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FORMATION OF INDIVIDUAL TRAJECTORIES OF GIFTEDNESS OF STUDENTS BASED ON THE ANALYSIS OF LARGE DATA ARRAYS

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ABSTRACT

This article discusses the issue of identifying giftedness, that is, the formation of a student's individual trajectories. The relevance of the problem lies in the development of a new paradigm of the information model, which allows to determine the degree of giftedness that meets the needs of digital education and the formation of trajectories for the development of giftedness among students. The article describes the methods of applying fuzzy logic to determine the student's individual trajectories. To do this, in this paper, an attempt was made to use the mathematical apparatus of fuzzy logic. The structure of the database covers all levels of skills in terms of the main indicators of the quality of education. The expert study was carried out on the basis of the Nazarbayev Intellectual School of Chemistry and Biology in Ust-Kamenogorsk. The results obtained made it possible to identify the multi-criteria formation of the trajectories of a gifted student.
Keywords: *Giftedness, Methods for determining giftedness, Fuzzy logic model, Rules, Individual trajectory*

1 INTRODUCTION

The current level of formation of an educated, talented society is characterized by the intensive development of giftedness among students. This development is characterized by the idea of self-organizing and competitive students who will undoubtingly contribute to the development of an economy.

One of the reasons for the active development in this area is that automation and systematization serve as the basis for changing processes and play an important role in the activities of man and society. There are many types of information systems: data processing systems, management information systems, marketing systems, accounting systems and others used in various organizations. A huge number of types of information systems has generated a large number of methodologies and technologies for their creation [1].

For process control, currently there are often applications for automation of technological processes, where fuzzy logic allows you to apply the experience of operators [1]. At the end of the 20th century, in the field of process control, there was a widespread interest in control methods called “fuzzy control logic”.

To process large data arrays, methods and algorithms of machine learning are currently used, in particular, methods for generating fuzzy inference rules for various subject areas.

The aim of the study is to identify the individual trajectories of student giftedness based on the analysis of large data arrays according to several criteria, through the use of theories, functions and principles of fuzzy logic.

2 METHODS FOR IDENTIFYING THE GIFTEDNESS OF STUDENT

The identification of giftedness in students for many years has been one of the hot topics in both the scientific and educational communities. Therefore, today the concept of "giftedness", its types and methods of its identification are widely discussed not only in many foreign literatures, but also in domestic ones too. The early identification and detection of talented students with high abilities and the need to provide adequate educational support is the responsibility of the family and school. The detection process requires special attention, such as assessment strategies. This is written in the writings of Huang, 2008 [5] and Renzulli, 2013[6].

Research (Moon, 2003) suggests that psychological assessment in the area of giftedness is important for three main reasons - identifying gifted students based on psychological characteristics, the second is diagnosing strengths and weaknesses in terms of student development and evaluating educational performance measurements[7]. This assessment has been enriched by advances in research as it is now widely accepted. Intelligence is not enough to explain giftedness. Therefore, due to the multidimensionality of giftedness, it is not enough to limit to the identification of gifted students for high scores in IQ tests and, therefore, it is necessary to include a variety of psychological aspects and their combination (Chart, Grigorenko, & Sternberg, 2008; Gagné, 2004; Renzulli, 2005; Sternberg, 2001). The combination of these factors in high ability is often dynamic and systemic and goes beyond individual psychological attributes[9]. Giftedness also emerges from educational contexts that promote the development of talent or high performance (Gagne, 2004, 2007; Shavinina, 2013; Sternberg, 1999, 2001; Subotnik, Olshevsky-Kubilius, and Worrell, 2011).

An analysis of domestic and foreign literature on this topic allowed us to establish that the identification of giftedness is one of the most important aspects of the development of education. In the book "Education in Lebanese Schools Gifted" by Sara El Khoury and Anies Al-Hroub, in the chapter Identification of Gifted Students: History, Tools, and Procedures, the order of methods for identifying giftedness is described, where different models are used [15]. Roethlisberg and McIntosh (2012) provide an overview of the use of brief intelligence tests to identify gifted students. They contain a number of comments and recommendations on the correct use of brief intelligence tests [17]. Assoulin and Lupklowski-Shoplik discuss a talent search model for identifying high ability students[18]. This innovative model was developed by Julian Stanley (1996) at Johns Hopkins University. This model has abandoned the notion of giftedness as a global category in favor of focusing on specific areas of academic interest (Keating, 2009) and has been successfully adopted by a number of leading scientists around the country. Kerr and her research team report the development of a new evaluation measure, this distance from privilege measures. The scales quantify distance from privilege to understand how groups of high ability minority students differ from the majority, privileged people. These results on the scale promise an increase in admissions in the fields of science, technology, engineering and mathematics (Kerr et al., 2012). Grigorenko, Sternberg, and colleagues provide data on a new giftedness assessment tool, Aurora, designed to change the way we measure and think about giftedness (Kornilov, Tan, Elliott, Sternberg, & Grigorenko, 2012). The authors of [19] offer a special model for improving the quality of education through different learning styles. Also, the authors of [20] use various approaches for learning that meets the student's requirement, which leads to effective learning.

This paper will also consider a model that reveals the possibilities of using information technology in determining the types of giftedness. To process large amounts of data on academic performance and creative skills in this study, the fuzzy logic model will be used.

A fuzzy model was developed for assessing the knowledge and skills of students. The model takes into account the assessed characteristics (knowledge of the subject, the ability to solve problems, the ability to think analogously) are presented as fuzzy subsets of a set of linguistic labels that characterize their performance in subject areas and skills, and the capabilities of all student profiles are also calculated. A detailed quantitative and qualitative study of students on their performance was done. As defuzzification methods in converting our fuzzy output to a crisp number, the total possible uncertainty and the center of gravity method are used. According to this method, the coordinates of the graph of the center of gravity of the involved membership functions provide a scale for student achievement. It also examines methods for assessing the individual abilities of students and provides examples that are presented to illustrate the use of our results in practice.

This article proposes to use fuzzy logic in assessing students' knowledge and skills, for this an action plan was made: first of all, we use our general fuzzy structure mentioned above as a tool for assessing skills in subject areas and identifying fuzzy logic rules. Next, we apply center of gravity methods and we present an example illustrating our results in practice using a table method for this.

An inference engine or algorithm is an important part of the basic architecture of fuzzy inference systems. The inference algorithm operates with the rules of fuzzy productions, in which conditions and conclusions are written in the form of fuzzy linguistic variables.

Let's consider how the data preprocessing is performed:

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1) The information that enters the input of the fuzzy inference system is the input variables measured in some way. These variables correspond to the real variables of the control process.

2) The information that is generated at the output of the fuzzy inference system corresponds to the output variables, which are the control variables of the control process.

3) Fuzzy inference systems are designed to convert the values of input variables of the control process into output variables based on the use of fuzzy production rules.

4) A base of rules for fuzzy productions is formed, and the implementation of fuzzy inference is in the form of fuzzy linguistic statements [2].

Thus, the main stages of fuzzy inference are:

- formation of a rule base for fuzzy inference systems;
- fuzzification of input variables;
- association of subconditions in fuzzy production rules.

The article describes methods for applying fuzzy logic to determine the model of a student's individual trajectories. And for this, in this paper, an attempt was made to use the mathematical apparatus of fuzzy logic to assess the effectiveness of the quality of education. The structure of the database covers all levels of skills on the main indicators of the quality of education.

To form the individual trajectories of the student, this fuzzy model was developed [4].

The following parameters are used as input variables:

- Progress in specialized subjects (about 1500 data);
- Progress in humanitarian subjects (about 1200 data);
- Creative skills (about 400 data).

As the first input variable, academic performance in core subjects (mathematics, physics, computer science) is used. It is known that the highest quality is the indicators for these subjects, the highest indicators, average indicators, the rest are classified as low indicators. These indicators will reveal to us the IT skills of the student.

Non-core subjects (languages, history, geography, art) are used as the second input variable. It is believed that the greatest effect brings indicators in languages, the smallest effect in other subjects. These skills will reveal to us the student is strong in the humanities or in the sciences.

The third input variable is student creativity. Indeed, the higher the performance in art, the more creative the student is.

Further, by combining the results according to the results obtained, it is possible to identify what the student is gifted with. The output variable is the effectiveness of education. An analysis of the effectiveness of education can serve as a basis for changes in the quality of education in rural and urban schools.

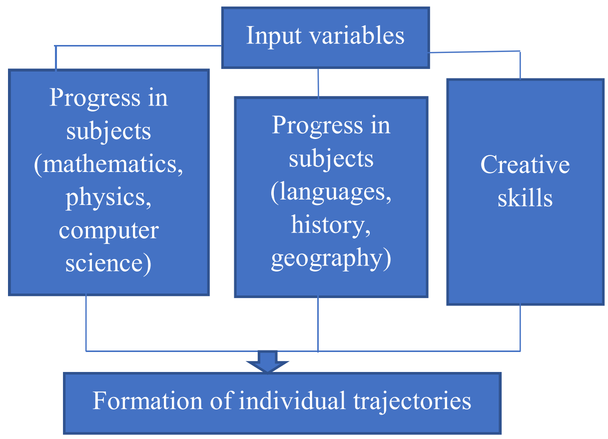

Fig.1. Model of formation of individual trajectories of a student

Fuzzy logic rule bases are the most commonly used tools in fuzzy logic applications, they are a set of rules that are usually used in parallel, but in most cases can be combined [3].

Rules of the following type apply:

For example: IF high score for physics AND high score for computer science AND high score for math THEN excellent computer knowledge.

As we already know, the processing of fuzzy logic consists of three parts (see Fig. 2).

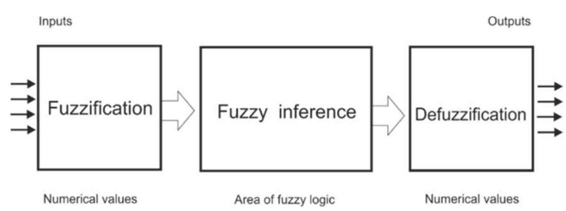

Fig. 2. Fuzzy logic processing process

Most commonly used for fuzzy inference by the Mamdani mechanism. Further in the article, the Mamdani rule bases are used. The result of a fuzzy rule is a combination of sentences joined by AND operators. The main idea of the Mamdani inference engine is the Mamdani fuzzy rule base, which contains linguistic rules that use membership functions to describe the applied concepts (see Fig. 3)

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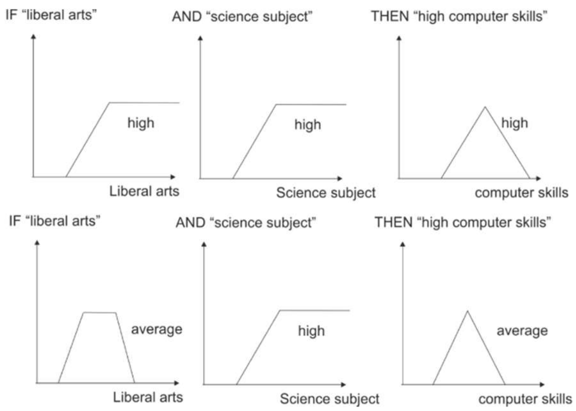

Fig. 3. Rule results

As we mentioned above, the inference mechanism consists of the following steps:

The problem statement (fuzzification) consists in deriving the membership functions used in rule statements as shown in the figure below. (see Fig. 4.)

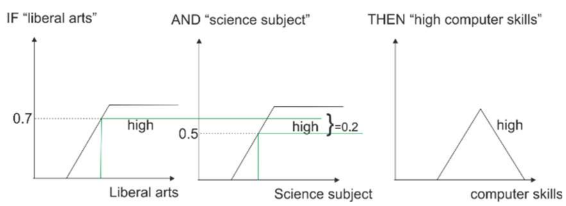

Fig. 4. Fuzzification

The degree of activation of the rule is used to determine the result of the rule. The resulting fuzzy set is constructed by searching for the minimum values among the activation degrees and membership functions and sorting the "truncated" membership functions (see Fig. 5).

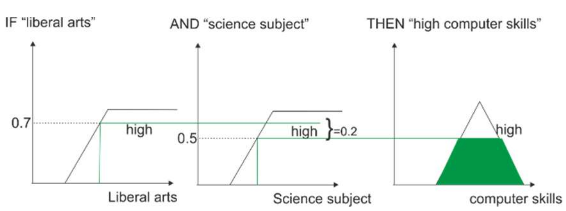

Fig. 5. Result output

The total output fuzzy set is obtained by combining the fuzzy sets obtained as a result of applying each generation rule for a given output. The example below shows the case when two rules influence the formation of one output. [5]. It is assumed that the rules are connected by the logical operation "OR", so it is necessary to find the maximum value among the resulting membership functions for each rule (see Fig. 6).

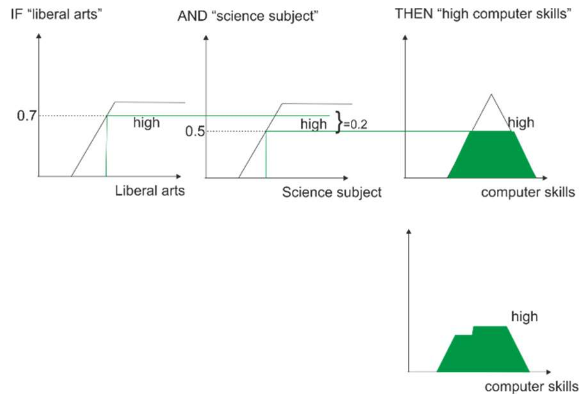

Fig. 6. Combining rules

At the end of the fuzzy inference stage, a finite odd set has already been identified, but it cannot be used directly to provide accurate information to the operator, since it is necessary to make a transition from the "fuzzy logic world" to the "real world", which is called defuzzification. A variety of methods are used for defuzzification, most often the method of calculating the "center of gravity" of a fuzzy set is used (see Fig. 7).

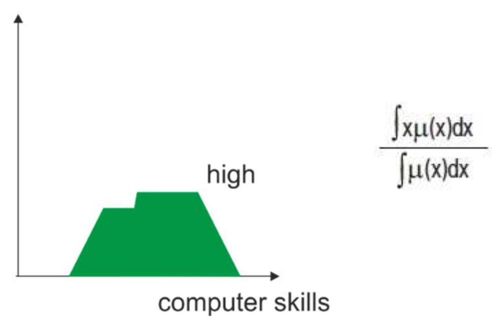

Fig. 7. Graphical way to represent the calculation of the "center of gravity" of a fuzzy set

3 RESULTS

Above are illustrations in graphical representations of the rules in the process of their use. In this work, 19 rules of thumb were compiled to determine IT skills using academic performance in core subjects.

1. IF high score for physics AND high score for computer science AND high score for math THEN excellent computer knowledge
2. IF average score for physics AND high score for computer science AND high score for math THEN excellent computer knowledge

3. IF average score for physics AND high score for computer science AND good score for math THEN excellent computer knowledge
4. IF average score for physics AND average score for computer science AND high score for math THEN good computer knowledge
5. IF average score for physics AND average score for computer science AND average score for math THEN average computer knowledge
6. IF high score for physics AND average score for computer science AND average score for math THEN average computer knowledge
7. IF average score for physics AND high score for computer science AND average score for math THEN average computer knowledge
8. IF average score for physics AND average score for computer science AND average score for math THEN average computer knowledge
9. IF low score for physics AND average score for computer science AND high score for math THEN average computer knowledge
10. IF low score for physics AND average score for computer science AND average score for math THEN average computer knowledge
11. IF low score for physics AND high score for computer science AND high score for math THEN average computer knowledge
12. IF high score for physics AND low score for computer science AND high score for math THEN average computer knowledge
13. IF high score for physics AND high score for computer science AND low score for math THEN average computer knowledge
14. IF low score for physics AND low score for computer science AND high score for math THEN average computer knowledge
15. IF high score for physics AND low score for computer science AND low score for math THEN average computer knowledge
16. IF low score for physics AND average score for computer science AND low score for math THEN low computer knowledge
17. IF average score for physics AND low score for computer science AND low score for math THEN low computer knowledge
18. IF low score for physics AND low score for computer science AND average score for math THEN low computer knowledge
19. IF low score for physics AND low score for computer science AND low score for math THEN low computer knowledge

A number of the above rules give us an explanation that if a student has excellent scientific knowledge based on rules No. 1-4, which states that the student shows excellent results in the subjects of physics, mathematics and computer science, then he will have high computer knowledge skills. And if a student has average scientific knowledge based on rules No. 5 - 15, which describe acceptable options between average and excellent, for example, excellent results in physics, high results in mathematics, average in computer science, then he will have average computer knowledge skills. The remaining 4 rules from #16-20 demonstrate that a student's low computer skills are based on the results obtained in these three subjects, where the results in the subjects range from average to low.

The above rules are all aimed at determining computer knowledge and skills, and the giftedness of students has multiple areas of skills and knowledge, for example, humanitarian knowledge, natural science knowledge, creative skills, sports, etc., and to determine these skills and knowledge, it will be necessary to build a base of fuzzy rules. This study provides a model of a gifted student who will build an individual trajectory, and identify what the student is gifted in, and give in what direction the teacher will need to work in the future when planning and conducting lessons.

A set of rules of thumb where academic achievement in the humanities is used.

1. IF high score in 3 languages AND high score in history AND high score in geography AND high score in art THEN low in science skills
2. IF average score in 3 languages AND high score in history AND high score in geography AND high score in art THEN low in science skills
3. IF high score in 3 languages AND average score in history AND high score in geography AND high score in art THEN low in science skills
4. IF high score in 3 languages AND high score in history AND average score in geography AND average score in art THEN low in science skills
5. IF average score in 3 languages AND average score in history AND high score in geography AND high score in art THEN average in science skills
6. IF average score in 3 languages AND high score in history AND average score in geography AND high score in art THEN average in science skills
7. IF average score in 3 languages AND high score in history AND high score in geography AND average score in art THEN average in science skills
8. IF high score in 3 languages AND average score in history AND average score in geography

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AND high score in art THEN average in science skills

9. IF average score in 3 languages AND average score in history AND average score in geography AND high score in art THEN average in science skills

10. IF average score in 3 languages AND average score in history AND average score in geography AND average score in art THEN average in science skills

11. IF low score in 3 languages AND low score in history AND low score in geography AND low score in art THEN excellent in science skills

12. IF average score in 3 languages AND low score in history AND low score in geography AND low score in art THEN excellent in science skills

13. IF low score in 3 languages AND average score in history AND low score in geography AND low score in art THEN excellent in science skills

14. IF low score in 3 languages AND low score in history AND average score in geography AND average score in art THEN excellent in science skills

The next series of identified fuzzy rules from No. 1-4 gives the concept that high results in any three languages (Kazakh, Russian, English, German, French, Chinese selectively), history and geography, the student has low knowledge in scientific subjects such as chemistry, biology and physics. Rules No. 5 - 10 show results in the humanities range from high to average, that is, the results obtained vary in this interval and show average knowledge in scientific subjects. The rest of the rules showing high knowledge in science subjects are based on low scores in the selected subjects to determine the results.

All 14 rules are aimed at identifying the level of humanitarian knowledge and natural science knowledge of the student, all language subjects are taken into account, of which there are subjects that are emitted by students of their choice, for example, someone is studying German and someone is Chinese, but in all subjects the level of proficiency in language competencies at the level passing international exams, which will help to choose the direction for both the student and the teacher for the further development of academic knowledge, participation in various project, olympiad competitions.

The main purpose of this study is to identify how much in which direction this or that student is gifted for the further development of his giftedness, and how to plan the lesson more effectively to help students know their focus. If the teacher knows the student's trajectory it will improve the educational process and benefit all partners in the educational organization, it will mainly help students with low academic performance as the teaching does not apply the correct way of teaching that does not match their skills.

For the experiment, a group of students in the amount of 36 people from three senior classes (grades 10, 11, 12) was analyzed. The present study showed that 40% or more of the students were unable to name their correct learning style. This study depended not only on the responses to questionnaires, but also an attempt to find out the relationship between different questionnaires, through a correlation process, which revealed that students had more than one learning style (orientation, learner skills). The proposed model for identifying their individual trajectories has proven that most students are likely to be multimodal learners, so we need to change learning strategies to help students learn effectively and better, both as a student and the education system.

There are several limitations to consider when selecting students in explaining the results of this study.

1. In this study, only high school was considered

of students who study in the choice of subjects. The remaining students of different specialties or schools were not evaluated.

2. This study did not take into account the gender of students to determine whether boys are more gifted or girls.

3. This study did not examine teachers' teaching methods and how the mismatch between teachers' teaching methods and students' learning styles would affect the enhancement of the learning process.

For data analysis, for example, the results for three grades 10, 11, 12 are taken. In each of their classes there are 12 students, the results of students for the 1st quarter are taken, the data are presented in the table below.

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Grade 12	Math	Physics	Computer science	Languages						History	Geography
				Kazakh	Russian	English	Germany	French	Chineese		
Student 1	60	65	70	95	88	85				90	96
Student 2	76	77	80	70	75		85			80	76
Student 3	69	80	65	68	70				80	86	76
Student 4	88	90	33	65	70	70				78	82
Student 5	92	56	86	80	79	81				80	60
Student 6	78	79	83	68	72	80				86	79
Student 7	41	66	69	80	85				75	87	85
Student 8	49	58	75	88	72	85				88	80
Student 9	88	79	38	77	79			88		90	89
Student 10	85	80	87	97	85				77	70	66
Student 11	64	70	75	94	90	90				75	73
Student 12	74	85	94	93	90			90		71	69

Grade 11	Math	Physics	Computer science	Languages						History	Geography
				Kazakh	Russian	English	Germany	French	Chineese		
Student 1	80	65	70	95	78	83				90	85
Student 2	76	77	80	70	75				83	67	76
Student 3	89	80	65	68	70		80			86	77
Student 4	88	91	53	70	80				70	78	82
Student 5	92	56	86	80	79	85				80	60
Student 6	78	79	83	77	80	80				56	69
Student 7	57	66	69	80	85				77	87	85
Student 8	49	58	75	67	86				85	77	80
Student 9	88	79	62	57	79			88		83	79
Student 10	85	43	87	97	85				77	70	66
Student 11	64	70	75	94	90	90				75	73
Student 12	74	85	67	73	60			90		71	96

Grade 10	Math	Physics	Computer science	Languages						History	Geography
				Kazakh	Russian	English	Germany	French	Chineese		
Student 1	70	65	70	95	78	83				90	85
Student 2	76	77	90	90	75	83				80	96
Student 3	89	80	40	68	70				80	86	77
Student 4	88	91	83	80	93	86				66	86
Student 5	87	56	78	79	83	85				80	60
Student 6	98	98	83	77	80	80				84	69
Student 7	90	86	69	80	85				77	87	85
Student 8	49	58	75	67	86	85				77	80
Student 9	88	79	90	57	79			88		83	79
Student 10	85	86	87	97	85				77	50	66
Student 11	84	70	75	94	90	90				75	73
Student 12	74	85	87	73	40			95		81	96

The results in the table are given as percentages from 1-100%. The scale is defined as follows, score 5 - from 85-100%, score 4 from 65-84%, score 3 from 50-64%, score 2 from 0-49%. Consider table 1 where the results of grade 12 are presented. Student 1 has 60% -3 in mathematics, 65% - 4 in physics, 70% - 4 in computer science, which shows average results; for 85%, which correspond to high results, which demonstrates to us compliance with the identified fuzzy rules, which shows that if the level of knowledge is high in all humanitarian subjects, then academic performance in scientific subjects will be low.

Fuzzification of input and output variables. As a term-set of the "Physics" variable, we use the set T1 = {"from 0 to 49", "from 50 to 84", "from 85 to 100"}, or in symbolic form T1 = {PS, PM, PB} with term membership functions shown in Fig. 8.

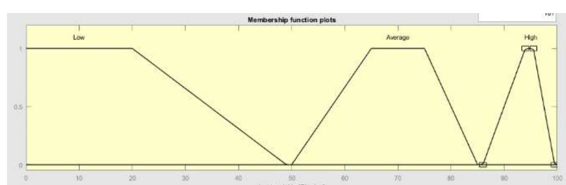

Fig. 8. Graph of terms belonging to the variable "Physics"

As a term-set of the variable "Informatics" we use the set T2 = {"from 0 to 49", "from 50 to 84", "from 85 to 100"}, or in symbolic form T2 = {PS, PM, PB} with term membership functions shown in Fig. 9.

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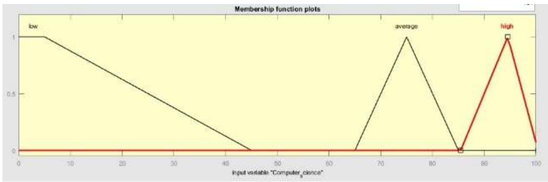


Fig. 9. Graph of terms belonging to the variable "Computer science"

As a term-set of the "Mathematics" variable, we use the set T3 = {"from 0 to 49", "from 50 to 84", "from 85 to 100"}, or in symbolic form T2 = {PS, PM, PB} with term membership functions shown in Figure 10.

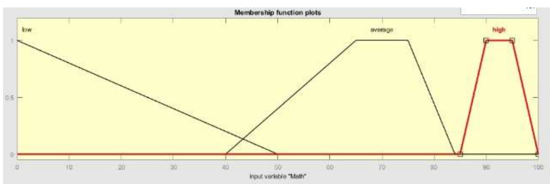


Fig. 10. Graph of terms belonging to the variable "Mathematics"

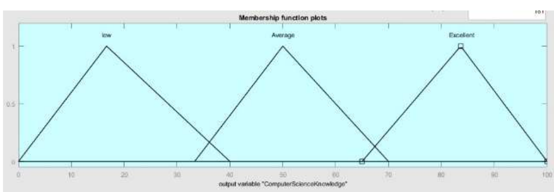


Fig. 11. Graph of terms belonging to the variable "IT skills"

As a term-set of the output variable "Effectiveness of the quality of education" we will use the set T4 = {"Low", "Medium", "High"} or in symbolic form T4 = {PS, PM, PB} with the membership functions of the terms shown in figure 11.

We will use the Mamdani method as a fuzzy inference scheme. This is the most common method of logical inference in fuzzy systems. It uses minimax composition of fuzzy sets. This mechanism includes the following sequence of actions:

1. Fuzzification procedure: the degrees of truth are determined, i.e. the values of the membership functions for the left parts of each rule (prerequisites). For a rule base with m rules, we denote the degrees of truth as Aik(xk), i=1..m, k=1..n;

2. Fuzzy conclusion. First, the "cutoff" levels for the left side of each of the rules are determined:

$$alfa_i = \min_i\left(A_{ik}\,(x_k)\right) \qquad (1)$$

Next are the "truncated" membership functions:

$$B_i^*(y) = \min_i(alfa_i\,, B_i(y)) \qquad (2)$$

3. Composition, or union of the obtained truncated functions, for which uses the maximum composition of fuzzy sets:

$$MF(y) = \max_i(B_i^*(y)) \qquad (3)$$

where MF(y) is the membership function of the resulting fuzzy set;

4. Defuzzification, or bringing to clarity. There are several defuzzification methods. For example, the mean center method, or the centroid method:

$$MF(y) = \max_i(B_i^*(y)) \qquad (4)$$

The geometric meaning of this value is the center of gravity for the MF(y) curve. Formation of the rule base of fuzzy inference systems. To build the rule base, we will use 19 fuzzy production rules, which are conveniently presented in the form of the following table (Table 1).

Table 1 - Fuzzy Production Rules For The Considered Fuzzy Inference System

Rule number	Physics	Computer science	Mathematics	IT skills
1	2	3	4	5
1.	PB			PB
2.	PM			PM
3.	PS			PS
4.		PS		PS
5.		PB		PB
6.		PM		PM
7.			PS	PS
8.			PB	PB
9.			PM	PM
10.	PB	PB	PB	PB
11.	PM	PM	PM	PM
12.	PS	PS	PS	PS
13.	PB	PB	PM	PB
14.	PB	PB	PS	PB
15.	PM	PM	PB	PM
16.	PM	PM	PS	PB
17.	PS	PS	PB	PS
18.	PS	PS	PM	PB
19.	PS	PM	PB	PB

Next, you need to define methods for aggregating sub conditions. Since in all rules 1-19 only a fuzzy conjunction ("AND" operation) is used as a logical connective for sub conditions, we will use the min-conjunction operation as the aggregation method.

To accumulate the conclusions of the rules, we will use the max-disjunction method, which is also used in the case of the Mamdani fuzzy inference scheme. Finally, we will use the center of gravity method as a defuzzification method.

Building a fuzzy model using Fuzzy Logic Toolbox and analyzing the results. We will build a fuzzy model using the graphical tools of the MATLAB system [24].

To this end, in the FIS editor, we will define 3 input variables named "Physics" (β1), "Computer Science" (β2), "Mathematics" (β3), and one output variable named "IT skills" (β4).

The view of the graphical interface of the FIS editor for these variables is shown in Figure 12.

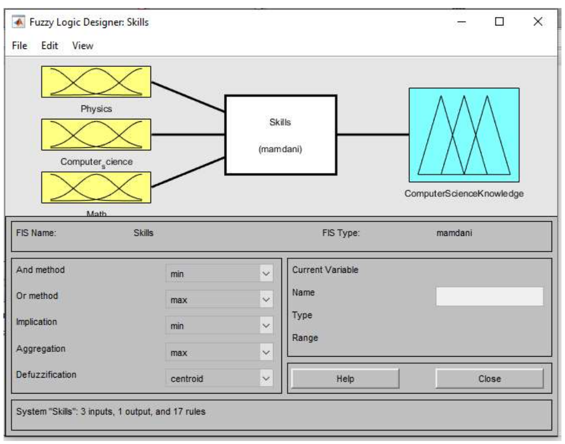


Fig. 12. Graphical Interface Of The FIS Editor After Defining The Input And Output Variables Of The CS Fuzzy Inference System

To solve the problem of fuzzy modeling, we will use a Mamdani-type fuzzy inference system. Let us leave unchanged the parameters of the developed fuzzy model, proposed by the MATLAB system by default, namely, logical operations (min for fuzzy logical AND, max for fuzzy logical OR), implication method (min), aggregation method (shah) and defuzzification method (centroid) [24].

Next, you should determine the membership functions of terms for each of the 3 input and the only output variables of the fuzzy inference system under consideration.

For this purpose, we will use the editor of membership functions of the MATLAB system. We will use the types of membership functions and the corresponding numerical values of their parameters.

The graphical interface of the membership function editor for the output variable "IT skills" is shown in Figure 13.

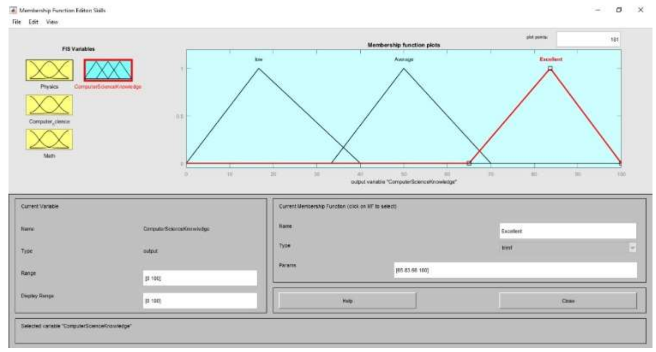


Fig. 13. Graphical Interface Of The Editor Of Membership Functions For The Output Variable "Efficiency Of The Quality Of Education"

Next, we set 19 rules for the developed fuzzy inference system (Table 4). For this purpose, we will use the MATLAB rules editor. The view of the graphical interface of the rules editor after setting all 19 fuzzy inference rules is shown in Figure 14.

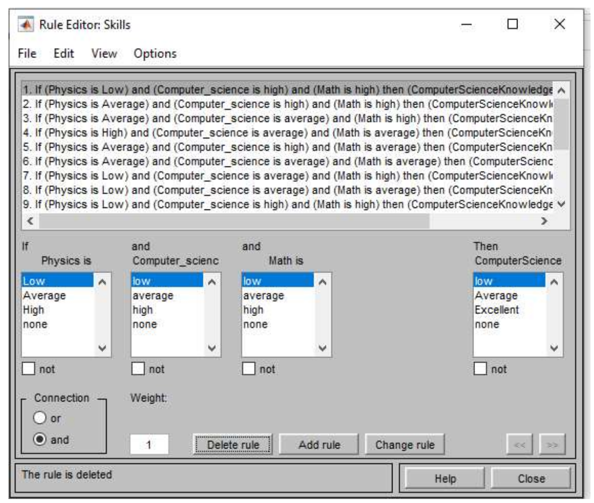


Fig. 14. The Graphical Interface Of The Rules Editor After Setting The Rule Base Of The Fuzzy Inference System

Now we can analyze the constructed fuzzy inference system for the problem under consideration.

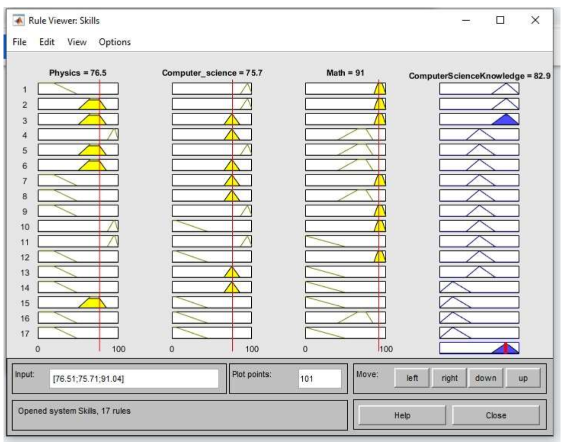
To this end, we open the window for viewing the rules of the MATLAB system and enter the values of the input variables for a particular case, when the value of the input variable "Physics" is 40.3%, the value of the input variable "Informatics" is 36.3%, the value of the input variable "Mathematics" is 37.9 %.

The fuzzy inference procedure performed by the MATLAB system for the developed fuzzy model results in the value of the output variable "IT skills" 46.2.

This is an average indicator for the formation of the student's individual trajectories.

Let's analyze the constructed system of fuzzy inference for the second variant of the initial data with higher values of input variables. To this end, we will change the values of the input variables: the value of the input variable "Physics" 76.5%, the value of the input variable "Informatics" 75.7%, the value of the input variable "Mathematics" 91%.

The fuzzy inference procedure performed by the MATLAB system for the developed fuzzy model results in the value of the output variable "IT skills" 82.9 (Fig. 15). This is a high indicator of the student's individual trajectories.



For a general analysis of the developed fuzzy model, it may also be useful to visualize the corresponding fuzzy inference surface.

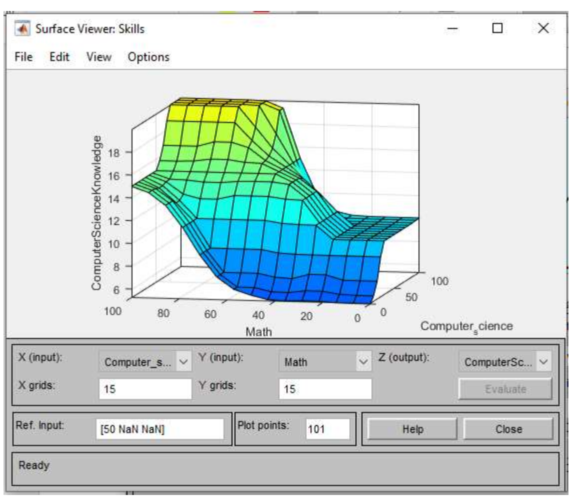


Fig. 15. Visualization Of The Surface Of The Fuzzy Inference Of The Model Under Consideration For The Input Variables "Informatics" And "Mathematics"

This fuzzy inference surface allows you to establish the dependence of the values of the output variable on the values of individual input variables of the fuzzy model. The analysis of these dependencies can serve as a basis for changing the membership functions of input variables or fuzzy rules in order to increase the adequacy of the fuzzy inference system.

The use of fuzzy logic is both a means of improving quality and productivity, fuzzy logic offers competitive advantages to manufacturing companies in search of technical and economic optimization, and our experience has shown that it can be applied to the education sector. This article identifies areas where this approach can be used most effectively. Thanks to the convenient user interface of the MATLAB programming environment [25], fuzzy logic is available to all users involved in automatic control who want to improve their skills and knowledge, as well as the performance of their developments. The application of fuzzy logic has its own special areas in which it excels: these are areas where practical experience is important, nuances in decision making and consideration of non-linear and subjective parameters, not to mention conflicting decision factors.

In this direction, several works have already been published [28-30], where an experiment was conducted specifically on the development of an academic language using differentiated learning, and there were also certain clear theoretical aspects in various learning styles. A literature review was made in studies of this topic. And an experiment was carried out on the basis of the school in the 7th parallel, to identify the competencies of students using the method of analyzing hierarchies.

4. CONCLUSION

This study, aimed at the formation of individual trajectories of student giftedness, is based on the analysis of large data arrays according to several criteria, through the use of theories, functions and principles of fuzzy logic, determined a list of significant factors that prevent the identification of student giftedness. As part of the study, data were taken from only a few classes (grades 10, 11, 12), where these data were used to determine the empirical rules of fuzzy logic, which were later used to form the student's individual trajectories. In the course of the study, the stages of fuzzy inference based on

- formations of the rule base of fuzzy inference systems;
- fuzzifications of input variables;

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- association of subconditions in fuzzy production rules.

Thus, from a variety of methods and models of fuzzy logic, we have applied the following, in the course of the study we used the empirical rules of fuzzy logic to analyze and identify giftedness, to accumulate the conclusions of the rules, the max-disjunction method was used, which is also used in the case of the Mamdani fuzzy inference scheme, also, as a defuzzification method, the center of gravity method was used, which made it possible to develop an author's model for identifying giftedness and building individual development trajectories for a gifted student. This model differs from the existing models in that it takes into account academic performance in all areas, humanitarian and profile subjects, and the subjects of the choice of which the student chooses independently for further in-depth study, as well as the student's creative skills, all these skills are determined on a scale and combined, then an individual trajectory of giftedness is built.

The results of the study are the basis for the subsequent formation of the individual trajectories of the student, which in the future, on its basis, correctly and clearly choose the direction for learning and developing the student's giftedness, which will facilitate the use of all stages of differentiation in the classroom.

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