Advances in Social Science, Education and Humanities Research, volume 273
International Conference on Communicative Strategies of Information Society (CSIS 2018)

Some Approaches to Analysis of Learning Trajectory Correction Using Theory of Fuzzy Sets

Rosa U. Stativko
Department of Information Technologies
Belgorod State Technological University
named after V.G. Shukhov
Belgorod, Russia
Stativko1@mail.ru, stativko.ru@bstu.ru

Abstract **- Modern society is characterized by a high development of technology, which forces a person to timely retrain in a professional way. The educational process requires using new educational technologies. The user of educational technologies needs approaches to assess his level of knowledge. Such approaches for evaluation can be developed using a fuzzy set apparatus.**

Keywords - educational technologies; linguistic variable; learning process; consumer

I. INTRODUCTION

World society is associated with the rapid development of technology, the change of nature, the emergence of new forms of employment and interaction of people, which in turn requires knowledge connected not only with one's professional field of activity, but also with knowledge of related work areas. To take up a successful position in society, a person needs to be well-oriented in the information space, be able to master the skills in time, have communication skills, and think creatively, which often requires the necessary education.

Modern education is characterized by a dynamically increasing and changing amount of knowledge in various branches of science and industry. Mastering a large amount of information in the learning process is problematic when using only classical learning technologies that are limited by time, geography and territory. Consequently, in such situations it is necessary to develop and use the latest educational technologies, combining both traditional methods, information and communication.

Information and communication educational technologies imply the totality of educational technologies using various possibilities of information technologies (author's educational disciplines, electronic library fund, multimedia, online technologies, etc.). The purpose of the development of new educational technologies is to improve the quality and speed of perception of educational material, to improve the quality of educational content, to develop approaches to adjust educational trajectories, which will allow the consumer of educational services to improve the educational level.

Modeling new educational technologies implies a combination of both developed knowledge structures and the presentation of educational material in different forms (choosing the form of presentation of educational material, colors when working with educational material, accompaniment/deactivation of sound, availability of graphic material, availability of a testing unit, tips, monitoring learning outcomes), as well as providing the consumer with educational services, the opportunity to monitor and analyze learning outcomes. All this will allow the consumer of educational services to carry out the learning process more effectively, and, if necessary, to make adjustments to the learning process, using various educational technologies available in the educational process of the educational institution.

II. CHARACTERISTICS OF THE STUDY AREA.

The educational process in a higher educational institution consists of a combination of various types of training (full-time education, distance learning, distance learning, advanced training), various training technologies that accompany relevant forms of education, subject to management control. In the global approach, a fragment of the structure of the educational process of a higher educational institution can be shown as in Fig.1. In the presented scheme, the consumer of educational services is an active participant in the educational process.

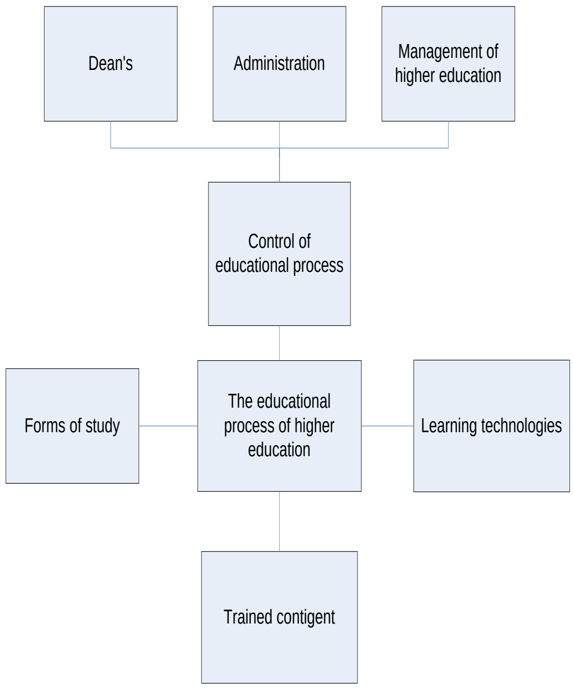

Fig. 1. Components of the structure of the educational process of a higher educational institution.

Based on the above, it can be concluded that the learning process is a complex semi-structured system consisting of a set of indicators that are different in nature [1-4]. The system is dynamically changing, for formalization of which existing formalized methods and approaches are not always suitable. A system requires adjustments in terms of changing the components that make it up in accordance with requests from the external environment. A system includes a consumer of educational services. A system uses a large amount of different data, for which fuzzy logic will provide an adequate display of uncertainties and inaccuracies.

The continuous development of society is accompanied by the disappearance of existing jobs and the emergence of new jobs requiring training. The task of the higher education institution is to respond flexibly to changes by modifying the corresponding components of the learning process and giving them to the consumer of educational services.

The consumer of educational services as an active participant in the educational process, regardless of the form of education using different training technologies, has the goal of obtaining quality education, which will allow the consumer to improve his position in the labor market and increase the level of demand. The availability of a timely opportunity to adjust the trajectory of training enables the consumer of educational services to obtain the required education and

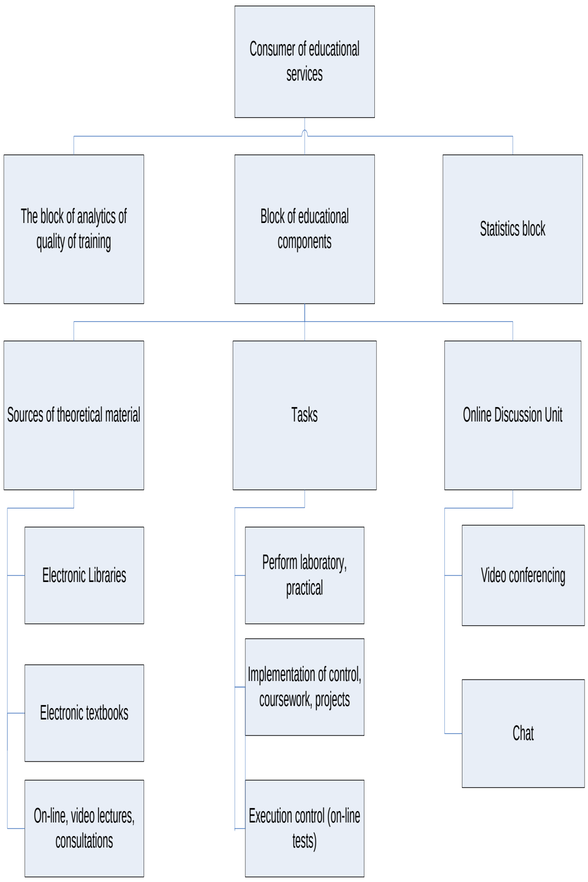

Fig. 2. The structure of the components included in the learning path

As mentioned above, the availability of the possibility of adjusting the educational trajectory allows the user to strengthen his position in the labor market, i.e. increase their own level of demand in the labor market. It is difficult to timely respond to the demands of the labor market. To achieve this goal, the consumer of educational services must have the technology to adjust the individual educational route, taking into account the choice of optimal forms and rates of education. There must be the possibility of applying different approaches in training that are most suitable for the individual characteristics of the consumer of educational services. Let us suppose that a consumer of educational services knows that his understanding of the material is more successful if the material he studies not only can be read, repeated as necessary, the most significant moments of the material, but he also has the opportunity to listen, use the graphical presentation, discuss the material, etc.

The consumer must have information about the characteristics of the educational process. Fig. 2 presents the structure of the constituent components included in the learning trajectory, with which, if necessary, you can make the required adjustment. In the process of adjusting the learning trajectory, the user inevitably faces the problem of the lack of an unequivocal list of requirements by the level of training, as well as a list of the indicators that should be included in the list being formed, how to evaluate these indicators different in nature [3-9]. unequivocally assess the concept of the "level of demand" in the labor market, since in this case there is a linguistic uncertainty. Let us suppose that a consumer of educational services received a “good level of knowledge,” but there is no information about vacant jobs in the labor market, or the consumer does not have a sufficiently high level of personal qualities, such as responsibility, etc., to match the vacant job.

III. MAIN PART.

The assessment of such linguistic concepts requires the involvement of experts, which in turn introduces a share of subjectivity. Considering the concept of “level of demand” as a linguistic variable, one should use the apparatus of fuzzy sets in order to adequately describe, formalize and obtain a numerical estimate in the numerical continuum. Imagine the "level of demand" as a set of three components (Fig. 3).

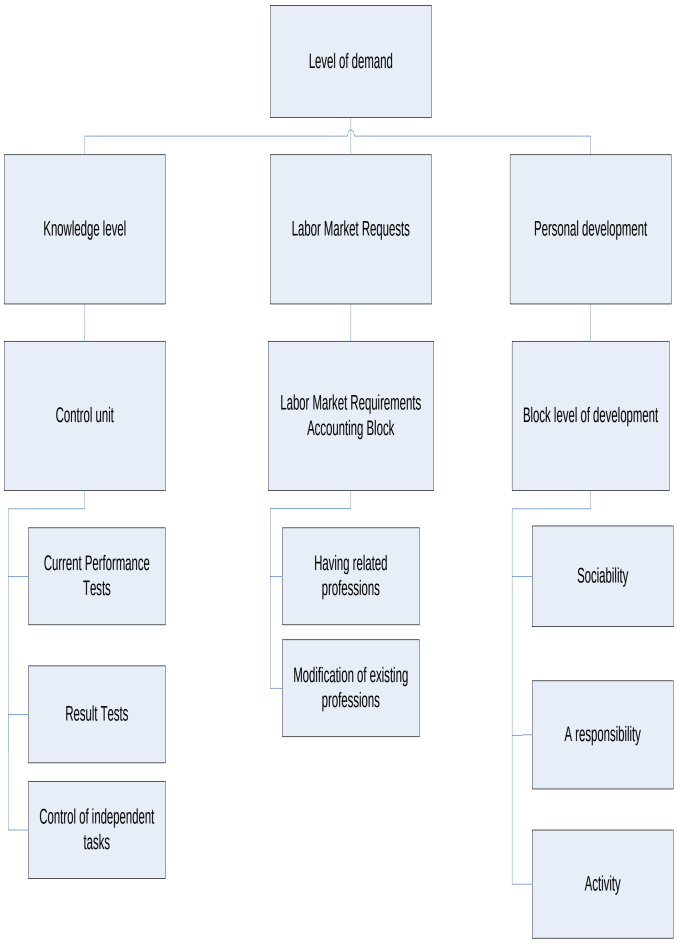

Fig. 3 Components of “demand level”

In this paper we will focus on the development of approaches to assess the level of knowledge. We will define the linguistic variable YZ “level of knowledge” by the following tuple:

$$YZ=<\beta, T_i, X, G, M>$$

where β – name of the linguistic variable "level of knowledge";

Ti (term set) - contains a set of linguistic values of a variable.

For example, T1 - "low level of knowledge";

T2 - “medium level of knowledge”;

T3 - "a high level of knowledge."

X is a base set. In this case, the numerical scale [0…100] will serve as the base set.

G is a syntactic procedure that generates new verbal values of a linguistic variable with the help of modifiers, based on the values included in the term set. For example, “very low level of knowledge” or “more or less acceptable level of knowledge”.

M is a semantic procedure that forms a set of semantic rules, as a result of which the value of a linguistic variable is mapped to fuzzy sets. The procedure allows one to formalize the qualitative knowledge of experts, which are often presented in the verbal form.

In order to move from a qualitative presentation to a formalized one, it is necessary to develop membership functions. There are no restrictions on the representation of the membership function, but in practice, the most frequently used membership functions are those with a simple mathematical representation.

On the basis of an expert survey procedure, piecewise-linear membership functions, in particular, both triangular and trapezoidal can be used to obtain an estimate of the values “low level of knowledge”, “medium level of knowledge”, and “high level of knowledge”.

Let us define a fuzzy model for the linguistic variable YZ, as a system with three inputs and one output.

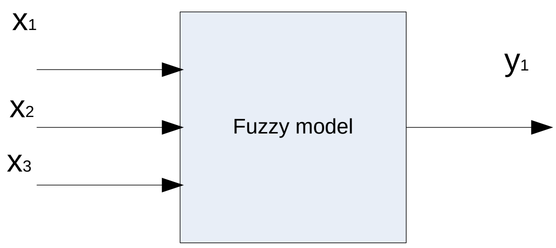

Fig 4. The structure of a fuzzy model

where x1 - results of tests of current performance; x2 - the resulting tests; x3 - control of independent tasks; y1 is the value of output linguistic variable YZ.

The value of the output variable y1 is obtained using a simplified fuzzy inference, which includes the following steps:

- development of a base of fuzzy rules;
- fuzzification of input and output variables;
- aggregation of sub-conditions;
- activation of sub-conclusions;
- accumulation of conclusions.

The bases of fuzzy rules are developed on the basis of rules of the form "if ... - then ..." reflecting the expert's knowledge. The peculiarity of such statements is that their adequacy does not change with minor changes in the data. The work presents a fuzzy system, which is based on expert knowledge and developed fuzzy rules. In this case, the fuzzy rules are set when the fuzzy terms membership form is selected, with the help of which the inputs and outputs of the fuzzy system are evaluated. As a rule, the higher the professional level of the expert, the higher the adequacy of the fuzzy model constructed at this stage of setting.

Let us consider the steps of a simplified fuzzy inference in the following view:
- define the input and output linguistic variables and their limits;
- define the membership functions for each input and output variable;
- develop a base of fuzzy rules that will be responsible for

managing operations;
• make the transition from fuzziness to specific numeric values.

Let us imagine each stage in turn.

Definition and interpretation of input variables and their limits. Previously, three parameters were indicated for assessing the level of knowledge; now we use them as three input variables:
x1 - the results of tests of current performance;
x2 - the resulting tests;
x3 - control of independent tasks.
Each input variable will be evaluated on a universal scale [0…100].

TABLE 1 CHARACTERISTICS OF THE CURRENT PERFORMANCE TEST SCORES

Linguistic characteristic	Lower value	Upper value
Excellent result	85	100
Good result	60	90
Average result	45	70
Below the average	25	50
Bad result	0	35

TABLE 2 CHARACTERISTICS FOR THE RESULTING TESTS

Linguistic characteristic	Lower value	Upper value
Excellent result	85	100
Good result	60	90
Average result	45	70
Below the average	25	50
Bad result	0	35

TABLE 3 CHARACTERISTICS FOR THE CONTROL OF INDEPENDENT TASKS

Linguistic characteristic	Lower value	Upper value
Excellent performance	85	100
Very good performance	60	90
Good performance	45	70
Not very good performance	25	50
Poor performance	0	35

Definition and interpretation of output variables and their limits. One output variable is available: y1 - the value of the output linguistic variable YZ. The output variable will also be evaluated on a universal scale.

TABLE 4 CHARACTERISTICS OF KNOWLEDGE

Linguistic characteristic	Lower value	Upper value
High level	85	100
Good level	60	90
Low level	45	70
Very low level	25	50
No level	0	35

The definition of the membership function for each input and output variable. We use trapezoidal membership function (1):

$$f_T(x;a,b,c,d)=\begin{cases} 0, & x \le a \\ \dfrac{x-a}{b-a}, & a \le x \le b \\ 1, & b \le x \le c \\ \dfrac{d-x}{d-c}, & c \le x \le d \\ 0, & d \le x \end{cases}. \qquad (1)$$

The function of this type characterizes the uncertainty of the form: "approximately equal", "similar to the object", "similar to ...". The lower and upper values define the trapezoidal membership function for each input and output variable. Graphically, the trapezoidal membership function has the following representation (Fig. 5).

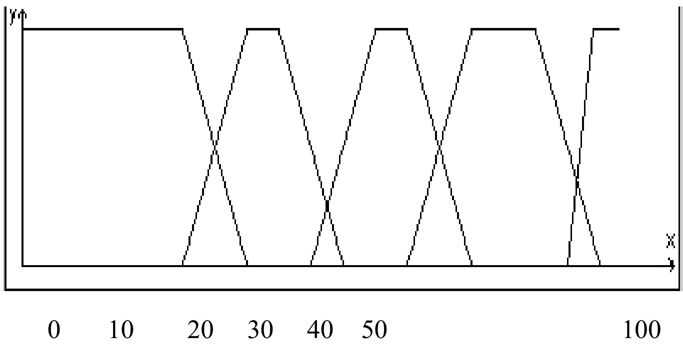

Figure 5. Membership functions of trapezoid view

Let us reduce the developed fuzzy rules in table 5.

TABLE 5 FUZZY RULE BASE

№	x1	x2	x3	y1
1	**2**	**3**	**4**	**5**
1	Excellent result	Excellent result	Excellent performance	High level
2	Excellent result	Excellent result	Very good performance	High level
3	Good result	Excellent result	Excellent performance	High level
4	Good result	Excellent result	Very good performance	High level
5	Excellent result	Good result	Excellent performance	High level
6	Good result	Good result	Very good performance	High level
7	Average result	Excellent result	Excellent performance	High level
8	Average result	Good result	Excellent performance	Good level
9	Good result	Average result	Very good performance	Good level
10	Average result	Good result	Good performance	Good level
11	Good result	Average	Good	Good level

		result	performance	
12	Average result	Average result	Good performance	Good level
13	Average result	Average result	Very good performance	Good level
14	Average result	Good result	Not very good performance	Low level
15	Excellent result	Very low result	Not very good performance	Low level
16	Good result	Very low result	Not very good performance	Low level
17	Average result	Very low result	Good performance	Low level
18	Good result	Very low result	Not very good performance	Low level
19	Average result	Very low result	Very good performance	Low level
20	Very low result	Good result	Good performance	Very low level
21	Very low result	Average result	Good performance	Very low level
22	Very low result	Very low result	Good performance	Very low level
23	Very low result	Very low result	Not very good performance	Very low level
24	Bad result	Bad result	Poor performance	No level

Transition from fuzziness to specific numeric values. Let us suppose: x1 - the results of tests of current performance, estimated at 52 points;

x2 - the resulting tests, estimated at 47 points;

x3 - control of independent tasks, estimated at 65 points.

Now it is necessary to determine which function is activated and to what extent. In Figure 6, in this case, an example is given of the activation of the membership function of the corresponding term set for the input linguistic variable x1 - "the results of current performance tests":

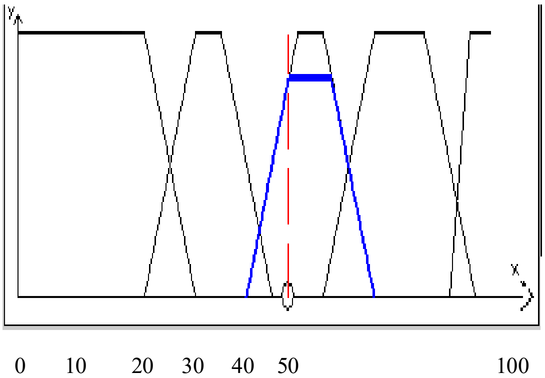

Figure 6. Activating the membership function of the input linguistic variable x1 - "test results of current performance"

The following rules are activated in the rule base:

Rule 12: If x1 - Average result And x2 - Average result And x3 - Good performance = min (0.8, 0.3, 0.6) = 0.3

Rule 13: If x1– Average result And x2- Average result And x3 - Very good performance = min (0.8, 0.3, 0.7) = 0.3

Rule 17: If x1– Average result And x2 - Below average And x3- Good performance = min (0.8, 0.4, 0.7) = 0.4

Rule 19: If x1– Average result And x2- Below average And x3 – Very good performance = min (0.8, 0.4, 0.6) = 0.4

The values obtained determine the intersection region for the output values y1.

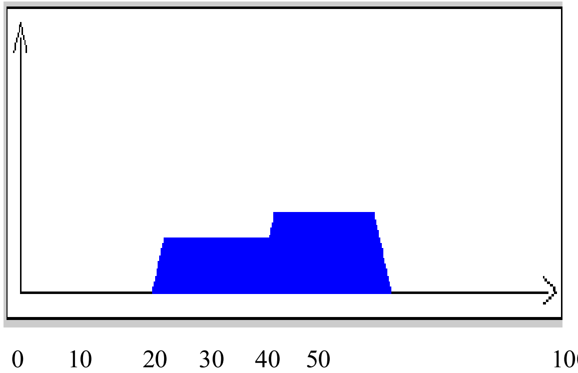

Figure 7. Area of intersection for knowledge output values

Now it is necessary to determine the maximum of the function with the minimum value of the argument. We get the value of y1 = 0.4 (in the numerical representation - 48).

IV. Conclusion

In this paper, brief concepts of a linguistic variable, its tuple are given, and characteristics are given to the components of a tuple. The knowledge of the linguistic variable is expanded, the scope of the linguistic variable is expanded. An analysis of approaches to assessing the level of knowledge has been carried out and a fuzzy system of knowledge control has been developed on the basis An example of the parameters by which the assessment of knowledge can be carried out.

The use of the developed fuzzy system with the involvement of experts will allow the consumer of educational services to carry out a timely assessment of the level of knowledge obtained in the learning process, and, accordingly, adjust the learning path.

Acknowledgement

The work is realized in the framework of the Program of flagship university development on the base of Belgorod State Technological University named after V.G. Shoukhov, using equipment of High Technology Center at BSTU named after V.G. Shoukhov.

References

[1] L. Zade, "The concept of a linguistic variable and its application for making approximate decisions", M.: Mir, 1976, p. 165.

[2] A.P. Ryzhov, "Elements of the theory of fuzzy sets and fuzziness measurements", Moscow: Dialogue-MSU, 1998, p. 116.

[3] S.A. Orlovsky, "Decision making problems with fuzzy source information", M.: Radio and communication, 1981, p. 286.

[4] A. Kofman, "Introduction to the theory of fuzzy sets", M.: Radio and Communication, 1982, pp. 432.

[5] L.A. Zadeh, “The role of soft computing and fuzzy logic in the understanding, design and development of information”, intelligent systems, News of Artificial Intelligence, No 2-3, 2001, pp. 7 – 11.

[6] A.N. Borisov, O.A. Krumberg, I.P. Fedorov, Making decisions based on fuzzy models: examples of use, Riga, ”Knowledge”, 1990, pp. 184.

[7] G.A. Miller, “Psychological Review”, 1956, No. 63, p. 81-97

[8] R.U. Stativko, “Score of index "use" of fuzzy information systems based on fuzzy qualimetry”, Devices and Systems. Management, Control, Diagnostics, Moscow, 2014, pp. 18-23.

[9] R.U. Stativko, “Use of the apparatus of fuzzy sets in the theoretical information analysis of the Internet portal of the educational organization”, XXI CENTURY: The results of the past and the problems of the present plus, Penza, volume 7, No. 3 (43), 2018, pp. 31-35.