Intelligent Decision Support in Complex Socio-Economic Systems

Nafisa Yusupova
Ufa State Aviation Technical University
Ufa, Russia
yussupova@ugatu.ac.ru

Aygul Agadullina
Ufa State Aviation Technical University
Ufa, Russia
aygul.agadullina@gmail.com

Tatyana Naumova
Ufa State Aviation Technical University
Ufa, Russia
naumova.21061974@gmail.com

Ekaterina Sazonova
Ufa State Aviation Technical University
Ufa, Russia
rassadnikova_ekaterina@mail.ru

Olga Smetanina
Ufa State Aviation Technical University
Ufa, Russia
smoljushka@mail.ru

***Abstract*—This article considers problems of organizing decision-making support for improving psychophysical readiness of persons for professional activity. Current state of the art, data properties used for the analysis and their features are presented. Classification signs of labor activity, classification of physical exercises, examples of professionally applied physical training of different students as well as tests for evaluation of professional performance are shown. The statement of the problem, mathematical setting of this problem and the process of collecting and processing data for recommendations formation are discussed. The proposed methodology includes collection and preparation of data for analysis, identification of new knowledge based on similarity of objects using clustering, their integration with expert knowledge, formalization of knowledge and formation of the knowledge base, obtaining solutions while making use of knowledge and inference engine. Tools for data mining, namely the analytical platform Deductor Studio, are shown. The results of experimental studies based on the proposed method are provided. Recommendations for improvement of the psychophysical readiness of persons for professional activities taking into account the results of cauterization are considered.**

Keywords—expert systems technologies, decision support, Data Mining, professionally important qualities, formalization of knowledge

I. INTRODUCTION

Any profession has a number of requirements and prerequisites, including physical and mental qualities and applied skills. The relevance of the study is based, on one hand, on increasing introduction of automation into all spheres of human activity, and as the consequence, changes of professionally important personal qualities (PIQ); on the other hand, there is decrease in physical activity of a person at the present time, and, as the result, occurrence of problems related to the performance of professional activities. Therefore, focusing on future labor activity, students of higher educational institutions should combine general physical training with professionally applied physical training (PAPT). The main purpose of professionally applied physical training is developing and maintaining at the optimal level those psycho-physical qualities of a person that are subject to increased requirements in the particular professional activity; production of functional resistance of the organism to the conditions of this activity and the formation of applied motor skills.

The existence of many professions entailing variety of professionally important personal qualities, methods of assessment, many means of maintaining at the required state and development of person psychophysical qualities leads to developing of information support for decision making. Therefore, formalized expert knowledge is proposed to be used for organizing information support for decision-making. Thus, knowledge obtained by mining implicit knowledge data is proposed to be used for group exercises. These allow to expand the obtained knowledge base for recommendations on planning lessons of physical education.

The study can be considered as interdisciplinary. There are many works in each of the knowledge areas. For instance, many specialists included in the study labor functions for various professions, in particular, B.I. Zagorsky, R.T. Raevsky, V.I. Ilinich, V.A. Kabachkova, S.A. Polievsky et al [1-3]; development issues professiogramm is discussed in the works of E.A. Klimova, E.P. Ilyin, V.L. Vasiliev et al; issues of diagnosis of psychophysical properties at indicators are considered in the works of V.A. Kantur, V.V. Petrosyants, D.Ya. Raygorodsky, O.P. Eliseev, E.P. Ilyin et al [4-6].

Formalized data is used for decision making. Many specialists, both in Russia and abroad, in particular, S.N. Vasilyev, A.N. Raikov, L.J., Gressgard, T. Nesheim, J.L. Medina Moya, B. Jarauta Borrasc, J. Menegaz, et al. [7-10], research issues of knowledge formalization.

Authors of this article propose to use formation of expert systems technologies for recommendations. The state of the art is presented, both in the field of professionally applied physical training and in the field of information support for decision-making; features of data and knowledge are described, statement of the problem and structure of the solution are provided, results of the experiment for IT-specialists are presented in this article.

II. THE STATE OF THE ART AND CHARACTERISTICS OF DATA AND KNOWLEDGE USED FOR ANALYSIS

The professiogramm is prepared for identifying the most significant factors of a specific profession. The professiogramm is a system of features that describes a particular profession and includes the list of rules and requirements imposed by this profession or occupation on employees. One of professiogramm components, as a rule, is the list of psychological characteristics that is named

«professionally important qualities», or PIQs. The concept of professionally important qualities in the field of professionally applied physical training is understood as "individual qualities of the subject of labor that affect the efficiency of professional activity and the success of assimilation" [11] (fig. 1)

The development of professiogramm is studied in the works of E. A. Klimova, E. P. Ilyin, V. L. Vasiliev et al. The separate issues of labor functions for various professions can be found in the works of B.I. Zagorsky, R.T. Raevsky, V.I. Ilinich, V.A. Kabachkova, S.A. Polievsky et al.

The results of the research analysis in the field of professionally applied physical training (Fig. 2) show that there are significant differences in conditions of professional activity for specialists in various fields.

The professiogramm can be constructed based on expert knowledge manually, or with using information systems. Thus, the author of the work [12] notes that the system "Eidos" allows to develop professiogramms based on the retrospective database by determining which respondent's signs (primary, directly installed, secondary, i.e., calculated) are the most characteristic for employees successfully working on various positions.

As an example, we can considered professionally important personal qualities of a computer engineer who must demonstrate attention, operational thinking, memory, emotional stability, etc. (Fig. 3). The professionally important personal qualities of a programmer can be slightly different from qualities of a computer engineer.

Special tests allow evaluating certain professional characteristics. Questions of diagnosis of psychophysical properties at the indicators are considered in the works of Kantur, Petrosyants, Raygorodsky, Eliseev, Ilyin et al. Some of the tests are listed in table I.

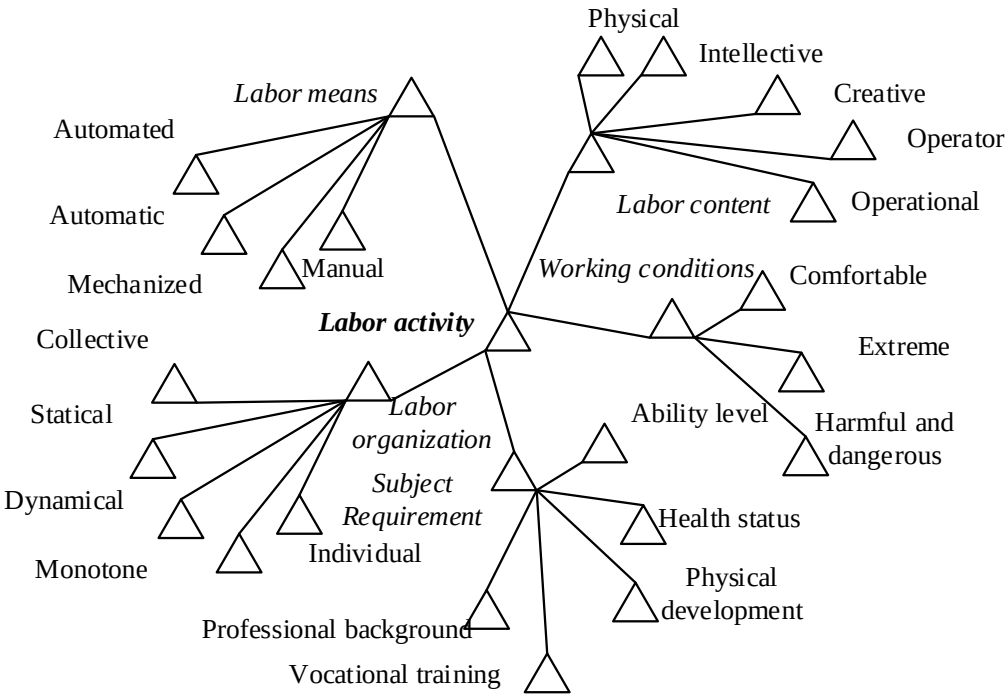

Fig. 1. Classification signs of labor activity

Professionally applied physical training of students of technical directions	Professionally applied physical training for non-technical directions
•students of technical universities (R.T. Raevsky, A.I. Davydenko) •students of engineering and marine universities (E.P. Baykov, A.F. Rozhnovsky) •students of construction universities (V. P. Zhidkikh)	•surgeons (E.P. Guk) •students of economics (N.I. Tonkov, S. Kirichenko, S.V. Ostroushko) •students of the textile industry (Lsong-Kim-Chung)

Fig. 2. Professionally applied physical training of students

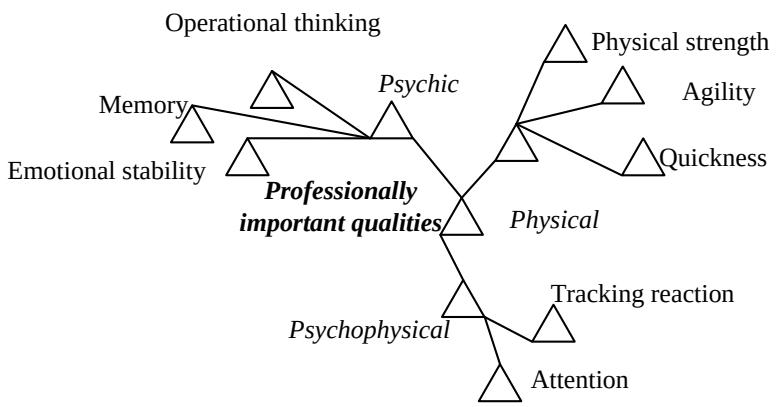

Fig. 3. Professionally applied physical training of students

TABLE I. FRAGMENT OF TESTS FOR PROFESSIONAL PERFORMANCE ASSESSMENT

Method	**Purpose**	**Scale (Estimate) / Border**			
		Excellent	***Good***	***Satisfactorily***	***Unsatisfactory***
Schulte Table	Assessment of attention, sustainability of attention	<34 sec.	34-42 sec.	43-58 sec.	.> 58 sec.
Rees test	Attention sustainability assessment	3 min. 30 seconds	6-7 min.		from 13 min and higher
Test of evaluation on courage and determination	Evaluation of courage and determination	Confidence and accuracy of movement is maintained on the high / low log	There are some indecision and 1-2 errors	There are signs of timidity and 2-4 errors; there is timidity leading to distortion of the exercise	The exercise is not performed, there is a fall or refusing from perform backwards

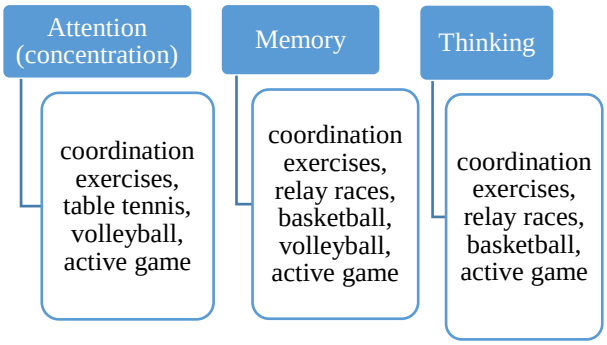

Fig. 4. Composition of tests for development and improvement of professionally important physical qualities

A specific composition of tests (Fig. 4) is available for developing and improving professionally important physical qualities and mental properties. The test breakdown shows how to improve specific characteristics. Knowledge of test use may be called expert knowledge for improvement of psychophysical qualities. Also, the works on the development of mathematical models of psychophysical readiness, the development of an information system for assessing psychophysical readiness, the role of physical education for improving the psychophysical readiness of a person for professional activity shall be mentioned here.

So E. A. Egorychev considers that construction of mathematical models considering the connection of qualifications, professionally important qualities and their interaction is possible for professions with increased requirements for the level of psychophysical readiness [13,14]. Also, E. A. Egorychev notes that using mathematical modeling of the structure for structuring higher mental functions allows to purposefully choose the means of physical culture and sports for the formation of psychological readiness of future specialists to extreme working conditions.

The information system for evaluating the psychophysical readiness of students for professional activity was developed by K. Sharopin [15,16]. The distinctive feature of this system is the possibility of obtaining the integrated assessment of professionally applied physical readiness and using of test technologies and expert assessment methods. The author also evaluates need for quantitative determination of the level of specialist possession of the required qualities .

V. V. Pichurin [17,18] describes the role of physical education in the development of psychological and psychophysical training of students for professional work.

The classification of physical exercises that can be used to form the complex for improvement of professionally important physical qualities and psycho-physiological properties is presented in Figure 5.

Many specialists are engaged in the research of knowledge formalization; their results are presented in the works [7-10, 17, 18].

However, the specifics of subject and problem areas require additional research. Issues of obtaining implicit knowledge based on data mining are discussed in [19-28].

According to the analysis of results, it can be concluded about the possibility of using Data mining tools and analysis results for informational decision-making support in considered subject area.

The study conducted by the authors is aimed at decision-making support in managing the development of the psychophysical state of a person for the effective performance of professional activity. The analysis results of the subject area made it possible to select the most professionally important qualities that contribute to maintaining the required state and development of the psychophysical qualities of a person as well as tests for evaluating these qualities / characteristics.

Formalized expert knowledge about the development of certain psychophysical qualities of a person using special physical exercises embedded in the knowledge base will contribute to the formation of recommendations. Taking into account training of students in groups through selection of students with similar characteristics will allow to formulate recommendations for groups and conduct joint training (Fig. 6).

Summarizing the above, we can conclude that the research topic is relevant, covering both the specifics of professionally applied physical training and features of data processing for the recommendations formation based on expert knowledge.

The used data are student test results (Schulte test, Risse test, etc.) of physical exercises. As baseline, knowledge of PIQ for a specific profession, associated tests, and means of developing and improving professionally important physical qualities and psychophysiological properties in the form of exercise and sports are used. Implicit knowledge is supposed to be obtained during clustering in order to prepare recommendations for group lessons.

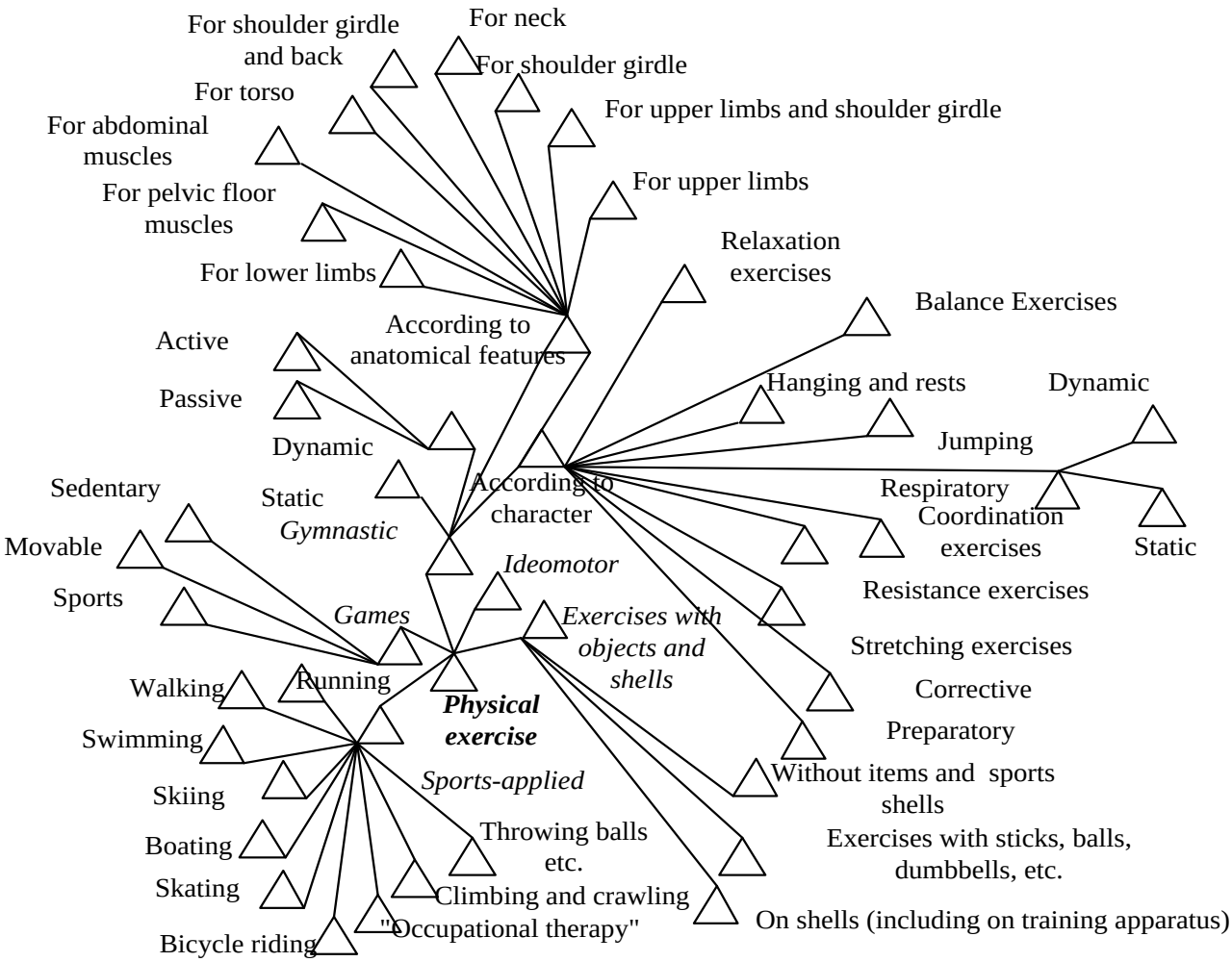

Fig. 5. Classification of physical exercises

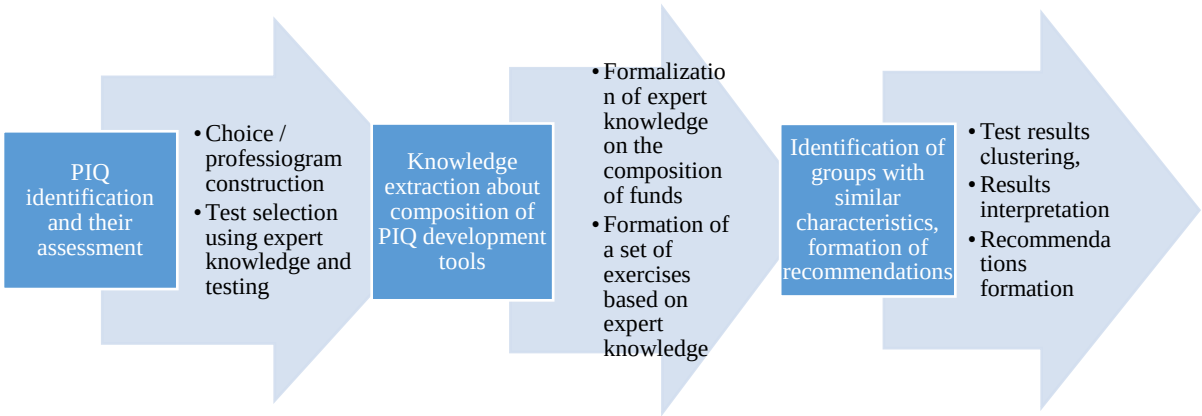

Fig 6. The process of collecting and processing data for recommendations formation

III. The Statement of the Problem

The formal statement of the data processing problem (test results) is to formulate recommendations for the development and improvement of professionally important physical qualities and psychophysiological properties using a set of exercises.

Given:

- a set of professiograms $P=<p_1, p_2, \ldots, p_s>$ $(k=1,\ldots, s)$, each of which includes a set of PIQ for a particular profession $X=<x_{11}, x_{12}, \ldots, x_{mn}>$ $(i=1,\ldots,m$ – value of i PIQ, $j=1,\ldots, n$ – value of j student);
- a value of i PIQ is a test result T_k;
- a set of physical exercises $FU=<f_{u1}, f_{u2}, \ldots, f_{uo}>$, allowing to improve the value of PVC;
- a set of exercises KU_i as a subset FU, $KUi \subseteq FU$,

it is required to build a system of rules (Rule) allowing to formulate recommendations. The consequent rules are represented by a set of special exercises for preparing KUi, the antecedent – by the boundary values of one or several PIQ.

If there is group training of students in physical education classes, the formation of recommendations for groups of students with similar characteristics (values of PIQ) is provided.

IV. Data Processing and Experiment

The process of data collection and processing described earlier for the formation of recommendations is presented in three stages: from data collection in the form of an assessment of PIQ and the knowledge formalization about the effect of physical exercises on various PIQ to recommendations formation.

Since the problem statement involves solving only the third stage, we will consider it in more detail.

The method for solving the problem (Fig. 7) includes three stages:

1) preparing data for analysis by using data cleaning algorithms (detecting anomalies, filling in gaps, identifying duplicates and contradictions) and identifying object similarities by clustering using the neural network (Kohonen network);

2) the revealed new knowledge in the form of similar objects (students) with close values of PIQ and their interpretation (2) make it possible to formulate recommendations for improving the psychophysical properties in the form of a set of exercises

3) also in addition to the revealed knowledge, it is proposed to use the knowledge of experts, including those presented by Fig. 4.

The result is a production knowledge base.

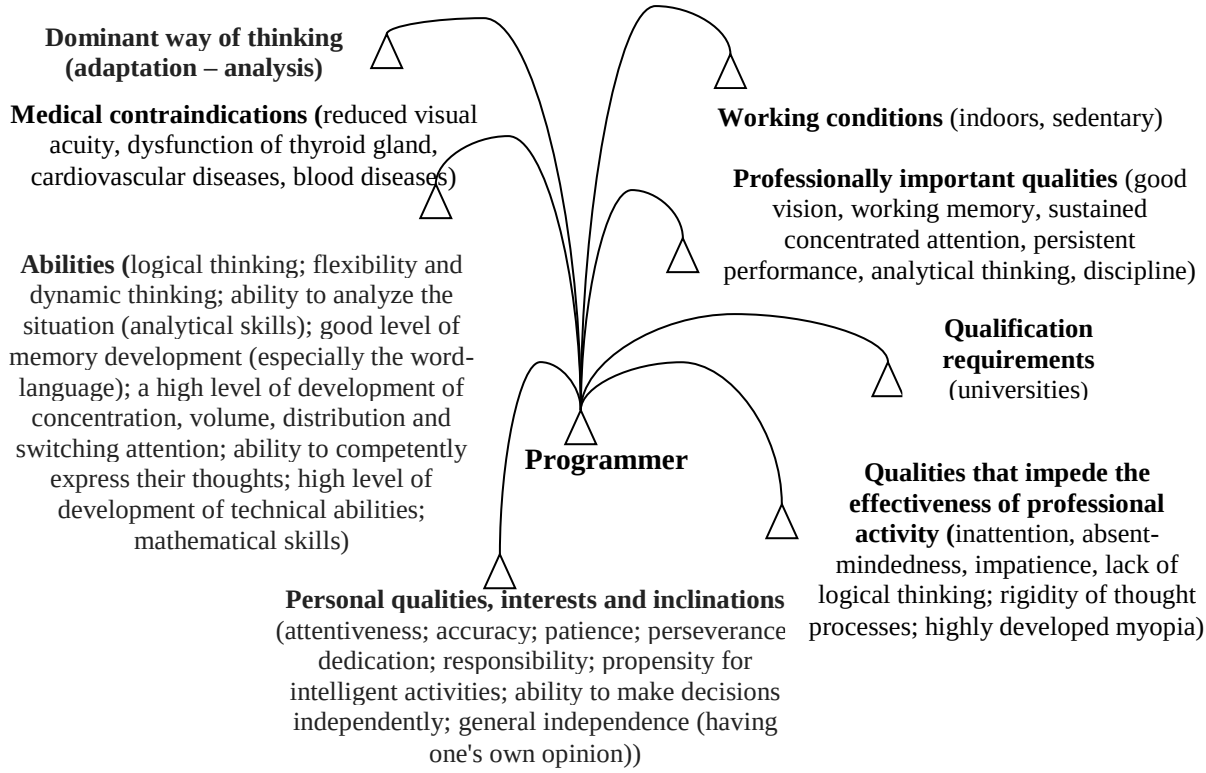

Fig 7. Programmer professiogram

The authors use the analytical platform Deductor Studio for data analysis, in particular, for clustering objects - Kohonen's neural network. As shown earlier, the purpose of the analysis is to identify similar objects to form a set of exercises for a group of students. The Kohonen network includes the input and output layers of neurons. The clustering procedure consists of learning the network and combining the cells into clusters.

The experiment was conducted with students in the areas of IT, in particular, the programmers. The programmer's professiogram is shown in Figure 7. The following tests were used to identify the QIP values: Tapping test (TT), Hook test (HT), Schulte test (ShT), Running to numbered places test (RT), Yarotsky's test (YaT).

The results of cluster analysis (Fig. 8, Table 2) and their interpretation allow us to formulate recommendations for the identified groups.

Analysis of the results shows that students in cluster 2 can perform a basic set of exercises. The students of cluster 1 should perform exercises that will allow them to develop static strength endurance of arm muscles. Balance exercises are also added for a small part of the group (the value of Yarotsky's test is less than 39).

For students included in *cluster 0*, the complex is similar to the previous cluster. In addition to this complex, exercises on spatial orientation and memory are necessary. *Cluster 3* is the most "difficult" group. In this case, it is necessary to make a complex that helps to improve all the "characteristics".

Examples of rules:

Rule 1. IF $155<T_1=\text{"TT"}<180$ AND $105<T_2=\text{"HT"}<145$ AND $22<T_3=\text{"ShT"}<40$ AND $7<T_4=\text{"RT"}<8{,}8$ AND $39<T_5=\text{"YaT"}<50$, THEN KU_{base};

RULE n. IF $165<T_1=\text{"TT"}<190$ AND $30<T_2=\text{"HT"}<63$ AND $22<T_3=\text{"ShT"}<30$ AND $7{,}8<T_4=\text{"RT"}<8{,}8$ AND $30<T_5=\text{"YaT"}<43$, THEN KU_1; where KU_1 – basic set of exercises - is complemented by exercises that allow to develop static strength endurance of the arm muscles.

Subsequent tests confirmed the success of the study. Best results were obtained.

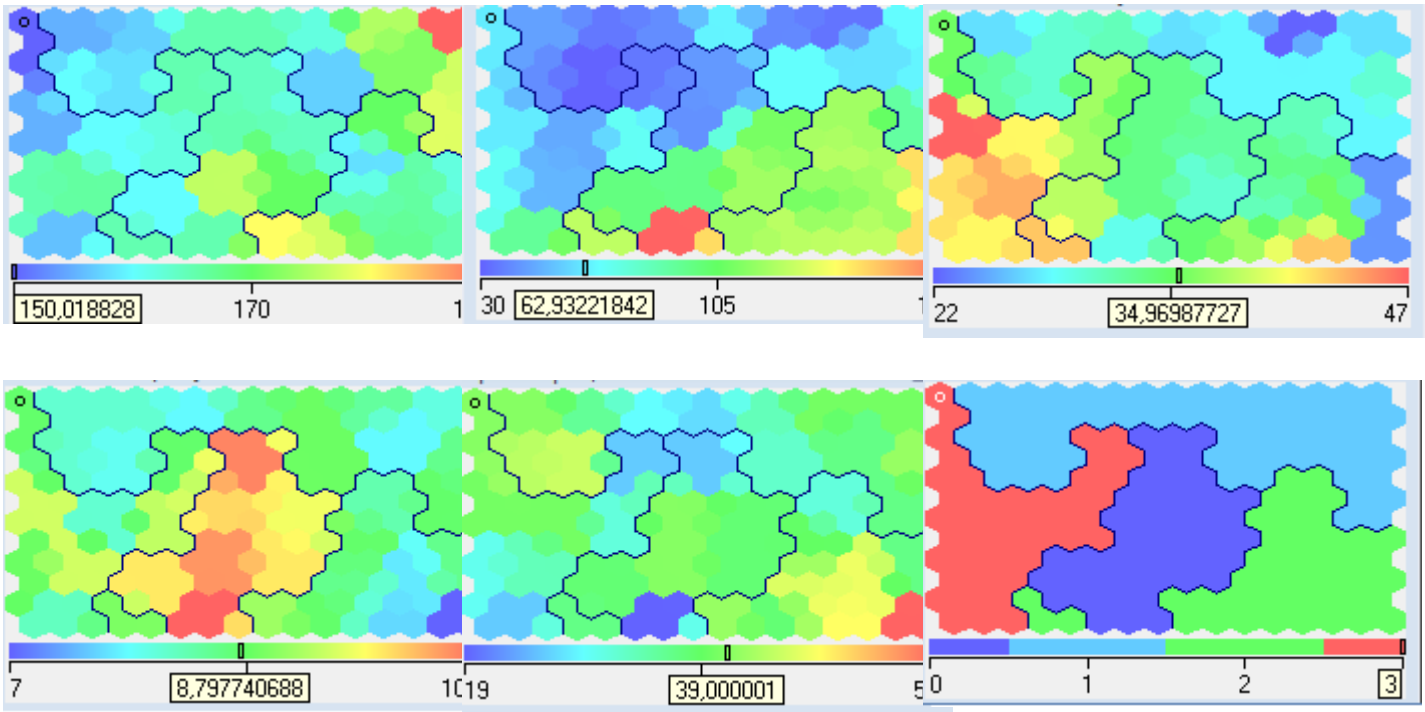

Fig 8. Cluster analysis results

TABLE II. ANALYSIS OF THE RESULTS

Cluster number	Tapping test (characteristic of nervous system)	Hook test (static power endurance of arm muscles)	Schulte test (characterization of the volume, distribution and switching attention)	Running to numbered places test (spatial orientation and memory)	Yarotsky's test (general equilibrium)"
0	160-180	40-180	28-40	9,75-10,7	19-39
1	165-190	30-63	22-30	7,8-8,8	30-43
2	155-180	105-145	22-40	7-8,8	39-50
3	150-170	45-105	34-47	7,9-9,7	23-39

V. CONCLUSION

A person must demonstrate a number of psychophysical properties specified in professiogram to ensure efficient and successful activity. Evaluation of these properties is carried out on the basis of periodically conducted tests.

Students can be divided into groups with similar values of PIQ to obtain general recommendations for a set of exercises during the organization of preparation for professional activities in physical education classes. Individual recommendations can also be given.

Knowledge of PIQ for a particular profession, related tests, and means of developing and improving professionally important physical qualities and psycho-physiological properties in the form of physical exercises and sports are used as baseline.

Implicit knowledge was obtained during clustering in order to prepare recommendations for group lessons.

Data mining tools are used for data analysis, recommendations are formalized as a system of production rules. The consequent rules are represented by a set of special exercises for preparation, the antecedent – by the boundary values of one or several characteristics.

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