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Development of Knowledge Assessment Algorithm in E-Learning Environment

Abstract: - The development of technology also manifests itself in the educational environment. The traditional education model is already being replaced by the modern online education model. An electronic learning environment is created here. Online education allows people to learn remotely. This is basically a pretty advanced feature for anyone with internet access. It is possible to get access to any classes at any time, regardless of time and place. E-learning, which has many advantages, also helps in the development of individual education.

Electronic universities are one of the places where electronic educational environment is applied. E-universities can offer more advanced services to more students. At the same time, it is possible to choose an individual educational trajectory here. The selection of the individual trajectory of students is carried out on the basis of a certain method. And the management of electronic universities is carried out in electronic form.

The article is devoted to the study of the electronic university project as an electronic educational environment and its main space. Online education, e-learning environment, e-universities, services offered by them, methods and means of implementing individual education, algorithm of e-university management, calculations and examples in this direction are mentioned here.

Keywords: Online education, E-learning, E-universities, Personalized education, Management, Algorithms.

I. INTRODUCTION

Online learning is becoming increasingly popular in today's fast-paced digital world. E-learning or e-learning allows students to access online study materials and coursework from anywhere in the world. E-learning has made education more accessible and convenient and paved the way for the development of e-universities. An e-university is a type of university that offers online degree programs, coursework, and other educational resources to students around the world.

Throughout history, education has led to the rise of society from the period of primitive community to the level of information society. During this period, he sought answers to new demands and problems, ensuring educational development. Society requires educational institutions to teach people how to learn. Therefore, over time, the terms teacher and student are replaced by the terms teacher and learner.

The e-university will form an individual educational trajectory for students, which in turn will help to increase their competitiveness in the labor market. In this regard, the preparation of the principles, models and methods of the intellectual electronic university, and the development of the operational concept of the electronic university are considered to be quite urgent issues. Solving this issue will allow meeting modern educational standards.

The main components of e-university are teachers and learners. Therefore, an educational environment with the following opportunities should be formed in the electronic university:

1. Preparation of educational materials (textbooks, videos, audio files, etc.) designed according to the intellectual potential of the learner - student;
2. There are no restrictions on the choice of time, place and device for the learner to listen to lessons, perform assignments, and participate in discussions;
3. The possibility of conducting live communication between the learner and the teachers when necessary;
4. Eliminating the dependence of space, time, hardware choice for learners and making it the most optimal.

The main student mass of the electronic university can be made up of those who are unable to get higher education in time, who work, live in the provinces - whose economic situation does not allow for formal education.

E-university is also economically very efficient. Traditional universities often have high tuition fees, and students must also pay for housing, transportation, and other living expenses. With e-universities, students can save on all these costs. Tuition fees for e-universities are generally lower than traditional universities, and students do not have to worry about additional costs such as accommodation and transportation. Students can save on transportation, housing, and other costs associated with attending a traditional university. This makes education more affordable for people who cannot afford to attend a traditional university.

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The e-university project helps to preserve the ecological balance. Thus, as a result of the implementation of virtual education, the destruction of 800 m^2 of forest and the pollution of 500 tons of clean water are prevented in 1 year for approximately 5,000 students.

The concept of an e-university has evolved over the past few decades as advances in technology have changed the way we learn and access information. The idea of e-university is to provide flexible, accessible and affordable education to anyone anywhere in the world. Overall, the development of the e-university concept has changed the landscape of higher education, making it more accessible and affordable for people around the world.

In recent years, developing electronic education and bringing it to the level of world standards has been one of the priority directions. E-learning allows to have a wider audience of use, to spend minimum costs in the creation and use of educational materials and expenses, to connect with specialists in different locations at any time through telecommunication capabilities and to create education. The application of e-learning serves the formation of a new generation with modern knowledge and skills. In the globalized world, the training of high-level personnel is primarily formed by the effective use of e-learning. In addition, electronic education, regardless of social status and place of residence, gives every person equal opportunities to realize the right to education and obtain information.

The research issues are as follows:

1. Analysis of existing methods for the application of adaptive approach in electronic education, determination of requirements for the system prepared on the basis of existing standards, and research of scientific-theoretical aspects of educational environment management;
2. Analysis of the electronic education systems in our country, investigation of their shortcomings and showing a way to solve them;
3. Determining the components of the electronic university and determining the mutual relations between them;
4. Development of methods for evaluating the learner's knowledge;
5. Development of a method of matching supply and demand for professions and specialties;
6. Selection and development of methods of the educational trajectory according to the potential of the learner - each student;
7. Development of software implementing the adaptive system of electronic education.

Object-oriented analysis, decision-making theory, neural networks, database management systems. Based on the analysis of the existing systems, the structuring of the system that meets the current requirements and the construction of the database are provided. The theoretical part of the work is based on the study of information creation, collection and processing processes. Scientific results are obtained using methods of system analysis and mathematical modeling, decision theory, optimization theory, graph theory, network planning and management.

The concept of the operation of the conceptual model of the electronic university that meets modern educational standards has been developed:

- The existing electronic university models in the world were examined and the conceptual bases of the electronic university suitable for the educational environment of Azerbaijan were developed with the results obtained;
- The main architectural components of the electronic university were defined and the mutual relations between them were worked out;
- The algorithm for determining the degree of perspective of professions and specialties was developed;
- A software package has been developed that implements methods of organizing the teaching process, which is characterized by a special structural arrangement of components that allows interactively changing the student's model and adapting the curriculum;
- The educational trajectory corresponding to the students' potential is selected and the Individual Educational Trajectory is defined in the electronic university.

There are some models and methods for determining the student's knowledge level in the e-learning environment. The basis of these models and methods is the creation of an individual educational trajectory for each student during the educational process. Customization of e-learning is one of the main requirements when building an e-learning system. Individualization of students' educational trajectory during e-education is considered the main trend of e-education. Intelligent systems provide interaction between students and teachers in electronic education, interactivity, students' connection with educational materials. Artificial intelligence causes important changes in the electronic education environment, such as the simplification of teaching materials and the preparation of intellectual content [11, 12, 13]. Decision making in the e-learning environment is based on statistics, image

recognition, classification, fuzzy logic, neural networks. In the e-learning environment, the application of artificial intelligence to the process of personalization of education is carried out.

The process of preparation of individual educational trajectory of students is carried out in 3 stages.

1. Assessment of initial knowledge level;
2. Orientation to professions;
3. Initial assessment

The use of electronic education in the training process is a form of adaptation to the development of information technologies. A number of educational institutions have developed e-learning systems with various features that can support the ease of the learning process since the pandemic. With e-learning, the distribution of materials from teachers and students can be easily implemented and coordinated. In addition, students can collect assignments and work on exam questions on the e-learning platform. In fact, e-learning can be used by students and teachers to implement all learning activities integrated into the system, so that e-learning makes the learning process more efficient, creates a pleasant learning experience for students, and enhances students and their learning activities.

The availability of e-learning makes it easier for teachers to assess student learning outcomes by giving tests or assignments. Exam questions can be organized in a variety of formats, such as multiple choice, true or false, short answer, and essay. Of course, the mechanism for evaluating students' learning results is adapted to the type of questions asked to students. Essay questions are considered the most useful way to measure student learning outcomes. Essay questions are considered as a means of measuring students' ability to memorize, remember, analyze and write the results of their ideas. With essays, students can demonstrate their skills and knowledge of the adopted learning material. However, grading essay responses is quite difficult for teachers because the process takes a lot of time, especially if the number of questions and students in the class is large enough, which leads to more questions being graded by the teacher. This situation can lead to a decrease in the quality of the evaluation, and it is difficult to conduct an objective evaluation.

Automatic grading function can be applied to e-learning to overcome these problems. Thus, the evaluation of student answers in the form of an essay can be carried out by the system. Several methods, such as Rabin Karp, Latent Semantic Analysis (LSA) and Cosine Similarity, have been applied to this problem by previous researchers. Rabin Karp is an algorithm that can be used to measure the similarity level of text. This algorithm can be used to check the level of plagiarism of a document. Rabin Karp matches strings using a hash function as a comparison between search strings and substrings in the text. If the two hash values are the same, the next comparison of characters will be performed. However, Rabin Karp's weakness is its inability to perform a single pattern search process. Hash calculation in Rabin-Karp only counts the number of hashes that have the same value in both documents. So, if the answers have the same meaning but the choice of words is not the same, this will create a low level of similarity.

Developing a knowledge assessment algorithm in an e-learning environment includes several main steps:

1. Define learning objectives: Clearly state the specific knowledge and skills to be assessed. This may include subject concepts, problem solving skills, critical thinking skills, or any other desired learning outcomes.
2. Design assessment methods: Select appropriate assessment methods that match the learning objectives. Common assessment methods in e-learning environments include multiple-choice questions, short-answer questions, essays, interactive simulations, and project-based assessments.
3. Collect assessment data: As students engage with the e-learning platform, collect data about their performance on assessments. This may include their responses, the time taken to complete the assessments, and any other relevant data points that may provide insight into their knowledge and skills.
4. Analyze evaluation data: Use statistical techniques and data analysis methods to evaluate the evaluation data collected. Identify patterns, trends, and indicators of student performance and proficiency levels. This analysis can help identify areas where students may struggle or excel.
5. Define evaluation criteria: Based on learning objectives, define criteria for evaluating student performance. This may involve assigning points, grades or skill levels to different assessment items or overall assessments. Consider the weight and importance of each learning objective and assessment item.
6. Develop an algorithm: Use the analyzed data and established assessment criteria to develop an algorithm to assess student knowledge. This algorithm should take into account different assessment methods, data points and criteria to ensure accurate and reliable assessment of student performance.
7. Test and refine the algorithm: Implement the algorithm in an e-learning environment and test it with a diverse group of learners. Monitor the effectiveness of the algorithm in assessing student knowledge and

collect feedback from both learners and instructors. Based on this feedback, improve the algorithm and make necessary adjustments to increase its accuracy and reliability.

8. Continuous improvement: Knowledge assessment algorithms in e-learning environments should be continuously evaluated and improved. As new data is collected and additional insights are gained, the algorithm must be updated and refined to ensure it remains effective in assessing student knowledge over time.

It is important to note that developing a robust knowledge assessment algorithm requires a combination of expertise in instructional design, data analysis, and algorithm development. Collaboration between instructional designers, subject matter experts, data analysts, and software developers is often necessary to create an effective assessment algorithm in an e-learning environment.

The COVID-19 pandemic has had a major impact on the world of education. Home learning using online media is a solution to keep the teaching and learning process going well. Adequate distance learning will provide great opportunities for students and educators to acquire knowledge and improve skills. E-learning can be defined as a computer-based online learning process that students use to review lecture materials, discussion forums, lecturer assessments, exam questions without reducing their face-to-face time in class. E-learning can be presented in various forms of text, sound, video, images and animation.

E-learning can be accessed by students regardless of time and place, thereby giving students more opportunities to review existing material. However, in general, e-learning developed by several previous researchers only had standard features such as discussion forums, file uploads and downloads, email notifications, student progress feedback, and search functions. This study proposes e-learning in a single learning media portal to support and facilitate the learning process in Vocational High Schools. E-learning materials have features such download/online chat/discussion, automatic grading of student assessments (multiple choice and essay), real-time student grade reporting and attendance. Downloading this material will vary by subject and major, so students can access only those relevant to their major. Online chat/discussion is used to facilitate real-time discussion between students and teachers during study hours according to the material in the session.

One of the most important goals in e-learning is to ensure that participants achieve their learning objectives. We have observed that having subject knowledge is not enough to achieve educational goals. Participants should also understand that they know what we call certainty. We can evaluate the method using Monte Carlo simulations. It is always possible to obtain reliable assessments of knowledge and confidence by using approximately 100 multiple-choice test questions on a given topic.

II. DEVELOPMENT OF THE METHOD OF DETERMINING THE STUDENT'S INDIVIDUAL EDUCATIONAL TRAJECTORY.

Identifying a student's individual learning trajectory involves assessing their unique learning needs, strengths, and interests to create an individualized learning path. Although we can provide an overview of method development, it is important to note that specific implementation may vary between institutions and systems.

1. Assessment and profiling: The first step in determining a student's individual learning trajectory is to conduct assessments to gather information about their academic abilities, learning styles, interests, and aspirations. These assessments may include standardized tests, teacher evaluations, self-assessments, and interviews.
2. Data analysis and evaluation: Once evaluation data is collected, it should be analyzed to identify patterns, strengths, weaknesses, and areas for improvement. Educators and related professionals, such as guidance counselors or special education experts, evaluate the data to gain insights into a student's learning profile.
3. Goal setting: Based on the assessment results, goals are set in collaboration with the student, parents or guardians, and educators. These goals may include academic goals, personal development goals, career aspirations, or skill development milestones. Goals (SMART goals) should be specific, measurable, attainable, relevant and time-bound.
4. Individualized education plan (IEP) or learning plan: An individualized education plan or learning plan is created to determine the student's educational trajectory. This plan is designed to meet the student's unique needs and goals. This may include accommodations or modifications for students with special needs, enrichment activities for gifted students, or targeted interventions for students who need additional support.
5. Flexible curriculum and instructional strategies: Flexible curriculum and instructional strategies are implemented to support the student's individual learning trajectory. This may include personalized learning approaches, differentiated instruction, project-based learning, online courses, or specialized programs based on student interests and goals.

6. Continuous monitoring and correction: Regular monitoring of student progress is essential to ensure the effectiveness of the individual learning trajectory. Educators work with the student and their support network to continuously assess the student's performance, adjust the learning plan as necessary, and provide timely feedback and support.
7. Collaboration and communication: The successful implementation of a personalized learning trajectory relies on collaboration and communication between various stakeholders. This includes teachers, parents or guardians, school administrators, support staff, and outside experts as needed. Regular meetings and feedback loops allow for discussion, exchange of ideas and collective decision-making.

Over time, as technology evolves, there is the potential to use educational data analytics, artificial intelligence, and machine learning to enhance the development and implementation of personalized learning trajectories. These tools can provide valuable insights into student performance and learning patterns, facilitating more targeted and personalized interventions. However, ethical considerations and student privacy must be respected when using these technologies.

Determining the individual educational trajectory is carried out through neural networks. In all cases, students' knowledge is checked separately for each subject. Neural network training consists of 3 layers: input, output and hidden intermediate layer.

Entry matrix “D” consists of 4 rows and 10 columns. Row numbers indicate topics and column numbers indicate questions. 1's in the matrix indicate that the questions are true and 0's are false. The results of the matrix are determined based on the results obtained from the electronic examination system.

$$D = \left(d_{m,s}\right)\left(m = \overline{1,4}; s = \overline{1,10}\right) \tag{1}$$

The output matrix "J" consists of 4 rows, 1 column.

$$J = \left(j_{1,m}\right)\left(m = \overline{1,4}\right) \tag{2}$$

A 0 in the output matrix indicates that the subject is not mastered. During the study period, the electronic system resends these topics to the student. The third layer, the hidden layer, also consists of 4 elements. In this layer, the mastery level of all 4 subjects is determined.

The signals in the input layer are collected in the hidden third layer. Transition function for layer:

$$f(x) = \begin{cases} 1 & x \geq M \\ 0 \end{cases} \tag{3}$$

Neurons become active when the condition M ≥ k is met. “t” indicates percentage of questions “f” assigned for each topic. It depends on the total number of "S"-questions.

$$t = \frac{S}{100} f \tag{4}$$

There are several methods for assessing the knowledge acquired by students during the period of study. The Rnd() function is used to make the method of preparing questions for students to be accurate. This function generates random numbers in the range of two specified numbers. The function is used in lessons, creating lesson schedules and similar fields during the period of study of students [39].

The function is also used in the process of selecting questions during electronic examinations of students. In order to get the 51%, result that students need for each subject, it is important to have the students' exam results. The result may vary depending on the university.

In traditional examinations, tickets are prepared by the teacher. These questions are prepared according to the course material. In this case, students can prepare in two ways:

- The exam papers (or we can say exam questions) are presented to students in advance;
- The exam papers (or we can say exam questions) generally not provided to students.

In the first option, if students are ready for 70% of the questions, the probability of drawing an exam paper for which the student is ready should be 0.7. In the second option, if the student is ready for 70% of the course materials, the probability of drawing the exam paper for which the student is ready will be 0.7. Preparation of exam paper according to the selected algorithm leads to the student's complete study of certain subject materials. Let's look at the probability of exam papers being selected.

The marks obtained by the students from the top 50% of the general indicators mean that they will receive "excellent", "good" and "satisfactory" marks in the exam they will enter. If we indicate the number of test-type

questions prepared in the specified subjects - N, the number of questions prepared by students - n, the number of questions that will be asked by the student - m, the number of questions that students are interested in - t, the probability can be calculated using the following formula

$$F = \frac{C_n^t * C_{N-n}^{M-t}}{C_N^m} \tag{5}$$

Let's denote the student's indicators as follows:

1. Probability of satisfactory – F(k)
2. Probability of being good – F(y)
3. Probability of being excellent – F(a)

Now let's consider the following conditions:

1. N=1200 – the number of questions for the subject determined during the exam
2. m = 50 – the number of questions to be asked to the student during the exam
3. t = 20 – the number of questions of interest for a satisfactory indicator
4. t = 35 – the number of questions of interest for a good indicator
5. t = 45 – the number of questions of interest for an excellent indicator
6. n = 500 – the total number of questions the student is ready for

$$F(satisfactory) = \frac{C_{500}^{20} * C_{700}^{30}}{C_{1200}^{50}} + \frac{C_{500}^{21} * C_{700}^{29}}{C_{1200}^{50}} + \ldots + \frac{C_{500}^{50}}{C_{1200}^{50}}$$

$$F(good) = \frac{C_{500}^{35} * C_{700}^{15}}{C_{1200}^{50}} + \frac{C_{500}^{36} * C_{700}^{14}}{C_{1200}^{50}} + \ldots + \frac{C_{500}^{50}}{C_{1200}^{50}}$$

$$F(excellent) = \frac{C_{500}^{45} * C_{700}^{5}}{C_{1200}^{50}} + \frac{C_{500}^{46} * C_{700}^{4}}{C_{1200}^{50}} + \ldots + \frac{C_{500}^{50}}{C_{1200}^{50}}$$

From the obtained results, we can say that we can select the questions during the electronic exam through the Rnd() function. The process leads students to master what they learn.

III. CONSTRUCTION OF THE ALGORITHMIC BLOCK DIAGRAM AND DATABASE OF THE ELECTRONIC MANAGEMENT SYSTEM

In the e-university environment, there are electronic systems for education management. These electronic systems also operate in Azerbaijan, such as Unibook used by Azerbaijan State Oil and Industry University and KOICA electronic systems used by Azerbaijan Technical University. The system used at Azerbaijan Technical University was developed by the Korea International Cooperation Organization. The system is based on the bimodal e-university model. The modules and algorithms used in the KOICA system do not fully respond to the current educational environment. Some algorithms and modules have been added to the system. It is important to have the following modules for the development of a system suitable for the electronic education environment of Azerbaijan [49, 50].

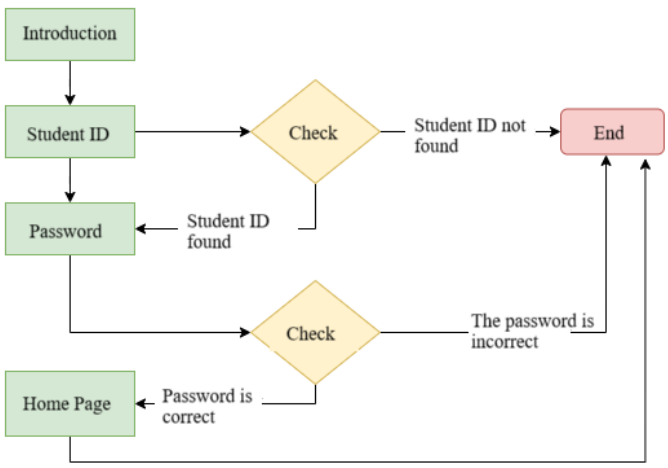

Figure 3.1. Block diagram of access to the electronic system

1. Profile – should be designed for both students and teachers. In the profile module, information related to students or teachers should be reflected. The information required for the student is listed below.
2. Student number – Student access to the electronic system must be done with student numbers. These numbers are generated by the university during student registration. The student number contains several information about the student.
   - The password of the specialty to which the student is admitted;
   - The student's admission ranking at the university;
   - Year of admission.

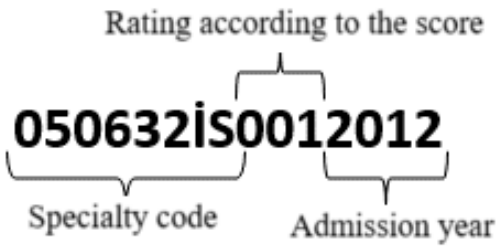

Figure 3.2. Formation of student number (ID)

Figure 3.2 shows an example of student number formation.

1. Name, surname, father name
2. Date of birth
3. Specialization/ Course
4. Group number
5. Academic advisor
6. Status – Graduated/Not Graduated
7. Tuition fees
8. Admission score
9. E-mail
10. Registration date

3. Class Registration – Contains the classes the student has acquired and must complete for the new session. These lessons are formed according to the specialty [41, 42].
4. Lesson schedule – Semester duration for each lesson consists of fifteen weeks. In total, there are three classes per week, and they consist of two hours.
5. Electronic magazine – intended for students' participation in classes. The lesson must consist of a student and absentee limit. Attendance is one of the administrative tasks that must be completed at the beginning of each class. This can take up valuable time at the beginning of the lesson and can sometimes be difficult to manage.
6. Tasks – The module contains tasks related to the student. These reflect the student's performance up to the annual exam. Tasks can be entered by the teacher as research, practical, etc. Assessment on assignments can be done in this module.
7. Educational Materials - Information in the electronic education process can be presented to students from this module. The student can get the materials in the form of textbooks, presentations, videos, audio files, etc. related to the relevant course.
8. Pricing/Price Schedule\
9. Examination schedule
10. Lesson schedule
11. My lessons
12. Department and Programs
13. Curriculum
14. My Students/Teachers
15. Announcements
16. Library
17. Online Services
18. Communication (chat)

Building an e-university database – Creating an e-university database involves several steps.

1. Determine the purpose and scope of the database: Before starting to build the database, it is important to determine what data will be stored, who will access it, and what queries or reports will be generated from it.
2. Design the database schema: A database schema is a blueprint of the database structure. It should include relationships between tables and fields. This can be done using a database management system (DBMS) such as MySQL, Oracle or SQL Server.
3. Create the database: After the schema is designed, the database can be created in the selected VBIS. This includes creating tables and fields, establishing relationships between tables, and defining constraints and indexes.
4. Populate the database: Once the database is created, data can be added to it. This can be done manually or by importing data from other sources.
5. Test the database: It is important to thoroughly test the database to ensure it works as intended. This includes checking data entry, retrieval and manipulation, as well as testing queries and reports.
6. Secure the database: The database should be secured to prevent unauthorized access and protect the data stored in it. This can be done through user authentication and access control, encryption and regular backups.
7. Maintaining the database: Once the database is operational, it should be maintained regularly to ensure optimal performance. This includes monitoring errors, optimizing queries, and performing regular backups.

IV. CONCLUSION

Based on the obtained scientific-theoretical and practical results, the issues resolved within the framework of the research work are as follows:

1. Existing electronic university models have been investigated. The positive and negative sides of the electronic university were investigated, and their solutions were determined;
2. Electronic education systems in Azerbaijan were analyzed and the missing modules were worked on;
3. The application of Data Mining technology in electronic education was investigated;
4. Big data analysis and perspectives in the electronic education system were investigated and its application in electronic education was developed;
5. E-learning standards, software platforms and methods of creating e-learning programs have been developed;
6. Algorithmic block-scheme of the modules needed for the electronic education system has been established;
7. Worked on tables, connections and information of modules that can be used in the electronic system in the Oracle environment;
8. Worked on the logic of the electronic system through the PL/SQL language;

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