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Adaptive Question Recommendation System Based on Student Achievement

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ABSTRACT

In this research, it is aimed to determine the success level of the students according to the answers given in the previous exams with TOPSIS method, to send the question to the related student by the authorized teacher according to the determined success level, to analyze the student's periodical (weekly-monthly-yearly) performance with graphical data and to create a data bank and to determine the overall performance of the student. Developmental research technique was used, which is one of the design-based research method derivatives including the design of educational tools. This study consists of question suggestion and question selection tool components. Adaptive question suggestion system perform generation, storage, classification, disclosure and publication of the content. The software has been successfully tested by 350 students and teachers by using 1000 questions prepared by the educator about the courses and subjects previously defined. As a result, it is seen that students check all the questions related to courses and subjects in the application database and submit the most appropriate question to the requestor in response to the question requests. Also it is observed that the TOPSIS algorithm quickly determined the desired number of questions from the question bank formed by the authorized teacher in accordance with the required criteria, and the process of creating a trial or subject test was performed successfully.

KEYWORDS: *adaptive question recommendation system; student achievement; multi-criteria decision making technique; developmental research; topsis*

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1. INRODUCTION

Today, technology development and diversity related to education of technology is increasing. The most up-to-date topics are that students can access e-learning content not only at school but also at other times and participate in constructivist education that will enable the active participation of students (Kong et al., 2014) Adaptive Learning Process is a computer based education method that organizes and plans the education of each student in the most appropriate way considering various needs situations (Szijarto and Cousins, 2019).The question recommendation system is the process of evaluating the system for a purpose by means of automatic or manual tuning and trial process, and observing the number of answers given as expected because it meets the specified response rate, and presenting the results to the system by determining the differences between them (Hansen et al., 2019). In this study, a system has been developed including the functions of storing, classifying, modifying, searching and listing the questions using TOPSIS algorithm, creating, modifying and publishing new contents using the questions prepared again.

2. MATERIALS AND METHODS

In this paper, developmental research technique was used, which is one of the design-based research method derivatives including the design of educational tools. This study consists of question suggestion and question selection tool components. Adaptive question recommendation system perform generation, storage, classification, disclosure and publication of the content. The main features of the question recommendation system are presented in Table 1. The developed software sends learning questions to students, answers them, and provides a level of achievement. Learning questions The most convenient and accurate way to mark the answers to test questions in SQL repositories can be provided by data standards. For this reason, some standardization studies were done on the data of learning questions (Stratakis et al., 2003).

Table1. The main features of the question recommendation system

Feature	Description
Search or Find	Be able to easily find Learning Tests with the data entered
Quality control	The Question Repository should provide a technical and pedagogical requirement comparison of Data and Test questions entered into the System
Presentation process	Test questions should be able to be sent to students' smart devices
Addition	Provide comprehensive search by gathering information from other question pools
Request	Question Repositories Must contain different options to provide test questions for learning

The developed software was developed with the aim of storing, searching, sharing, and selecting the appropriate test question for learning purposes. To accomplish these functions, an MSSQL Server 2016 database management system and LINQ to SQL and DataSet.xsd techniques can be used in conjunction with C # and MSSQL. These features are prepared with ASP.Net technology. This software, which processes according to the student achievement, allows the addition of learning objects for any different academic studies.

3. ADAPTIVE QUESTION RECOMMENDATION SYSTEM

Instructors use the Adaptive Question Recommendation System (AQRS) software to automatically send test question contents to the system of the course students, to make assessments about their study notes or students, and to access this recorded information at any time. In the software, relational database applications, WebApi applications and Another purpose of the software is to store learning objects and tests in the database and use them when needed.

There are three types of user roles in AQRS software that are administrator, instructor and student. In order to add any objects or use other features of the software, users must register to the system. Membership requests are sent through the user of the Windows Form base. Dev Express (v18.2.6) The Win Form library functions to interface the software, and then administrators examine these requests to allow appropriate user roles. After the administrator has entered the usage role by the administrator, users can use the AQRS software. Learning tests and objects are stored in the system via MSSQL Server interfaces. If necessary, learning can be easily accessed by testing and listing method by data or types of objects.

In the AQRS software, the necessary components for the learning test and object data were prepared. In addition, any data format can be stored in the system as a JSON-based file format and can be converted to Web Api format at any time and sent. Users can answer, analyze, comment on learning objects and tests, and identify problems using their interfaces. One of the most important features of the AQRS software is that the instructor approves the quality control of test questions and objects in the system. After checking the test questions prepared for learning purposes, the test questions have the feature that all students registered in the software can be transmitted to their mobile devices. The main page of the authorized instructor and the unauthorized instructor for access to the system shown in Figure 1 is as follows.

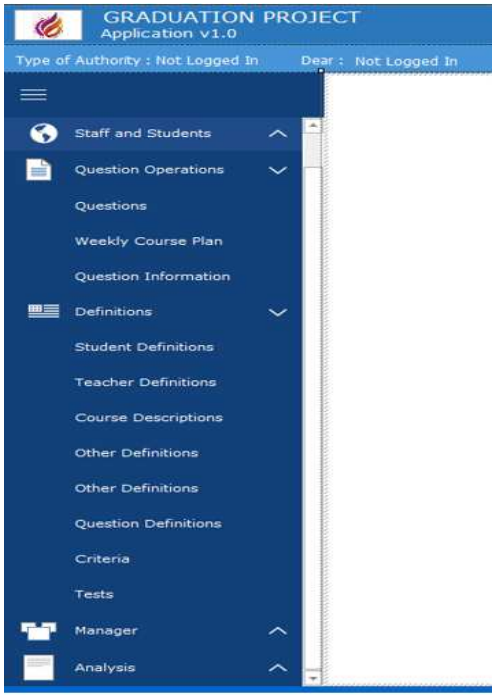

Figure1. Instructor and the unauthorized instructor for access to the system

3.1. Architecture of AQRS software

The developed AQRS software is based on a multi-layered software architecture and an object-oriented programming approach. There are two horizontal layers in the upper layer architecture of the software. These are both the presentation layer and the data layer. These layers have the component structures required for the system operational state of the AQRS software shown in Figure 2. The existence of these two layers makes the software project modular. For example, extra component structures can be added to the software simply and quickly. The connection between the database and the application in the data layer is prepared.

The Entity Framework sets an open source object option for the ADO.NET and C # .NET programming language. In Figure 2, instructors can use these interfaces to add, list, and view the data of learning tests using the Windows Form base. In the work layer, there are operations of the data conversion engine. When a request is received by the presentation layer, the system makes a decision and transmits it to the data layer in order to process the workflow state that appears in the software faster. The data layer adds comments about the instructor and students, reporting problems, users and roles, and all data such as the topic and the sub-subject that fits the database.

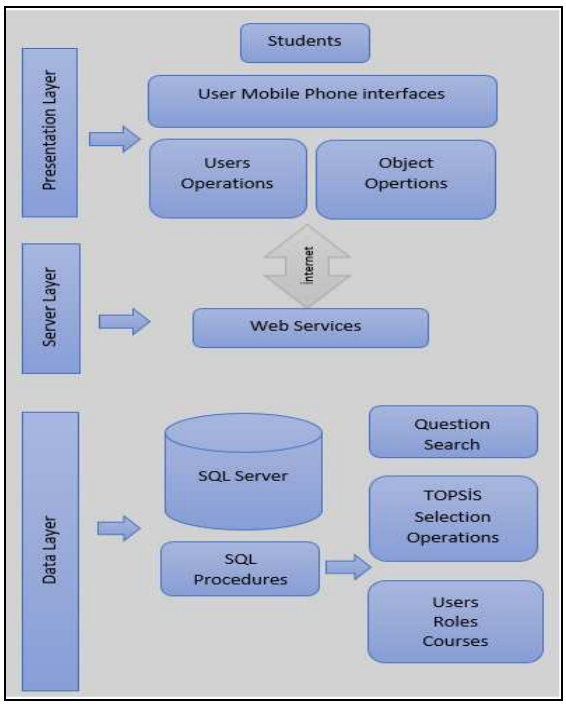

Figure2. Architectural structure of AQRS

3.2. Selection of Tests with TOPSIS Algorithm

Trainers and students try to find the most appropriate learning objects from many sources (Sinclair et al., 2013). For this reason, it is necessary to carry out efficient studies on the quality of tests for learning purposes. The quality of learning objects or tests is difficult to measure because instructors and learners can respond according to the requirements and requirements to which they depend. There are many selection methods to find the test that is most suitable for learning. There are many types of software to measure the quality status of tests for learning purposes (Vargo et al., 2003).

The AQRS application is set to submit test questions by evaluating the status of measurement and analysis according to the achievement status, interaction, participation, availability and content categories of the students with TOPSIS algorithm. According to the scoring results, there are various softwares that use multi-criteria evaluation methods to select the best alternative test for learning (Kurilovas, 2009). There are cases where each multi-criteria decision making technique is superior to other criterion techniques (Ömürbek et al., 2013). For this reason, which multi-criteria decision-making method should be applied to the decision problem, natural structure of decision problem, various options, scales of evaluations, type status of uncertain rate, dependency ratio of criteria, expectation status of the decision maker, data quantity and quality status to be entered factors should also be taken into consideration (Ceiling and Hatami-Marbini, 2011).

TOPSIS algorithm is applied in production, marketing, planning, group decision making, distribution of resources, education, health, selection of markets, transportation, support of decisions and many other areas (Geuna and Martin,2003). The TOPSIS algorithm is known as one of the most excellent multi-criteria decision making methods because it has the advantage of being able to sort out the the excessively large number of alternatives and to quickly determine the best alternative outcome (Tavana and Hatami-Marbini, 2011).

TOPSIS algorithm is used in AQRS software according to student achievement level. This decision-making criterion is based on the theory of priority. Also, problems involving complex decision-making criteria can be easily solved with TOPSIS. It is useful for logically using the data entered into the system and the decisions of experts. Since the TOPSIS algorithm does not contain mixed mathematical expressions, it is easy to use and has a transparent structure for decision makers because of the sorting criteria. The steps for selecting adaptive questions with TOPSIS are shown as follows.

In the TOPSIS method, the state of formation of the decision matrix (A), the state of formation of the standard decision matrix (R), the state of formation of the weighted standard decision matrix (V), the states of formation of the solutions in the ideal direction (A^*) and the negative ideal direction (A^-), It consists of a number of steps, such as calculating the degree of discrimination criteria and calculating the relative proximity to the ideal solution.

Step 1: First, the decision matrix (A) needs to be established. The evaluation matrix is started by creating the decision matrix in which alternative values are required to be listed in the rows and criteria to be evaluated based on the decision-making evaluation in the columns. The step by the decision makers, known as the initial matrix, which consists of alternative and n criterion evaluations, is as follows:

$$A_{ij} = \begin{bmatrix} a_{11} \cdots & a_{1j} \cdots & a_{1n} \\ a_{21} \cdots & a_{2j} \cdots & a_{2n} \\ a_{m1} \cdots & a_{mj} \cdots & a_{mn} \end{bmatrix}$$

Step 2: The standard decision matrix (R) needs to be established. The initial values that take place in our decision matrix must be brought to the standard state.

Step 3: Since the weighted standard decision matrix (V) needs to be established, the weighting ratios $(w_i)$of the criterion assessments must first be determined.

$$\sum_{i=1}^{n} w_i = 1$$

Then, each individual value found in the R matrix must be multiplied by the values of the criterion (w_i) to which it is connected and a Weighted Standard Decision Matrix (V) should be created.

Step 4: Solution results in the ideal direction (A^*) and negative in the ideal direction (A^-) should be established. The TOPSIS method assumes that each criterion assessment has shown a tendency to increase or decrease steadily. For this reason, the maximum value in each column in the matrix V represents the ideal direction (A^*) solution, the minimum value is the negative ideal solution (A^-) solution.

$$A^+ = (v_1^+, v_2^+, \ldots, v_n^+)$$

$$v_j^+ = \{(mak\ v_{ij}, j \in N) \quad i = 1, \ldots, m\}$$

$$A^- = (v_1^-, v_2^-, \ldots, v_n^-)$$

$$v_j^- = \{(min\ v_{ij}, j \in N) \quad i = 1, \ldots, m\}$$

Step 5: The state of calculation of the separation criteria degrees. The distance in the Euclidian Approach is used to calculate the distance of the criterion at each decision point to the solution point in the ideal direction and the negative ideal direction. According to these values, the distance of the ideal solution S_i^* in the ideal solution and the distance of the ideal solution in the negative direction S_i^- are calculated by the formulas shown below.

$$S_i^* = \sqrt{\sum_{j=1}^{n} (V_{ij} - V_j^*)^2}$$

$$S_i^- = \sqrt{\sum_{j=1}^{n} (V_{ij} - V_j^-)^2}$$

Step 6: Calculate the degree of proximity relative to the ideal solution result. Using the distinction criteria in the ideal direction and in the negative ideal direction, the relative proximity of each alternative case to the ideal solution result C_i^* is calculated.

$$C_i^* = \frac{S_i^-}{S_i^* + S_i^-} \quad C_i \in [0,1] \text{ i= 1, ..., m}$$

The determination of the criteria for selecting the test question for learning purposes and other criteria belong to the administrator or trainer and the criteria are adjusted according to the test statistics. These criteria can be evaluated manually by instructors by manual input or by decision-making methods.

The trainers were interviewed to determine the selection criteria of the data-based test questions. Ten instructors participated in the interview. According to the data in the interview, TOPSIS question coefficient criteria (reliability, discrimination, cognitive area, degree of difficulty of the question) were determined for the selection of test questions.

Test questions with the highest value obtained by TOPSIS algorithm are selected. As shown in Table 2, the AQRS software was tested with four criteria. In the first few trials, the CRs of the criteria were found to be greater than 0.2, indicating that the criteria did not proceed consistently with the selection of test questions. At the end of the fifth trial, the CR of the criteria was found to be 0.877802262, which was below 0.877, and the criteria and points given were therefore consistent. When necessary, instructors can change the number of criteria up to 10 or even more and enter alternatives according to preference. Test questions are evaluated according to four different criteria.

Table2. Criteria weights

Question Number	Criteria weights						
	C1	C2	C3	C4	Total	S-	S+
	0,1	0,3	0,4	0,2			
Q14	6	3	5	4	0,877802262	0,012309	0,088422
Q8	5	3	4	3	0,719027294	0,028831	0,073780
Q9	5	3	4	3	0,719027294	0,028831	0,073780
Q13	4	2	5	4	0,711699469	0,030011	0,074085

4. CONCLUSION

In this research, it is aimed to determine the success level of the students according to the answers given in the previous exams with TOPSIS method, to send the question to the related student by the authorized teacher according to the determined success level, to analyze the student's periodical (weekly-monthly-yearly) performance with graphical data and to create a data bank and to determine the overall performance of the student. The software has been successfully tested by 350 students and teachers by using 1000 questions prepared by the educator about the courses and subjects previously defined. As a result, it is seen that students check all the questions related to courses and subjects in the application database and submit the most appropriate question to the requestor in response to the question requests. Also it is observed that the TOPSIS algorithm quickly determined the desired number of questions from the question bank formed by the authorized teacher in accordance with the required criteria, and the process of creating a trial or subject test was performed successfully.

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