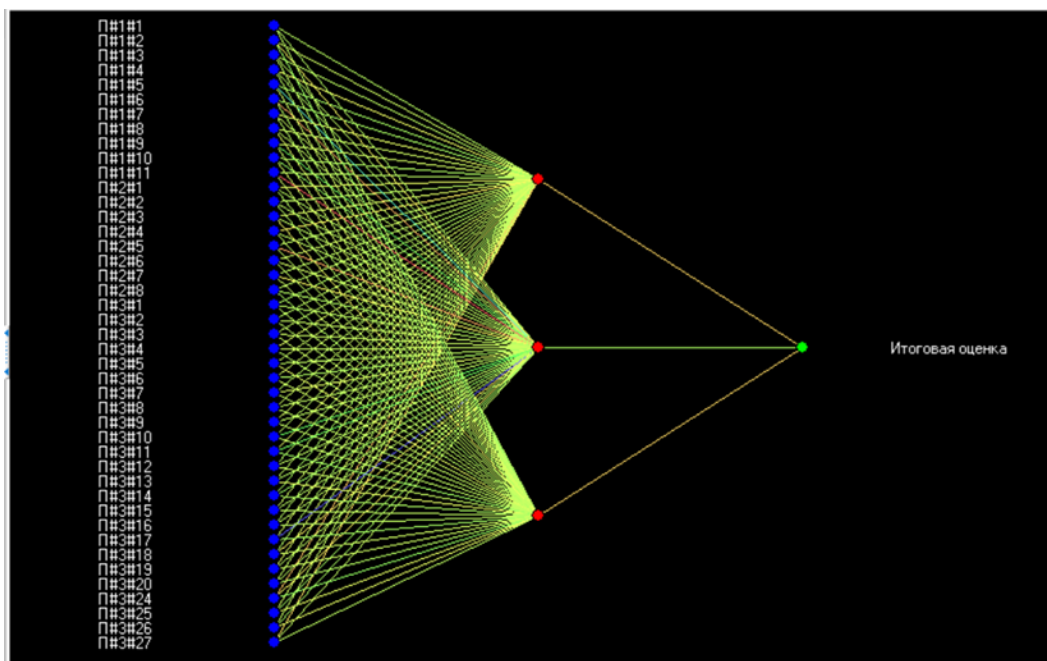


Figure 8: Visualization of neural network

The input variables of the neural network are as follows:

1. Quality criterion:

- The share of individual educational cards with a positive growth rate in the total number for the considered educational organization;
- Decile coefficient of positive growth rate (the ratio of the average score for the year of 10% of students with the best results to the average score for the year of 10% of students with the worst results);
- Growth rate of student's educational results;
- Share (percentage) of students who have mastered the program on "good" and "excellent";
- Percentage of graduates who passed the final exam with a score higher than 160 points in three subjects;
- Percentage of graduates who passed the final exam with a score higher than 220 points in three subjects;
- Average score of independent diagnostics conducted by the regional center for education quality assessment;
- Share of medalists among graduates of an educational organization;
- Number of students-winners, prize-winners (laureates) of Olympiads, competitions of all-Russian and regional levels from the Federal and regional list;
- The number of subjects in which the educational organization has winners or prize-winners of Olympiads, competitions of the all-Russian, district, regional, and municipal levels;

- Percentage of students enrolled in additional education programs implemented by the educational organization itself and other organizations.
2. Accessibility criteria:
- Percentage of students registered (and staying) in this territory who receive basic General education services;
 - Percentage of students registered (and staying) in this territory who receive additional education services;
 - Percentage of students enrolled in pre-school education programs;
 - The percentage of students who continued their education in the basic General education program, out of the number of those who completed their education in the primary General education program;
 - The percentage of students who continued their education in the secondary General education program, out of the number of those who completed their education in the basic General education program;
 - Percentage of students receiving basic General education services in specialized educational institutions;
 - Percentage of students receiving basic General education services in inclusive educational institutions;
 - The presence of a regularly updated website of the educational organization.
3. The criterion of efficiency of resource use:
- Share of extra-budgetary funds in the total amount of financial resources of the educational organization;
 - The share of funds spent on the remuneration of teaching staff in relation to the total remuneration Fund;
 - Share of funds from the extra-budgetary Fund spent on remuneration of teaching staff;
 - The number of students per teaching staff;
 - The density of the load (average number of training hours) one of the school's office;
 - The decile ratio of the density of loading one of the school's office;
 - Number of innovative projects implemented;
 - Number of target programs implemented;
 - Availability of experimental sites at the Federal, regional, and municipal levels;
 - Percentage of teachers with the highest qualification category;
 - Percentage of teachers who have passed independent certification;
 - Percentage of teachers who have completed advanced training courses in the past three years;
 - Share of teachers of the organization who prepared winners, prize-winners (laureates) of competitions of all-Russian, district / regional, municipal levels during the last three years;
 - Percentage of teachers whose effective teaching experience was distributed at the national and regional level;

- Total number of downloaded lesson scenarios;
- Total Russian scientific citation index;
- Number of students per computer compared to the municipal average;
- The proportion of computers with access to the Internet;
- Number of media library programs implemented in the educational process;
- Availability of extended day groups;
- Providing students with free hot meals;
- The presence of the gym;
- The presence of the stadium;
- Availability of specialized workshops/land plots;
- The ratio of the total area of the educational organization to the number of students;
- The ratio of the classroom area to the total number of students;
- The ratio of the number of specialized offices and laboratories to the total number of classrooms;
- Share of funds for the creation and development of the educational environment (including material and technical support).

Output is the final value of the rating of the educational organization.

The nodes of the graph shown in blue are the incoming numeric values of the quality criteria, availability, and efficiency of the use of resources of each individual educational organization. The nodes of the graph, colored in red, represent the numeric value of the individual criteria of the educational organization. Finally, the graph node, colored green — is the final numerical value of the evaluation of an educational organization, taking into account all three criteria, on the basis of which the overall rating for 50 educational organizations will be compiled.

Using the scatter plot (Figure 9) it is possible to estimate the degree of deviation of the predicted data from the accepted standard. In this case, it is possible to visually determine the correctness of calculating the final values of the assessment for educational organizations from which the rating is compiled. When visualizing the chart, two lines were drawn that form a confidence interval.

Almost all points (all received rating numerical values for educational organizations) lie within the “corridor” set by them. This means that we can say that the built neural network model of managing a large educational system works effectively.

The rating score calculated using the neural network model allows us to develop effective control actions aimed at achieving the goals of functioning of a large educational complex.

The model can be applied autonomously, or as a module of the decision support system for managers and specialists of educational management bodies.

5. Conclusion

As a result of the study, the authors proposed:

- mathematical model of the process of calculating the values of indicators that fully characterize the activities of an educational organization. The criteria are best represented as a directed graph whose vertices correspond to the stages of calculating the rating score, and their weight is equal to the corresponding numerical values obtained at each stage;

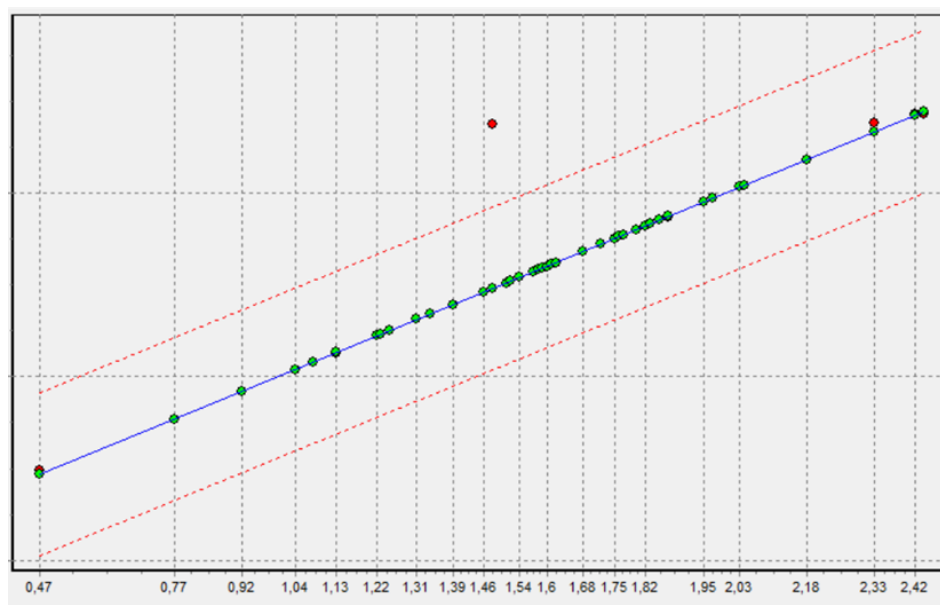


Figure 9: The scatter chart

- the problem of optimization of control over a given set of elements of a hierarchical structure is formulated. using dynamic programming methods, the solution of the problem is described and the values of labor intensity are obtained;
- an example of the proposed information system that implements a mathematical model for building a rating of an educational complex is given.

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