

DETERMINING THE KNOWLEDGE LEVEL OF PUPILS IN THE INFORMATION SYSTEM OF "SMART SCHOOL"

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***Abstract.** At a time when current information technologies are rapidly developing, the effectiveness of the quality of education in secondary schools, the transparency of the teacher evaluation system and the analysis of several other indicators with the help of artificial intelligence are the urgent issues of the day. In this method of analysis, initially the value is entered by school experts. This value consists of a pupil in a certain category among pupils and his grades. The term category refers to various criteria, such as pupils with different levels of mental activity, pupils who are learning poorly, who are missing a lot of lessons, and the level of learning is high or low within the specified subjects or topics. The "Smart School" information system forms arrays consisting of the number of grades and grades of pupils according to the criteria entered by experts, and has the ability to sort the values that are similar to the entered value. The solution to the problem posed in this article is explained mathematically and practically. Based on the proposed mathematical models, the business process was modeled, a business process software product was developed, and statistical data was obtained.*

Keywords: array, association rule, fuzzy logic, information system, mathematical model, set elements, signs of similarity, smart school, time series.

Introduction

The population growth in Uzbekistan leads to an increase in the number of pupils in schools, which increases the difference in the ratio of school teachers to pupils. Naturally, the teacher cannot always participate in the evaluation of the pupils' knowledge level, in determining the topics that are difficult to master, and in other processes related to education. The inability of teachers to deal with each pupil individually can lead to a sharp decrease in the quality of education.

Ensuring the intellectual and physical development of pupils in schools, creating a foundation for them to fully use their abilities in the future and to find their place in society is one of the urgent issues of today (Asemi, 2006).

To date, there is a lot of research on improving the quality of education through artificial intelligence systems (Zaenab, 2015; Henry & Abala, 2009; Omidinia et al., 2013). We analyzed the 37 scientific articles (Sampebua & Mangiwa, 2017; Hennessy et al., 2005; Mahmudi et al., 2008; Puteh et al., 2004).

Automation of the educational process in the higher and general secondary education system is one of the painful points of the education system (Muslimov, 2015; Tolipov, 2005). At present, this problem has been partially solved, an automated information system for secondary education has been developed. Currently, the system has been put into practice in 10 general public schools in Uzbekistan. The "Smart School" program allows to analyze the effectiveness of the quality of education in schools, the transparency of the teacher evaluation system, and several other indicators with the help of artificial intelligence. In addition, subjects that are difficult for pupils in current schools to master are automatically identified. It is as a result of taking systematic measures on the topics that are difficult to master, identifying pupils who are inactive in classes and those with low mastery individually, effective work is being organized with each pupil. There are opportunities to notify parents about changes in their child's learning regularly in the form of a histogram in the mobile application, and to provide advice to teachers and parents in identifying pupils who regularly miss classes and finding the reasons for it.

The Smart School program is software designed for electronic management and analysis of work processes in schools, including journals and daily documents, and serves to automate the work of school director, deputies' director, teachers and other employees. The system performs analysis of pupils' cognitive potential and physical development in the educational system using Artificial Intelligence systems (search based on associative rules, time series prediction, fuzzy logic).

Electronic journal, electronic diary, online information exchange with parents, ability to view exam schedule and results online, online lesson schedule will help pupils to fully participate in classes and improve learning efficiency (Bustanov & Xasanov, 2010). It is worth to note that the program has the ability to analyze the physical development and physical training of the pupil according to his age, to recommend physical exercises that should be performed according to the standard rules, and exercises to ensure the health of the pupil.

The "Smart School" project uses artificial intelligence systems such as searching based on associative rules, predicting time series, and identifying similarities. In short, it has the ability to identify multiple pupils who have similar grades to a random pupil. In achieving this possibility, the problem of identifying similarities was encountered.

Research methodology

A number of scientific works on identifying similarities were analyzed. The analyzed scientific works showed that the similarity requires the usage of different methods depending on the object. For example, Chinese scholars Haipeng Chen and Xiwen Yang (Chen, Yang, & Lyu, 2020) in determining the forgery of their copied works of art based on such 4 principles:

- Method based on frequency domain
- Method based on size reduction
- Method based on local binary pattern
- Texture based method

In addition, a number of scientists, such as Varun Chandola (Chandola et al., 2009), Luke Michael Febriansyah (2019), Farhan Ullah (Ullah et al., 2020) have conducted research on similarity coefficients in different directions. It is worth to mention that, regardless of whether it is the similarity between bodies or determining the similarity between arbitrary objects, we have seen that the decision is made based on the elements of mathematical statistics and the theory of probabilities. When making decisions in this area, it is appropriate to take into account some rules:

Associative rules are guidelines that help to determine the probability of correlation between elements in large data sets in various types of databases (Agrawal, 1993; Hu et al., 2002). It helps to determine the probability of dependency of the grades received by pupils on one subject on the grades they received or may receive on other subjects.

Time series prediction is (data) collected based on the sequence of a certain time interval (Box et al., 2008). The method of time series analysis provides an opportunity to predict its indicator (essence) based on the past and future of numerical variabilities.

Fuzzy logic is a branch of the artificial intelligence system, which is implemented through computer devices that model human intelligence (García-Honrado, 2012; Ismail & Syaiful, 2015). It accepts human intelligence and helps people make decisions. In its process, fuzzy logic makes predictions and draws conclusions based on its experience patterns, which become a tool for users to get advice. Fuzzy logic has been widely used in many fields (Albayrak et al., 2015; Zadeh, 1965) one of which is educational evaluation. In the "Smart School" program, fuzzy logic models (Melihov et al., 1990) are used to assess the level of knowledge of pupils in subjects.

The large number of training load imposed on the teacher complicates the process of assessing the level of pupil's. If a teacher spends 3-7 minutes to assess the knowledge of 1 pupil through questions and there are 20-40 pupils in a class, it means that the teacher needs more time and energy. Such problems can be solved through artificial intelligence systems. In the "Smart School" program, the grades

received by the pupils in each subject are analyzed and it is determined with the help of artificial intelligence systems the pupil is active in which subjects in appropriation there are problems within which subjects (Masharipov et al., 2022).

The value is entered by school experts in this article. This value consists of a pupil in a certain category among pupils and his grades. The term category refers to various criteria, such as pupils with different levels of mental activity, pupils who are learning poorly, who are missing a lot of lessons, and the level of learning is high or low within the specified subjects or topics. The "Smart School" program forms arrays consisting of the number of grades, grades of pupils in subjects according to criteria entered by experts and the ability to sort values that are similar to the entered value. The following problems are solved in this article: a parent who enters the "Smart School" information system with a login and password can see his child's grades, as well as the problem of identifying other pupils at the same level as his child.

Solution of the problem

To solve the problem, we need an array of grades of pupils in one category. For example, an array of 7th class pupils' grades or an array of 7th class pupils' grades in several subjects such as algebra, geometry, physics, or an interval at the end of the school year can be an array of control values. Let's suppose that parents or experts want to determine the grades of a particular pupil and other pupils who are similar to him during the optional time of the school year. In such situation, we select as an object a two-dimensional array consisting of the total grades of pupils from the academic year to the current time.

$$A = \begin{pmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ a_{m1} & a_{m2} & \dots & a_{mn} \end{pmatrix} \quad (1)$$

Here $a_{ij} \in \{2,3,4,5, \emptyset\}$, a_{ij} i – is the grade of the i -pupil on the j -subject, $n \in \mathbb{Z}$ is the number of subjects in the class denotes the number of subjects and $m \in \mathbb{Z}$ denotes the number of pupils in the class. Table 1 below shows the elements of array A.

Table 1 Array of pupils' grades (made by authors)

	Theme 1	Theme 2	Theme 3	Theme 4	Theme 5	...	Theme n
P 1	5	4	4	3	5	...	4
P 2	4	3	5	5	4	...	5
P 3	5	5	4	3	4	...	5
P 4	4	4	5	5	3	...	5
P 5	3	5	4	4	5	...	4
...
P m	4	5	4	5	4	...	5

Operations are performed on selected elements of matrix A. The elements of matrix A consist of 5 different grades 0, 2, 3, 4, 5 (where the number 0 means not graded on the subject). Now the number of grades for each pupil is counted and as a result, matrix B is formed

$$B = \begin{pmatrix} b_{11} & b_{12} & b_{13} & b_{14} \\ b_{21} & b_{22} & b_{23} & b_{24} \\ \dots & \dots & \dots & \dots \\ b_{m1} & b_{m2} & b_{m3} & b_{m4} \end{pmatrix} \quad (2)$$

Here b_{i1} – number of 5 grades of i th pupil, b_{i2} – number of 4 grades, b_{i3} – number of 3 grades, b_{i4} – number of 2 grades. That is to say:

$$B = \begin{pmatrix} 2 & 4 & 5 & 2 \\ 5 & 3 & 1 & 0 \\ \dots & \dots & \dots & \dots \\ 7 & 0 & 0 & 0 \end{pmatrix}$$

a matrix consisting of such values is formed.

Let's assume that the system is required to identify pupils whose grades are similar to the grades of k -pupil:

$$x_k = \{b_{k1}, b_{k2}, b_{k3}, b_{k4}\}$$

x_k array C consisting of elements of array B satisfying the condition $|b_{k4} - b_{i4}| \leq 1$ between the number of grades of the pupil and the number of grades of other pupils is created.

$$C = \begin{pmatrix} c_{11} & c_{12} & c_{13} & c_{14} \\ c_{21} & c_{22} & c_{23} & c_{24} \\ \dots & \dots & \dots & \dots \\ c_{y1} & c_{y2} & c_{y3} & c_{y4} \end{pmatrix} \quad (3)$$

Here $1 < y < m$.

Array D is formed by dividing the elements of the created array C with the condition $|b_{k3} - b_{i3}| \leq 1$, the difference between the numbers of 3 values in the array C consists elements of the set $\{-1; 0; 1\}$

$$D = \begin{pmatrix} d_{11} & d_{12} & d_{13} & d_{14} \\ d_{21} & d_{22} & d_{23} & d_{24} \\ \dots & \dots & \dots & \dots \\ d_{z1} & d_{z2} & d_{z3} & d_{z4} \end{pmatrix} \quad (4)$$

Here $1 < z < y$

In the next step the 2nd column of the array D, i.e. the number of 4 grades of the pupils, the array E consisting of elements satisfying the condition $|b_{k2} - b_{i2}| \leq 1$ is created.

$$E = \begin{pmatrix} e_{11} & e_{12} & e_{13} & e_{14} \\ e_{21} & e_{22} & e_{23} & e_{24} \\ \dots & \dots & \dots & \dots \\ e_{p1} & e_{p2} & e_{p3} & e_{p4} \end{pmatrix} \quad (5)$$

Here $1 < p < z$

Now it's time to calculate the differences between the 5 grades of the pupils and this operation is performed on the elements of the E array. As a result, an array F consisting of elements satisfying the condition $|b_{k1} - b_{i1}| \leq 1$ of the array E is created.

$$F = \begin{pmatrix} f_{11} & f_{12} & f_{13} & f_{14} \\ f_{21} & f_{22} & f_{23} & f_{24} \\ \dots & \dots & \dots & \dots \\ f_{l1} & f_{l2} & f_{l3} & f_{l4} \end{pmatrix} \quad (6)$$

Here $1 < l < p$

F is the resulting array, the differences between the values of the current k-pupil $x_k = \{b_{k1}, b_{k2}, b_{k3}, b_{k4}\}$ consisting elements of the set $\{-1, 0, 1\}$ are extracted. Now, according to the order of the array F, the elements between the elements of the array A are separated

$$A' = \begin{pmatrix} a'_{11} & a'_{12} & \dots & a'_{1n} \\ a'_{21} & a'_{22} & \dots & a'_{2n} \\ \dots & \dots & \dots & \dots \\ a'_{l1} & a'_{l2} & \dots & a'_{ln} \end{pmatrix} \quad (7)$$

The resulting array of A' elements is required to be sorted when presenting the results to the user. It is expedient to perform the sorting according to the sum of elements of the array A' . Let S be ordered matrix

$$S = \begin{pmatrix} s_1 \\ s_2 \\ \vdots \\ s_l \end{pmatrix} \quad (8)$$

Elements of the array A' are displayed which satisfying the condition $s_i = f_{i1} + f_{i2} + \dots + f_{in}$ and $s_1 \geq s_2 \geq s_3 \geq \dots \geq s_l$

We will consider the process of solving this problem based on the above mathematical expressions.

The "Smart school" information system is developed in the Java programming language in which the interfaces are initially written. Individually written interfaces are inherited and generated methods are filled and passed to the browser. The interface that creates the elements of array A can be composed of the following methods.

```

List<Fan> getFanListAtThatDateBySinflId(int sinflId, String sana, String lang);
List<Jurnal> getJurnalListByGuruhIdAtThatDate(int sinflId, String sana, String lang);
List<Jurnal> getJurnalListGuruhIdByBetweenDate(int guruhId, String sana);
List<Jurnal> getJurnalForBahoMap(String sana, int sinflId, int fanId, double soat, String lang);
List<Jurnal> getJurnalForHisobot(String sana, int sinflId, int fanId, double soat, String baho);
List<Jurnal> getJurnalByFanIdAndSinflId(int fanId, int sinflId, int param, String begin, String end);
List<Jurnal> getJurnalByFanIdAndSinflIdInSoat(String sana, int fanId, int sinflId);
List<Jurnal> getJurnalByFanIdSanaSinflSoat(int fanId, String sana, int sinflId, double soat);

```

Interface methods are written according to the necessary categories. Pupils' grades were obtained from the database with the help of written methods.

Methods for other similar categories are written and elements of array A are created. An array B is created based on the generated array and a one-dimensional array x_k is also created based on the entered value. In the next step, arrays B and x_k are compared. Comparing two arbitrary arrays can be done using the code below

```

public class Test1 {
    private static double data1[] =
    {0.7,0.57,0.81,0.32,0.33,0.68,0.91,0.24,0.2,0.5,0.0,0.64,0.12,0.43,0.74,0.28,0.38,0.3,0.0,0.4,0.9,0.68,0.75,0.8,0.9,0.6,0.75,0.38,0.16,0.26};
    private static List<List<Double>> testList = new ArrayList<>();
    private static List<List<Double>> resultList = new ArrayList<>();
    public static void main(String[] args) {
        double minValue = 0;
        double maxValue = 0;
        for (int i = 0; i < 10; i++) {
            List<Double> testData = new ArrayList<>();
            for (int j = 0; j < 30; j++) {
                testData.add(Double.parseDouble(String.format("%.2f", Math.random()).replace(',', '!')));
            }
            testList.add(testData);
        }
        for (List<Double> dList : testList) {
            System.out.println(dList);
            List<Double> fResult = new ArrayList<>();
            for (int i = 0; i < dList.size(); i++) {
                double d = 1-dList.get(i);
                double d1 = Double.parseDouble(String.format("%.2f", d).replace(',', '!'));
            }
        }
    }
}

```

```
fResult.add(d1); }
resultList.add(fResult);
System.err.println(fResult); } } }
```

Using this method, the arrays are compared and the necessary results are presented to the user.

The results of research and discussions

Based on the mathematical models developed above and the business process modeled on their basis, a similarity detection function was introduced for the "Smart School" information system. 10 schools where the information system has been implemented are identifying pupils with a significant level of accuracy based on the information entered into the program. If this function is required to cover the grades of 10 school pupils it is required to enter the resulting number of pupils. For example, the system needs to determine how many pupils have similar grades to the current pupil. In that case, the system requires the user to enter the required number of students. Apart from that, the system determined the indicators of learning in schools as follows:

Analyzing the learning of math by 10th grade pupils of schools 2, 21 and 40, it was found that learning the following topics was difficult for pupils to learn: (Table 2).

Table 2 Knowledge level of math (made by authors)

<i>Schools</i>	<i>Themes</i>		
	<i>Negation, disjunction and conjunction</i>	<i>Simple percentage, complicated percentage</i>	<i>Simple rational equations and their systems</i>
<i>School №40</i>	<i>4.18</i>	<i>3.18</i>	<i>3.82</i>
<i>School №21</i>	<i>1.77</i>	<i>0.37</i>	<i>0.89</i>
<i>School №2</i>	<i>1.91</i>	<i>1.48</i>	<i>2.67</i>

Table 2 shows that in 2 schools it is difficult for pupils of the 10th grade to master these topics in algebra, while in the school №40, these topics are mastered relatively well. In this case, studying the methodology of teaching math in school №40 and applying it to other school may lead to master the subject in all other schools.

In addition, the "Smart School" information system has the ability to determine the mastery coefficients of subjects that are difficult for pupils to master. This possibility can be seen in the diagram below:

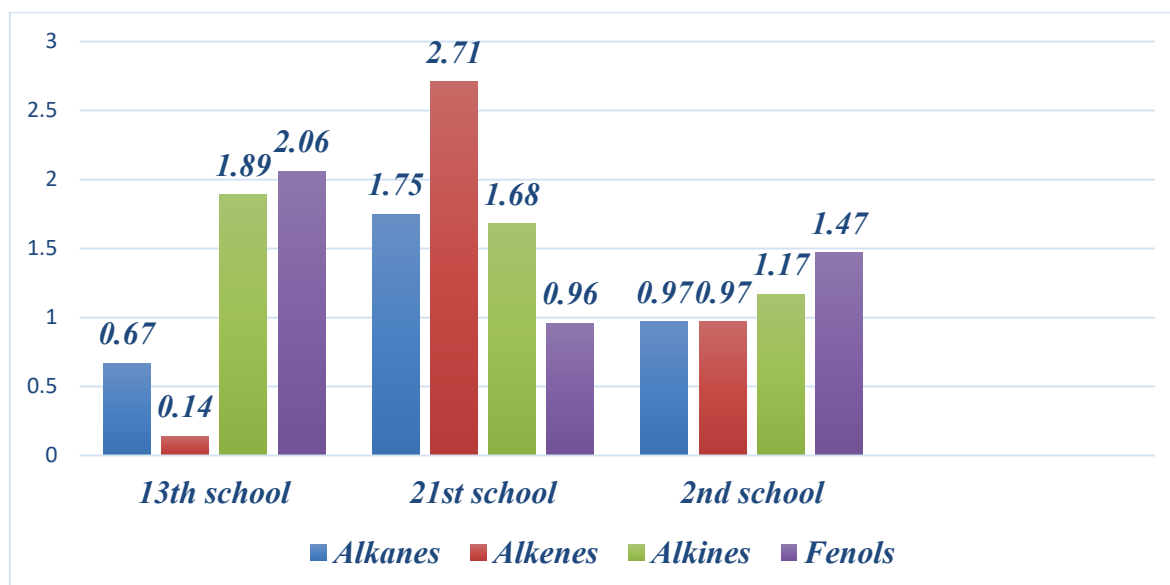


Figure 1 Coefficients of mastering topics (made by authors)

It can be seen from the diagram that the coefficients of assimilation of subjects assessed as difficult to master within the framework of schools have been developed. In the system of public education, it is desirable to revise the methods of teaching these subjects with more understandable form. In the same way, the learners can highlight topics that are more difficult to master in other subjects.

Summary

The developed information system identifies students with a high level of knowledge in accordance with such criteria as the number of grades received by students, the frequency of participation in classes, and indicators of mastery of subjects. If we look at the example of the school №10, it was found that there are 4 pupils in the 5th "A" class and 3 pupils with a high level of knowledge in the 6th "G" class. In addition, in the school №10, the level of pupils in the mother tongue of the 5th "E" grade was 4.9 on a maximum of 5 points, and the average indicator of the class was determined by the program according to the level of each pupil. . Through this method of analysis, it will be possible to assess the level of pupils and classes by school.

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