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ABSTRACT

of the dissertation for the degree of PhD

DEVELOPMENT of MODELS and METHODS for INTELLECTUAL MANAGEMENT of BIMODAL ELECTRONIC UNIVERSITY in AZERBAIJAN

Specialty: 3338.01 - "System analysis, control and information processing"

Field of science: Technical Sciences

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GENERAL CHARACTERISTICS OF THE WORK

Today, the rapid change of technology, the shortening of life cycle of knowledge, the failure of education system to meet the requirements of knowledge and skills of graduates in labor market timely remain one of the main challenges in developed countries. Various initiatives, conceptual approaches and tools are offered in this regard. With the Fourth Industrial Revolution, the process of knowledge obsolescence will accelerate and the problems of education flexibility, access to knowledge for every member of society, regardless of economic and social status, access to teaching materials in all fields will become more distinct.

At the background of these problems, the transition of traditional education to a virtual environment is inevitable. This form of education combines best features of previous forms and allows organizing high quality educational process using information and telecommunication technologies (ICT).

Transition of classical university to so-called electronic university (e-university) include the management of online interaction between teachers and learners at all levels of educational process based on computer networks.

One of the ways of solving the problem of improving the quality of education is the intellectualization of educational process.

The application of intelligent technologies in the educational process, the implementation of the concept of forming an individual curriculum for learners will help increase their competitiveness in the labor market. Currently, the lack of an individualized education model is due to number of unsolved issues. These may include the lack of applicants' support system, the definition of prospects of professions and specialties and their demand and supply, taking into account the intellectual potential of learner in the learning process, self-study opportunities, "learner-teacher" communication and feedback, lack of knowledge assessment mechanism, etc.

The personalization of education requires the e-university to form the following educational opportunities:

- Providing opportunities for the selection of teaching materials in accordance with the learner's intellectual potential, needs and cognitive abilities;
- Elimination of all restrictions on the choice of time, space and communication means in the learning process;
- Full provision of economic, social and scientific interests for teachers.

Solution of these problems requires the intellectualization of the educational environment. In this regard, the development of models and methods for the intellectual management of e-university in a bimodal e-university environment is quite relevant. Solving this problem will allow the e-university to meet modern educational standards.

The goal of the dissertation is to develop the concept, model, method and intellectual tool for intellectual management of e-university in a virtual educational environment.

The research issues are as follows:

1. Analysis of scientific and theoretical aspects of the innovative educational environment in the information society and development of the concept of intellectual management of bimodal e-university for the educational environment of Azerbaijan;
2. Development of support system for entrants through the method of determining the degree of perspective of specialties in the changing labor market, and;
3. Development of a model and method for assessing the "start" knowledge of learner in the context of personalization of education and directing him/her to specialty more appropriate to her/his knowledge level;
4. Development of a method for determining the individual educational trajectory of learner in virtual educational environment, as well as the development of management decision methods for the interaction of teachers and learners in the virtual environment

and for the intellectual management of the lesson-time division and assessment of the quality of virtual education;

5. Development of a method for decision support on the selection of content from global educational resources according to the knowledge level of learner;
6. Development of architectural-technological model and algorithms of intellectual management system of individual educational trajectory in e-university and tools implementing the system.

The research methods. System analysis, object-oriented analysis, fuzzy set theory, decision-making theory, multi-criteria selection and ranking methods, neural networks, situations analysis, database management systems.

Basic provisions set for defense. The main issues raised in research are as follows:

1. Conceptual model of intellectual management of bimodal e-university for educational environment of Azerbaijan;
2. Methods for determining the degree of perspective of specialties in changing labor market and the adequacy of supply and demand for specialties;
3. In the context of personalization of education, a model and method for learner's "start" knowledge assessment and directing him/her to a specialty more appropriate to his/her knowledge level and determining the individual educational trajectory;
4. Decision support method for the content selection that meets the needs of learner from global educational resources;
5. The method for Teacher-learner interaction in the virtual learning environment and intellectual management of lesson-time division;
6. Architectural-technological model of intellectual management system of individual educational trajectory in e-university and software package implementing the system;

The scientific novelty of the dissertation is determined by the following **results:**

1. A concept of intellectual management of bimodal e-university in accordance with the educational environment of Azerbaijan is developed;

2. Methods for determining the degree of perspective of specialties and the adequacy of supply and demand for specialties are developed with reference to the Bellman-Zadeh method and the fuzzy sets theory;

3. New models, methods and algorithms are developed to assess learner's "start" knowledge and select an educational trajectory appropriate to learner's intellectual potential in the context of personalization of education based on fuzzy sets and neural networks;

4. A method for content selection from global educational resources appropriate to learner's requirements is developed through fuzzy ranking approach;

5. A method of teacher-learner interaction and intellectual management of lesson-time division in virtual learning environment with the application of neural networks is developed;

6. Architectural-technological models and algorithms that support the intellectual management of individual educational trajectories in bimodal e-university are developed.

Theoretical significance of study is determined by the development of new conceptual principles, models and methods ensuring the intellectual management of virtual learning environment of the bimodal e-university with reference to fuzzy models and methods, neural networks and to provide the dynamism, flexibility and personalization of education.

Practical significance of study is determined by the development of applied methods, algorithms and tools for the intellectual management of virtual educational environment of different types of electronic universities based on the proposed scientific methodological tools.

Realization and application of results of work. Theoretical and practical results obtained in the dissertation were applied at Nakhchivan State University. University students were registered with the implemented instrumental tools, their knowledge levels were checked electronically, and their group ratings were determined. According to the rating indicators obtained, the number of scholarships for courses and specialties was approved by the Order No. 38 of the Cabinet of Ministers of the Republic of Azerbaijan dated

February 5, 2016. Intellectual distribution was provided in accordance with the "Procedure for determination and payment of scholarships to doctoral students, students of higher education, secondary special and vocational education institutions, as well as master's degree students of the Azerbaijan National Academy of Sciences".

Approbation and application. The main scientific-theoretical and practical results were discussed at the following international conferences and scientific seminars:

- "Elektron dövlət quruculuğu problemləri" I respublika elmi-praktiki konfransı, Bakı 2014.
- Beynəlxalq Telekommunikasiya İttifaqının 150 illiyinə həsr olunmuş informasiya təhlükəsizliyinin multidissiplinar problemləri üzrə II respublika elmi-praktiki konfransı, Bakı. 2015.
- Ümummilli Lider Heydər Əliyevin anadan olmasının 93-cü ildönümünə həsr olunmuş "Gənc tədqiqatçıların IV beynəlxalq elmi konfransı", Bakı. 2016.
- XXIII Международная научная конференция "Актуальные научные исследования в современном мире", Переяславль-Хмельницкий. 2017.
- İnternational Conference of Science, Ankara. 2017.
- "Proqram mühəndisliyinin aktual elmi-praktiki problemləri" I respublika konfransı, Bakı. 2017.
- The 2nd International Conference Of Distance Learning And Innovative Educational Technologies, Ankara. 2018.
- 5 th international conference on lifelong education and leadership for all - ICLEL 2019, Baku.2019.

Published scientific works. According to the results of the dissertation, 18 scientific works: 8 articles, 4 of them were published in prestigious foreign journals in accordance with the requirements of HAC, 9 conference proceedings and 1 methodical aid.

The structure and scope of the dissertation. The dissertation consists of an introduction, 4 chapters, main results, bibliography and appendices. The main part of the work is commented on 204 pages, a list of 204 references. 67 figures and 14 tables were used in the study.

BRIEF OVERVIEW OF THE WORK

Introduction substantiates the relevance of dissertation topic, defines the goal and tasks of research, indicates the main scientific innovations, theoretical and practical significance of the work, and provides information on the application of proposed models and methods and approbation of the work.

Chapter 1 analyzes the theoretical and methodological bases of the transformation of universities and the formation of an innovative educational environment in the information society. The first section of the chapter examines the requirements of UNESCO new education concept and their current status. The concept mainly includes the principles of "Lifelong Learning", "Education for All", "Education without Borders - Anytime, Any Place, for Everyone" and "Inclusive Education - for People with Disabilities". Establishing an educational environment that meets these principles is possible only through distance or remote learning.

Distance education is a form of the educational process in which education is organized based on electronic telecommunications, software and hardware. The characteristics of distance education also include flexibility, modularity, economic efficiency, the new role of teacher, special control over the quality of education, the use of specialized tools and technologies in training, etc.

Modern distance learning technologies currently have 7 classifications. Each of these classifications has advantages and disadvantages. As a whole, the essence of the distance learning process can be described as shown in Figure 1.

One of the educational requirements of the modern world is more perfect, that is convertible form of education. In the form of convertible education, depending on learners' wishes, the teaching process can be implemented in different forms, i.e., face-to-face, correspondence or distance.

The second section examines the current state of the learning environment and management in existing e-universities (Figure 2).

During the research it was found out that e-university is a large system consisting of a combination of subsystems such as

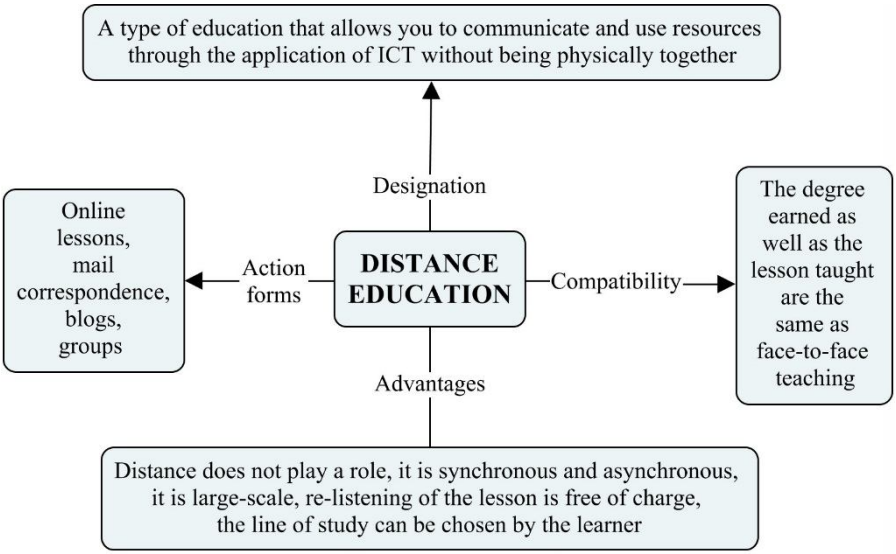

Figure 1. The essence of distance education system

"Applicant", "Monitoring", "Electronic exam", "Contingent", "University orders", "Personnel", "University financial activity", "Electronic document management", "Course load ", "Library", "University Performance indicators", "Session", and "Alumni Control".

In the information society, there are e-university models such as bimodal, distance, consortium, teleuniversity, virtual university.

Current processes ongoing in the world, that is globalization deepening, rapid and uncertain changes in labor market requirements and competition parameters, a global pandemic or other emergencies that may occur at all, an escalation of the economic decline, the attractiveness of the knowledge economy that emerges in the background of instability of national currencies and wealth values, and etc. can be assessed as a factor requiring the establishment of an e-university in Azerbaijan [11].

Taking into account the requirements of existing education law in our country, the material and technical base of existing universities

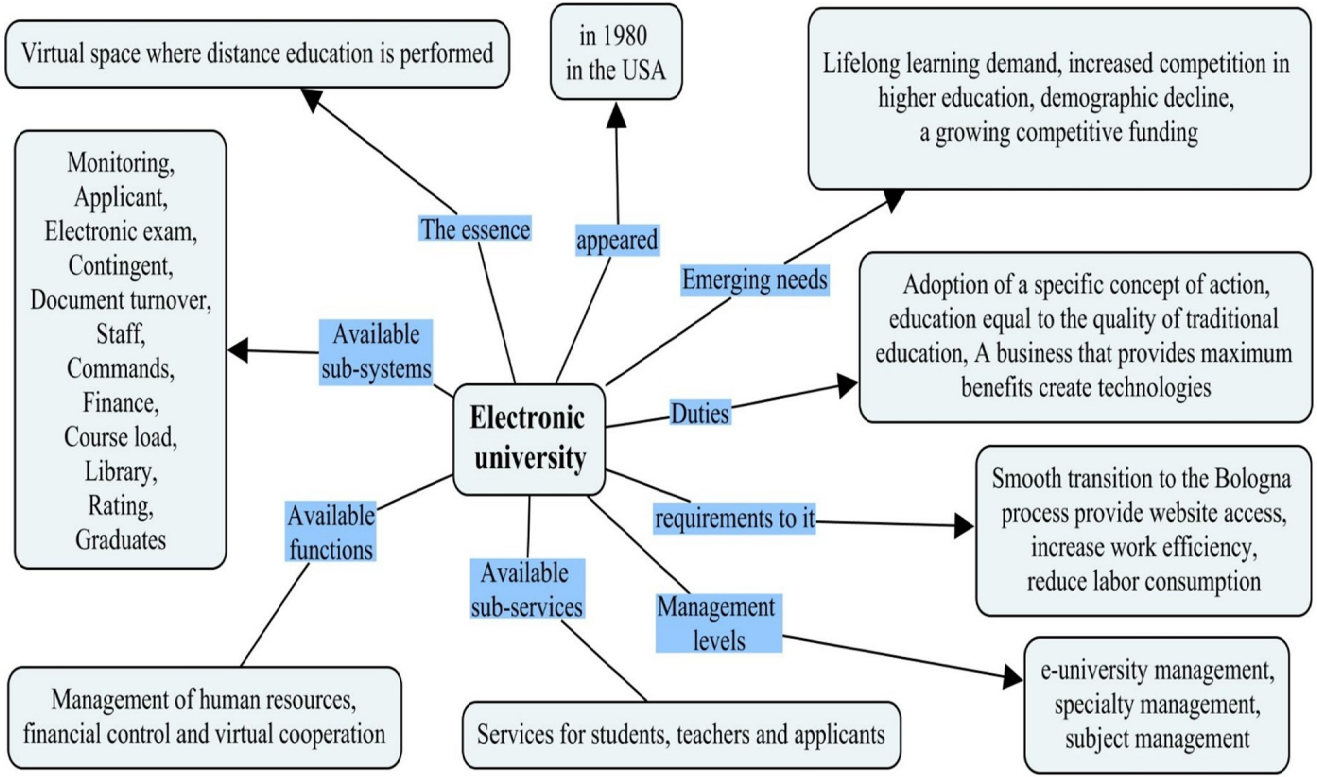

Figure 2. Educational environment and management principles in existing e-universities

and the current level of ICT knowledge of human resources, it can be concluded that the bimodal e-university model is more appropriate for the Azerbaijani educational environment [1]. Therefore, this study is conducted within the bimodal-university model.

In addition to the traditional teaching of subjects, **bimodal concept-based e-universities** may form an inclusive, flexible and mixed learning environment. For this, first of all, educational institutions themselves must have stronger datas security [10].

The application and development of convertible education in traditional universities is characterized by a number of advantages. Thus, distance education in classical universities: 1) Allows to expand the range of services provided; 2) Increases competitiveness against other education providers (within the country or abroad) which develop and present non-traditional training courses; 3) In many cases, based on self-financing principle, creates favorable conditions for the expansion of commercial opportunities.

However, e-university can also be realized as a virtual, non-commercial equivalent of a classical university.

The bimodal e-university model is used in foreign curricula at Deakin University, Murdoch University, the University of New England, the University of California, Nova University, the University of South Carolina, Texas, Wisconsin and Madison. In Fiji, Jamaica, Papua, New Guinea and Zambia, this model is also used in distance education programs.

A bimodal e-university project was implemented at Nakhchivan State University by KOICA, South Korea. However, as the modules and algorithms applied in the designed e-universities do not meet the requirements of the existing education law, a number of modules and algorithms were added to the system, which are described in detail in Chapter 4 of the dissertation.

The third paragraph of the chapter discusses the scientific and theoretical approaches to the concept of e-university development in the globalization context, highlights the need for training competitive specialists in the labor market as a result of globalization, and the improvement of e-university projects that meet the new realities. It

identifies and clarifies the main architectural components of e-university (Figure 3).

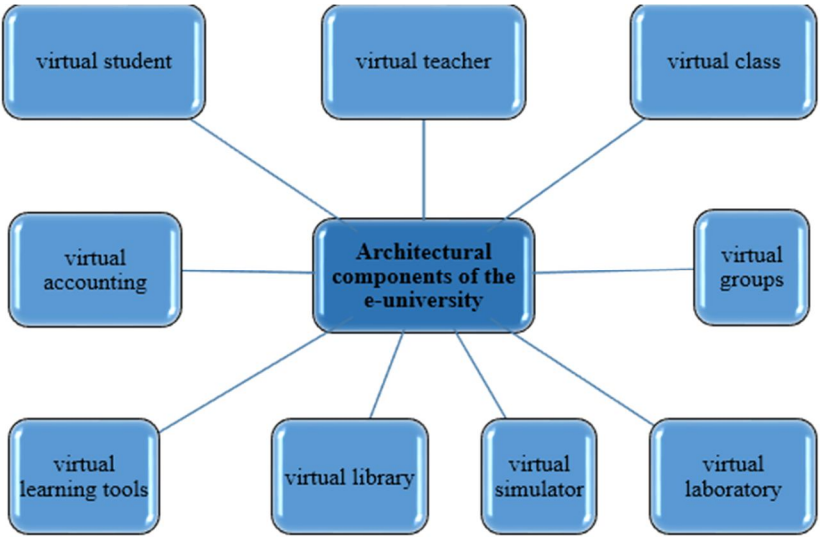

Figure 3. The main architectural components of e-university

In the fourth paragraph of the chapter, the conceptual models of existing e-universities are comparatively studied, future prospects are shown, the evolution of conceptual models are presented (Figure 4) and currently evolving university model 4.0 is presented taking into account its futures, and within the requirements of University 4.0 model, unsolved problems and question are identified (Figure 5):

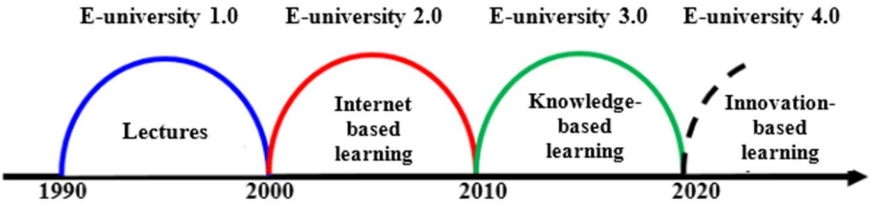

Figure 4. Evolution of conceptual models of e-universities

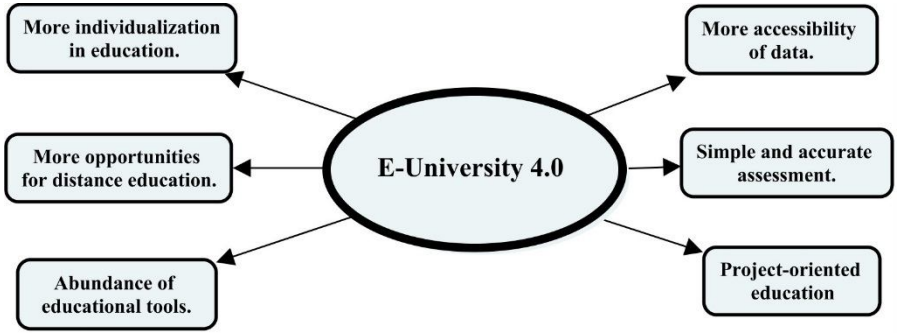

Figure 5. Features of e-university 4.0 model

Then, the availability of teaching material of KOICA NSU e-university model only in the current semester, the transfer of authority to individuals, not to positions, and other shortcomings are presented (Figure 6).

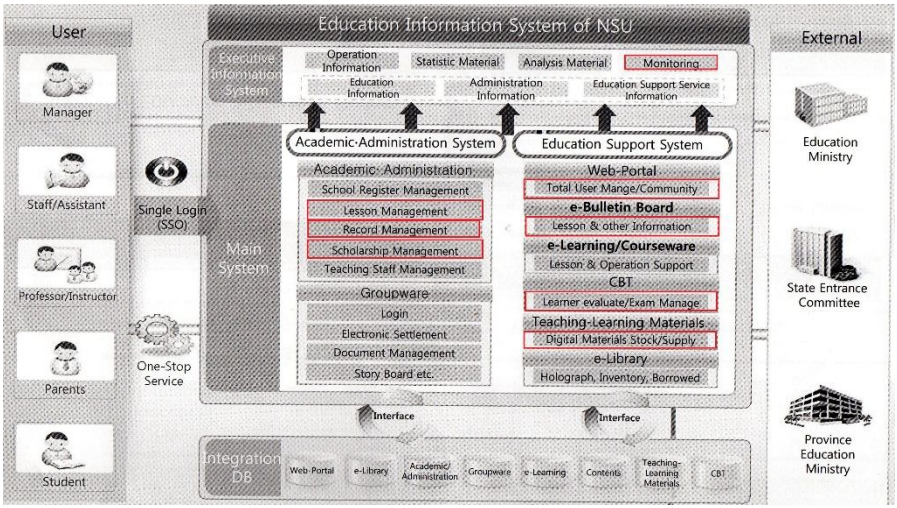

Figure 6. Disadvantages of KOICA NSU e-university project

In order to ensure that the education system meets the requirements of the fourth industrial revolution and to provide a gradual transition to this model in our country, a number of reforms and ways to solve problems are shown.

The last paragraph of the chapter examines the approaches to intellectual management of the virtual learning environment of e-university, and identifies the following uncertainties of the virtual learning process:

1) Uncertainty of the environment due to the influence of difficult to predict external and internal factors;

2) Uncertainties due to the specificity of the main subjects of educational activities for the subjects of interaction, the variability of their learning trajectories, the uniqueness of each type of interaction with real educational objects, and the existence of communication only during the interaction.

The issues included in the intellectual block of e-university are identified. These issues are presented in the research issues section of the abstract.

At the end of the chapter, a structural model of e-university more suitable for the Azerbaijani educational environment is presented (Figure 7).

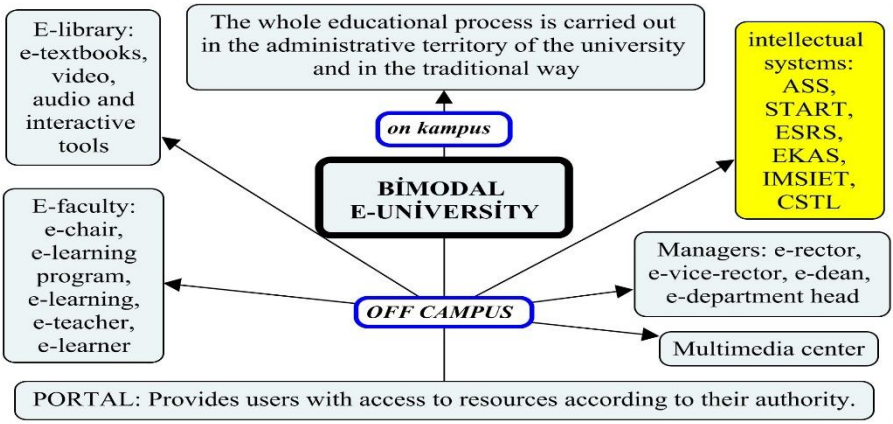

Figure 7. Conceptual structural model of the proposed e-university for the Azerbaijani educational environment

As seen from the figure, the core of the model is the virtual learning environment. MDDSP Method for determining the degree of specialties' perspective, MHSDS Method for harmonization of supply and demand for specialties, CSR Content Selection Method, MIME Method for intellectual management of education are developed for the solution of intellectual problems of virtual educational environment. In addition, ASS Applicant Support System, START Applicant's initial knowledge assessment system, ESRS Electronic student registration system, EKAS Electronic assessment system of knowledge and skills acquired by learners, IMSIET Intellectual management system of personal educational trajectory, CSTL Teacher-learner coordination system are realized based on abovementioned methods.

Chapter 2 is devoted to modeling the processes of organization and intellectual management of educational environment in bimodal e-university (Figure 8).

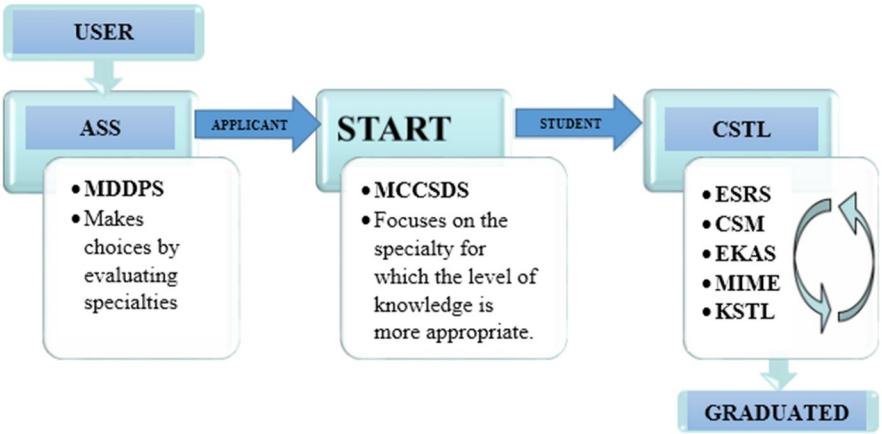

Figure 8. Educational environment at Bimodal e-University

Bimodal e-university intellectual management refers to the integration of intellectual architectural components into the educational process and their relationship management. Architectural

components that require intellectual management in e-university and the relationships between them.

In bimodal e-universities, the essence of management principles over off-campus platform, architectural components, functional blocks, management systems, and administrators varies somewhat (Figure 9).

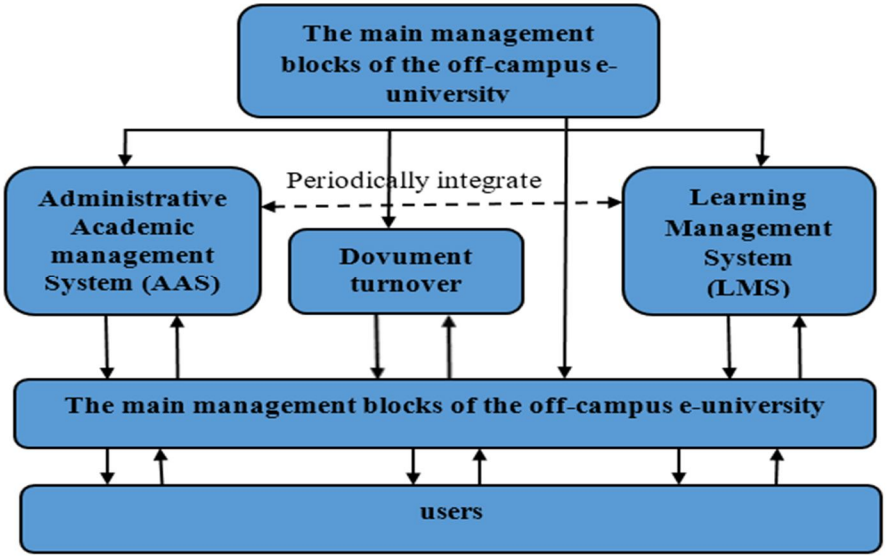

Figure 9. Functional units of off-campus e-university

Thus, the Off campus e-university includes administrative-academic management, electronic document management, education management and portal functional units. Here:

Administrative-academic management (AAS) provides general management.

The main functions of the **Learning Management (LMS)** section include the intellectual management of the individual educational trajectory, the provision of learners and teachers with virtual classrooms, the provision of learner-teacher connection and feedback, and the knowledge assessment (Figure 10).

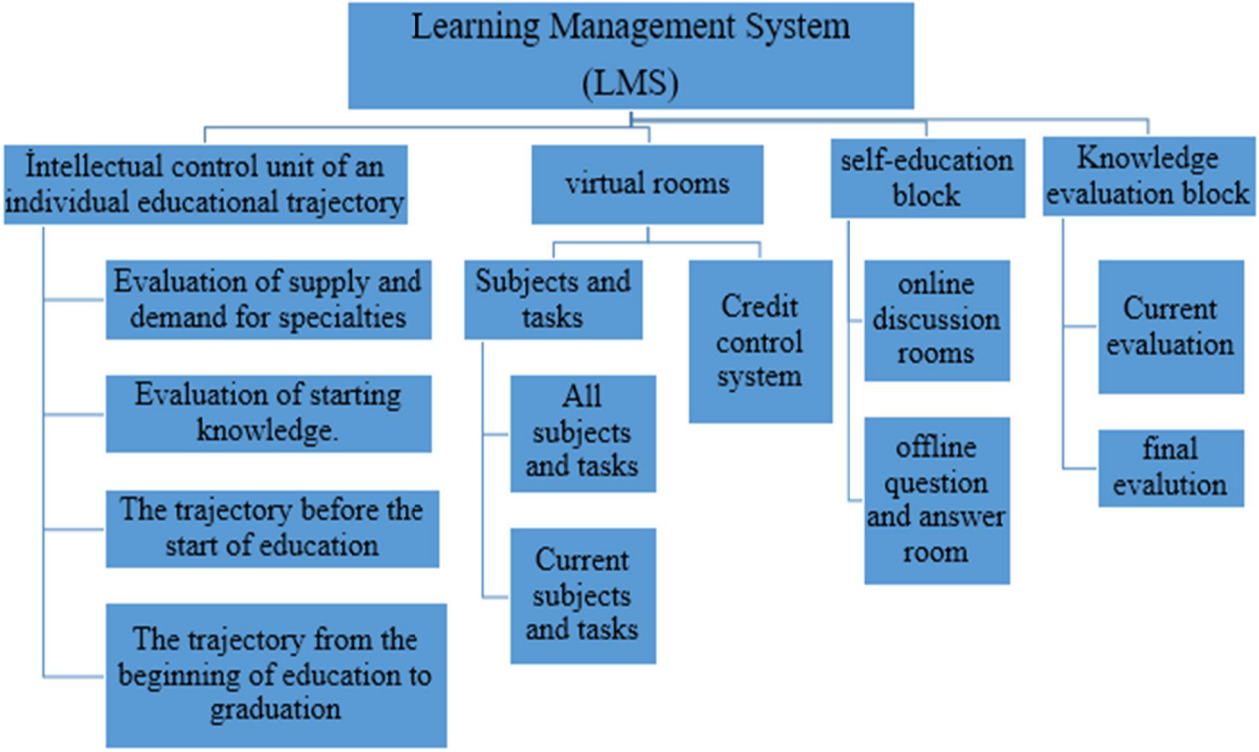

Figure 10. Block diagram of the Learning Management System (LMS) (EMU).

The subunits included in the LMS and the functions they perform are as follows:

• The Intellectual Management Unit of the Individual Education Trajectory determines the supply and demand for specialties and the assessment of "START" knowledge, as well as the educational trajectory.

Virtual classrooms consist of shelves of current subjects and current tasks and provide learners with access to educational materials throughout the learning process. One of the main functions of the unit is to ensure the management of online teaching materials [3].

• Learner-virtual learning environment-teacher communication and feedback unit provides teacher-learner communication at optimal times regardless of device and spatial dependence.

• The knowledge assessment unit provides acquired knowledge assessment and decisions on the transition to the next "point" of educational trajectory.

The main functions of the **electronic document turnover unit** are the preparation of e-document, control over its signing, its movement and execution.

The portal provides a virtual connection between users and control units. The Applicants support system is also added to the portal.

The second paragraph of this chapter develops a conceptual approach to determining the specialties' perspective degree in changing labor market and an applicants' support system. Research shows that applicants prefer others' opinions as they cannot get the right information when choosing a specialty (Figure 11). This is due to the fact that currently no university website has a section with detailed information about the specialties. Taking all this into account, it is considered convenient to add an applicant support system to the portal section.

Today, the problem of determining the structure and requirements of the labor market in the context of professions and specialties is one of the most pressing and still unexplored problems in many countries, including Azerbaijan. For this reason, the issues of determining the

supply and demand for various professions and specialties, adapting the education system to the needs of the labor market as a priority are reflected in a number of policy documents.

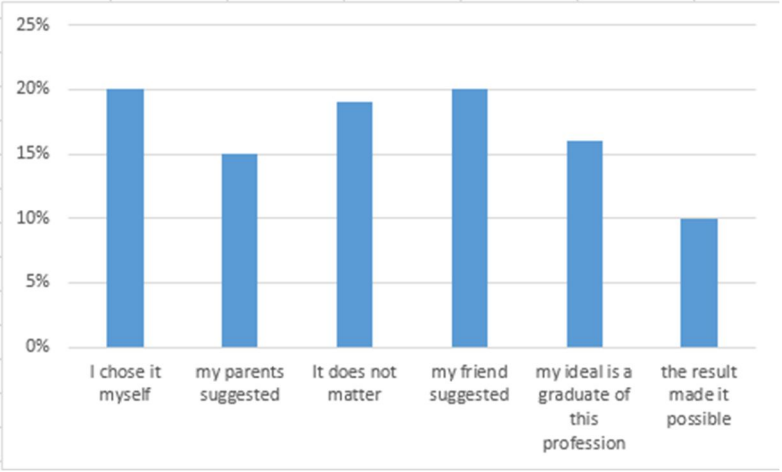

Figure 11. Ratio of opinions preferred by students when choosing profession

The main issues in choosing more promising specialties are:

1. Determining the changes rate in the profession perspective covered by the specialty.
2. Formation of a set of possible alternatives.
3. Description of multiplicity of criteria that are basis for alternatives' assessment.
4. Preparation of criteria scale.
5. Selection of an expert.
6. Determining the expert's competency.
7. Determining the decision-making scheme to determine the more accurate perspective degree.
8. Possibility to check the adequacy of decisions made by alternative methods.

The Bellman-Zade approach, which is an individual approach to determining more accurate perspective of specialties, is used.

Suppose that $X=\{x_1, x_2, \dots, x_n\}$ is a list of contents from which the most suitable one should be selected, and $K=\{k_1, k_2,..,k_m\}$ is a set of criteria.

Then the following fuzzy set can be considered for the criterion K:

$$K=\{\mu_k(x_1) / x_1, \mu_k(x_2)/ x_2, \dots \mu_k(x_n) / x_n\}$$

Here $\mu_k(x_i)\in[0,1]$ is the assessment of an alternative determined by the level alternative x_i to satisfy the criteria K.

The level of set of alternatives X to satisfy the criteria K is determined by the following set of affiliation functions:

$$\mu_{k_j}(x_i) : X \times K \to [0,1], j=\overline{1,m}$$

Here $\mu_{k_j}(x_i)$ represents the level of alternative x_i to satisfy the criterion k_j.

Then the procedure for selecting the best alternative can be written as the intersection of corresponding fuzzy sets:

$$\Omega = k_1 \cap k_2 \cap \dots \cap k_m$$

As the most suitable (effective) alternative, the alternative x * with the largest affiliation function:

$$\mu_\Omega(x^*) = \max_{i=1,n} \mu_\Omega(x_i)$$

In the context of personalization of education, learner's "start" knowledge was assessed and a model and method for orienting to a specialty more appropriate to knowledge level was developed.

In e-university, "start" knowledge can be checked by written tests. The comprehensiveness and conciseness of the topic is considered to be an important point in the applicant's assessment, who presents his/her knowledge in writing. Plagiarism is checked by modern instrumental tools.

"Start" knowledge is tested in two stages (Figure 12).

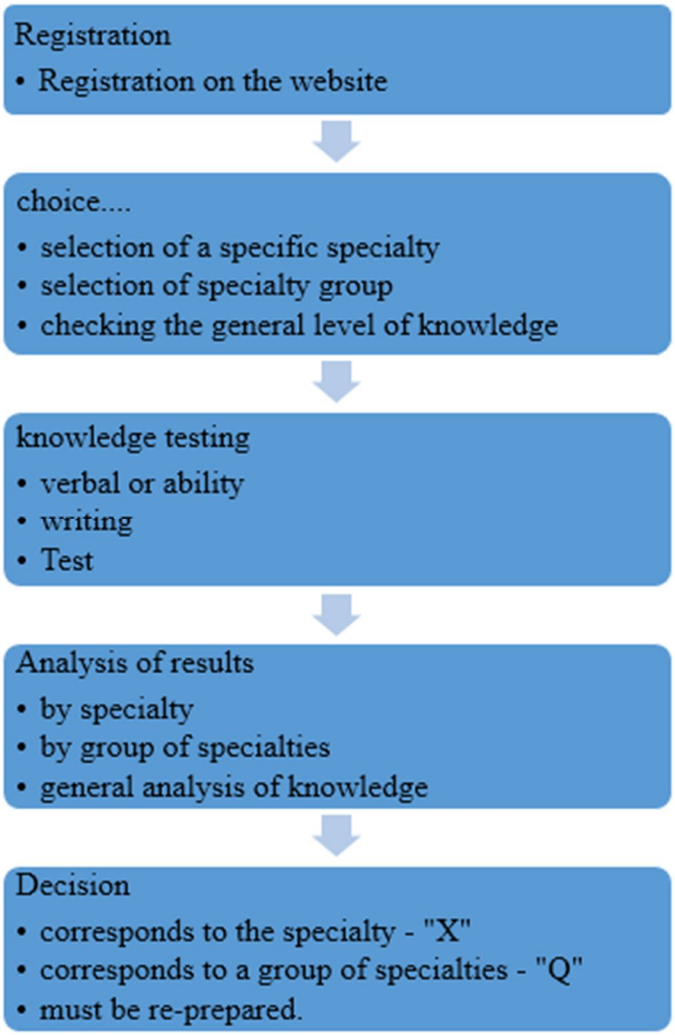

Figure 12. Applicant's "start" knowledge testing and specialty orientation system

In the first stage, the learner is presented 10 questions from each 10 subjects covering the specialty groups and the compliance of the

general knowledge level with the specialty requirements is determined.

In the second stage, the student is presented 25 questions related to each of two main subjects covered by the specialty group. These questions are mainly related to the discussions covered by the specialties taught at the university. At the end of this stage, the most suitable specialty or specialties are determined for learner.

To differentiate the questions by themes and topics, it is suggested to assign additional theme and topic parameters to each question (Figure 13). Thus, the set S fuzzy varies depending on the subsets F, B and M.

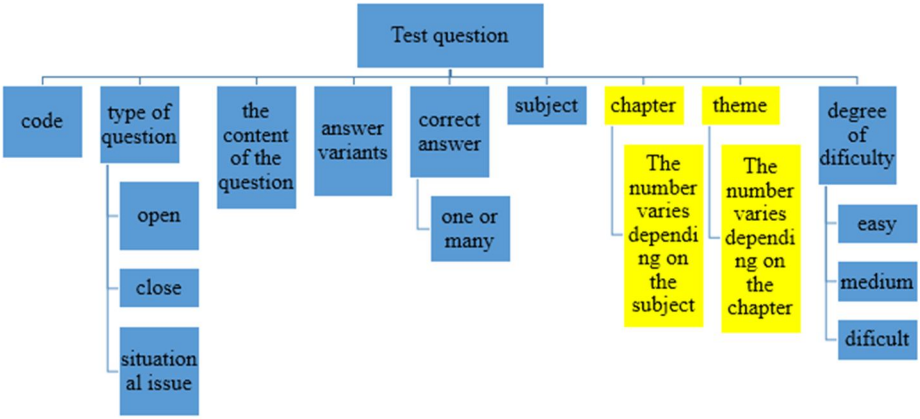

Figure 13. Structure of test questions

Formal statement and solution of the problem. Suppose that $S = \{S_a\}, (a = \overline{1,p})$, $F = \{F_i\}, i = \overline{1,k}$, $B = \{B_j\}, j = \overline{1,n}$, $M = \{M_y\}, y = \overline{1,t}$ are sets of questions, subjects, themes, and topics, respectively. In this case, the following relationships can be written:

$$S_{ijy}^{(a)} \in M_{jy} \in B_{ij} \in F_i \in S;$$

$$S_a (a = \overline{1,p})$$

$$p \to \max$$

Thus, if there is a set of applicants $O = \{O_h\}, h = \overline{1,z}$, then the demand model for the questions presented to the applicant can be described by a matrix A = (S): $O_h = \|s_{ha}\|_{zp}$.

General descriptions and forms of sets of specialties and specialty groups can be given as $\dot{I} = \{\dot{I}_v\}, v = \overline{1,z}$ and $\dot{I}Q = \{\dot{I}Q_r\}, r = \overline{1,4}$.

Then the requirements for the knowledge level required by specialty groups for subjects can be described in the form of matrix T_{ig} (r).

$$T_{iq}(r) = (f_w); w = \overline{1,W}.$$

Here, W is the number of subjects included in the r-th specialty group.

The demand model for different subjects of different specialty groups can be constructed with a two-dimensional matrix $\dot{I}Q=(T_{iq})$.

$$IQ_{Tiq} = \|Tiq_{rw}\|_{4W}$$

Thus, the degree of satisfaction of the knowledge level in the subjects of specialty group is determined by a fuzzy set with an affiliation function $\mu_{t_f}(IQ_w): IQ \times T \to [0,1]$.

The results of each learner whose initial knowledge is tested can be described as $N_{iq}(O) = (f_g); g = \overline{1,G}$.

The demand model for the results of individual learners in different subjects can be constructed with a two-dimensional matrix $O=(N_{iq})$. $O_{Niq} = \|Niq_{hg}\|_{zG}$.

In this case, the rate at which the set of learners satisfies the results matrix is expressed as a fuzzy affiliation function $\mu_{N_f}(O_h): O \times N \to [0,1]$.

The general requirement for the knowledge level by specialty groups can be described as UT_{iq} = SUM(T_f), and the general result indicators of learner can be described as UN_{iq} = SUM(N_f).

The requirements for subject groups specified by specialty groups and the degree of fuzzy inclusion of learners' results in subjects can be written as follows.

$$\theta(\widetilde{O}_h, I\widetilde{Q}_w) = \min\left|\mu_{Tf}(IQ) - \mu_{Nf}(O)\right|$$

For the second stage, the requirements of the specialties to the subjects and the degree of mutual fuzzy inclusion of the learners' results in the subjects can be written as follows.

$$\theta(\widetilde{O}_h, \widetilde{I}_v) = \min\left|\mu_{T_{vfb}}(I) - \mu_{N_{hfb}}(O)\right|$$

The practical implementation of knowledge assessment by specialty groups is carried out through a complete neural network. It should be noted that the number of neurons of all neural networks implemented during the study is selected according to the resources of personal computer.

The presented model has 100 input and 4 output neurons (Figure 14).

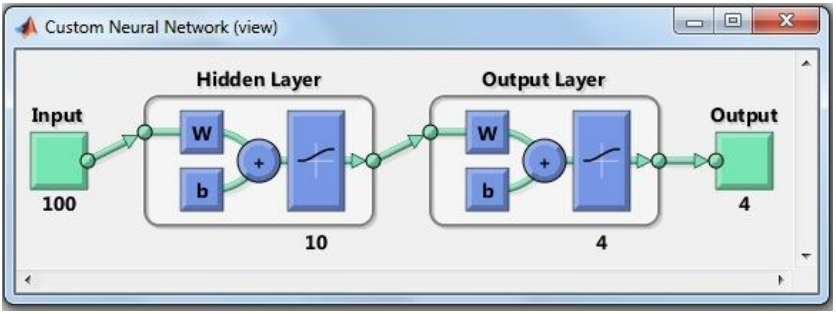

Figure 14. Description of the neural network in the first stage of learner's initial knowledge assessment

Signals from each of following 10 neurons in input layer are concentrated in the next j-th layer of hidden layer, which determines the learner's knowledge level in subjects. These results are transmitted to each neuron of output layer and the suitability of the specialty group is determined.

The neural network, which is activated at the stage of guiding the learner to appropriate specialty, consists of input, output layers and two hidden layers.

The first hidden layer identifies the themes in which the learner has more potential, and the second hidden layer determines the most promising specialties on subjects. In output layer, the profession or specialties with high learner potential in both subjects are identified.

The third chapter of the dissertation solves the issues of intellectual management of individual educational trajectory in bimodal e-university.

The first paragraph of the chapter develops methods for harmonizing the supply and demand for specialties in a personalized educational environment and determining the individual educational trajectory of the learner.

The method of harmonizing supply and demand for specialties in the individual educational environment is developed to meet the needs of labor market for qualified personnel, which is an uncertain environment. To solve the problem, the applicant's competencies and basic knowledge are taken as a basis.

Formal statement and solution of the problem. If we conditionally indicate the professions taught at e-university as "P", then the requirements for the professions can be described as follows:

$P = \{P_b\}, b = \overline{1,d}$ expresses a set of professions;

If $V = \{v_z\}, z = \overline{1,y}$ denotes personal characteristics of a learner applying for vocational education, , $F = \{f_o\}, o = \overline{1,r}$ - professional competencies, and $E = \{e_t\}, t = \overline{1,x}$ - knowledge level on individual subjects, then demand model for each profession *P=(V,F,E)* is described by three matrices:

$$P_V = \|v_{bz}\|_{dy}, P_F = \|f_{bo}\|_{dr}, P_E = \|e_{bt}\|_{dx}$$

According to the knowledge level, the applicant's suitability for profession is determined by a neural network. The satisfaction rate of

indicators v_{dy}, f_{dr} and e_{dx} of profession $P_b\left(b=\overline{1,d}\right)$ is determined by the following fuzzy sets with affiliation function:

$$\mu_{v_{bz}}(P_b): P\times V\to[0,1], \mu_{f_{bo}}(P_b): P\times C\to[0,1], \mu_{e_{bt}}(P_b): P\times E\to[0,1]$$

and reflects the required affiliation level by e-university for selected profession on individual indicators.

Applicants can be displayed in the form of set $A=\{A_h\}, h=\overline{1,s}$. In this case, $V=\{v_z\}, z=\overline{1,y}$ denotes the personal characteristics, $F=\{f_o\}, o=\overline{1,r}$ - competencies possessed by the applicant wishing to study in the specialty, and $E=\{e_t\}, t=\overline{1,x}$ - set of indicators of initial level of knowledge possessed by the applicant in individual subjects and themes.

In this case, the supply model *A = (V, F, E)* is also described by three matrices: $A_V=\|v_{hz}\|_{sy}, A_F=\|f_{ho}\|_{sr}, A_E=\|e_{ht}\|_{sx}$. The affiliation level of a specific applicant A_h to personal characteristics ($h=\overline{1,s}$) *V*, *F* competencies and *E* knowledge levels in subjects is determined by the following affiliation function:

$$\mu_{v_{hz}}(A_h): A\times V\to[0,1], \mu_{f_{ho}}(A_h): A\times C\to[0,1], \mu_{e_{ht}}(A_h): A\times E\to[0,1]$$

The process of placing applicants in a specialty is a set of two fuzzy situations describing the state of supply $\widetilde{P}_b$ and demand $\widetilde{A}_h$:

$$\widetilde{P}_b=\left\{<\mu_{v_{bz}}(P_b)>,<\mu_{f_{bo}}(P_b)>,<\mu_{e_{bt}}(P_b)>\right\}=\left\{\mu_{p_b}(y)/y\right\}$$

$$\widetilde{A}_h=\left\{<\mu_{v_{hz}}(A_h)>,<\mu_{f_{ho}}(A_h)>,<\mu_{e_{ht}}(A_h)>\right\}=\left\{\mu_{A_h}(y)/y\right\}$$

Here, a set $\widetilde{P}_b=\left\{\mu_{p_b}(y)/y\right\}, b=\overline{1,d}$ is the fuzzy reference situations or fuzzy images sought by e-university for specialties, and $\widetilde{A}_h=\left\{\mu_{A_h}(y)/y\right\}, h=\overline{1,s}$ is a set of real situations that the applicant has, i.e., sought fuzzy images of supply.

The degree of fuzzy penetration $\theta\left(\widetilde{A}_h,\widetilde{P}_b\right)$ of fuzzy situation $\widetilde{A}_h$ to fuzzy situation $\widetilde{P}_b$ is defined as follows:

$$\theta\left(\widetilde{A}_h, \widetilde{P}_b\right) = \&\theta\left(\mu A_h(y), \mu P_b(y)\right) = \underset{y\in Y}{\&}\left(\max\left(1 - \mu A_h(y), \mu P_b(y)\right)\right) = \min\left(\max\left(1 - \mu A_h(y), \mu P_b(y)\right)\right)$$

According to the following expression, the specialty with the maximum consistency is selected as a result of the search:

$$\max\left\lfloor \min\left(\max\left(1-\mu A_h(y), \mu P_b(y)\right)\right)\right\rfloor, h=\overline{1,s}, b=\overline{1,d}$$

As a proximity measure of two arbitrary fuzzy situations, the degree of fuzzy equality is defined as follows.

$$\mu\left(\widetilde{A}_h, \widetilde{P}_b\right) = \vee\left(\widetilde{A}_h, \widetilde{P}_b\right) \vee \left(\widetilde{P}_b, \widetilde{A}_h\right) = \&\mu\left(\mu A_h(y), \mu P_b(y)\right) =$$

$$= \min_{y\in Y}\left[\min\left(\max\left(1-\mu A_h(y), \mu P_b(y)\right), \max\left(\mu A_h(y), 1-\mu P_b(y)\right)\right)\right].$$

When ψ reaches the specified limit, i.e., if $\mu\left(\widetilde{A}_h, \widetilde{P}_b\right) \geq \psi$, then $\widetilde{A}_h \approx \widetilde{P}_b$.[8, 18].

After the "start" knowledge assessment, individual educational trajectory is also determined through neural networks. The knowledge level is checked on separate subjects. The neural network is designed in the form of a perceptron consisting of input, output and 1 hidden layer. The input layer consists of 30 neurons and the output layer consists of 3 neurons.

The hidden layer of the network also consists of 3 elements. The perception level of each of 3 topics covered in this layer is determined.

Incoming signals from the input layer are collected in the hidden layer. The transition function for a layer is a single leap function.

$$f(x) = \begin{cases} 1 & x \geq T \\ 0 & \end{cases}$$

Neurons in this layer are activated when $T \geq k$.

"K" is the percentage "f" of questions submitted on the topics, and depends on the number of questions "S". "S" and "t" are defined by the academic management team.

$$k = \frac{S}{100} f$$

An element of output matrix with a value of 0 indicates that the topic has not been mastered at required level.

Solution of the problem of content selection from global educational resources according to the needs of learner is performed in the following main stages:

1. Most accurate determination of the current rating of learner.
2. Formation of a set of possible alternatives.
3. Definition of a set of criteria as basis for evaluating alternatives.
4. Preparation of criteria scale.
5. Selection of an expert or group of experts (students of previous years may be experts).
6. Determination of experts' competence (based on success indicators).
7. Determination of decision method to select the most appropriate content.
8. Solution of selection problem using the most appropriate decision-making method for the specified problem.
9. Possibility to check the adequacy of decisions made by alternative methods.

In order to solve the problem, it is expedient to choose a decision-making method that allows the transition from separate assessments on the criteria to the integrated assessment of results.

Formal statement and solution of the problem. Assume that $X=\{x_i,\ i=\overline{1,n}\}$ are alternatives, and $K=\{k_j,\ j=\overline{1,m}\}$ are sets of criteria.

The level criterion k_j satisfies alternative x_i is determined by the following affiliation function:

$$\varphi_{kj}(x_i):X\times K\rightarrow[0,1]$$

To solve the problem, certain alternatives are ranked based on non-dominated preference relations in the set of alternatives $\eta(x_i,x_j)$:

$$\tilde{\eta}^{\,n.d.}(x_i)=1-\sup_{x_j\in X}\left[\eta(x_j,x_i)-\eta(x_i,x_j)\right]$$

$$\eta^{\,'.n.d..}(x_i)=\min\left\{\tilde{\eta}^{\,'.n.d..}(x_i),\eta(x_i,x_j)\right\}$$

a set of fuzzy non-dominant alternatives is defined from these expressions and more efficient alternative that satisfies the function $\eta^{n.d.}(x)$ most is selected:

$$\eta^{n.d.}(x) = \sup_{x_j \in X} \eta(x_i)$$

Selected alternative coincides with one of the individual decisions as a group decision.

The method for learner's knowledge assessment within the framework of PETIIS

The method of presenting various questions to students using the function Rnd () proposed in the dissertation serves for more accurate knowledge assessment. This is confirmed by the calculations of the probability of occurrence of cases for different values (Table 1).

Table 1. Dependence of probability of student's grades, as unsatisfactory, good and excellent, on the volume of material read

Volume of material read	10%	20%	30%	40%	50%	60%	70%	80%	90%	92%
P (unsatisfactory)	0,000	0,001	0,079	0,56	0,95	0,99	1	1	1	1
P(good)	0,000	0,000	0,000	0,000	0,003	0,09	0,57	0,97	1	1
P(excellent)	0,000	0,000	0,000	0,000	0,000	0,000	0,001	0,044	0,61	0,79

Note that in classical estimation, the case of P (excellent) = 0.60 occurs when there is a 60% proficiency.

Managerial decision support method in assessing the quality of virtual education within PETIIS.

At present, the general knowledge level of students at Azerbaijani universities is calculated based on UOMG by formula (1).

$$UOMG = \frac{b1\overline{k1}^{*} + b2k2^{*} + \ldots + bnkn^{*}}{k1 + k2 + \ldots + kn} \qquad (1)$$

However, such presentation of students' success rate does not justify itself when applying for a job. Thus, the average value of success rate does not allow to differentiate the knowledge level by professions. For e-university model in order to ensure more convenient identification of graduates' knowledge levels by occupations to ensure graduates to better master the priority subjects for their specialties, it is proposed to add a new parameter to the formula (1) for e-university model in addition to the number of subject credits, that is subject coefficient parameter "E", in this case, formula (2) is obtained.

$$UOMG = \frac{b1e1k\overline{1} * + b2e2k2 * + ... + bnenkn *}{k1 + k2 + ... + kn} \qquad (2)$$

The following cases are suggested for differentiating subjects and the grades they will get.

1. For general university subjects -. E = 1.
2. For auxiliary subjects on specialty - E = 2.
3. For main specialty subjects - E = 3.

Note that the coefficients defined for subjects fuzzy varies depending on the requirements set by the employers for professions and on the level of meeting these requirements by the candidates for these professions.

Teacher-learner interaction in virtual environment and intelligent lesson-scheduling management are developed for the online platform with the application of neural networks.

For the neural network implementation, the group schedule is considered as a two-dimensional matrix. In this case, the general schedule of university is a complex three-dimensional matrix in which all the elements are highly interdependent.

There will be 15 elements of a table matrix conventionally called C. Each element $C_{s,g}$ is a separate lesson where g denotes a week day and s - lesson hour.

$$C_{s,g} \mapsto d \ (d \in D_i \, i=1..k)$$

A lesson consists of a combination of several platforms. These platforms are as follows:

• Subject is denoted by f and included in the set of subjects F.

$$(f \in F_e\ e=1..e)$$

• A type of subject is indicated as n and gets the values such as mergers, lectures, seminars, laboratory classes.

• The teacher teaching the subject is denoted as m and refers to the set of teachers M.

$$(m \in M_t\ t=1..t)$$

• Audience is denoted by a and included to the set of audiences A.

$$(a \in Ap\ p=1..p)$$

• Technical resources are denoted by r and included to the set of resources R.

$$(r \in R_s\ s=1..s)$$

Given this, the lesson can be described as $d = f + n + m + a + r$. If the weekly employment or free graph is viewed as a three-dimensional matrix 3*5 and the value of the corresponding element of the matrix assumed to be equal to 0 for their free conditions, then it is necessary and sufficient for the same position elements of matrices of all other parameters, the position of each parameter "***d***" in the table to be equal to 0.

However, the requirements on online platform different. It consists of a combination of parameters of teacher (M) and learner (S) on online platform $D = M + S$.

Matrices M and S are two-dimensional and in form of 3*5.

1. For task realization, each teacher is conditionally numbered (Table 2).

Table 2. Numerical comparison of subjects by teachers

Course Name	No
History of Azerbaijan (M. Aliyev)	1
Mathematics (N. Guliyev)	2
Fundamentals of law (T.Babasoy)	3
Introduction to Economics (F. Alili)	4
Microeconomics (J. Ahmad)	5
Ecology (G. Budagov)	6

2. When a student needs to communicate online with a teacher, he/she enters the teacher's personal number in the form of matrix according to his/her free time. This matrix is conventionally called the demand matrix.
3. All combinations of demand matrix are generated.
4. At the moment of access to the system, the employment schedule of each teacher for that moment from the database is submitted to the neural network in the form of a matrix. Here, the matrix element of the teacher's free time is 0, and for the teacher's busy time 2 is shown in Table 2.
5. The employment status of teachers is found for each element of demand matrix and the results are combined in a separate matrix. The new matrix obtained is conventionally called MK (combination of teachers) (Figure 15).
6. Demand and MK matrices are included in the network.
7. The neural network provides the most appropriate time distribution by analyzing all combinations that meet the student's requirements and teachers' free time [6, 7]. The most appropriate variant is considered to be the case when the values of all elements of MK matrix corresponding to any combination of demand matrix are 0.

Chapter 4 presents the tools implemented for Bimodal e-university during the research - Learner Registration and Movement System (SERS), Electronic journal (E-journal), Electronic exam (E-exam), Lesson-scheduling in off-line environment (Table) :

SERS mainly includes information about faculties, specialties and students by providing information about e-university learners, their success, credit repayment levels, and ratings. The codes of specialties were determined in accordance with the codes in the list approved by the decision of the Cabinet of Ministers of the Republic of Azerbaijan dated January 12, 2009 No. 8 "List of specialties (programs) of bachelor's degree in higher education." Abbreviated capital letters of specialties are added to the end of the codes to distinguish the professions confirmed by the same code, as well as to eliminate

overlaps (Information Technology and Systems Engineering - 050632IS).

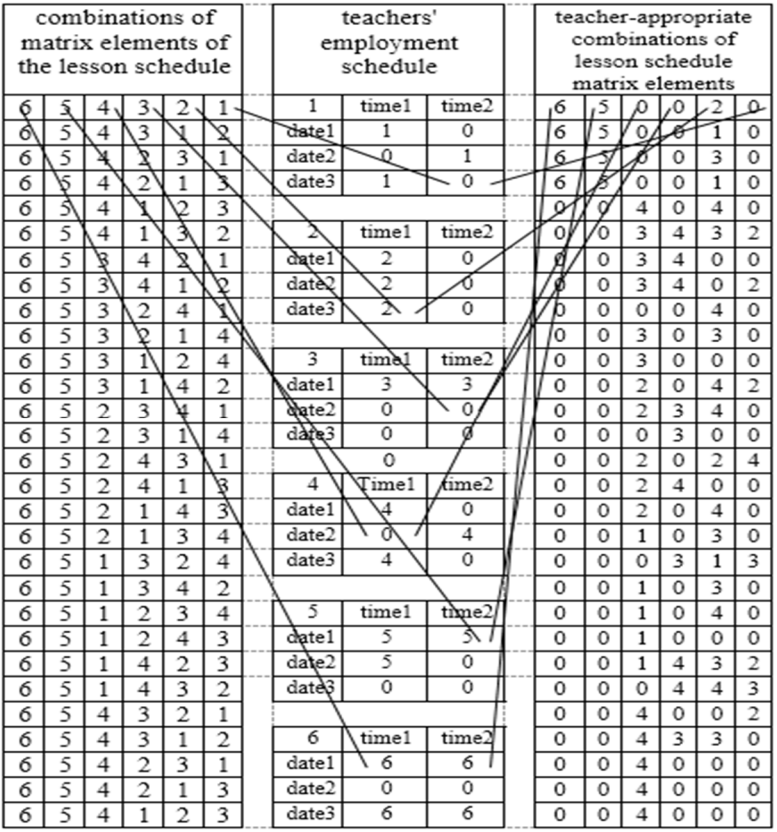

Figure 15. Class schedule combinations according to teachers' employment schedules

In addition to tables, surveys and modules are developed to ensure the sustainable system operation.

e-Journal is a system of 9 modules and 15 questionnaires and provides e-learning process during the semester at bimodal e-university. Lessons are monitored automatically (Figure 16).

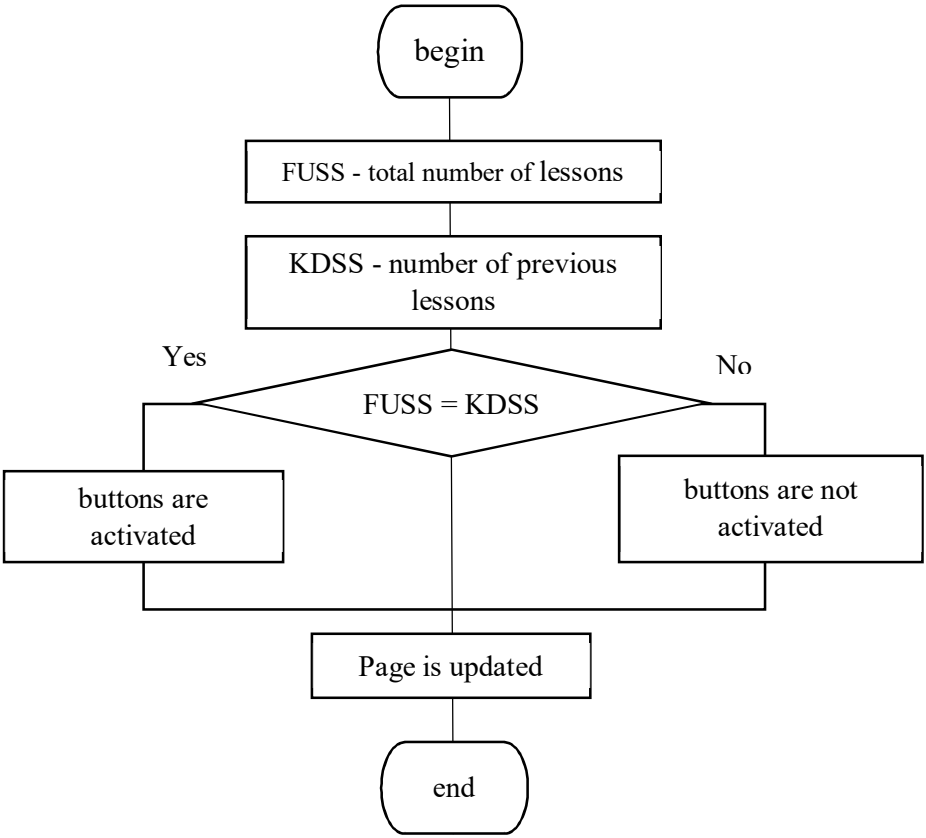

Figure 16. Algorithm for controlling the lessons by subjects

The application **e-Exam** is designed to conduct a final knowledge assessment (Figure 17).

During the exam, 50 questions are randomly selected from the database for each learner (Figure 18).

As questions are presented to learner during the exam, there is a shift between the answer options. When sliding, the new position of answer option is determined by the formula ***t = int(rand()*(5-1)+1).***

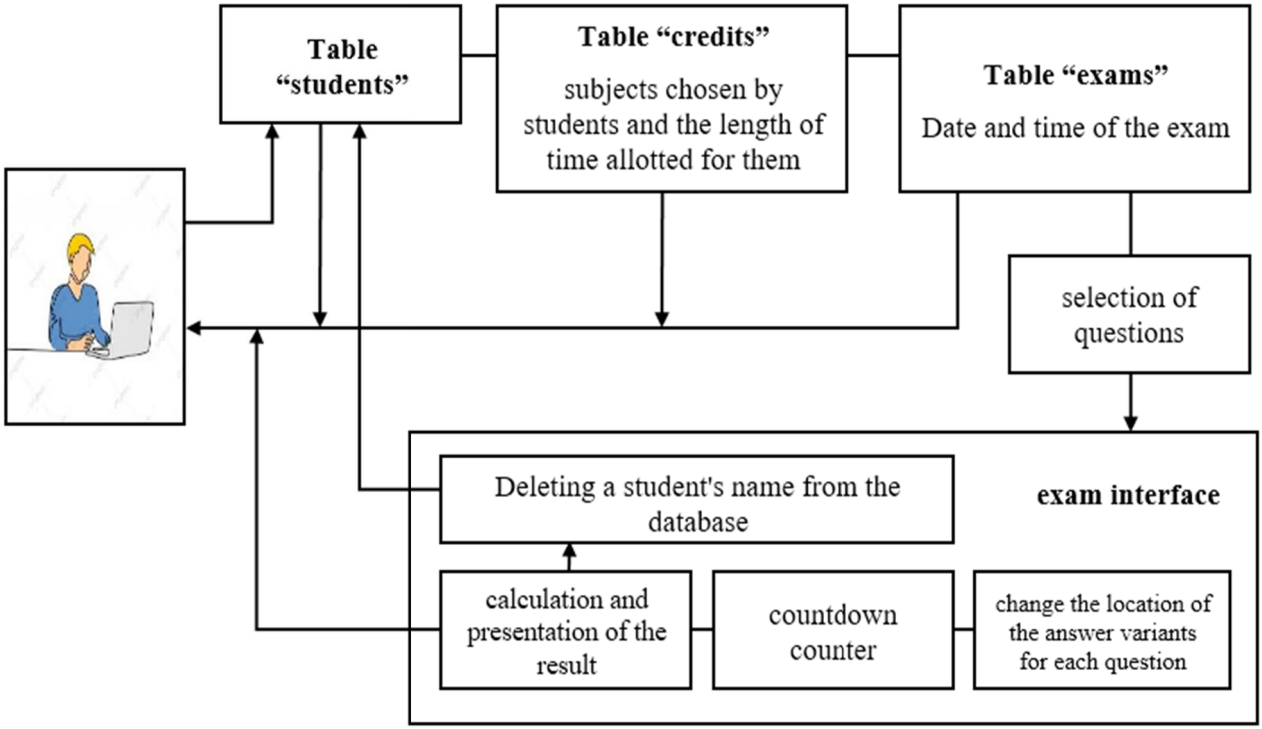

Figure 17. Schematic diagram of e-exam

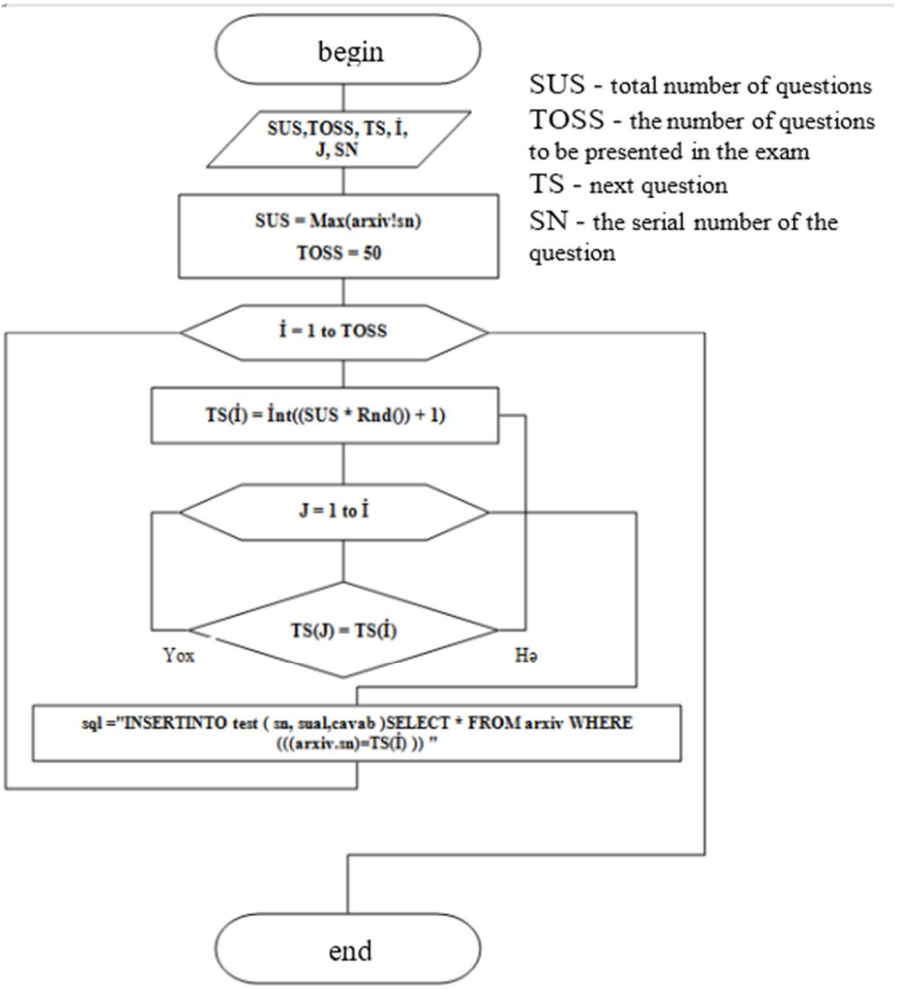

Figure 18. Algorithm for selecting questions in the electronic exam

The next module function to be used in this case is to limit the use of portable data carriers [15]. At the end of group exam, the learner rating (UOMG) is set automatically.

The algorithm of intellectual management of lesson-scheduling in off-line environment is developed to provide the "Learner - educational environment-teacher" relationship in the traditional educational environment. The conventional name of subsystem is "Schedule".

"Schedule" provides automatic compilation of lesson schedules for specialties and courses. The relationship between the modules and procedures in subsystem is based on the principle of operation of production expert systems. Schedule is compiled in two forms. In the first case, the compilation is performed automatically. In this case, the positioning of subjects in the form of combination in schedule and the elimination of conflicts between teachers, groups, classrooms are performed automatically. The second form of compilation is designed for exceptional cases. In this case, the elimination of conflicts is performed in dialogue mode with user (Figure 19). In the case of automatic (intellectual) design of the table, the compiler notes only the classes held in the form of combination and the groups which these classes are held with. The system then automatically compiles the schedule. The time spent for a group during the automatic compilation of the schedule varies from 2 to 7 minutes, depending on the parameters of the computer.

Once the table is compiled, the table can be edited for exceptions.

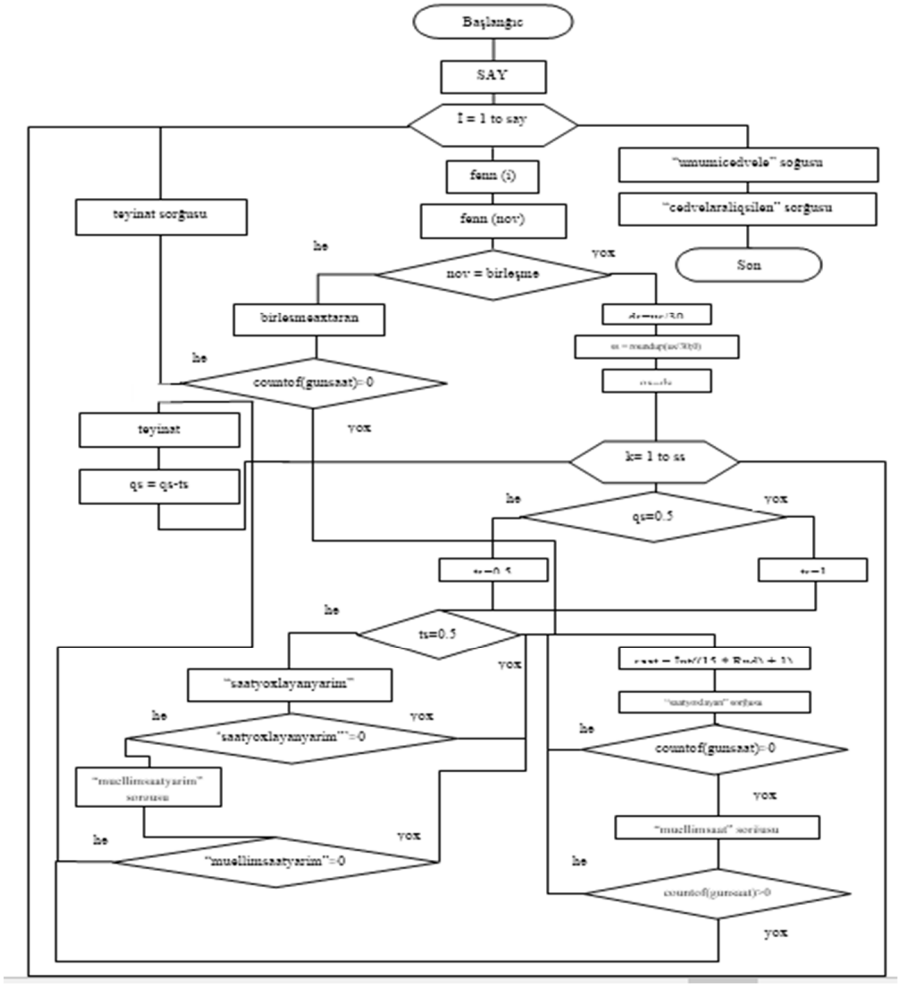

Figure 19. Algorithm for automatic lesson scheduling

MAIN RESULTS

The issues to be resolved within the framework of the research conducted on the basis of the obtained scientific-theoretical and practical results are as follows:

1. The concept of intellectual management of bimodal e-university for the educational environment of Azerbaijan was developed;
2. Within the framework of the applicant support system, methods were developed to determine the degree of perspective of specialties and the adequacy of supply and demand for specialties, with reference to the Bellman-Zadeh method and fuzzy sets theory;
3. The issues of intellectual management of the virtual educational environment by supporting the personalization of education in bimodal e-university were identified,
4. New models, methods and algorithms were developed to assess learner's "start" knowledge and select an educational trajectory appropriate to learner's intellectual potential in the context of personalization of education based on fuzzy sets and neural networks;
5. Methods for determining the individual educational trajectory of learner, assessment of knowledge and intellectual management of education in virtual educational environment were developed;
6. Methods for selecting content appropriate to learner's knowledge from global educational resources with a fuzzy ranking approach were developed;
7. The method for intellectual management of teacher-learner interaction and lesson-time division in the virtual educational environment with the application of neural networks is developed;
8. Architectural-technological models and algorithms that support the intellectual management of individual educational trajectories in bimodal e-university were developed.

The main content of the dissertation is represented in 18 scientific publications:

1. Qasımov, H.Ə. Elektron universitetlərin növləri, nəzəri əsasları, Azərbaycan təhsil mühitinə uyğun elektron universitet modeli.// - Naxçıvan: Elmi əsərlər. NDU,- 2016. № 8 (81) s. 67-73 (AAK)
2. Mammadova, M.H., Gasimov, H.A. E-university: conceptual, technological and architectural approaches // – Baku: Problems of Information Technology, – 2017. №2, – p.51-62 (AAK)
3. Qasımov, H.Ə.Elektron universitet üçün "Onlayn tədris – metodiki komplekslər" antologiyasının işlənməsi.// - Bakı: Gənc tədqiqatçı, -2017, №1. s. 46-40 (AAK)
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5. Qasimov, H.A. Application of Rnd () function in the process of question choice in electronic exams // - Vienna: European science review, -2017, №3-4. p. 94-97(EBSCO, Google Scholar, Crossref, Urlich ...)
6. *Гасымов Г.А.* Разработка механизма интеллектуального управления отношениями "студент-преподаватель" в пространстве виртуального образования с применением нейронных сетей.// - Москва: Открытое Образование. -2018, Т. 22. № 5. С. 94-103 (РИНЦ)
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11. Məmmədova, M.H., Zeynalov, C.İ., Qasımov, H.Ə. İnformasiya cəmiyyətində e-universitin informasiya təhlükəsizliyi // Beynəlxalq Telekommunikasiya İttifaqının 150 illiyinə həsr olunmuş informasiya təhlükəsizliyinin multidissiplinar problemləri üzrə II respublika elmi-praktiki konfransı, - Bakı, - 14 may, - 2015, s128-129.

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13. Qasımov, H.E., Elektronik sınavlarda taşınan bilgi taşıyıcıları kullanımının önlenmesi prosedürü //İnternational Conference of Science, -Ankara, - 11-12 iyun, - 2017, s. 7-8.

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16. Qasımov, H.E., Bulanık kümeler yöntemi ile öğrencinin intelleküel potensialine uyğun eğitim trayektorisinin seçilmesi metödleri //The 2nd International Conference Of Distance Learning And Innovative Educational Technologies, -Ankara, - 11-12 aralık, - 2018, s.29.

17. Zeynalov,C.İ.,Qasımov, H.E., Yapay sinir ağları kullanarak öğrencinin bilgi düzeyine daha uygun üniversite meslek seçimine yönlendirilmesi metödünün yapılandırılması // The 2nd International

Conference Of Distance Learning And Innovative Educational Technologies, -Ankara, - 11-12 aralık, -2018, s.21-27.

18. Mammadova, M.H., Gasimov H. A., Methods For Managing Supply And Demand Requirements For Applicants Within The Scope Of Individual Education Trajectory //5 th international conference on lifelong education and leadership for all - ICLEL 2019, -Baku, - 9 -11 iyul, -2019, s.1282-1288

Personal role of the applicant in the works published with co-authors:

[2] - Existing conceptual approaches to the design of UNESCO new education concept and e-universities were explored.

[7] – Sample problem was solved with the application of an artificial neural network.

[10] - study and comparison of existing e-university models in the world, as well as the positive impact of e-university on the social and economic development of the state, were calculated.

[11] - Real data threats in the example of e-universities, some e-universities subjected to cyber-attacks, and the damage they suffered were examined.

[17] - Method of determining the individual educational trajectory according to the knowledge level of learner was proposed, the method was implemented with artificial neural networks.

[18] - Possible scenarios were developed for learners to match supply and demand.

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