Development of Decision Support System for Quality Management of University Education

Nikulcheva O.S.*
Voronezh state university of engineering technologies
Voronezh, Russia
e-mail: Strogonova.ox@yandex.ru

Khaustov I.A.
Voronezh state university of engineering technologies
Voronezh, Russia
e-mail: haustov_ia@mail.ru

Nazina L.I.
Voronezh state university of engineering technologies
Voronezh, Russia
e-mail: nazina_lyudmila@mail.ru

Tikhomirov S.G.
Voronezh state university of engineering technologies
Voronezh, Russia
e-mail: Tikhomirov_57@mail.ru

Abstract — **The subject of the study is the process of studying at University. The purpose of the research is the development of an information system, which could record all the events related to the process of obtaining education for a particular student at all its stages. The article describes the main information systems out both Russian and foreign. The analysis of the considered systems allows concluding that none of the proposed products allows for an in-depth analysis and forecasting of a possible option for the development of the educational process. A number of works on the issues of building a competency model of a graduate were studied, including mathematical models and approaches to evaluate learning outcomes. Based on the research of developments in this area, we can conclude that the available information systems make it possible to solve individual problems associated with the support of the educational process, there is also no methodology for the design and synthesis of such ISs, taking into account their integration into existing ISs at universities. The paper proposes the use of system analysis methods in order to: obtaining the structure of an IS for analysis and management of the competence-building process; the study of the design object, methods and means of its interaction with the environment; identification of functional subsystems implementing individual tasks, their structural elements that implement individual information processing and analysis algorithms; identification of functional relationships in the form of interacting input and output information flows of system elements; determining the order and logic of their interaction in the implementation of individual tasks of the information system. The article proposes to use the developed information system for analysis and management to identify common system properties and the main laws of information processing in assessing the competence of graduates taking into account professionally significant personal qualities.**

Keywords — competence, competency model of the graduate, system analysis, information system.

I. INTRODUCTION

In the tasks of ensuring the necessary level of competence of graduates able to solve professional problems in the areas of professional activity, an important role is played by the management of the learning process. At the same time, obtaining objective information about the current state of the control object and automating this process are directly based on the use of an information system (IS), which could record all events related to the process of obtaining education for a particular student at all its stages. At the moment, universities use both internally developed and commercial information systems. Among these software products, one can single out both Russian ("Galaxy University Management", "1C: University", "Axiom", DBMS "Dekanat", "Tandem University", "Universys WS", etc.) and foreign ("SIMS .net Capita Education", "IBS: University Personnel Management ", "Bleak Board", etc.) ones.

II. LITERATURE REVIEW

The educational organization management software "SIMS.net Capita Education" is used in 80% of all schools in England and contains information systems for managing education in schools from primary to higher, an information system for managing municipal institutions, and an electronic educational environment. The system contains an intelligent software solution for stimulating students' achievements, but at the same time its significant drawback is the lack of decision-making systems for managing the educational process.

The IBS: University Personnel Management system is designed for efficient staff management, which ensures a high level of professionalism of the teaching staff and helps to improve the motivation of administrative and service personnel. This system is not intended for monitoring and analyzing student performance. [1]

Consider the Moodle system, which belongs to the class of LMS – learning management systems. In Russia, this software is used in many universities to organize distance education. The functionality of Moodle allows designing, creating and managing the resources of the information and educational environment [2]. For teachers, the IS under consideration makes it possible to present the educational and methodical material of the course, to conduct theoretical and practical classes, and organize the educational activities of students. The main form of knowledge control in distance education is testing, LMS Moodle has an extensive toolkit for creating tests and conducting training and control testing with the possibility of statistical analysis of test results and the complexity of

individual test questions for students, which is if great importance. With these advantages of this software product, the main drawback should be noted – the impossibility of registering and analyzing data on student performance outside this system.

The comparative analysis of domestic design solutions and software developments allows highlighting their advantages and disadvantages. Thus the system "1C: University PROF" allows storing and processing information about the contingent of universities, as well as monitoring the achievements of students. A significant drawback of this system is the lack of the ability to display statistical reports based on the results of control points. [3]

The Galaxy University Management system allows creating and maintaining sheets on disciplines and forms of intermediate control and final control, information on the results of the exams in the form of a set of statistical reports, while this IS does not allow predicting possible events [4]

The "Plan" information system has the most automated functionalities: creating sheets, creating a rating based on the results of control points, sending the electronic sheet filled out by the teacher to a centralized repository automatically, creating summary sheets automatically. The data obtained are accumulated in the form of statistical data and their analysis is not carried out, which is a significant drawback of this IS [5]

An analysis of the systems considered allows concluding that none of the proposed products allows in-depth analysis and forecasting of a possible option for the development of the educational process.

To build an IS for the process of forming the competence of students in a university, there is a need to develop a competency model for a graduate. Currently, a number of researchers have proposed various models of the university graduate [6–8], in which the emphasis is on individual components, including professional abilities and personal qualities.

Methods for assessing the formation of competencies are an integral part of the educational process. Currently, these methods are used in various forms: traditional (oral and written answers, tests, practical work, final qualification work) and innovative methods – case studies, competency tests, etc. However, the formation of a competence-based approach requires an additional assessment of the personal qualities of the graduate, which justifies the need for the introduction of a portfolio, as an essential element in assessing performance.

The final stage of the process of obtaining education in the basic professional educational program is an assessment of the development of mastered competencies. Currently, a number of researchers have developed and described various mathematical models and approaches to evaluate learning outcomes [9]. In this case, methods of mathematical statistics, probability theory, graph theory, theory of fuzzy sets, theory of latent-structural analysis, etc. are used [10, 11]. The work of Lisitsyna L.S. is devoted to intelligent knowledge control systems of mathematical modeling related to information modeling and the use of various knowledge models [12]. The works of A.A. Proskurin, L.V. Zaitseva, N.O. Prokofieva, O.G. Berestneva, Avanesov V.S., Glebova L.N., Kuznetsova M.D.,

Shadrikov V.D. [13] and others are devoted to reviews of methods for assessing learning outcomes. Based on the research of developments in this area, we can conclude that the available information systems make it possible to solve individual problems associated with the support of the educational process. For example, analysis of the results of academic performance, control of acquired knowledge and so on. In addition, tasks such as assessing the professional portrait of a graduate and his ability to solve various problems in professional activities proposed in [12] are practically not considered. There is also no methodology for the design and synthesis of such ISs, taking into account their integration into existing ISs at universities

III. METHODOLOGY

To justify the structure of the IS, the work uses well-known methods of system analysis, including those related to the formulation of the design problem and its decomposition, identifying the characteristics of the IS, input and output information flows, intra-system connections, justification and algorithm creation of the logical structure of the interaction of the individual components of the system, development information processing algorithms, which ultimately, when composing the system, must provide specified functions.

At the same time, in the works [14, 15] scientifically substantiated ideas about assessing the quality of education as an essential educational component are examined in detail, which allow developing information processing techniques and applying their methods of analysis and management of the process of formation of students 'competencies at the university.

Thus, the purposes of using system analysis methods in work are:

1. Obtaining the structure of an IS for analysis and management (ISA and M) of the competence-building process;

2. The study of the design object, methods and means of its interaction with the environment;

3. Identification of functional subsystems implementing individual tasks, their structural elements that implement individual information processing and analysis algorithms;

4. Identification of functional relationships in the form of interacting input and output information flows of system elements;

5. Determining the order and logic of their interaction in the implementation of individual tasks of the IS.

IV. RESULTS AND DISCUSSION

The representation of design object (DO) and the relationship with the external environment can be represented in the form of Figure 1. Figure 1 illustrates in general terms the formulation of the design problem associated with obtaining information about the competence of graduates and the rational area of their employment.
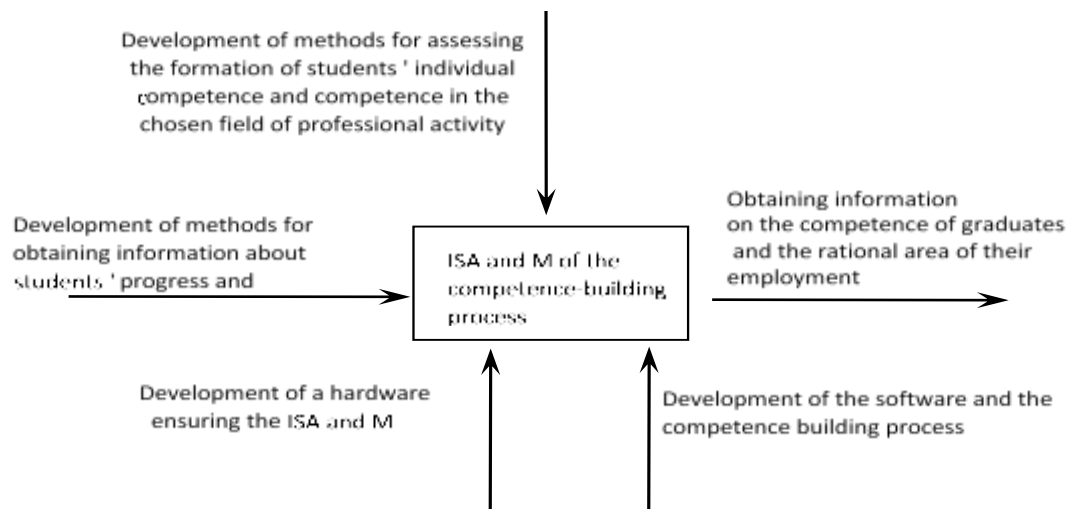
Fig. 1. Formulation of the problem DO

Obviously, obtaining this kind of information requires:

- the use of methods for assessing the student's formation of a separate competency and level of competence in the chosen field of professional activity;

- the development of methods for obtaining information about current student performance and achievements;

- the hardware selection and software development.

The general structural diagram of the DO, consisting of software and hardware components that implement the tasks can be represented in the form of Fig. 2.
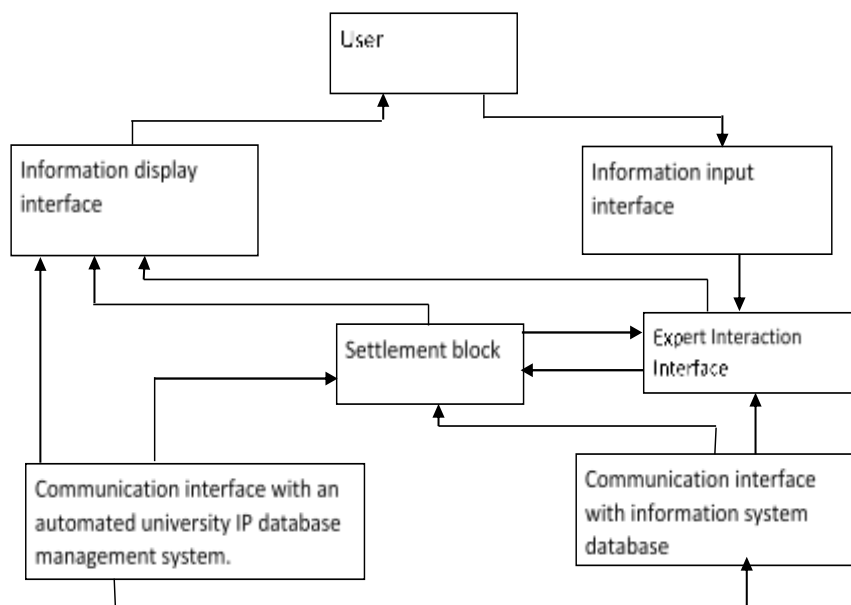

Fig. 2. Block diagram SHC IS

The main structural subsystems of ISA and M competency building process are components that ensure the implementation of automated procedures for information processing, output assessments and receiving recommendations for managing the educational process.

However, when describing the system it is not enough to list the elements of which it consists, it is necessary to decompose it into subsystems (elements) and components and show how the tasks are accomplished in the object [16, 17].

Figure 3 shows the structural diagram of the DO, in which not only the primary decomposition of the DO is performed, but also its structure is shown with the separation of its elements according to the class of tasks being accomplished.

The structure of the system contains both object (object-oriented) subsystems – designed to receive and process data, and serving subsystems – dialog procedures, control, input and output of information (including graphic).
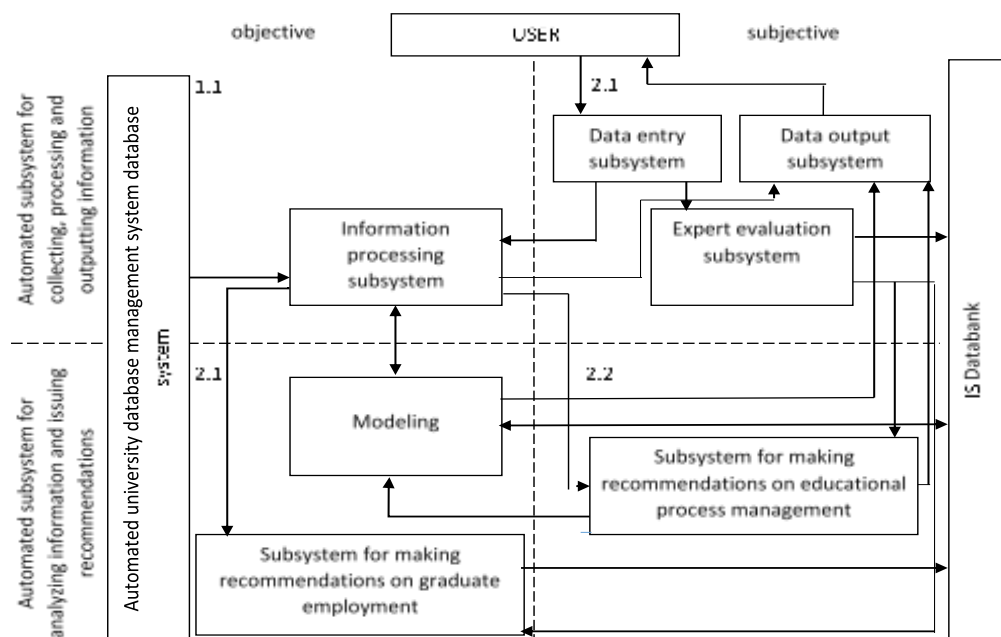

Fig. 3. Primary decomposition of the OD according to the class of problems to be solved

To describe the interaction of information flows in each subsystem, the modeling methodology DFD and IDF03 can be used, which show not only the data flows between the individual subsystems, but also the cause-effect relationships between situations and events in an intelligible form using the structural method of expressing knowledge about how the system is functioning.

Figure 4 shows the information structure of ISA and M of the process of formation of the graduate's competence. The considered information system operates in 5 modes: Mode 1.1 – expert assessment of learning elements (calculation of weight coefficients), mode 1.2 – mode of updating information about the educational program and students, mode 1.3 – formation of a professional portrait of the graduate, mode 1.4 – mode of mathematical modeling, 1.5 – control mode.

Thus, in mode 1, the data necessary for calculating the weighting coefficients by experts (a_i, b_i, c_i) is used. $<l, S, i>$ 1 – discipline, i – competency, xperts provide information on the values of weight coefficients necessary for calculating a comprehensive quality indicator $(\delta_j, \gamma_j$ — weight coefficients determined by the expert method, taking into account the influence of each type of assessment (disciplinary, multidisciplinary and non-disciplinary) on the competence in j-th APA provided that). After the calculation behavior, information in the form of a tuple of data $<a_i, b_i, ci, \delta_j, \gamma_j>$ enters the data bank, and can also be displayed on a display device.

In mode 2, information on a specific educational program and student's affiliation is updated. The user provides information about the EP, which is ultimately represented as a tuple of data $<N,OP,l,S,,i,j,z_l,\alpha_l,\beta_l,r,x,n>$ and is registered in the data bank..

Mode 3 – the formation of a professional portrait of a graduate includes processes for calculating the qi – assessment of the formation of the i-th competence of the educational program; calculation of a complex indicator Q_{ij}. To do this, the user provides information about the student in the form of his IDS, information from the data bank comes in the form of a tuple of data $<a_i, b_i, ci\ i, z_l, \alpha_l, \beta_l, r, d_l, k_l, t_l, p_j, x, n; S>$ for calculating qi. Next, a complex indicator is calculated, which is displayed in the form of an array $\{Q_{ij}\}$, the data for calculation in the form of a tuple $<(\delta_j, \gamma_j, j, i,,r, r_i>$. Starting to build a professional portrait of a graduate, the user enters the data $< Qi, m >$, where m – is the number of areas of activity. Using a set of features in the course of cluster analysis, the angle of inclination (cos (d)) to a specific area of PA is determined, the vector R_{spec}. is constructed. Information qi, $\{Q_{ij}\}$, R_{spec}., d is output to a display device.

Mode 4 simulation – in this mode, data analysis with the prediction of possible events is carried out. The user enters IDS data, information about current performance $< d_l ;k_l ; t_l; p_j >$ comes from the data bank. Estimated indicators qi, $\{Q_{ij}\}$, R_{spec} in the current time mode allow predicting possible variants of events with a random or probabilistic distribution of grades in undeveloped disciplines.
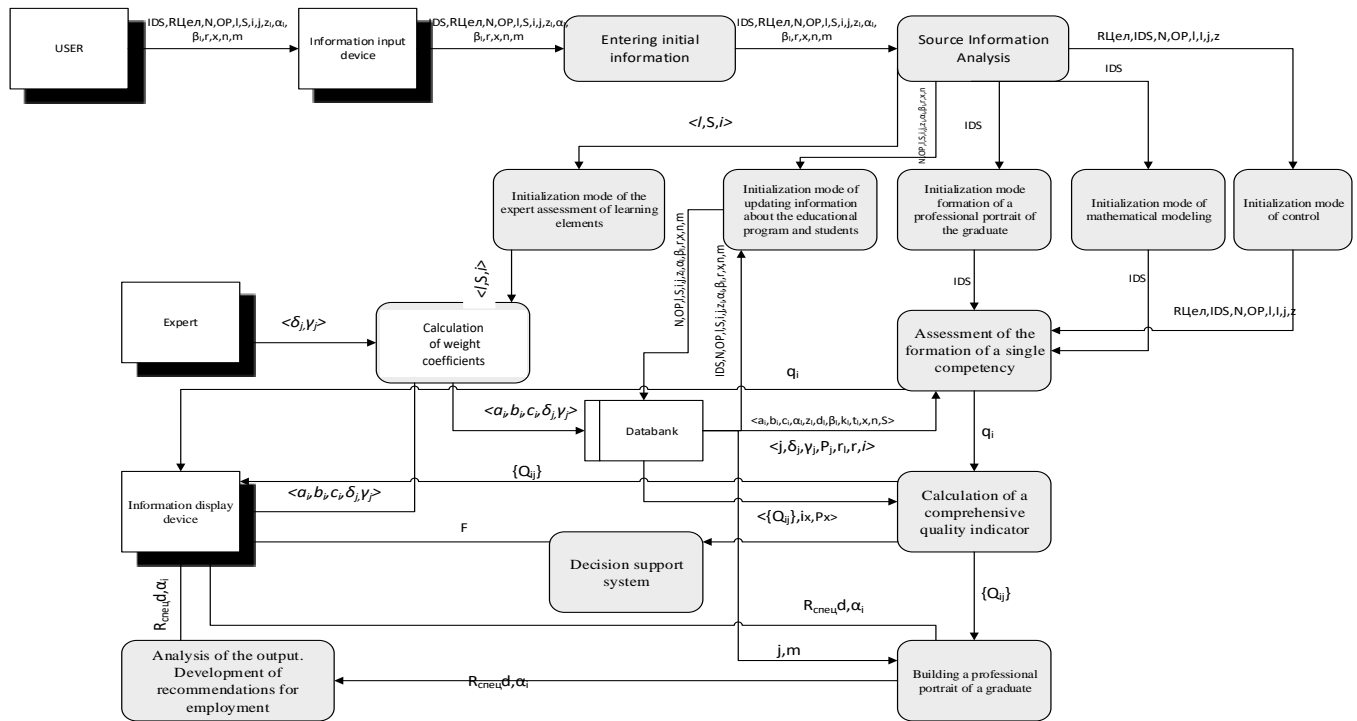
Fig. 4. DFD model of ISA and M of the process of formation of the graduate's

TABLE I. NOTATION OF VARIABLES

Rspec	The orientation vector of the portrait of the graduate, which shows the direction of movement of the student in professional growth	d_l	assessment by discipline (assessment by examination sheet or rating by discipline, intermediate certification for which is "offset")
R_{TAR}	Orientation vector of a perfect graduate portrait	β_l	share of training allocated to students' independent work
Q_{ij}	assessment of the readiness of a graduate to perform professional tasks in the j-th APA, characterized by a different set of competencies, is a normalized value (average weighted value)	k_l	multidisciplinary assessment of disciplines forming the i-th competency, determined by the totality of the results of the completion of term papers and projects, forming a specific APA
$\bar{I}_j$	unit vector in the direction of the j-th APA, $j = \overline{1, m}$	t_l	multidisciplinary assessment of practices that form the i-th competency
δ_j, γ_j	weighting factors determined by the expert method, taking into account the impact of each type of assessment (disciplinary, multidisciplinary and non-disciplinary) on competency in j-th APA provided that $(\delta_j + \gamma_j) = 1$	$a_i,$ $b_i,$ c_i	weight coefficients determined by the expert method, $(a_i + b_i + c_i) = 1$
θ_j	vector determining the composition of competencies for the jth APA, $\vec{\theta}_j = A_j \cdot \vec{q}$	z_l	the number of credits z in the l-th discipline, forming the i-th competence (part of the competence)
$\vec{q}$	development assessment vector PK $(\overline{1, n})$, $\vec{q} = (q_1, q_2, ..., q_n)^T$	I	competence
q_i	assessment of the formation of the i-th competence of the educational program	J	area of professional activity
m	amount APA	N	training direction
r	number of competencies included in j APA	OP	educational program
z_i	the number of credits allocated to the i-th competency	IDS	student identification number
p_j	portfolio assessment (the part of the portfolio that relates to the j-th APA)	F	additional workload
α_l	the share of theoretical training for the l-th discipline, forming the i-th competency	i_x	undeveloped disciplines
	number of disciplines defining a specific competency	P_x	additional portfolio items
	Number of factors affecting a particular competency	X	competency factors

Mode 5 is used to calculate possible control actions for organizing the learning process and developing recommendations for the development of additional and elective training load F (electives, elective subjects, portfolio items), as well as a list of disciplines recommended for recertification The user provides information about the student in the form of his IDS and Robjective- vector of the ideal

professional portrait of a specialist. Using a set of features in the course of cluster analysis, the current angle of inclination (cos d) is determined to a certain area of PA. As in the mode 3, the value of the single competency and the complex indicator $\{Q_{ij}\}$ are calculated. As a result of these calculations, an additional training load is offered for the selected student. For the full formation of a specific APA, the expert method

determines the missing elements of the training F (electives, subjects of the topics of final qualification work, etc.).

V. CONCLUSION

As a result of the system analysis, the identification of system links between the individual functional modules of ISA and M was carried out in relation to each area of its application considered in the work. System analysis made it possible to identify general system properties and the main laws of information processing when assessing the competence of graduates taking into account professionally significant personal qualities, as well as to exclude repetitive elements of information processing in the design of IS.

References

[1] N.N. Fedyakova, "Improving university management information systems", Education Integration, vol. 2, pp. 198–210, 2016.

[2] L.M. Mukhametshin, L.L. Salekhova, M.M. Mukhametshin, "Use of the LMS MOODLE system in the modern educational process", Philosophy and Culture, vol. 2, pp. 274–279, 2019.

[3] D.M. Khudyakova "1C-Bitrix: the internal portal of the educational institution "+" 1C: University PROF "is an effective solution for a university ", New Information Technologies in Education, vol. 2, pp. 202–204, January 2019 [19th International Scientific and Practical Conference, p. 605, 2019].

[4] K.V. Kravchenko, "The advantages of organizing work with the student body at a university based on a single corporate system", Symbol of science. vol. 5. pp. 2011–2013, 2015.

[5] Official site of the information system "Plans". Retrieved from: http://www.mmis.ru/programs/plany

[6] N.F. Efremova, "Approaches to assessing the competencies of first-year students embarking on the development of basic educational programs " Proceedings of the DSTU. vol. 5, no. 48, pp. 369–777, 2010.

[7] E.N. Mosolova, "Key specialist competencies: the view of employers", Professional education in Russia and abroad, vol. 5, pp 23–26, 2012.

[8] T.O. Gordeeva, D.A. Leontiev, E.N. Osin. Personal potential: structure and diagnosis. 2011, pp. 642–668.

[9] A.E Poropat, "A Meta-Analysis of the Five-Factor Model of Personality and Academic Performance", Psychological Bulletin, vol. 135, no. 2, pp. 322–338, 2009.

[10] L.R. Fionova, " Models and algorithms for building an individual educational program ", Science and world. vol. 1, no. 5, pp.122–130, 2014.

[11] L.V. Zaitseva, N.O. Prokofiev, "Models and methods of adaptive knowledge control", Educational Technology & Society, vol. 7, no. 4, 2004. Retrieved from:: http://ifets.ieee.org/russian/depository/v7_i4/html/1.html.

[12] L.S. Lisitsyna, "The concept and methodology of managing the development of the educational process for the preparation of competent graduates by means of a network information system", doctoral dissertation: 05.13.06, St. Petersburg, p. 184, 2008.

[13] L.N. Glebova, M.D. Kuznetsova, V.D. Shadrikov, Monitoring the quality of higher pedagogical education, 2012, p. 367.

[14] O.S. Nikulcheva, S.G. Tikhomirov, I.A. Khaustov, L.I. Nazina, "Assessment of competence and readiness of graduates to solve the problems of professional activity", Questions of modern science and practice, vol. 3, no. 69, pp 155–165, 2018.

[15] O.S. Nikulcheva, S.G. Tikhomirov, I.A. Khaustov, L.I. Nazina, "A model for the formation of professional competencies among university graduates", Mathematical modeling and information technology in engineering and business applications, pp 114–123, September 2018 [Mathematical modeling and information technology in engineering and business applications, p. 390, 2018]

[16] D.A. Shageev, T.A. Chuhonceva, "Universal rapid method of assessment and management decision-making of situational problems in the enterprise", Proceedings of the Voronezh State University of Engineering Technologies, vol. 81, no. 2, pp 359–376, 2019.

[17] A.N. Desyatirikov, Y.B. Nechaev, E.N. Desyatirikova, A.Y. Shestopalov, "Information analysis and synthesis of the organizational structure of the unique project in the classical control theory", Proceedings of the Voronezh State University of Engineering Technologies, vol. 80, no. 4, pp 463–470, 2018.