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Competence of Economic Specialties Students

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THE INFORMATION TECHNOLOGIES FOR EVALUATING THE SPEECH-COMMUNICATIVE PROFESSIONAL COMPETENCE OF ECONOMIC SPECIALTIES STUDENTS

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Abstract. The authors propose information technologies for evaluating the level of speech-communicative professional competence of economic specialties students with the use of artificial intelligence, in particular, mathematical apparatus of neural networks and fuzzy logic. To transform the set of input to the set of output solutions the authors of the article propose the use of aggregation functions which are allow to assess the levels of: psychophysical qualities of the student; personal qualities of the student; language competence of the economic specialties students; economic specialties student's speech competence; ability to ensure the quality of the student's speech; skills to increase the effectiveness of the communicative process of student's speech. The purpose of the article is to formalize the process of evaluating the level of speech-communicative professional competence of language competence of the economic specialties students on the basis of mathematical apparatus of neural networks and fuzzy logic. The scientific novelty of the obtained results is the formation of methodological principles for evaluating the level of speech-communicative professional competence of language competence of the students on the basis of the mathematical apparatus of artificial intelligence and modern mathematical automated means. In particular, for the first time, it was proposed: the mathematical model for estimating the level of speech-communicative professional competence of economic specialties students and the method of its formalization which based on the mathematical apparatus of fuzzy logic and the Hopfield's neural network. It allows precisely and adequately with less losing time to map the set of input parameters to the set of resulting solutions, taking into account the wide range both quantitative and qualitative factors of influence to take into account the complexity and dynamism of such a process.

Keywords: information technologies in linguistics, professional speech-communicative competence of students, language competence, speech competence, language norms, Hopfield's neural network, fuzzy logic.

1 Introduction and related works

The new language training of economic specialties students should be universal adapted to the modern labor market using a person-centered approach to the educational process, its informatization and continuity. It has to consistently form in specialists the innovative and technical thinking and consciousness, a rational attitude to

the chosen profession. Language training has to enrich economic specialties specialists with theoretical knowledge and practical skills on the peculiarities of work, to need a vision of perspective; learn to master the basics of scientific organization of labor under the modern market relations; to evoke desire and need in the student to improve the results of their work on a daily basis, to cultivate the innovation thinking, initiative, diligence and discipline.

The whole system of professional speech-communicative competence formation of economic specialties students is based on the competence approach and is aimed at ensuring the professional readiness of the future employee for professional activity. Modern requirements for students' speech and communication competence are implemented in the discipline «Ukrainian language (by professional focus)» which is more effective, if there is an adequate monitoring of knowledge, skills and abilities of economic specialties students acquired after studying it.

One of the productive ways to evaluate the level of speech and communicative professional competence of economic specialties students is the use of mathematical apparatus of fuzzy logic (FL) and the Hopfield's neural network. The fuzzy-logical approach allows receiving of cardinal estimations for qualitative parameters, that is enables process of their formalization. Hopfield's neural network identifies the level of speech-communicative professional competence of economic specialties students with help of limited number of etalons which significantly reduces the time and money spent on such evaluation process.

Speech-communicative professional competence (SCPC) in modern science is an integrated phenomenon. In linguistic, linguodidactic complex studies this concept is interpreted differently. In particular, in K. Klimova's research [1] the criterias for the formation of speech-communicative professional competence which correspond to its constituent components: orthographic, phonological and orthoepic, lexical and phraseological, grammatical and punctuation, stylistic and discursive competence are defined. According to such criteria the levels of students' speech-communicative professional competence formation are determined as low (minimum), medium (sufficient), appropriate and high (creative) [1]. In particular, it is provided that for a high level of this competence the student ought: to have a thorough systematized knowledge of the Ukrainian language and effectively use it in the process of professional communication and desire for self-study, study.

In the study of T. Symonenko [2] the structure of professional communicative competence consists of four main competencies: linguistic, subject, pragmatic, technological. Accordingly, linguistic competence involves a set of knowledge about the structure of the language system as well as the ability to operate it in professional activity; subject competence determines the availability of professional knowledge in the system of philological disciplines, as well as the ability to apply them; pragmatic competence combines knowledge about the essence and features of pedagogical communication; technological competence involves the ability to clearly and distinctly express an opinion, to know the laws of speech technique. But such a structure of SCPC is only suitable for students of philological specialties and cannot be used as a universal criterion for evaluating the SCPC of students of any other specialties, for example, economics.

In modern research the issues of linguistic and communicative competence and implementation of new methods of its development during training are studied from an interdisciplinary point of view. So, in the article [3] a theoretical approach to the concept of SCPC is carried out, contextualized in the Spanish educational system which gives way to the description of a specific intervention proposal: the Program for Educational Innovation School Language Project. Much attention is also focused on the study of the problem of foreign language competences formation [4 – 6]. The concept and models for developing foreign language communicative competence in non-linguistic university students are also proposed [7, 8].

In the works devoted to SCPC in the context of studying the universal discipline «Ukrainian language (by professional focus)» researchers focus mainly on the analysis of methods and ways of forming SCPC, rather than evaluating the level of mastering it. In particular, it is a question of competence in the context of studying language norms and application of the acquired knowledge in professional activity. It is determined that most violations of the norms of modern Ukrainian literary language occur at the lexical-phraseological, syntactic and orthoepic levels [9].

Given the multifaceted interpretations and the lack of a clear approach for evaluating the level of student's SCPC, the authors believe that using their proposed method for evaluating based on artificial intelligence [10, 11] with an optimized set of estimation criteria, makes possible to form a clear system of evaluating of economic specialties student's SCPC.

Since speech-communicative professional competence is an important component of the general professional competence of economic specialties students, its research in terms of both the means of formation and monitoring the level of its mastery is an urgent task of modern linguistic research. Finding the criteria and levels of formation of student's SCPC and development of a method for evaluating the levels of this formation will allow better training of future professionals on the basis of objectivity of estimation, scientific, uni-formity of requirements and regularity.

The SCPC monitoring methods proposed in the above-mentioned works require a lot of time and material resources. They are rather limited in the set of evaluation parameters, are not strictly formalized and are mainly descriptive. These factors determine the need of the formalization of the process of estimating the level of economic specialties student's SCPC by development of an appropriate mathematical model and methodological approach based on artificial intelligence [10].

To better and more accurately determine the formation of economic specialties student's SCPC the authors of the article significantly expanded the set of estimation parameters, adding, in addition to language competence (7 indicators of knowledge based on modern Ukrainian literary language), speech competence (9 indicators based on basic speech activities – reading, writing, speaking, listening), as well as, assessing the skills of ensuring the quality of student speech and evaluating the level of skills to enhance the effectiveness of the communicative process of student speech [12]. In addition, the result would be incomplete and inaccurate without taking into account the levels of psychophysical and personal qualities of the student.

The **purpose** of the article is to formalize the process of evaluating the level of speech-communicative professional competence of economic specialties students on the basis of mathematical apparatus of neural networks and fuzzy logic.

2. Experimental Model

2.1 Building of mathematical model for evaluating the level of speech-communicative professional competence of economic specialties students

Mathematical model for evaluating the level of speech-communicative professional competence of economic specialties students should include the optimal set of input and output parameters which formed taking into account the criteria of completeness, efficiency and non-correlation and non-collinearity.

To do this, first of all, according to the criterion of completeness, it is necessary to select such a set of input evaluation parameters that they characterize as widely as possible the level of SCPC on the basis of a thorough analysis of all its elements of influence. Limiting the formed set of evaluation parameters according to the criterion of efficiency allows selecting parameters with the maximum degree of efficiency. Further reduction of the set should be carried out taking into account the criterion of minimality, i.e. the exclusion of all collinear and correlated parameters, etc.

The authors of the article propose a mathematical model for evaluating the level of speech-communicative professional competence of economic specialties students as:

$$\begin{aligned} \mathbf{X}^* \rightarrow \mathbf{Y}, \quad \mathbf{X}^* = \{x_p\}, \quad p = \overline{1, P}, \quad \mathbf{X} = f(\mathbf{X}^*), \quad \mathbf{X} = (x_{ij}), \quad i = \overline{1, n}, \quad j \in M, \quad \mathbf{Y} = (y_s), \quad s = \overline{1, 3}; \\ \mathbf{Y} = F(f_1, \dots, f_6), \\ f_1 = f(x_{11}, \dots, x_{17}), \quad f_2 = f(x_{21}, \dots, x_{28}), \quad f_3 = f(x_{31}, \dots, x_{36}), \quad f_4 = f(x_{41}, \dots, x_{49}), \quad f_5 = f(x_{51}, \dots, x_{57}), \\ f_6 = f(x_{61}, \dots, x_{66}) \end{aligned}$$

where the mapping functionality F is estimated on the basis of such functions:

- f_1 – evaluating the level of student’s psychophysical qualities – $f_1 = f(x_{11}, \dots, x_{17})$;
- f_2 – evaluating the level of student’s personal qualities – $f_2 = f(x_{21}, \dots, x_{28})$;
- f_3 – evaluating the level of economic specialties student’s language competence – $f_3 = f(x_{31}, \dots, x_{36})$;
- f_4 – evaluating the level of economic specialties student’s speech competence – $f_4 = f(x_{41}, \dots, x_{49})$;
- f_5 – evaluating the level of skills to ensure the quality of economic specialties student’s speech – $f_5 = f(x_{51}, \dots, x_{57})$;
- f_6 – evaluating the level of skills to enhance the effectiveness of the communicative process of student speech – $f_6 = f(x_{61}, \dots, x_{66})$.

In turn, the input evaluation parameters (x_{ij}) , $i = \overline{1, n}$, $j \in M$ for these functions are:

- for function f_1 :

x_{11} – visual perception;

x_{12} – auditory perception;

x_{13} – memory (mnemonic actions);

x_{14} – imagination (imaginative actions);

x_{15} – oral speech (interpersonal actions);

x_{16} – emotional and volitional regulation (self-control);

x_{17} – psychomotor skills (motor actions);

- for function f_2 :

x_{21} – attentiveness (actions of external control);

x_{22} – sociability (interpersonal actions);

x_{23} – mental skills;

x_{24} – interpersonal communication skills;

x_{25} – level of executive discipline;

x_{26} – compromise;

x_{27} – self-organization and responsibility;

x_{28} – level of social adaptation (ability to work collectively);

- for function f_3 :

x_{31} – knowledge of orthoepic norms of modern Ukrainian literary language (MULL);

x_{32} – knowledge of spelling rules of MULL;

x_{33} – knowledge of lexical norms of MULL;

x_{34} – knowledge of grammatical norms of MULL;

x_{35} – knowledge of stylistic norms of MULL;

x_{36} – knowledge of MULL punctuation rules;

- for function f_4 :

x_{41} – ability to listen;

x_{42} – the ability to express an opinion orally;

x_{43} – the ability to express an opinion in writing;

x_{44} – correctness of speech;

x_{45} – speech accuracy;

x_{46} – precision of speech expression;

x_{47} – speech adequacy;

x_{48} – knowledge of the peculiarities of the use of language tools depending on the style of speech;

x_{49} – knowledge of the peculiarities of the use of pictorial means of speech;

- for function f_5 :

x_{51} – mastery of the economic terms;

x_{52} – mastery of speech logic;

x_{53} – mastery of intonation variability;

x_{54} – predicting of communicative behavior;

x_{55} – implementation of interaction;

x_{56} – implementation of emotional-experimental influence;

x_{57} – mastery of speech etiquette;

- for function f_6 :
- x_{61} – formation of the purpose of speech (the whole communicative process);
- x_{62} – initiating the speech process;
- x_{63} – selection and implementation of types of speech;
- x_{64} – adaptation of communicative skills to social and educational conditions and a specific interlocutor;
- x_{65} – use of the results of speech analysis and communication process;
- x_{66} – implementation of speech process control and its correction.

According to the criteria of completeness and efficiency we form the following set of initial solutions $\mathbf{Y} = (y_s), s = \overline{1, 3}$:

- y_1 – high level of speech-communicative professional competence of economic specialties students;
- y_2 – medium level of speech-communicative professional competence of economic specialties students;
- y_3 – low level of speech-communicative professional competence of economic specialties students.

Quantitative and qualitative evaluation parameters are calculated on the basis of the set of input primary parameters \mathbf{X}^* . To transform the set of input primary parameters \mathbf{X}^* to the set of output parameters \mathbf{Y} we use the mathematical apparatus of fuzzy sets. Fuzzy logic has a special advantage for solving the problem, given the need to obtain cardinal estimates of qualitative parameters.

For the evaluation parameters we will use a single scale of linguistic terms: L – low, M – medium, H – high.

The set \mathbf{X} of evaluation parameters consists of quantitative: x_{11}, x_{12}, x_{13} and qualitative parameters of influence (the rest). For estimating the value of the membership functions of the evaluation parameters it is necessary to have the value of the linguistic terms of these indicators. So, the following approach of identification of values of the membership functions of qualitative parameters is proposed.

Consider, for example, the evaluation of the qualitative parameter x_{44} – the correctness of speech of economic specialties students – we propose to use such characteristics that most fully describe it and have a score (Table 1).

Table 1. Professional characteristics for evaluating the correctness of speech of economic specialties students – parameter x_{44}

| The name of the parameter | Score – b_i , (0 – 10] |
|--|-----------------------------|
| Correct accent of words | (0 – 7] |
| Correct pronunciation of sounds and sound combinations | (0 – 9] |
| Ability to choose a word for the context depending on its meaning | (0 – 10] |
| Ability to choose the correct grammatical form of a word | (0 – 8] |
| Ability to formulate language constructions depending on the situation and communication style | (0 – 10] |

Using expert knowledge on the influence of input parameters (described in table 1) on the level of correctness of the economic specialties student's speech we propose to calculate the parameter x_{44} using the following ratio:

$$x_{44} = \begin{cases} L, & \text{if } 0 \leq \sum_{i=1}^6 b_i \leq 15; \\ M, & \text{if } 15 < \sum_{i=1}^6 b_i \leq 32; \\ H, & \text{if } 32 \leq \sum_{i=1}^6 b_i \leq 44. \end{cases}$$

Similarly, it is possible to identify the values of all other qualitative estimation parameters x_{ij} of set \mathbf{X} . There are relevant formulas for calculation for quantitative parameters – x_{11}, x_{12}, x_{13} [13, 14].

After estimating the values of the set of input parameters we calculate the values of their membership functions. To do this, we define the membership functions $\mu^t(x_{ij})$ for each parameter separately. Each quantitative parameter is described by a separate membership function to three fuzzy terms as it shown in Fig. 1.

$$\mu^L(x_{i,j}) = \begin{cases} 1, & x_{i,j} \in [a, c); \\ \left(\frac{b-x_{i,j}}{b-c}\right)^{1,3}, & x_{i,j} \in [c, b), \end{cases} \quad \mu^M(x_{i,j}) = \begin{cases} \left(\frac{x_{i,j}-a}{c_1-a}\right)^{1,3}, & x_{i,j} \in [a, c_1]; \\ 1, & x_{i,j} \in (c_1, d_1); \\ \left(\frac{b-x_{i,j}}{b-d_1}\right)^{1,3}, & x_{i,j} \in [d_1, b], \end{cases}$$

$$\mu^H(x_{i,j}) = \begin{cases} \left(\frac{x_{i,j}-a}{d-a}\right)^{1,3}, & x_{i,j} \in [a, d]; \\ 1, & x_{i,j} \in (d, b]. \end{cases}$$

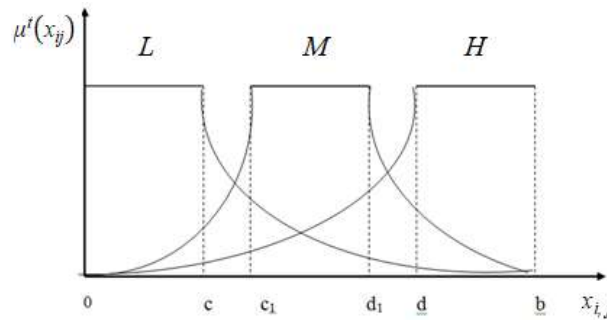


Fig. 1. Membership functions in $T=3$ fuzzy T terms $t = \overline{1, T}$ for quantitative parameters

The values c, c_1, d_1, d, b for each quantitative parameter are determined based on the proposed range of parameter changes.

The qualitative parameters x_{ij} the authors also suggest to describe with corresponding linguistic term $t, t = \overline{1, T}$ from the set of terms T . We choose 3 linguistic terms ($T=3$): ($t_1 - H; t_2 - M; t_3 - L$). For $T=3$ we will construct graphs of membership functions as it shown on Fig. 2 [13].

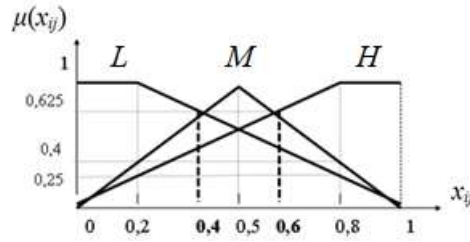


Fig. 2. Membership functions in $T=3$ fuzzy T terms $t = \overline{1, T}$ for qualitative parameters

Based on the function graphs, the value $\mu^t(x_{ij})$ we'll determine such way. If the qualitative parameter is characterized by the term «low» (L), then the value of membership function are determined for $x=0,2$ and $\mu^L(0,2)=1; \mu^M(0,2)=0,4; \mu^H(0,2)=0,25$. If the qualitative parameter is described by the term «middle» (M), then $\mu^M(0,5)=1; \mu^L(0,5)=\mu^H(0,5)=0,625$. For the term «high» (H): $\mu^L(0,8)=0,25; \mu^M(0,8)=0,4; \mu^H(0,8)=1$. These exact values of the membership functions are obtained on the basis of analytic expressions of the corresponding functions for $x_{ij}=0,2; 0,5; 0,8$ [13]. The whole set of membership functions values for $T=3$ is given in Table 2.

Table 2. Values of membership functions in $T=3$ fuzzy T terms $t = \overline{1, T}$ for qualitative parameters

| Терм | $\mu^L(x_{ij})$ | $\mu^M(x_{ij})$ | $\mu^H(x)$ |
|------|-----------------|-----------------|------------|
| L | 1 | 0,4 | 0,25 |
| M | 0,625 | 1 | 0,625 |
| H | 0,25 | 0,4 | 1 |

To determine mathematical expressions describing the membership functions of qualitative parameters, we use the equation of the straight line. So, we obtain the following expressions for describing the type of membership functions:

$$\mu^L(x_{ij}) = \begin{cases} 1, & x_{ij} \in [0, 0,2]; \\ \left(\frac{1-x_{ij}}{0,8}\right)^{1,3}, & x_{ij} \in (0,2, 1], \end{cases} \quad \mu^M(x_{ij}) = \begin{cases} \frac{x_{ij}}{0,5}, & x_{ij} \in [0, 0,5]; \\ \left(\frac{1-x_{ij}}{0,5}\right)^{1,3}, & x_{ij} \in (0,5, 1], \end{cases}$$

$$\mu^H(x_{ij}) = \begin{cases} \frac{x_{ij}}{0,8}, & x_{ij} \in [0, 0,8]; \\ 1, & x_{ij} \in (0,8, 1]. \end{cases}$$

The process of evaluating the level of speech-communicative professional competence of economic specialties students on the basis of the mathematical apparatus of fuzzy logic should contain a mechanism of clear logical inference to determine y_s , $s = \overline{1, 3}$, on the basis of appropriate source information. Therefore, a necessary step in the analysis is the formation of knowledge matrices which were compiled for each f_i (x_{ij}), $i = \overline{1, n}$, $j \in M$ to evaluate the value of the functions $f_1 - f_6$ to the above T terms and obtain the corresponding logical equations:

$$\begin{aligned} \mu^t(f_1) &= \max_{r=1}^7 \left\{ \min \left[\mu^{tr7}(x_{1j}) \right] \right\}; \quad \mu^t(f_2) = \max_{r=1}^5 \left\{ \min \left[\mu^{tr6}(x_{2j}) \right] \right\}; \\ \mu^t(f_3) &= \max_{r=1}^5 \left\{ \min \left[\mu^{tr6}(x_{3j}) \right] \right\}; \quad \mu^t(f_4) = \max_{r=1}^5 \left\{ \min \left[\mu^{tr9}(x_{4j}) \right] \right\}; \\ \mu^t(f_5) &= \max_{r=1}^5 \left\{ \min \left[\mu^{tr7}(x_{5j}) \right] \right\}; \quad \mu^t(f_6) = \max_{r=1}^5 \left\{ \min \left[\mu^{tr6}(x_{5j}) \right] \right\}, \end{aligned}$$

where r – the line number in the set of values for the function f_i , $i = \overline{1, 6}$;

j – the number of the evaluation parameter in the subset of the parameters x_{ij} , that determine the aggregative function f_i .

Thus, for the estimating the function f_1 – evaluating of the level of student's psychophysical qualities – the experts compiled the following logical equations that determine its level and have such form:

$$\begin{aligned} \mu_{f_1}^H &= \mu^H(x_{11}, \dots, x_{17}) = \mu^H(x_{11}) \cdot \mu^H(x_{12}) \cdot \mu^H(x_{13}) \cdot \mu^H(x_{14}) \cdot \mu^H(x_{15}) \cdot \mu^H(x_{16}) \cdot \\ &\mu^M(x_{17}) \vee \mu^H(x_{11}) \cdot \mu^H(x_{12}) \cdot \mu^H(x_{13}) \cdot \mu^H(x_{14}) \cdot \mu^H(x_{15}) \cdot \mu^M(x_{16}) \cdot \mu^H(x_{17}) \vee \\ &\mu^H(x_{11}) \cdot \mu^H(x_{12}) \cdot \mu^H(x_{13}) \cdot \mu^H(x_{14}) \cdot \mu^M(x_{15}) \cdot \mu^H(x_{16}) \cdot \mu^H(x_{17}) \vee \\ &\mu^H(x_{11}) \cdot \mu^H(x_{12}) \cdot \mu^H(x_{13}) \cdot \mu^M(x_{14}) \cdot \mu^H(x_{15}) \cdot \mu^H(x_{16}) \cdot \mu^H(x_{17}) \vee \\ &\mu^H(x_{11}) \cdot \mu^H(x_{12}) \cdot \mu^M(x_{13}) \cdot \mu^H(x_{14}) \cdot \mu^H(x_{15}) \cdot \mu^H(x_{16}) \cdot \mu^H(x_{17}) \vee \\ &\mu^H(x_{11}) \cdot \mu^M(x_{12}) \cdot \mu^H(x_{13}) \cdot \mu^H(x_{14}) \cdot \mu^H(x_{15}) \cdot \mu^H(x_{16}) \cdot \mu^H(x_{17}) \vee \\ &\mu^M(x_{11}) \cdot \mu^H(x_{12}) \cdot \mu^H(x_{13}) \cdot \mu^H(x_{14}) \cdot \mu^H(x_{15}) \cdot \mu^H(x_{16}) \cdot \mu^H(x_{17}); \end{aligned}$$

$$\begin{aligned} \mu_{f_1}^M &= \mu^M(x_{11}, \dots, x_{17}) = \mu^H(x_{11}) \cdot \mu^H(x_{12}) \cdot \mu^M(x_{13}) \cdot \mu^M(x_{14}) \cdot \mu^M(x_{15}) \cdot \mu^M(x_{16}) \cdot \\ &\mu^M(x_{17}) \vee \mu^M(x_{11}) \cdot \mu^H(x_{12}) \cdot \mu^H(x_{13}) \cdot \mu^M(x_{14}) \cdot \mu^M(x_{15}) \cdot \mu^M(x_{16}) \cdot \mu^M(x_{17}) \vee \\ &\mu^M(x_{11}) \cdot \mu^M(x_{12}) \cdot \mu^H(x_{13}) \cdot \mu^H(x_{14}) \cdot \mu^M(x_{15}) \cdot \mu^M(x_{16}) \cdot \mu^M(x_{17}) \vee \\ &\mu^M(x_{11}) \cdot \mu^M(x_{12}) \cdot \mu^M(x_{13}) \cdot \mu^H(x_{14}) \cdot \mu^H(x_{15}) \cdot \mu^M(x_{16}) \cdot \mu^M(x_{17}) \vee \\ &\mu^M(x_{11}) \cdot \mu^M(x_{12}) \cdot \mu^M(x_{13}) \cdot \mu^M(x_{14}) \cdot \mu^H(x_{15}) \cdot \mu^H(x_{16}) \cdot \mu^M(x_{17}) \vee \\ &\mu^M(x_{11}) \cdot \mu^M(x_{12}) \cdot \mu^M(x_{13}) \cdot \mu^M(x_{14}) \cdot \mu^M(x_{15}) \cdot \mu^H(x_{16}) \cdot \mu^H(x_{17}) \vee \\ &\mu^M(x_{11}) \cdot \mu^H(x_{12}) \cdot \mu^H(x_{13}) \cdot \mu^H(x_{14}) \cdot \mu^M(x_{15}) \cdot \mu^M(x_{16}) \cdot \mu^M(x_{17}); \end{aligned}$$

$$\begin{aligned}
\mu_{f_1}^L &= \mu^L(x_{11}, \dots, x_{17}) = \mu^L(x_{11}) \cdot \mu^L(x_{12}) \cdot \mu^L(x_{13}) \cdot \mu^L(x_{14}) \cdot \mu^L(x_{15}) \cdot \mu^L(x_{16}) \\
&\cdot \mu^M(x_{17}) \vee \mu^L(x_{11}) \cdot \mu^L(x_{12}) \cdot \mu^L(x_{13}) \cdot \mu^L(x_{14}) \cdot \mu^L(x_{15}) \cdot \mu^M(x_{16}) \cdot \mu^L(x_{17}) \vee \\
&\mu^L(x_{11}) \cdot \mu^L(x_{12}) \cdot \mu^L(x_{13}) \cdot \mu^L(x_{14}) \cdot \mu^M(x_{15}) \cdot \mu^L(x_{16}) \cdot \mu^L(x_{17}) \vee \\
&\mu^L(x_{11}) \cdot \mu^L(x_{12}) \cdot \mu^L(x_{13}) \cdot \mu^M(x_{14}) \cdot \mu^L(x_{15}) \cdot \mu^L(x_{16}) \cdot \mu^L(x_{17}) \vee \\
&\mu^L(x_{11}) \cdot \mu^L(x_{12}) \cdot \mu^M(x_{13}) \cdot \mu^L(x_{14}) \cdot \mu^L(x_{15}) \cdot \mu^L(x_{16}) \cdot \mu^L(x_{17}) \vee \\
&\mu^L(x_{11}) \cdot \mu^M(x_{12}) \cdot \mu^L(x_{13}) \cdot \mu^L(x_{14}) \cdot \mu^L(x_{15}) \cdot \mu^L(x_{16}) \cdot \mu^L(x_{17}) \vee \\
&\mu^M(x_{11}) \cdot \mu^L(x_{12}) \cdot \mu^L(x_{13}) \cdot \mu^L(x_{14}) \cdot \mu^L(x_{15}) \cdot \mu^L(x_{16}) \cdot \mu^L(x_{17})
\end{aligned}$$

To estimate the function f_3 – evaluating the level of economic specialties student's language competence – experts have compiled such logical equations that determine its level and have the form:

$$\begin{aligned}
\mu_{f_3}^H &= \mu^H(x_{31}, \dots, x_{36}) = \mu^H(x_{31}) \cdot \mu^H(x_{32}) \cdot \mu^H(x_{33}) \cdot \mu^H(x_{34}) \cdot \mu^H(x_{35}) \cdot \mu^H(x_{36}) \vee \\
&\mu^M(x_{31}) \cdot \mu^H(x_{32}) \cdot \mu^H(x_{33}) \cdot \mu^M(x_{34}) \cdot \mu^H(x_{35}) \cdot \mu^M(x_{36}) \vee \\
&\mu^M(x_{31}) \cdot \mu^M(x_{32}) \cdot \mu^H(x_{33}) \cdot \mu^H(x_{34}) \cdot \mu^M(x_{35}) \cdot \mu^H(x_{36}) \vee \\
&\mu^M(x_{31}) \cdot \mu^H(x_{32}) \cdot \mu^H(x_{33}) \cdot \mu^H(x_{34}) \cdot \mu^M(x_{35}) \cdot \mu^H(x_{36}) \vee \\
&\mu^H(x_{31}) \cdot \mu^H(x_{32}) \cdot \mu^H(x_{33}) \cdot \mu^H(x_{34}) \cdot \mu^M(x_{35}) \cdot \mu^M(x_{36});
\end{aligned}$$

$$\begin{aligned}
\mu_{f_3}^M &= \mu^M(x_{31}, \dots, x_{36}) = \mu^M(x_{31}) \cdot \mu^M(x_{32}) \cdot \mu^M(x_{33}) \cdot \mu^M(x_{34}) \cdot \mu^M(x_{35}) \cdot \mu^M(x_{36}) \vee \\
&\mu^M(x_{31}) \cdot \mu^M(x_{32}) \cdot \mu^M(x_{33}) \cdot \mu^M(x_{34}) \cdot \mu^M(x_{35}) \cdot \mu^M(x_{36}) \vee \\
&\mu^M(x_{31}) \cdot \mu^M(x_{32}) \cdot \mu^H(x_{33}) \cdot \mu^M(x_{34}) \cdot \mu^L(x_{35}) \cdot \mu^M(x_{36}) \vee \\
&\mu^L(x_{31}) \cdot \mu^H(x_{32}) \cdot \mu^H(x_{33}) \cdot \mu^M(x_{34}) \cdot \mu^M(x_{35}) \cdot \mu^M(x_{36}); \\
&\mu^M(x_{31}) \cdot \mu^H(x_{32}) \cdot \mu^H(x_{33}) \cdot \mu^M(x_{34}) \cdot \mu^L(x_{35}) \cdot \mu^M(x_{36});
\end{aligned}$$

$$\begin{aligned}
\mu_{f_3}^L &= \mu^L(x_{31}, \dots, x_{36}) = \mu^L(x_{31}) \cdot \mu^L(x_{32}) \cdot \mu^L(x_{33}) \cdot \mu^L(x_{34}) \cdot \mu^L(x_{35}) \cdot \mu^L(x_{36}) \vee \\
&\mu^M(x_{31}) \cdot \mu^L(x_{32}) \cdot \mu^L(x_{33}) \cdot \mu^L(x_{34}) \cdot \mu^M(x_{35}) \cdot \mu^L(x_{36}) \vee \\
&\mu^H(x_{31}) \cdot \mu^L(x_{32}) \cdot \mu^L(x_{33}) \cdot \mu^L(x_{34}) \cdot \mu^L(x_{35}) \cdot \mu^L(x_{36}) \vee \\
&\mu^L(x_{31}) \cdot \mu^L(x_{32}) \cdot \mu^L(x_{33}) \cdot \mu^L(x_{34}) \cdot \mu^H(x_{35}) \cdot \mu^L(x_{36}) \vee \\
&\mu^L(x_{31}) \cdot \mu^L(x_{32}) \cdot \mu^M(x_{33}) \cdot \mu^M(x_{34}) \cdot \mu^L(x_{35}) \cdot \mu^L(x_{36}).
\end{aligned}$$

In these functions the sign « \vee » denotes the logical operation «OR». The logical operation «AND» is indicated by « \cdot ». Therefore, to determine the desired result on the basis of a logical record of membership functions which are combined by operations AND (« \cdot »), it's necessary to choose the minimum value of them. To determine the desired result on the basis of a logical record of membership functions which are combined by operations «OR» (\vee) it's necessary to choose the maximum value of them.

Similar, logical equations are compiled for the remaining functions: $f_2(x_{ij})$, $f_4(x_{ij}) - f_6(x_{ij})$.

Consequently, the process of evaluating the level of speech-communicative professional competence of economic specialties students consists of **two stages**:

1) evaluating (with help of fuzzy logic) the linguistic values of aggregative functions $f_1 - f_6$ characterized by T linguistic terms, $t = \overline{1}, \overline{T}$ ($T=3$);

2) based on the Hopfield's neural network define the belonging of level of student's SCPC to one of the possible result levels $y_s, s = \overline{1,3}$ of speech-communicative professional competence (L, M, H) of economic specialties students.

2.2 Building the mathematical method for evaluating the level of speech-communicative professional competence of economic specialties students on the basis of Hopfield's neural network

The authors of the article propose the process of speech-communicative professional competence evaluating of economic specialties students to implement the two above stages.

Thus, at the second stage for evaluating the result level $y_s, s = \overline{1,3}$, authors propose to build the Hopfield's neural network [15–20], inputs for which are the linguistic evaluations $\mu_{f_i}^t$ of aggregative functions $f_i, i = \overline{1,6}$ obtained at the stage 1.

Based on the specifics of the Hopfield's network [15] the authors propose on its inputs to enter the binaries codes z_l («1» and «-1») of the linguistic evaluations $\mu_{f_i}^t$ of aggregative functions $f_i, i = \overline{1,6}$.

Describe the format of the code with three digits to encode $T=3$ linguistic terms $t=\overline{1, T}$: low level of $f_i - (-1,-1,-1)$; the middle level of the function $f_i - (-1, 1, 1)$; the high level of the function $f_i - (1, 1, 1)$.

The proposed Hopfield's network (Fig. 3) allows comparing the input vector $Z = (z_l), l = \overline{1, L}, L = 18$ which describes the codes of values of aggregative functions $f_i, i = \overline{1,6}$, with 9 standard samples (Tabl. 3) which selected as the most typical of the lines of logical equations that define the nearest standard vector $U=(u_l)$ (system output).

Table 3. Standard samples for evaluating the y_s levels, $s = (\overline{1,3})$

| f_1 | f_2 | f_3 | f_4 | f_5 | f_6 | y_s |
|--------|--------|--------|--------|--------|--------|----------------|
| 111 | -111 | 111 | 111 | -111 | -111 | y ₁ |
| 111 | -111 | 111 | 111 | 111 | -111 | |
| 111 | 111 | 111 | 111 | 111 | 111 | |
| 111 | -111 | 111 | -111 | -111 | -111 | y ₂ |
| 111 | 111 | -111 | -111 | -111 | -111 | |
| -111 | -111 | -111 | -111 | -111 | -111 | |
| 111 | -111 | -1-1-1 | -1-1-1 | -1-1-1 | -1-1-1 | y ₃ |
| -1-1-1 | -1-1-1 | -1-1-1 | -1-1-1 | -1-1-1 | -1-1-1 | |
| -1 1-1 | -1 1-1 | -1 1-1 | -1-1-1 | -1-1-1 | -1-1-1 | |

Thus, the network identifies that standard sample which is most similar to the one described above. Each standard sample determines a certain level of SCPC of economic specialties students – $y_s, s = \overline{1,3}$.

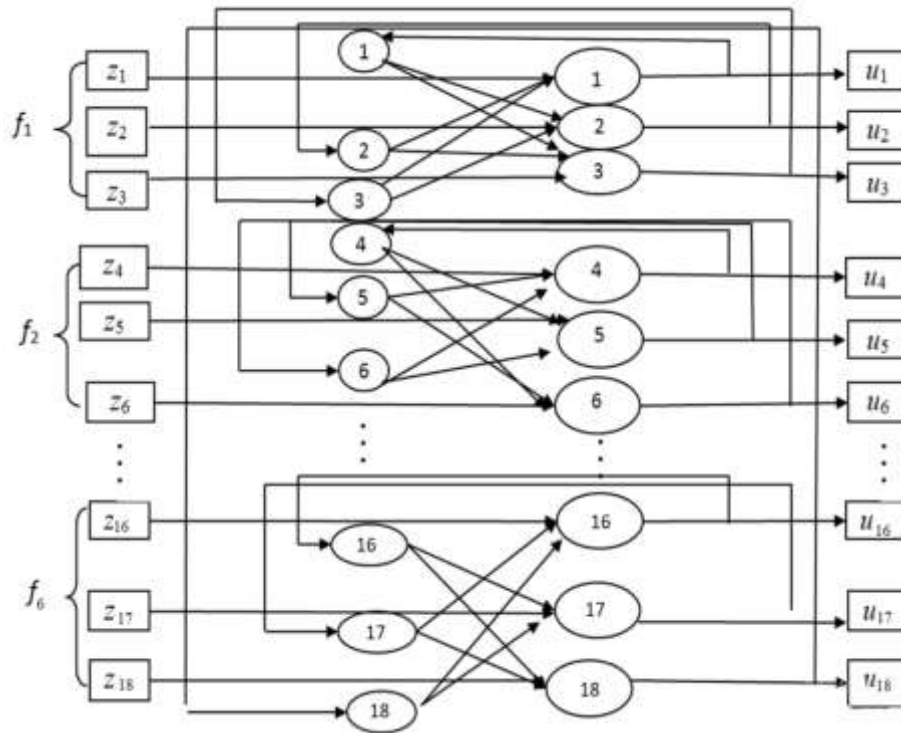


Fig. 3 – Hopfield's neural network for evaluating the level of speech-communicative professional competence of economic specialties students

3 Results and discussions

After encoding the Hopfield's network compares the input vector (which describes the speech-communicative professional competence of analysed student) with 9 standard samples (given in Table 3) compiled on the basis of expert data.

Proposed model and methods authors use for evaluating the level of speech-communicative professional competence of 100 students of 5 specialties: «Management», «Entrepreneurship», «Marketing», «Economic», «Logistics» of Vinnytsia National Technical University.

On the basis of the above approach (based on the fuzzy logic) the following values of aggregative functions f_i for 100 students were obtained.

Let's introduce the operation of the Hopfield's neural network for the first student (specialty «Economic») of the analysed set of students. Thus, the aggregative functions f_i for first student were obtained as $f_1=H, f_2=M, f_3=M, f_4=H, f_5=H, f_6=M$.

We present these linguistic estimates of functions f_i with corresponding codes as shown in Table 4.

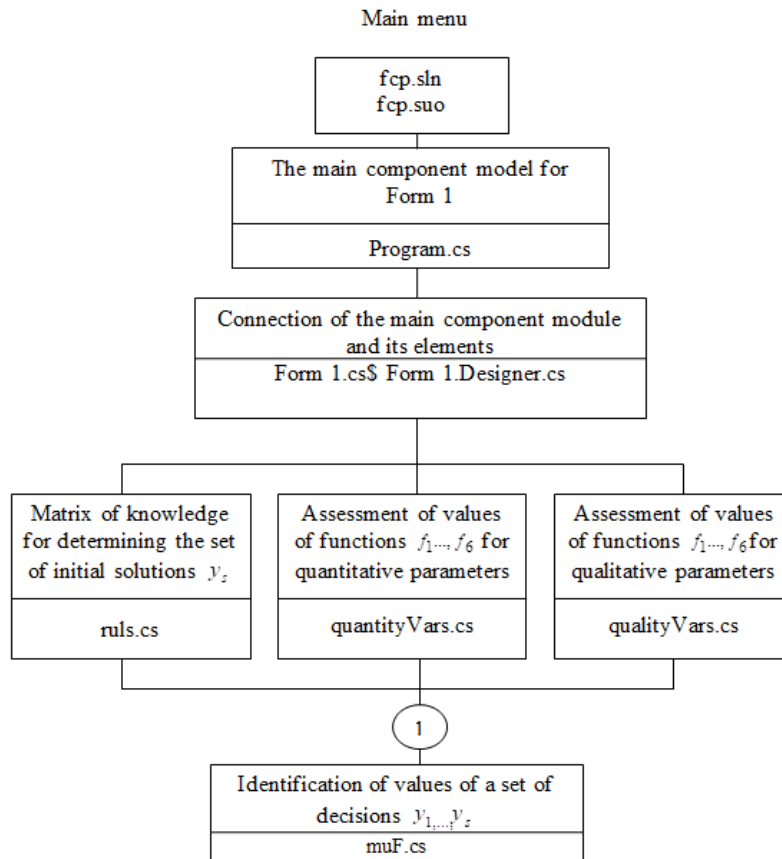


Fig. 4. Generalized scheme of interaction component modules of program «SCPC of student»

Let's consider below the main module's small excerpt of program «SCPC of student»:

```

Form1.cs (main component module of program «SCPC of student»):
using System;
using System.Collections.Generic;
using System.ComponentModel;
using System.Data;
using System.Drawing;
using System.Text;
using System.Windows.Forms;
namespace fcp
{
    public partial class Form1 : Form
    {

```

```

#region FormDefenition
private double x1, x2, x3, x4, x5, x6, x7, x8, x9, x10, x11, x12, x13, x14, x15,
x16, x17, x18, x19, x21, x22, x23, x24, x25;
public double m_x71, m_x72, m_x73, m_x81, m_x82, m_x83, m_x84, m_x85;
double[] muF1 = new double[5];
double[] muF2 = new double[5];
double[] muF3 = new double[5];
double[] muF4 = new double[5];
double[] muF5 = new double[5];
double[] muF6 = new double[5];
double[] muF7 = new double[5];
double[] muF8 = new double[5];
double[] muYN = new double[5];
private double[,] full_func_array = new double[20, 10];
private double[,] muFArray = new double[7, 5];
private double[,] muYArray = new double[5, 5];
public Form1()
{
    //muF();
    InitializeComponent();
}
#endregion
#region QuantityVarsCals
private bool checkDoubleValue(object value)
{
    TextBox textControl = (TextBox)value;
    String stringValue = textControl.Text.ToString();
    if (!String.IsNullOrEmpty(stringValue))
    {
        try
        {
            Double doubleValue = Double.Parse(textControl.Text.ToString());
            textControl.Text = String.Format("{0:0.###}", doubleValue);
            return true;
        }
    }
}
}

```

4 Conclusions

The article proposes information technologies that allow (by means of mathematical apparatus of artificial intelligence) to describe the procedure of evaluating the level of economic specialties student's professional speech and communication competence. Author's mathematical model maps the set of input parameters to the set of result solutions. In this case, the set of input parameters is formed from the main elements of influence on the level of economic specialties student's SCPC. The set of input parameters is formed as the optimal (by the criteria of completeness, minimality and effectiveness) set of elements of influence on the level of economic specialties student's SCPC. These elements are combined into blocks – aggregative functions f_i

which comprehensively characterize the evaluating process, particular: f_1 – evaluating the level of student’s psychophysical qualities – $f_1 = f(x_{11}, \dots, x_{17})$; f_2 – evaluating the level of student’s personal qualities – $f_2 = f(x_{21}, \dots, x_{28})$; f_3 – evaluating the level of economic specialties student’s language competence – $f_3 = f(x_{31}, \dots, x_{36})$; f_4 – evaluating the level of economic specialties student’s speech competence – $f_4 = f(x_{41}, \dots, x_{49})$; f_5 – evaluating the level of skills to ensure the quality of student speech – $f_5 = f(x_{51}, \dots, x_{57})$; f_6 – evaluating the level of skills to enhance the effectiveness of the communicative process of student speech – $f_6 = f(x_{61}, \dots, x_{66})$.

The set of output parameters $\mathbf{Y} = (y_s), s = \overline{1, 3}$, in turn, allows describing all possible levels of economic specialties student’s SCPC (y_1 – high level of economic specialties student’s SCPC; y_2 – medium level of student’s SCPC; y_3 – low level of speech-communicative competence of economic specialties students).

The scientific novelty of the obtained results is the formation of methodological principles for evaluating the level of speech-communicative professional competence of economic specialties students on the basis of the mathematical apparatus of artificial intelligence and modern mathematical automated means. In particular, for the first time, it was proposed: the mathematical model for estimating the level of speech-communicative professional competence of economic specialties students and the method of its formalization which based on the mathematical apparatus of fuzzy logic and the Hopfield’s neural network. It allows precisely and adequately with less losing time to map the set of input parameters to the set of resulting solutions, taking into account the wide range both quantitative and qualitative factors of influence to take into account the complexity and dynamism of such a process.

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