The object of the study is the system of training aviation specialists. The problem solved in the research is to increase the efficiency of decision making in the tasks of professional training of pilots while ensuring a given reliability, regardless of the hierarchy of the system of evaluation indicators. The subject of the research is the process of assessing the qualities of civil aviation pilots using fuzzy cognitive maps. The hypothesis of the research is to increase the number of indicators for assessing the quality of training of civil aviation pilots, with restrictions on the efficiency and reliability of decision making. The list of factors that influence the professional training of aviation personnel involved in ensuring flight safety is given.

A mathematical model of professional training of aviation personnel involved in ensuring flight safety has been developed. This mathematical model differs from the previously known results:

– the possibility of forming a generalized indicator of assessment and selection of decisions on the basis of changing sets of partial indicators, taking into account the complex multi-level structure of assessment of aviation personnel;

– the ability to aggregate heterogeneous indicators (both quantitative and qualitative) to assess and select solutions that differ in measurement scales and value ranges;

– taking into account compatibility and different values of partial indicators in the generalized assessment of decisions;

– flexible adjustment (adaptation) of evaluation models when adding (removing) indicators and changing their parameters (compatibility and significance of indicators).

According to the results of the analysis of the effectiveness of the proposed model, it can be seen that the proposed assessment model takes into account 30 % more assessment indicators than standardized ones

Keywords: fuzzy cognitive models, aviation personnel, civil aviation, flight safety, aviation

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THE DEVELOPMENT OF A MATHEMATICAL MODEL OF PROFESSIONAL TRAINING OF AVIATION PERSONNEL PARTICIPATED IN ENSURING FLIGHT SAFETY

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1. Introduction

The high qualification of the activities of aviation personnel involved in ensuring flight safety has high requirements for their professional reliability, which includes the stability of the combination of motivational, intellectual, emotional, physical and psychophysiological components, aimed at the successful provision of professional functions.

The above mentioned structural elements are laid down at the moment of professional self-determination and are most actively developed during training at a higher educational institution. The implementation and preservation of professional reliability requires the search for the latest ways and resources of professional training, appropriately reflecting the specifics of the work of aviation specialists. The need to search for funds that provide the most effective professional and psychological training of future civil aviation employees is indicated by a variety of factors [1, 2]:

– firstly, the peculiarity of the work of aviation personnel determines the requirements for the state of health, physical education, emotional stability and the ability to work at the required pace;

– secondly, a person must possess a high level of development of the required knowledge, professional skills and abilities, perfectly assimilate new information;

– thirdly, in conditions associated with an increased psychophysiological load, they are prone to stress. For stress resistance, it is necessary to know by what devices and methods an optimal psychophysiological state is acquired, to have experience in self-regulation in emergency situations.

The improvement of computer technologies has opened up the broadest prospects for improving the technical devices of training, especially simulators, both for modeling flight dynamics and for providing a real recreation of the extra-cockpit space.

The progressiveness of the technical devices, which are necessary to maintain the required level of professional training of aviation specialists, is becoming a characteristic component of the learning process. It is possible to increase the efficiency and quality assessment of the professional training of aviation specialists through the use of innovative integrated training systems of a new generation, which will significantly affect the reduction in the number of errors of aviation specialists in their activities.

In accordance with the statistics of the automated system for ensuring the safety of aircraft flights in civil aviation, to a greater extent, all aviation events occur in the aerodrome area during taxiing, takeoff, approach and landing of aircraft. Approximately 14 % of the total number of flight accidents are rolling out aircraft outside the runway [1–5].

Taking into account the above, the topical issue is the improvement of existing approaches (development of new ones) to solve a set of tasks for assessing the level of training of aviation specialists in civil aviation, both at the initial stage and after passing the appropriate training.

Taking into account the complexity of this task, the vagueness of factors, the need to take into account their mutual influence on each other, the use of the mathematical method of fuzzy cognitive maps (FCM) is proposed to ensure the convenience of modeling the dynamics of systems with measured expert-qualitative variables.

Fuzzy cognitive maps are the ways of displaying real dynamic systems in a form that matches the human perception of such processes. This is the main reason for their wide application in various spheres of life.

The main advantages of fuzzy cognitive maps are:

1. The ability to include feedback in the model.

2. The ability to include many variables in the model, even with fuzzy values.

3. The ability to model relationships between variables that are not known exactly, but can be described in categories such as «a little», «a lot».

4. The ability to model systems where the amount of accurate information is limited, but expert knowledge is available.

5. Ease and speed of building cognitive maps and obtaining the desired results.

6. Ease and speed of combining disparate knowledge.

7. Ease and speed of modeling the situation and obtaining the results of applying a particular policy.

This makes it possible to observe the principle of incompatibility of high complexity with high accuracy. The presence of a scientific interdisciplinary dialogue makes it possible, to achieve a more systematic analysis of the problem under the research in the problem of aviation personnel training.

Therefore, research on the development of development of a mathematical model of professional training of aviation personnel participated in ensuring flight safety is relevant to reduce the number of aviation incidents in civil aviation.

2. Literature review and problem statement

The work [2] analyzed the civil aviation pilot training system. The shortcomings of the current civil pilot training system are shown. At the same time, the paper does not indicate the factors that affect the effectiveness of the control of the pilot of the aircraft in terms of taking the aircraft out of complex spatial positions to improve the level of flight safety in the country. Emphasis is made on the need to improve the system for assessing the qualities of aviation personnel by expanding the number of assessment indicators.

The work [3] shows the basic indicators for assessing the quality of training of civil aviation personnel. The levels of assimilation of knowledge by aviation personnel of civil aviation are indicated. The criteria for assessing the quality of training of civil aviation personnel are listed. However, the evaluation system is not complete, namely, additional factors are not taken into account, such as the climate of the crew, the level of cohesion of the aircraft crew, basic knowledge, etc.

The work [4] shows the relevance of additional consideration of psychophysiological factors affecting the quality of performance of aircraft piloting tasks by civil aviation pilots. At the same time, fatigue is not only the only factor that affects the quality of flight performance by aviation personnel, so this factor should be considered in the general system of indicators, which are given above.

The work [5] proposed the criteria for assessing the process of piloting skills formation during the initial flight training of pilots. This approach is based on the use of Pearson's criterion, the main disadvantage of which is its insensitivity to function scaling. Also, the proposed approach does not take into account the new requirements that apply to civil aviation personnel, which does not allow it to be supplemented with new assessment indicators.

The need to take into account additional factors that have both qualitative and quantitative indicators of evaluation requires the creation of a new approach to the procedure for assessing the quality of training of civil aviation personnel. Based on the foregoing, it is proposed to use artificial intelligence methods to assess the quality of civil aviation personnel training.

The work [6] describes the agent-based approach used in a multi-agent information-analytical system and considers the problems of information decision making support. The disadvantages of the approach include the limited representation of complex systems, namely, none of the agents has a representation of the entire system.

The work [7] presents an operational approach for spatial analysis in the maritime industry to quantify and capture associated ecosystem services. This approach includes the three-dimensionality of the marine environment, considering separately all marine areas (sea surface, water column and seabed). In fact, the method builds 3-dimensional models of the sea by evaluating and mapping associated with each of the three sea domains through the adoption of representative indicators. The disadvantages of this method include the impossibility of flexible adjustment (adaptation) of evaluation models while adding (removing) indicators and changing their parameters (compatibility and significance of indicators).

The work [8] proposes an approach to assess the living cost for a client in the field of air transportation. In this approach, the regression model is used first, after which the indirect estimation model is used. The final step is to compare the evaluation results using both evaluation models. The disadvantages of the approach include the impossibility of determining the adequacy of the obtained assessment.

The work [9] provides a scoring approach for evaluating the optimal selection or testing of analytical methods. Objective criteria related to analytical performance, sustainability, environmental impact and economic costs are assessed through the determination of penalty points, divided into five different blocks. For each block, the overall qualification is scaled from 0 to 4 and displayed on a regular hexagonal pictogram to allow comparison of analytical procedures. The disadvantages of this approach include the inability to increase the number of estimated indicators.

The work [10] provides a mechanism for transforming information models of construction objects to their equivalent structural models. This mechanism is intended to automate the necessary operations of transformation, modification and addition in such an exchange of information. The disadvantages of this approach include the inability to assess the adequacy and reliability of the information transformation process. Also, the disadvantage of this approach is the lack of consideration of the uncertainty of information about the object state.

The analysis of works [2–10] showed that the vast majority are based on the use of general scientific methods, such as systemic, comparative, structural and functional analysis,

the method of expert assessments, the method of scenario analysis of socio-economic systems and the information-theoretic approach.

But in order to eliminate subjectivity, improve the accuracy and reliability of decision making regarding the quality of training of civil aviation personnel, it is necessary to develop software products that meet the following requirements:

– the possibility of forming a generalized indicator of evaluation and choice of solutions based on changing sets of partial indicators, taking into account the complex multi-level structure of evaluation;

– the possibility of aggregating heterogeneous indicators (both quantitative and qualitative) for evaluating and choosing solutions that differ in measuring scales and ranges of values;

– taking into account the compatibility and different significance of partial indicators in the generalized assessment of decisions;

– flexible adjustment (adaptation) of evaluation models while adding (removing) indicators and changing their parameters (compatibility and significance of indicators).

For this purpose, it is proposed to develop a model that would allow to assess comprehensively of the professional training of aviation personnel involved in ensuring flight safety. The specified model should have flexible settings, implement direct and reverse evaluation within a single model and be able to be integrated into decision making support systems.

3. The aim and objectives of the study

The aim of the study is to develop a mathematical model for the professional training of aviation personnel involved in ensuring flight safety.

To achieve this aim, the following objectives are accomplished:

– to determine the factors influencing the quality of training the civil aviation pilots;

– to select the procedures to be taken into account when developing the model for the professional training of aviation personnel.

4. Materials and methods of research

The object of the research is the system of professional training of civil aviation pilots. The subject of the research is the process of assessing the qualities of civil aviation pilots using fuzzy cognitive maps. The hypothesis of the research is to increase the number of indicators for assessing the quality of training of civil aviation pilots with restrictions on the efficiency and reliability of decision making.

The limitations, assumptions and assumptions of this study include the fact that it was developed using standardized procedures for assessing aviation personnel, which are used for the main nomenclature of aircraft in Kazakhstan.

In the course of the research, the general provisions of the theory of artificial intelligence were used to solve the problem of determining the relationship between factors that affect the quality of training the civil aviation pilots. The research used fuzzy cognitive models to build a model for the professional training of civil aviation pilots. The simulation was carried out on an Intel Core i3 PC (USA).

5. Research results on the development of a mathematical model for the professional training of aviation personnel involved in ensuring flight safety

5. 1. An identification of factors affecting the quality of training of civil aviation pilots

Mathematical modeling of the process of assessing the level of training of civil aviation pilots devices describing the processes using a limited number of significant factors and abstracting from those whose influence can be ignored under certain circumstances.

Therefore, while choosing a set of concepts, let's propose to take into account the factors associated with the process of training civil aviation pilots, accelerating or slowing down the process of their training (Table 1). This decomposition is based on standardized procedures for assessing the quality of training of aviation personnel, which is recognized by the world community and improved by the author of the study.

It should be noted that there is no universal way to determine the factors, and in our case, the only source of information on the criteria is the expert position of the author of the article, expressed in natural language, based on a certain idea of the situation, knowledge, experience and intuition of the researcher.

Table 1

Factors influencing the civil aviation pilot training process

Name of indicator	Factors affecting the civil aviation pilot training process	
	Positive influence	Negative influence
Pilot age	20–35 years old	35 years and above
Pilot education	Higher education	Secondary education
Achievement in the exact sciences in the learning process	High performance in physics and mathematics (exact sciences) in the process of learning in educational institutions	Average (low) performance in physics and mathematics (exact sciences) in the process of learning in educational institutions
Pilot's criminal records	No convictions for administrative (criminal) offenses	Presence of convictions for administrative (criminal) offenses
Bad habits	Absence of bad habits (addictions)	Presence of bad habits (addictions)
Foreign language skills	Availability of certificates of knowledge of a foreign language (several foreign languages)	Lack of certificates of knowledge of a foreign language (several foreign languages)
Aircraft piloting experience	Experience in piloting civil aviation aircraft of the same class	Lack of aircraft piloting experience
Having team skills	Have managerial experience	Lack of management skills
Learnability	Successful acquisition of knowledge, skills and abilities	The need to repeat the training course
Ability to communicate with other crew members or maintenance personnel	High communication with the rest of the crew (staff)	Low communication with the rest of the crew (staff)
The presence of leadership qualities	High leadership qualities	Poor leadership qualities or their complete absence
Stress resistance	High	Below the average

This somewhat goes against the modeling principle of F. Lanchaster:

– F. Lanchaster's equations are not adapted to work with expert opinion, which we take as a source of information in this article for modeling under uncertainty;

– the performance parameters included in the equations are based on difficult statistics and the reliability of which may be questionable.

5. 2. The procedures to be taken into account when developing the model for the professional training of aviation personnel

For a possible assessment of the quality of training of civil aviation pilots, let's make a fuzzy cognitive map (FCM) of the tension between them. The basis for its compilation is the mathematical theory of fuzzy sets and fuzzy logic as a generalization of classical set theory and formal logic. An FCM is a directed graph whose arcs are weighted by fuzzy terms. The vertices of the graph, called concepts, correspond to the variables that are taken into account in the model and the weights of the arcs reflect the strength of the impact of variable causes on variable consequences. The term «cognitive» emphasizes that the initial data for modeling is a subjective information about the forces of influences, which are described by the words «increase» or «decrease». The term «fuzzy» means that the FCM uses different levels of «increase» and «decrease». These levels are set by numbers from the intervals [0, 1] and [–1, 0], which correspond to the terms *low, medium, high and others* according to the theory of fuzzy sets.

At the same time, the mathematical theory of fuzzy sets makes it possible to describe fuzzy concepts and knowledge, operating with this knowledge and to make fuzzy conclusions. In fuzzy logic, in contrast to classical logic, instead of the values «true» and «false», the value of the degree of truth is used, which takes any values from an infinite set from 0 to 1 inclusive.

The main concept that we will operate in this article is the concept of «ranking» (eng. «ranging», «ranking», «rating»), which means the placement of values in order of importance, significance. In our case, this is the compilation of certain factors that reduce the quality of civil aviation pilot training. The ranking of the proposed factors is considered by the authors as a task of multi-criteria analysis in the conditions of uncertainty. As an example, one can make an example of the researches of regarding the problem of the alternative-possible choice of political parties during the election race.

In order to solve the problem in this article, let's use the theory of decision making in a fuzzy environment and the idea of fuzzy perfection proposed in the scientific works. The method for using the FCM in the following way:

The concepts. Let $C=\{C_1, C_2, ..., C_n\}$ is a known set of concepts, i. e., variables used in the model of a dynamic system. In this work, the concept C_i estimated by the number $x_i \in [\underline{x}_i, \overline{x}_i]$, determined by an expert, where $\underline{x}_i, (\overline{x}_i)$ is the lower (upper) limit of the range of acceptable values of the concept C_i.

Links between concepts. Weight w_{ij} of the arc connecting concepts C_i and C_j, indicates the strength of the impact C_i on C_j:

– $w_{ij}>0$ (positive influence of C_i on C_j), if the increase (decrease) in the value x_i leads to an increase (decrease) in the value x_j;

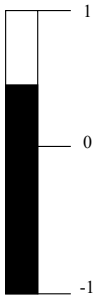
– $w_{ij}<0$ (negative influence of C_i on C_j), if the increase (decrease) in the value x_i leads to an increase (decrease) in the value x_j;

– $w_{ij}=0$ (the lack of influence of C_i on C_j), if the value x_j does not depend on the value x_i.

The power of influence (w_{ij}) will be assessed by experts using linguistic terms and the thermometer scale (Table 2).

Table 2

Evaluation of the impact force

Thermometer scale	Linguistic estimates	Numeric values
	Positive maximum	1
	Positive above average	0.75
	Positive average	0.5
	Positive below average	0.25
	Absent	0
	Negative below average	–0.25
	Negative average	–0.5
	Negative above average	–0.75
	Negative maximum	–1

If the opinions of several experts are taken into account, then the value is estimated as the average of the estimates of each of the experts.

Recurrent relation. A recurrence relation is a formula of the form $a_{n+1}=F(a_n, a_{n-1}, ..., a_{n-k+1})$, where F is some function of k arguments, which allows to calculate the next members of the numerical sequence due to the values of the previous members. The recurrence relation uniquely determines the sequence a_n, if the first k terms of the sequence are specified.

The following concepts are used to describe the oscillatory process in the FCM:

– $(n\times n)$ is the matrix of influence forces of concepts C_i on top of each other, in which the diagonal elements are equal to zero, i. e.:

$$W_0 = \begin{bmatrix} 0 & w_{12} & ... & w_{1n} \\ w_{21} & 0 & ... & w_{2n} \\ . & . & ... & . \\ w_{n1} & w_{n2} & ... & 0 \end{bmatrix}; \quad (1)$$

– initial state of the FCM, defined by the vector:

$$X^0 = \left[x_1^0, x_2^0, ..., x_n^0\right], \quad (2)$$

whose elements are equal to the value of concepts at step $k=0$.

– stationary state of the FCM, defined by the vector:

$$X^l = \left[x_1^l, x_2^l, ..., x_n^l\right], \quad (3)$$

at such step l, when, as a result of the interaction between the concepts, the FCM enters a steady state, in which the elements of the vector (3) stop changing.

The dynamics of step-by-step change in the meanings of concepts is determined by the ratio $x_i^{k+1} = x_i^k + \sum_{j=1}^{n}\left(x_j^k - x_j^{k-1}\right)w_{ji}$, which can be written in matrix form [8]:

$$X^{k+1} = X^k \oplus \left(X^k \ominus X^{k-1}\right)W_0, X^1 = X^0 \oplus X^0 W_0, \quad (4)$$

where «⊕» and «⊖» are the operations of the element-by-element addition and subtraction of vectors performed according to the scheme:

$$[a,b]\oplus[c,d]=[a+c,b+d], [a,b]\ominus[c,d]=[a-c,b-d].$$

Prediction of the value of the original variable. Consider the system «inputs – output», in which the concept C_n is the output variable and other concepts C_1, C_2, ..., C_{n-1} are input variables that affect each other. Then the prediction of the value of the original variable is performed according to the following algorithm:

Step 1. Set the initial state of the FCM (2):

$$X^0 = \left[x_1^0, x_2^0, ..., x_{n-1}^0, x_n^0 = 0\right],\ x_i \in \left[\underline{x}_i, \overline{x}_i\right]. \quad (5)$$

Step 2. Using the recurrence relation (4), calculate the vector (3) of concept values in the stationary (stable) state.

Step 3. In the resulting vector (3), fix the value x_n^l and take it as a forecast of $\hat{x}_n$ output corresponding to the given input vector (5).

A mathematical model of professional training of aviation personnel is proposed using fuzzy cognitive models.

Let's rank the influence of factors on each other. Concept importance indices C_1, C_2, ..., C_7 by the level of their influence on the concept C_7 match the values $\hat{x}_7$, which are calculated using the algorithm with the following initial vectors (6) (Fig. 1–3):

$X_0 = [50, 0, 0, 0, 0, 0, 0]$ – for concept influence C_1,

$X_0 = [0, 50, 0, 0, 0, 0, 0]$ – for concept influence C_2,

…

$X_0 = [0, 0, 0, 0, 0, 50, 0]$ – for concept influence C_6.

To assess the even effects of factors on the concept C_7 used initial vectors of the form:

$X_0 = [50, 50, 0, 0, 0, 0, 0]$ – for concept influence C_1 and C_2,

$X_0 = [50, 0, 50, 0, 0, 0, 0]$ – for concept influence C_1 and C_3,

…

$X_0 = [0, 0, 0, 0, 50, 50, 0]$ – for concept influence C_5 and C_6.

The diagram of the most important even impacts is shown in Fig. 2.

Concept importance indices C_1, C_2, C_4, ..., C_7 according to the degree of their influence on the concept C_3 coincide with the stationary values $\hat{x}_3$, which are calculated with the following initial vectors:

$X_0 = [50, 0, 0, 0, 0, 0, 0]$ – for concept influence C_1,

$X_0 = [0, 50, 0, 0, 0, 0, 0]$ – for concept influence C_2,

$X_0 = [0, 0, 50, 0, 0, 0, 0]$ – for concept influence C_4,

…

$X_0 = [0, 0, 0, 0, 0, 0, 50]$ – for concept influence C_7.

Similarly a diagram of pairwise influences of factors on the concept was obtained (C_3), which is shown in Fig. 3.

Therefore, fuzzy cognitive maps (FCM) are analogous to differential equations. The advantage of the FCM in comparison with differential equations lies in the possibility of using expert information to directly take into account interrelated factors that affect the quality of training of civil aviation personnel.

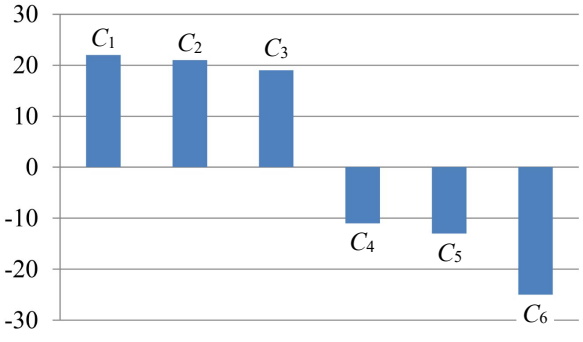


Fig. 1. Diagram of paired effects on the concept C_7

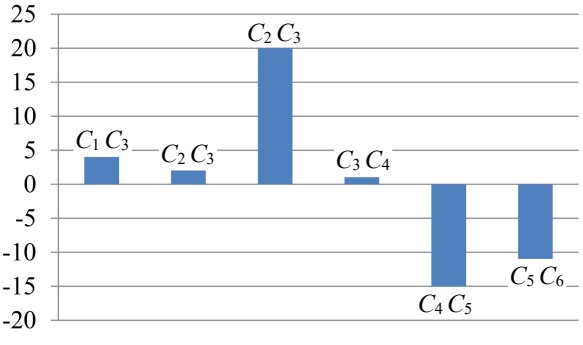


Fig. 2. Diagram of paired effects on the concept C_7

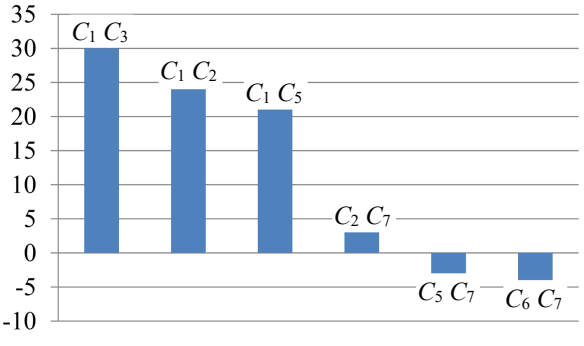


Fig. 3. Diagram of paired effects on the concept C_3

In Fig. 4, a fuzzy cognitive model for assessing the readiness of civil aviation personnel has been introduced.

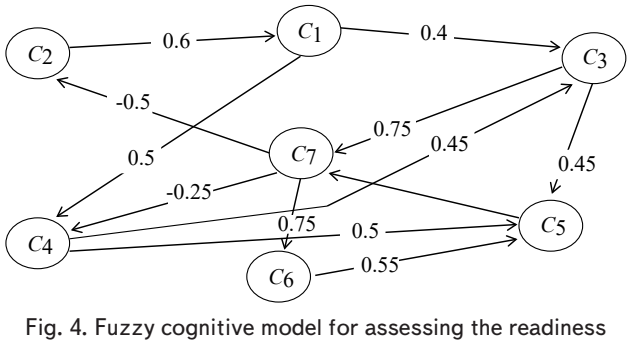


Fig. 4. Fuzzy cognitive model for assessing the readiness of civil aviation personnel

These graphic dependencies show the relationship between indicators that assess the quality of training of civil aviation workers.

Comparison of the proposed approach to assess the quality of training of aviation personnel of civil aviation aircraft of one of the aviation carriers of Kazakhstan. Comparative

evaluation was carried out by analyzing the test tasks that were civil aviation pilots during admission to flights from 2015 to 2022. During that time, 62 civil aviation pilots were tested for admission to flights. Testing for admission to flights was carried out under the MPL program of ICAO. Evaluation of the effectiveness of the proposed approach was carried out according to the criterion of the number of indicators for assessing the quality of training of civil aviation pilots, according to which the quality of their training is assessed. The results indicate the following:

– coincidence with the test results is on average 70 % (indicators coincide in the range of values from 56 % to 73 %);

– according to the results of the investigation of aviation incidents that occurred with the participation of pilots of the carrier's civil aviation, it was established that the main reasons for them were precisely the lack of coherence of the actions of the crews, the leadership qualities of the crew members, the psychological fatigue of aircraft crews, which are not taken into account in standardized assessment procedures, but are proposed for consideration in this study.

The proposed approach just takes into account the indicators that caused these aviation incidents.

6. Discussion of the results of the study of a mathematical model

The advantages of the developed set of indicators for assessing the quality of training of aviation specialists in civil aviation pilots are:

– it has a flexible hierarchical structure of indicators, which makes it possible to reduce the problem of multi-criteria evaluation of alternatives to one criterion or use a vector of indicators for selection (Table 1), in contrast to the study [5];

– the ability to add (extract) evaluation indicators from the general scorecard;

– it allows to take into account different types of indicators for assessing the professional training of aviation personnel and to be a subject to priority assessment (Table 1, (1)–(5)) in contrast to the study [10];

– the uniqueness of the obtained assessment of the quality of professional training of aviation personnel ((1)–(5)) in contrast to the study [16];

– adaptation of a set of indicators of evaluation of aviation specialists of civil aviation for a specific aircraft;

– the ability to assess the quality of training of civil aviation specialists by indicators that have both quantitative and qualitative origins.

The main advantages of the proposed assessment the procedures to be taken into account when developing the model for the professional training of aviation personnel are:

– wide use area (decision making support systems) ((1)–(5)) in contrast to the study [5];

– the simplicity of mathematical calculations ((1)–(5), Fig. 1–4);

– the possibility of synthesizing the optimal structure of the decision making support system (Fig. 4), in contrast to the studies [5, 10–18].

It is expedient to use the developed model in decision making support systems for assessing the quality of professional training of aviation personnel in order to increase the efficiency and reliability of decisions made.

The limitations of the research should be considered the availability of sufficient computing resources. It depends on the hierarchical system of indicators that are part of the model for assessing the quality of training of aviation specialists in civil aviation, however, it does not exceed 3–5 % of the total computing power of a personal computer.

This model will allow:

– to evaluate the professional training of aviation personnel;

– to identify effective measures to improve the efficiency of professional training of aviation personnel;

– to increase the speed of assessment of the professional training of aviation personnel;

– to reduce subjectivity in assessing the professional training of aviation personnel;

– to substantiate measures aimed at improving the efficiency of professional training of aviation personnel.

Based on the results of the analysis of the effectiveness of the proposed method, it can be seen that the proposed assessment model takes into account 30 % more assessment indicators than standardized ones.

Directions for further research should be aimed at reducing computational costs in assessing the professional training of aviation personnel.

7. Conclusions

1. The difference between the proposed set of indicators is that this set of indicators is flexible, allows to add new assessment indicators (remove the necessary ones), which allows to customize for a specific type of aircraft, as well as take into account specific conditions and factors affecting the safety of civil aviation. This is achieved by presenting the evaluation indicators in the form of term sets, which can be presented later in a form convenient for calculation, which further eliminates the subjectivity of the evaluation.

2. Efficiency improvements of decisions made on assessing the quality of professional training of aviation personnel involved in ensuring flight safety can be achieved due to:

– sequential solution of problems of forward and backward planning using simulation modeling of the dynamics of professional training of aviation personnel;

– the possibility of taking into account both quantitative and qualitative indicators for assessing the quality of professional training of aviation personnel involved in ensuring flight safety;

– the scalability of indicators for assessing indicators for assessing the quality of professional training of aviation personnel involved in ensuring flight safety.

According to the results of the analysis of the effectiveness of the proposed model, it can be seen that the proposed assessment model takes into account 30 % more assessment indicators than standardized ones.

This is achieved by using the apparatus of fuzzy cognitive models, which allows to take into account the influence of a separate indicator on the quality of training of civil aviation pilots, and to obtain a generalized assessment of the quality of training of civil aviation specialists in terms of ensuring flight safety.

Conflict of interest

The author declares that there is no conflict of interest regarding this research, including financial, personal nature, authorship or other nature that could affect the research and its results presented in this article.

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Data availability

The manuscript has associated data in the data store.

References

1. Rodionov, M. A. (2010). Informatsionno-analiticheskoe obespechenie upravlencheskikh resheniy. Moscow: MIGSU, 400.
2. Degtyarev, V. S., Mashoshin, O. F., Degtyareva, A. V. (2021). Upset recovery training for civil aviation pilots. Civil Aviation High Technologies, 24 (1), 8–15. doi: https://doi.org/10.26467/2079-0619-2021-24-1-8-15
3. International Civil Aviation Convention. Appendix 6. Aircraft Operation. Part I. International commercial air transport. Aircraft (2016). ICAO.
4. Mayorova, Yu. A., Guziy, A. G. (2015). Pilot Fatigue as the Psychophysiological Factor of Risk to Flight Safety. Psychology and Psychotechnics, 7, 707–716. doi: https://doi.org/10.7256/2070-8955.2015.7.15222
5. Aydarkin, D. V., Kachan, D. V., Kosachevskiy, S. G. (2017). Razrabotka kriteriev dlya otsenki protsessa formirovaniya navykov pilotirovaniya v khode pervonachal'nogo letnogo obucheniya pilotov. Nauchnyy vestnik UI GA, 9, 91–97.
6. Onykiy, B., Artamonov, A., Ananieva, A., Tretyakov, E., Pronicheva, L., Ionkina, K., Suslina, A. (2016). Agent Technologies for Polythematic Organizations Information-Analytical Support. Procedia Computer Science, 88, 336–340. doi: https://doi.org/10.1016/j.procs.2016.07.445
7. Manea, E., Di Carlo, D., Depellegrin, D., Agardy, T., Gissi, E. (2019). Multidimensional assessment of supporting ecosystem services for marine spatial planning of the Adriatic Sea. Ecological Indicators, 101, 821–837. doi: https://doi.org/10.1016/j.ecolind.2018.12.017
8. Xing, W., Goggins, S., Introne, J. (2018). Quantifying the Effect of Informational Support on Membership Retention in Online Communities through Large-Scale Data Analytics. Computers in Human Behavior, 86, 227–234. doi: https://doi.org/10.1016/j.chb.2018.04.042
9. Ko, Y.-C., Fujita, H. (2019). An evidential analytics for buried information in big data samples: Case study of semiconductor manufacturing. Information Sciences, 486, 190–203. doi: https://doi.org/10.1016/j.ins.2019.01.079
10. Çavdar, A. B., Ferhatosmanoğlu, N. (2018). Airline customer lifetime value estimation using data analytics supported by social network information. Journal of Air Transport Management, 67, 19–33. doi: https://doi.org/10.1016/j.jairtraman.2017.10.007
11. Ballester-Caudet, A., Campíns-Falcó, P., Pérez, B., Sancho, R., Lorente, M., Sastre, G., González, C. (2019). A new tool for evaluating and/or selecting analytical methods: Summarizing the information in a hexagon. TrAC Trends in Analytical Chemistry, 118, 538–547. doi: https://doi.org/10.1016/j.trac.2019.06.015
12. Ramaji, I. J., Memari, A. M. (2018). Interpretation of structural analytical models from the coordination view in building information models. Automation in Construction, 90, 117–133. doi: https://doi.org/10.1016/j.autcon.2018.02.025
13. Pérez-González, C. J., Colebrook, M., Roda-García, J. L., Rosa-Remedios, C. B. (2019). Developing a data analytics platform to support decision making in emergency and security management. Expert Systems with Applications, 120, 167–184. doi: https://doi.org/10.1016/j.eswa.2018.11.023
14. Chen, H. (2018). Evaluation of Personalized Service Level for Library Information Management Based on Fuzzy Analytic Hierarchy Process. Procedia Computer Science, 131, 952–958. doi: https://doi.org/10.1016/j.procs.2018.04.233
15. Chan, H. K., Sun, X., Chung, S.-H. (2019). When should fuzzy analytic hierarchy process be used instead of analytic hierarchy process? Decision Support Systems, 125, 113114. doi: https://doi.org/10.1016/j.dss.2019.113114
16. Rybak, V. A., Shokr, A. (2016). Analysis and comparison of existing decision support technology. System analysis and applied information science, 3, 12–18.
17. Rodionov, M. A. (2014). Problems of information and analytical support of contemporary strategic management. Civil Aviation High Technologies, 202, 65–69.
18. Bednář, Z. (2018). Information Support of Human Resources Management in Sector of Defense. Vojenské rozhledy, 27 (1), 45–68.