The relevance of the study is due to the problem of forming the concept of the information environment from the point of view of management. The theoretical foundations for the construction and practical application of the information environment of educational institutions are given, a model of an individual educational trajectory is designed, and the methodology for modeling the information environment of educational institutions based on systems theory is described. This is important, since the information environment helps to improve the efficiency and quality of the educational process through the implementation of information technology capabilities. An individual educational trajectory is considered as a process of making a decision by a student based on a system of individual values and personal meanings; contains a qualification model of a specialist in the world of professions and opportunities for the implementation of vital plans. The qualification model of a specialist includes a qualification portrait of a specialist, regulatory requirements – a set of linguistic assessments and a set of numerical assessments that meet the requirements of employers.

As a result of the study, a systematic approach was applied, which makes it possible to determine the limitations of the system's functioning, the procedure for planning activities and the system for stimulating elements of the organization. A detailed review of the main models of interaction between the elements of the organization is made: bureaucratic, democratic participation and parity compromise. The bureaucratic model is characterized by a clear hierarchy of rules and decisions, strict regulation of job descriptions. The model of democratic participation is focused on the development of creative abilities of an employee, when, performing a particular function, he expects to achieve personal goals, directing his efforts to achieve the goals of the organization.

The results of the study are aimed at an effective choice of interaction models depending on the main elements of systemic activities in educational institutions related to improving the quality of work and education

Keywords: information environment, individual educational trajectory, system analysis, information technology

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DEVELOPMENT AND MODELING OF COMBINED COMPONENTS OF THE INFORMATION ENVIRONMENT

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1. Introduction

From the point of view of management, the information environment is an organization that has a multifaceted purpose of existence, expressed in the form of ideology, laws and instructions. And since it needs to be structured (divided into sub-goals), it inevitably becomes necessary to highlight separate levels of management and elements of the organization responsible for a particular area of activity. The definition, identification, formation of a structural relationship of the elements of the system, leading to emergence, are the most important moment in the creation and design of the system functioning. For organizational systems, such as the information environment, consisting of a large number of interconnected elements, before proceeding to the modeling of functioning mechanisms, it is necessary to establish the main basic relationships between the elements [1].

Let us formulate the definition of the concept of "Information educational environment" and designate its categorical features.

Under the information educational environment, we mean a holistic set of progressively replacing each other learning situations in the virtual space, during the resolution of which students are educated, nurtured and developed, as well as improve professional skills and abilities, expanding their professional horizons [2].

Under the information environment – a set of conditions implemented on the basis of information and communication

technologies aimed at the implementation of educational activities that contribute to the formation of professionally significant and socially important qualities of a person in the conditions of informatization of society.

The features that characterize the information and educational environment include:

– integration of information and communication technologies;

– development of new information processing technologies;

– use of network resources in the educational process;

– use of modern means, methods and forms of education.

In the future, speaking about organizational systems, we will assume that all reasoning applies to the information environment of educational institutions.

In this regard, an organizational system is a finite multiplicity of functionally defined and active elements, which is characterized by a common goal, which is an informational image of the final product for which the system exists [3]. It has at least two kinds of dynamics: dynamics "in time" and dynamics "in space". Under the dynamics "in time" we mean that as a result of external and internal interactions, all systems are subject to constant changes occurring with different intensity. Under the dynamics "in space" we mean, first of all, that any system is a part of some larger system, as a result, the whole world can exist as a hierarchy of nested, interacting systems [4].

The existence of any organizational system "in time" and "in space" is determined by the fact that it is in the environment of purposeful activity. The goal synthesizes the internal and external integrity of the system, determines the rational structure of the system and its functions. It turns out that an organizational system is a system with a social and economic interest, which has a purpose of existence and has the resources to build, based on the purpose of the existence, the structure and relationships necessary to obtain some result, which is usually called the final product.

The correct definition and setting of goals are the main thing for the existence of an organizational system. This, on the one hand, is its ineradicable subjectivism, and on the other, a reflection of objective processes. On the basis of certain goals, the strategy and tactics of system management are built, the structure of the system is formed, which implies the presence of a management system and a management object.

As it was pointed out, when determining the purpose of the organizational system, there are two principles – objective and subjective. The objective principle is determined by the problematic situation that arises in society. The existence of a problem gives rise to the need for system-forming activity.

Identification and description of a problem situation are one of the most complex and responsible processes. The emergence of problem situations is a consequence of the dialectical nature of the development of systems. Unsatisfied needs, which, as a rule, are initially objective, ultimately receive subjective expression in assessing the parameters of existing systems and realizing the need to change them. The possibilities of meeting the needs are limited by many objective and subjective factors: existing systems, management methods, the level of scientific and technological development, resource provision, nature and the permissible level of impact on it.

Determination of goals in organizational systems is a specific, subjective process, however, the extent to which objective reality and higher-level goals are taken into account determines the reliability and viability of the created organizational systems. Undoubtedly, it is easier to manage a simple system, so the governing body – the management system often seeks to simplify the situation and to some extent limit, or, ultimately, the same thing, control the activity of the control object. At the same time, the rational principle of building relationships between the elements of the system to achieve the goal is to ensure the most efficient functioning with the rational use of resources. To implement this principle, it is really necessary that the control system clearly defines the functional tasks of the elements of the system and the incentive system, on the other hand, the greatest constructive activity of the elements will be achieved if the interests of the subjects and their goals are consistent with the goals of the entire system.

Summing up some results regarding the definition of a multi-level organizational system, we can conclude that this can be done by considering the main stages of activity for its synthesis and analysis.

In other words, one should be aware of the problematic situation; determine the purpose of its liquidation; implement the goals to build an appropriate organizational structure; develop an individual educational trajectory of learning; determine the limitations of the system functioning, the procedure for planning activities and the system for stimulating the elements of the organization, while ensuring organizational harmony, the available resources should be taken into account and rationally used. All these circumstances determine the relevance of the study.

2. Literature review and problem statement

The authors [5] believe that the traditional education system cannot fully ensure the success of new educational results within the traditional content of education. Attention is paid to the construction of the process of network interaction, which is in constant dynamic development, contributes to the achievement of a new quality of education through the creation of a virtual information environment based on online learning platforms. The work summarizes the results of the initial phase of project implementation. The diagnostic and thematic master class conducted by the authors proved the importance of the organized activity. We agree with the authors who note that the main task of today's education system is to create conditions for quality education.

The authors propose the new approach aimed to build specialized knowledge bases generated using artificial intelligence technology and focused on the use of multiple heterogeneous resources or data sources on specific educational topics. The model and structure of the IT-oriented ontological framework designed to ensure the components convergence of the university three-platform information and communication environment are developed. Within the framework of design and formation of the knowledge sector disciplinary structure "Information Technologies" in the context of the competence approach to education, the architecture of the competence descriptors of the semantic analysis system is proposed [6].

In this study, an interesting approach seems to be that allows you to systematize the content, structure and connections of information technology components to adjust the range of competencies in the field of computer technology.

In [7], an analysis of predominantly English-speaking authors is presented and a list of professional journals, both Russian and English, has been prepared, in which materials have been published regarding the use of multimedia in the educational process, Web 2.0 technologies, Web technologies in linear learning, the impact of ICT on the educational process, approaches to the use of ICT. The relevance of the study is due to the urgent need to consider the experience of using information and communication technologies to improve the educational process in the modern information society.

Significant for our study is the experience of foreign countries (China, Ukraine, USA, Brazil, Finland, India, UAE, etc.) in the use of information technologies in the educational process.

The constituents of the quality management system of educational activity are considered. The subsystems of the automated control system of educational activity of the university have been characterized and analyzed. The key elements of the information systems used are the following electronic databases: students and their academic performance; results of employment; students' satisfaction with educational programs; distribution of the teaching load; teachers' performance; learning and teaching resources, facilities, equipment and their cost; other indicators of university activity. The results of the research are of practical value since the implementation of the considered software products can improve the quality and effectiveness of the management of educational activities of higher education institutions [8]. We are close to the position of the authors who highlight the results of the practical application of modern information technologies in the management of an educational institution.

Scientific-practical and methodological experience in the development, implementation and use of the interdisciplinary automated training system based on the Moodle system in the educational process was considered. The structure of the typical training course is presented and recommendations for the development of information and educational resources for different types of lessons and self-study students were set out.

We agree with the position of the authors, who described and substantiated approaches to the implementation of information-educational and educational-research resources in an interdisciplinary automated learning system. The proposed approaches can be applied to a wide range of technical and natural science disciplines in a multilevel graduate training system [9].

In [10], the formalization complex model of the e-learning of variability with the electronic educational resource of the new generation is developed, conditionally decomposed into three basic components: the formalization model of the course in the form of the thesaurus classifier ("Author of e-resource"), the model of learning as management ("Coordination. Consultation. Control"), the learning model with the thesaurus classifier ("Student"). According to the authors, the developed theoretical provisions and basic components for the model of variation e-learning with the electronic educational resource of the new generation allow the student to realize functional mastering of knowledge, abilities and skills of trainees on the basis of variation approach, and also to choose a personal student-centered way of "finding the concept (meaning)" of the given tasks in the process of motivated learning based on formalized information thesaurus classifier of electronic educational resource.

Of particular interest is the study [11], which describes an approach to the formation of the information and educational environment of a technical university, based on the deep integration of electronic educational content with methods and tools for solving engineering and economic problems. The Application Program Interface (API) is considered as the main integration tool.

In [12], the necessity of system analysis and efficiency improvement of information interaction between heterogeneous subjects and means of a complex technological process of automated formation of remote knowledge is substantiated. It was found that the innovative block of parametric cognitive models is the information basis of system analysis, contains cognitive models of the subject of education and learning tools, each of which acts as a complex repertoire of parameters (indicators), echeloned into a number of portraits and stratified into several independent sets located at two different levels of the selected hierarchy. When formalizing the structure of a parametric cognitive model, a number of innovative ways of representing its structure (models (metadata)) are used: mathematical calculus using tuples on domains (analytical), directed graph combining mathematical set theory (graphical) and (hierarchical) multilevel block diagram. The proposed algorithm is the basis of the apparatus of cognitive modeling technology developed by the author and provides the formalization of an iterative sequence of ordered stages that form the structures of parametric cognitive models.

We agree with the opinion of the authors of this study that a systematic analysis of information and educational environments initiates the need to take into account a wide range of fundamental and applied areas of modern science, and also necessitates the use of an innovative research apparatus.

At the same time, in the presence of the results obtained so far, the problem of developing mechanisms for the formation of an information and educational environment has not been sufficiently resolved. The main reasons for this are:

– the lack of a generally accepted understanding of the information and educational environment as a complex phenomenon that requires targeted measures for its development, which have significant potential in solving the problem of improving the quality of education;

– insufficient development of the theoretical foundations of the process of developing the information and educational environment, reflecting its essence, structure and improvement opportunities;

– insufficient development of the content and methodological aspects of the development of the information and educational environment.

The analysis of publications shows that a large number of methods and mechanisms have been developed aimed at the formation and development of the information and educational environment. Starting with the analysis of the external and internal environment, the selection, implementation of strategies and scenarios, and evaluation of the simulation are covered. There are gaps in the choice of models for building an information and educational environment.

3. The aim and objectives of the study

The aim of this study is to develop and model the combined components of the information environment. All this

allows the educational institution to quickly respond to the requirements of the external environment in the field of the content of educational programs in areas of specialization.

To achieve the aim, the following objectives are accomplished:

– to substantiate the methodology for modeling the information environment of educational institutions based on systems theory and develop models of interaction between elements of the organization: bureaucratic, democratic parity and parity compromise;

– to develop a model for building an individual educational trajectory that contributes to the definition of specialization.

4. Materials and methods

The theoretical basis for the formation of approaches to solving the listed problems is provided by a system analysis. The above presentation of the main concepts of this system research tool basically corresponds to the traditions of active systems analysis [1] and the methodology of system analysis [13].

The study examines the main components of the information environment, which include: the curriculum, the relationship of competencies and disciplines, models of graduate profiles and positions, models and algorithms for assessing competencies, algorithms for improving the effectiveness of the curriculum, algorithms for constructing an individual learning path.

The form of interaction of elements depends on the size of the organization, the strategies and tactics used by the organization in society, the production technologies used, and many other factors. We propose to single out three models of interaction that reflect the level of agreement in the system:

– bureaucratic model;

– model of democratic participation;

– model of parity compromise.

The best method of conveying the concept of solving the second problem is modeling. Process modeling is an integral part of the study, which allows decomposing the subject area, showing the implementation of the process stages from the point of view of an external observer.

To formalize the model, it was decided to use the matrix algebra apparatus, which can most successfully show the pairwise interaction of all learning outcomes. For clarity of the methodology of formation of the content of academic disciplines of maximum usefulness of specialization, it was decided to use elements of set theory.

At present, the process of developing the information environment, based on the experience and expert assessment of specialists, needs serious improvement and scientific substantiation of the decisions made. Their effectiveness is determined by such factors as: compliance of the studied disciplines, practices with the lists of competencies enshrined in the relevant educational standards; compliance with the time allocated for the study of individual topics and the degree of its use in other disciplines; interrelationships between disciplines.

Approbation of the method was carried out at the Department of Information and Communication Technologies of the Non-Profit Joint Stock Company "North Kazakhstan State University named after M. Kozybaev" (Republic of Kazakhstan) on the example of specialization of IT specialists.

5. Results of research

5. 1. Methodology for modeling the information environment of educational institutions based on systems theory, modeling the interaction between elements of the organization: bureaucratic, democratic parity and parity compromise

Let's consider each interaction model. The bureaucratic model (Fig. 1) is characterized by a clear hierarchy of rules and decisions, strict regulation of job descriptions. The bureaucratic approach of the control system to the problems of interaction with the control object can be described by the simplest cybernetic model with feedback.

The following assumptions are typical for this type of management organization:

– most employees of the organization are passive;

– to manage subordinates, it is necessary to control all their actions;

– to obtain results consistent with the goals of the organization, a clear system of rewarding positive efforts and punishing deviations from the standards is necessary.

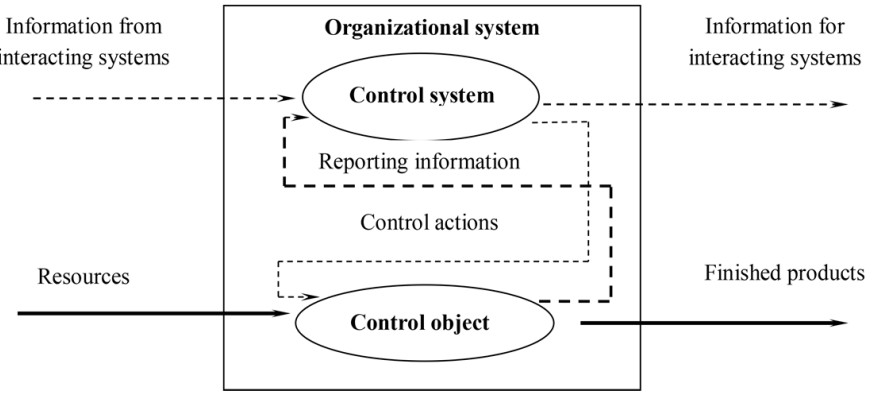

Fig. 1. Bureaucratic model of organization management

The undoubted advantage of the bureaucratic model of interaction is a clear organization of labor, delimitation of powers, and a well-organized control system. The main drawback is associated with ignoring the active role of employees in the activities of the organization and the lack of motivation for creative work.

The model of democratic participation is focused on the development of the creative abilities of an employee, when, performing a particular function, he expects to achieve personal goals, directing his efforts to achieve the goals of the organization. This can be achieved with proper planning and promotion (Fig. 2).

The meaning of the existence of any organizational system is the implementation of certain goals, which can be described by setting and then estimating the values of the system parameters. The most important parameters reflecting the goals of the system will be denoted by $X^d = \{x_j^d\}$. The state of the organization is also characterized by a

number of parameters that are less significant at the considered point in time. They can be considered informational $-X^i = \{x_j^i\}$. Planning and evaluation of the system activity are carried out by the governing body according to the set of parameters X^d, which is further defined taking into account the internal and external conditions for the existence of the system by a number of parameters from x_j^i. At the same time, a set of functioning parameters that are relevant from the point of view of achieving the system goals is determined. By setting the standards for this set at a certain point in time t: $X^n(t) = \{x_j^n(t)\}$, planning is carried out. Estimating the values of the system parameters at time t, the governing body determines the incentive system for the elements of the system $F(t)$. These actions of the management system constitute the macro level of management of the organizational system.

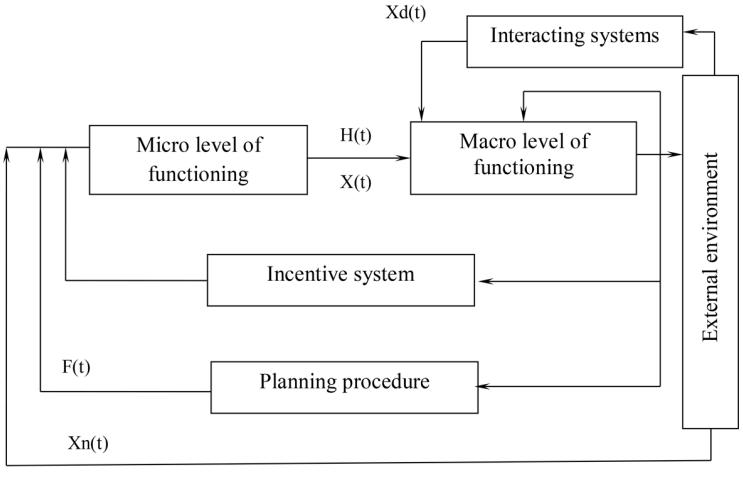

Fig. 2. Levels of functioning in the model of democratic participation

At the micro level of the system, the processes associated with the creation of final products of activity are implemented. These processes are under the influence of the stimulation system F. The ability of elements to create final products is limited by the permissible intensity of their work H, which is determined by existing resources and technology. Under the influence of the incentive system and the permissible intensity of activity, a deterministic type of behavior of the elements is formed, which at some point in time t is described by the state of the system parameters $\{x(t)\}$. Thus, in the model of democratic participation, in order to achieve the goals of the system, the governing body faces the interrelated tasks of forming the law of regulatory planning and the incentive system, taking into account the real processes of the functioning of the elements.

Elements of the organizational system behave actively. At the same time, they take into account the actually existing system of stimulating activity and, in addition, to a certain extent independently interact with the external environment. At the level of elements in the system, microprocesses are implemented that are not essential for the system as a whole and cannot be fully described by normative parameters. Micro-level processes are not deterministic. They are influenced by the parameters of the incentive system $F(t)$, being reflected in the processes of the macro level. As a result, the system has a deterministic type of behavior, which is described by the trajectory of the system, which is formed by the trajectories of its elements. The control system is designed, operating the incentive system, to ensure the minimum mismatch between the current system parameters $x(t)$ and the normative parameters $x^n(t)$, while the parameters that are set taking into account the needs of the external environment x^d are of particular importance.

The main advantage of the considered model of interaction is the coordination of the personal interests of employees with the goals of the organization in the case of a properly constructed incentive system. The disadvantage is that it is quite difficult to build a correct incentive system and correct it in time, therefore, as a rule, there is a delay in stimulating the actual functioning parameters.

The solution to the problems of democratic participation is achieved by bringing it closer to the model of parity compromise. This model assumes, in turn, program-target management methods. The goals of the organization in this case should be determined and formulated with such a degree of detail that the level of their implementation can be used to assess the effectiveness of the elements of the system structure.

The consistency of the interests of the elements of the system with the goals of its existence makes it possible to move on to decentralized management, which takes the form of a collective interaction of elements. This type of control becomes inevitable for complex, large systems.

The bottom line is that parity management can be implemented by creating management hierarchies that correspond to the goals of the system, ensuring the consistency of the interests of the system elements with the goals, and ensuring full awareness and communication skills at all levels of the hierarchy.

We will assume that the hierarchy of the organization goals is defined and there is a tree of system goals [13, 14]. Denote the global goal of the system C_1. The subgoal of the i-th level of the tree of goals will be denoted as C_α, where $\alpha = (1, i_1, i_2, \ldots, i_{\lambda-1})$ is a word whose number of letters matches the number of the level of the tree of goals. Since we believe that at the top level we have a single goal, the first letter is always one. As an alphabet, we use a series of natural numbers 1, 2, ..., n, ..., for example: $C_{1,2}$, $C_{1,5,17}$. The ratio $C_{\alpha 1} \subseteq C_{\alpha 2}$ will mean that the goal $C_{\alpha 1}$ is a subgoal of the goal $C_{\alpha 2}$. In this case, α_2 is the beginning of the word α_1, that is, $\alpha_1=(\alpha_2, \alpha_3)$, where α_3 is some word or Ø.

Let $\gamma\alpha$ be the number of subgoals into which the goal C_α is decomposed, then it generates goals $C_{\alpha,1}$, $C_{\alpha,i}$,...,$C_{\alpha,\gamma\alpha}$. Denote by α the word obtained from α by discarding the last letter. The number of letters in the word α is denoted by α. The set of all indices α corresponding to goals C_α of the goal tree will be denoted by A, the number of levels of the goal tree will be H.

As mentioned above, the tree of goals generates an elementary structure for managing the organizational system, in which the level of the management hierarchy corresponds to the level of the tree of goals. The elements of this structure, which we denote by S_α, actually represent decision-making systems, that is, a way to implement management in an organizational system. In practice, in parity systems, on the one hand, the distribution of management (distribution of tasks, responsibilities, incentive opportunities) corresponds to the tree of goals, and on the other hand, it is possible to coordinate the work of any level of management due to free correspondence of information.

Let us introduce the notation:

ξ^{α} – the state of the system S_{α};

$u^{\alpha,i}$ – the control action of the system S_{α} on the elements of a lower level $S_{\alpha,i}$=1, 2, ..., γ_{α};

w^{α} – integrated information about the field of activity determined by the goal C_{α}, transmitted from S_{α} to S_{α} (at $|\alpha|\geq 2$);

$\{\omega^{\alpha,1}, ..., \omega^{\alpha,\gamma\alpha}\}$ – information about the fields of activity $C_{\alpha,1}, i=\overline{1,\ldots,\tilde{a}_{\alpha}}$;

$\Lambda_{\alpha}=\lambda_{ij}^{\alpha}$ – the intensity matrix of correspondence between elements of level α, i, j=1, 2, ..., γ_{α};

$T_{\alpha}=t_{ij}^{\alpha}$ – the matrix, the elements of which reflect the complexity (bandwidth of communication lines, distance, etc.) of communication between elements of level α, i, j=1, 2, ..., γ_{α}.

The system S_1 manages the activities of the entire organizational system, so it receives concentrated information about the state and final product of the entire system. Moreover, S_1 must have elements of self-organization, that is, adjust the goals and structure of the system.

The system S_{α} of the middle level, i.e. $1<|\alpha|<H$, is connected with the control system S_{α} and control objects $S_{\alpha,i}$. The coordination of the work of the elements of the structure is carried out not only and not so much by linear control actions, but by ensuring full awareness and free movement of the corresponding information λ_{ij}^{α} between performers of the same complex of works.

In accordance with Fig. 3, the parity control scheme of the element S_{α} is as follows.

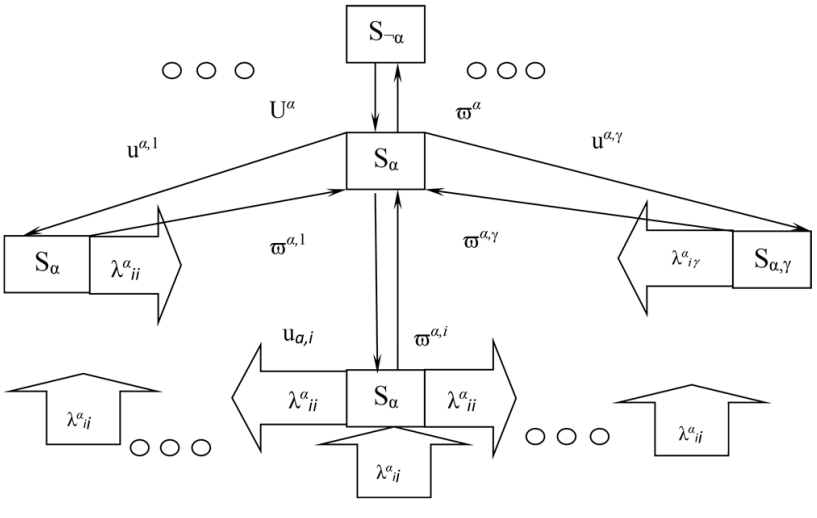

Fig. 3. Scope of element S_{α} in the parity compromise model

The level of interaction between the elements of the organization can be estimated by a value that expresses the intensity of providing communication links between them. So, for a system of level α, such an estimate can be expressed by the quantity Q_{α}.

$$Q_a=\sum_{i=1}^{\gamma_{\alpha}}\sum_{j=1}^{\gamma_{\alpha}}\lambda^{\alpha}_{ij}l^{\alpha}_{ij}.$$

The sum Q_{α} for all levels from α=1 to α=H gives an estimate of the intensity of communication links in the system – Q. It should be noted that these parameters are not traditional parameters of organizational system elements.

This situation is a consequence of the lack of proper structuring of the links between the elements, their complex multivariate nature. The development of control systems and their automation increase the importance of determining and analyzing the parameter Q.

5. 2. Modeling and results of the study of the implementation of the algorithm for constructing an individual learning path

When modeling the information environment, it is important to highlight the specific personal abilities of students as guidelines for their educational activities. This is realized through an individual educational trajectory.

In the course of the educational process, carried out along an individual educational trajectory, the students' abilities are identified, realized and developed. This gives grounds to believe that the path of mastering these disciplines will often be determined not so much by the logic of these subjects, but by the totality of the student's personal abilities.

When developing an individual educational trajectory, it is important to take into account the opinion of employers. This raises the problem of quantifying the level of competencies formed by students. To determine the personality traits of students, which determine their ability to perform certain work, we introduce the concept of a competency-based qualification unit (CBQU).

In an individual educational trajectory, in a certain period, the teacher and employers evaluate the level of CBQU.

Let's represent the qualification model of a specialist in the following form:

$$\tilde{E}=\left\{K^1,K^2,\ldots,K^M\right\},$$

where K^M – linguistic description of CBQU;

$m=\overline{1,M}$ – CBQU number in the set;

M – total count of CBQU in the set.

Each element from the set of K^M will be assigned a numerical score that reflects the corresponding level of CBQU. Let's introduce the variable Kl^M – the achieved level of CBQU K^M. Determining the achievement of the CBQU level is carried out by a group of experts (teachers and employers).

Let us define the term-set of the variable $\{Kli^M\}$ – the set of possible verbal assessments of the actually formed level of the CBQU K^M. In this case, Kli^M, $l=\overline{1,L}$ – the verbal value of the linguistic variable that characterizes the level of the m-th CBQU, L – the number of evaluation levels.

We represent the universal term-set of linguistic errors $\{Kli^M\}$ as follows: {"lack of qualification", "very low level of qualification", "low level of qualification", "average level of qualification", "high level", "very high level of qualification"}. To the term-set of the given variable we assign a set of numerical estimates. We use a 100-point numerical rating scale.

Let $[Kuo^M, Kum^M]$ be the allowable interval of scoring estimated values for CBQU K^M, with each interval including the obtained estimated values $Kum^M\in[Kuo^M, Kum^M]$, $t=\overline{1,T}$, where T is the number of elements in the estimated interval. Let us construct a set of functions that match the estimated values of Kum^M with the elements of the above-described term-set of the variable $\{Kl^M\}$.

Experts identify boundary points for each l-th value of the linguistic variable $Kl^M\in[Kuo^M, Kum^M]$. If for each l-th qualification level of K^M a quantitative assessment of Ku_f^M is

formed, then it is possible to determine the value of the membership function $\mu^{l}Ku_f^M$, which reflects the degree of compliance of students' qualifications with this level. These parameters are normalized.

Each verbally given level of CBQU K^M will be assigned a certain number that characterizes its compliance with the requirements. The opinions of experts on the compliance of the qualification levels of the *m*-th CBQU with the requirements of employers are processed by statistical methods and the membership functions $\eta(Kl^M)\in[0, 1]$ are constructed. With the use of this function, we construct an aggregated function $\mu(Ku^M)$, which characterizes the degree of compliance of the CBQU level actually formed among students with the requirements.

Based on the results of the assessment, a qualification model of a specialist is built. Such a model for the *s*-th specialty includes:

– qualification portrait of a specialist

$$\overline{E}_s = \left\{K_s^1, K_s^2, \ldots, K_s^M\right\},$$

list of CBQU. This list was formed by a group of experts: employers and teachers of the university;

– a set of linguistic estimates

$$\overline{E}_l = \left\{Kl_s^1, Kl_s^2, \ldots, Kl_s^M\right\},$$

such that $\eta\left(\widetilde{El}_j^m\right)=1$. Thus, the normative levels of CKE are determined;

– a set of numerical estimates

$$\overline{K_s} = \left\{k_s^1, k_s^2, \ldots, k_s^M\right\},$$

such that $\mu\left(\widehat{E_s^m}\right)=1$. That is, the level of CBQU fully meets the requirements of employers.

In this regard, we note that at all stages of assessment for each student, his actual qualification portrait can be obtained: $\overline{d_i} = \left\{d_i^1, d_i^2, \ldots, d_i^M\right\}$, where $i=\overline{1,St}$; where *St* is the total number of students participating in the assessment procedure.

We also note that the distribution of students by specialization is carried out in such a way as to ensure their demand in the future in the labor market. In this regard, it is necessary to apply methods that allow one to obtain approximate values of the parameters of the predicted demand for graduates.

To do this, we will use an approach based on the extrapolation of trends in the development of personnel systems of employers who are leaders in their industries. This method is based on the approach to assessing the predictive demand for graduates of various specialties, directions, specializations and training profiles at a leading enterprise [12, 15].

Let us construct a branching algorithm for the individual educational trajectory of students, using membership functions that characterize the correspondence of CBQU scores to linguistic evaluation levels and using predictive estimates of the demand for graduates. This stage consists of two stages.

Stage 1. Determination of specialization within the framework of the individual educational trajectory of students. Let's say *St* is the total number of students. For students $i=\overline{1,St}$ and specialization $sp=\overline{1,Sp}$, the degree of deviation of their CBQU from the requirements of industry standards is calculated by the formula:

$$\overline{\Delta kd_i^{sp}} = \sqrt{\sum_{m=1}^{M}\lambda_{sp}^m\left(\mu\left(k_{sp}^m - \mu\left(d_i^m\right)\right)^2\right)},$$

where λ_{sp}^m – the relative importance of the *m*-th CBQU, a specialization graduate $sp=\overline{1,Sp}$;

$\mu\left(d_i^m\right)$ – values of the implemented function, characterizing the level of actually formed CBQU of the *i*-th student;

$\mu\left(k_{sp}^m\right)$ – the values of the membership function, characterizing the level of CBQU that fully meets the requirements of employers [12, 15].

Stage 2. Choosing an individual educational trajectory for students.

Each *i*-th student $\left(i=\overline{1,St}\right)$ has a set of qualification characteristics. The CBQU level from the set for each student is characterized by the vector $\overline{d_i} = \left\{d_i^1, d_i^2, \ldots, d_i^M\right\}$, where d_i^M is the score of the *m*-th CBQU level for the *i*-th student. Having calculated the formed CBQU for each student for one or another assessment level, we obtain the matrix $\left\{\mu_i\left(d_q^m\right)\right\}$, $q=\overline{1,Q}$, $m=\overline{1,M}$, where *Q* is the number of assessment levels.

The result of solving the problem of distribution of first-year students by specializations is shown in Table 1. The number "1" indicates a recommendation to the student to choose the appropriate specialization.

Table 1

Distribution of first-year students of the specialty "Information Systems" by specializations

Students	Specialization		
	Automation and design	Web technologies	Business Administration in Information Systems
Student 1	1	0	0
Student 2	1	0	0
Student 3	0	1	0
Student ...	0	1	0
Student *n*	1	0	0

The solution of the problem for the first five students is presented in Table 2.

Table 2

Results of solving the problem of forming individual (personally oriented) educational trajectories

Students	Academic disciplines included in the student-centered program					Vacancies				
	AD1	AD 2	AD 3	...	AD 13	V1	V2	V3	...	V19
Student 1	1	1	0	...	1	1	1	1	...	0
Student 2	0	1	1	...	0	0	1	0	...	1
Student 3	0	1	0	...	0	1	0	1	...	0
Student ...	0	0	1	...	1	0	0	1	...	1
Student *n*	1	0	0	...	1	1	1	0	...	0

Experimental data on the implementation of an individual educational trajectory are presented in Table 3.

The data in Table 3 are shown in Fig. 4 for visual presentation.

Thus, an individual educational trajectory is an element of knowledge management and is aimed at obtaining optimal results and fully meets the needs of the strategic development of the entire system of an educational institution.

Table 3

Experimental results based on the Wilcoxon test

–	Average score									
	2018–2019		2019–2020		2020–2021		2021–2022		For the entire period	
	1E	2E	1E	2E	1E	2E	1E	2E	1E	2E
Experimental group 1–2	4	4.03	4.08	4.06	4.17	4.14	4.24	4.22	4.11	4.16
Control group	4.04	4.04	4.04	4.04	4	4	3.85	3.85	3.82	3.82
Amount of change	–0.04	–0.01	0.04	0.02	0.17	0.14	0.39	0.37	0.39	0.34
Change rank	–3.5	–1	3.5	2	6	5	9.5	8	9.5	7

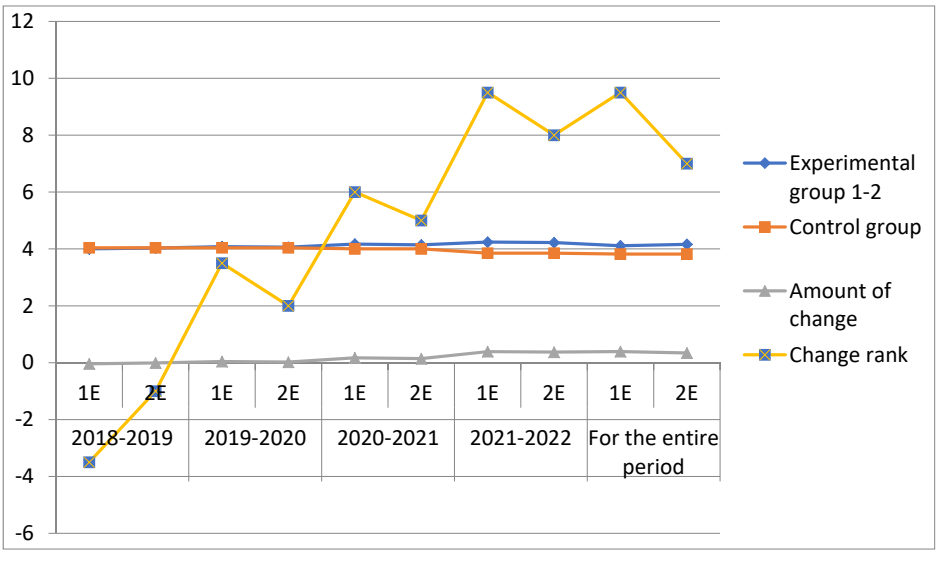

Fig. 4. Experimental results based on the Wilcoxon test

Let us present the data of the experiment on the introduction of an individual educational trajectory. As performance criteria, the average assessment of academic performance, motivation, the choice of an educational trajectory (the next educational route), participation in extracurricular and scientific activities, the level of achievement, the formation of intellectual qualities were used. The paired Wilcoxon test was used to compare the results. The principle of applying the criterion is as follows. For each group, the value of the average annual assessment and the value of the change in the observed trait are calculated. The observed features are ordered by absolute value. The sign of the change is then assigned to the ranks and these "sign" ranks are summed up – the result is the value of the Wilcoxon W test. The experimental data are shown in Table 3.

In accordance with the values obtained, the assumption that the sample means are statistically significantly different from each other was confirmed, with the probability of an acceptable error not exceeding 3 % (Fig. 5, Table 3). W=46 (0.02). The change in the indicator is statistically significant.

The paper also considers three main models of interaction between elements of the organization: bureaucratic, democratic participation and parity compromise.

The method of modeling the interaction of elements of the organization was implemented programmatically on the MySQL database, JavaScript, PHP, SQL. The choice of parameters of the interaction model was carried out on a set of data related to the direction of training "Information Systems" (qualification "Bachelor"), but can be expanded for other areas of training. Software implementation of the method of interaction between elements of the organization (bureaucratic model (Fig. 1), democratic participation model (Fig. 2) and parity compromise model (Fig. 3)) was performed in the form of a web application for monitoring the educational process, assessing students' competence and improving the effectiveness of the curriculum.

The developed software system uses a DBMS as a data storage. The database consists of 24 tables and relationships between them, which can be represented as a physical and logical ER model.

6. Discussion of experimental results obtained in the development of mechanisms for the formation of an information and educational environment

The model of an individual educational trajectory is presented. The organization of training on an individual trajectory requires a special methodology and technology. To solve this problem in modern didactics, two main methods are usually proposed, each of which is called an individual approach.

The choice of an individual educational trajectory should be made after the completion of the undergraduate studies. The results of the experiment (Table 1) make it possible to identify three main profiles of students' professional growth along the corresponding educational trajectories. At the end of the first year, students choose an individual, student-centered educational trajectory, which includes a cycle of general education disciplines, as well as elective disciplines.

The task of forming personality-oriented individual trajectories for students was realized in two stages:

1. A set of educational disciplines has been defined that ensure full compliance of the qualification characteristics with the requirements of potential employers for each student.

2. Next, it is necessary to select individual educational trajectories from the resulting set.

Thus, the result of solving this problem is a matrix of academic disciplines that are included in a personality-oriented program designed for each student, as well as about vacancies offered by a potential employer (Table 2).

The results of a computer experiment proved that the choice of a model for the interaction of elements of an organization is effective:

1. The bureaucratic model is effective when the operating technologies are fully defined and debugged.

2. The model of democratic participation is effective if the technologies used require the manifestation of an individual character, creativity.

3. The model of a parity compromise is effective if the functioning is based on complex modern technologies focused on competitive market relations in the external environment.

Thus, the implementation of these models, which one is decisive, depends on how the main elements of systemic activity in educational institutions are defined. However, in the same organization at different levels of management, management hierarchies can arise that use combined models of interaction.

This study requires development, since the final development of a methodology for modeling the interaction of elements of educational institutions requires additional selection criteria that meet the stated requirements, as well as the problem of protecting the information environment in order to fully ensure the quality of educational services.

7. Conclusions

1. Thus, the paper considers three main models of interaction between elements of the organization: bureaucratic, democratic participation and parity compromise. As a result of the experimental work, we select the parameters that determine the choice of the interaction model:

– the bureaucratic model of interaction is characterized by a clear organization of labor, delimitation of powers, a well-organized control system, and coordination of the personal interests of employees with the goals of the organization. The disadvantages include the passive role of employees in activities;

– the model of democratic participation is characterized by competition and non-antagonistic game of interests of employees to achieve goals;

– the parity compromise model is characterized by the consistency of the interests of the elements of the system with the goals of its existence. For large and complex systems, this type of control is not applicable.

Also, the choice of models of interaction between elements of the organization from the point of view of systems theory is influenced by the external environment. However, in the same organization at different levels of management, management hierarchies can arise that use different models of interaction. The implementation of these models, which one is decisive, depends on how the main elements of systemic activity in the organization are defined.

2. A model of an individual educational trajectory has been developed. The model combines both classical approaches to information modeling and informatization of educational activities, and modern specific approaches based on the use of the advantages of modern information processing and telecommunications tools, the latest methods of information presentation.

After analyzing the data on the progress of the control and experimental groups, their intellectual qualities and the choice of an individual educational trajectory, it can be argued that as a result of training on an individual educational trajectory of learning proposed by the authors, the qualitative indicators of the intellectual and psychophysiological state improved, and the personal and intellectual potential of their activities increased. An individual educational trajectory is presented as a process of making a decision by a student based on a system of individual values and personal meanings.

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