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Application of a Synergetic Model to Assess the Effectiveness of Retraining and Advanced Training of Aviation Personnel

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***Abstract* - The ways to improve the quality of the process of retraining and advanced training of aviation personnel are proposed, which are based on the application of a synergetic model for assessing the effectiveness of the training process, which is based on a thermodynamic approach. This model provides an opportunity to quantify the effectiveness of training, which in turn allows the formation of rational management actions aimed at improving the quality of training of aviation personnel. Using the proposed synergetic approach to quantifying the impact of direct and feedback on the effectiveness of retraining or advanced training of aviation personnel allows you to choose the appropriate teaching methods which can be: nonlinear dialogue, self-learning, training that stimulates self-motivation and so on. All this creates the preconditions for the adaptation of the learning process to the real conditions that are created during its implementation in order to save resources (costs) in achieving the ultimate goal - the acquisition of established competencies or a certain level of qualification.**

***Index Terms* - Advanced training, aviation personnel, efficiency of retraining, synergetic model**

INTRODUCTION

The training objectives and recommendations of the International Civil Aviation Organization (ICAO) [1] require integration processes in the training of aviation personnel (AP) including the military.

Such processes should be aimed, first of all, at the development of professional competencies in training. Taking into account Ukraine's aspirations to join the European Union (EU) and NATO [2], the training of aviation personnel should be carried out taking into account the uniform requirements for the quality of training. This also applies to the training of the AR on the control of unmanned aerial vehicles [3]-[4].

Such criteria are universal and at the same time formal in nature, which to some extent eliminates the subject content, significance and features of the disciplines studied in the process of training the military AP [5].

The modern paradigm of AP training base on the evolutionary-synergetic approach. This paradigm emphasizes the interdisciplinary aspects of science, the integrity of theoretical knowledge, skills, abilities and their unity with the requirements of guidelines and regulations. Guidelines and regulations govern aviation activities and conditions of implementation.

This situation of formation of "post-classical, synergetic worldview" [6] puts forward new requirements to the content of retraining and advanced training programs, to the technology and infrastructure of the training process, evaluation of its effectiveness and quality, to the management system of training in general.

There is no doubt that the preparation of AP in modern conditions, both at the macro and micro levels has the character of an open multicomponent, multifactorial system in which there are processes of self-organization. Constant structural changes and transitions of parts, subsystems and systems as a whole from one ordered state another. Thus, the macro level is represented by the training system of the Air Forces, which has developed at a certain point in time, or retraining and advanced training courses and so on. The micro level can be associated with a study group, unit, etc. The orderly state is represented by the actual levels of training of the AP, which are determined by the relevant courses (programs) of training. The importance of the level of training is influenced by external (changes in regulations, the state of aircraft, the requirements of senior managers, the availability of logistical and financial resources, etc.) and internal (physical, psychological, moral properties and capabilities) factors. This is especially actual for training during the COVID-19 pandemic [7].

Thus, the training of AP is a typical nonlinear process. This means that under certain conditions, the system may be sensitive to the influence of very weak factors and to a slight change in parameters. It may respond with a significant change (improvement or deterioration) in the functioning and efficiency of its work. In military aviation, such an unpredictable change can lead to catastrophic consequences (insufficient level of training of the AP can provoke non-fulfillment of combat or training and combat missions and failure to ensure the required flight safety indicators).

LITERATURE REVIEW AND PROBLEM STATEMENT

In modern sources, the economic efficiency of education is considered mainly its higher component. It is evaluated by the ratio of the contribution of the specialist to society to the costs of society for the training of such a specialist [8]. In such models of assessing the economic efficiency of education, first of all, attention is paid to the training of specialists. However, although the economic effect in modern society plays a very important role, the preparation of the military AP requires the formation of a range of qualities and competencies necessary for teamwork, aimed at fulfilling the combat and training and combat tasks. At the same time, in the vast majority of ICAO recommendations concerning the preparation of the AP in the direction of ensuring the required flight safety indicators, the consideration of the economic component is considered inexpedient. In addition, ICAO recommends that when creating national AP training systems, take all necessary measures to improve the efficiency and quality of such systems [1].

In the paper [9] the educational and disciplinary model of teaching is considered. The purpose of the model is to equip students with knowledge, skills and abilities, to instill obedience. Methods of communication are instructions, explanations, prohibitions, demands, threats, punishments, notations, shouting.

The advantages of the model are time and effort savings, effective management of the learning process, and an easier way of mastering complex knowledge. The disadvantages of the model are the introduction of "ready-made" knowledge, the lack of the need to independently and productively think, there are few opportunities for individualization and differentiation of learning.

In the paper [10] a student-centered learning model is considered. The purpose of the model is to contribute to the development of the student as a person. The model is focused on the psychological health of students, individual development of students. The disadvantage of the training model is that it does not fully take into account the specifics of training aviation personnel.

Synergetic interdisciplinary methodology provides researchers with basic models that formalize various in essence, but those that proceed according to a single algorithm [11]-[12]. The synergetic model is based on the provision that complex processes of knowledge transfer to students, the formation of the necessary skills and abilities can be explored by considering a holistic dynamic system of “teacher-students” as the most important (if not the main) component of educational clusters of various scales [13]. The decisive role in this system is the phenomenon of self-organization [14]. The display of an educational object in the form of a system with self-organization allows the use of a wide range of both qualitatively intuitive and quantitative mathematical methods of modeling and research of learning processes [15].

In this paper we will consider the process of retraining and advanced training of AP from the standpoint of synergetic. To do this, we will build a synergetic process model for predicting the effectiveness and quality of training for individual components of training, taking into account their content and focus on the formation of certain competencies. Based on the received values of efficiency and quality we will develop the mechanism of working off optimum administrative decisions directed on improvement of indicators of the considered process.

MATERIALS AND RESEARCH METHODS

The model of evaluating the effectiveness of the process of retraining and advanced training of AP is built using the methods of analogy [16] and entropy [17], which is widely used to solve probabilistic problems in various fields of research.

We can imagine the no equilibrium environment in which the process of retraining and advanced training of AP takes place as an analogue of the no equilibrium thermodynamic environment. The interaction between thermodynamic flows J_i and thermodynamic forces X_k present in such an environment can be represented by a phenomenological relationship [15]:

$$J_i = \sum_{k=1}^{n} L_{ik} X_k \ , \ i = 1,2,3\ldots, n \ , \qquad (1)$$

where L_{ik} – the phenomenological coefficients.

Traditionally, the learning process is the interaction of two competing factors. One of them is the work of a nonlinear source of knowledge (the activities of teachers, instructors) creates an imbalance, orderly heterogeneity in this environment. The second factor is the dissemination and acquisition of knowledge, skills and abilities by students. This factor dissipates the heterogeneity created by teachers (instructors) [16]. The efficiency of such a system E is due to the imbalance and the corresponding production of entropy. Based on the following positions (1) will take the form (2):

$$J_i = \sum_{k=1}^{2} L_{ik} X_k \ , \ i = 1,2 \ . \qquad (2)$$

The growth of knowledge, their dissemination, assimilation and consistency among students characterizes the increase in learning efficiency and the functioning of the learning environment. To quantify the effectiveness of the learning environment, we will use the "performance indicator" *E* [18]. This indicator characterizes the properties of the whole system, which does not have any of its separate parts. Varying the possible conditions for the implementation of the educational process and calculating this indicator, we will assess how successful, complete and high-quality educational system is the transformation of knowledge of teachers (instructors) into knowledge, skills and abilities of students. At the same time, we will monitor and identify the factors that contribute to this transformation in order to develop optimal solutions for the management of the educational system to achieve the goal of improving the system and improving the quality of education.

The effectiveness of the educational process to master a specific program of retraining and advanced training AP will be analyzed on the basis of a basic model for predicting the effectiveness of energy (entropy) transformations that occur in no equilibrium thermodynamic systems [17]. Methods of simplification or "coarsening" of models allow you to simply describe the essence of the phenomena, while the distortions carried out by the "rough" model are not significant and they cannot significantly change the end result [15]. From such positions, the learning environment of the chosen scale (faculty or department) can be considered as a non-equilibrium self-organizing environment with a well-developed network of nonlinear differential ties between the participants of the educational process of retraining and advanced training AP.

The product of the educational process in this case [18] are the knowledge, skills and abilities acquired by students, formed competencies, as well as advanced training, growing scientific and methodological and pedagogical skills of teachers (instructors). In the first approximation, the chosen learning environment can be represented by a two-stream no equilibrium system. The cost of retraining or advanced training of the listener and the corresponding qualification and competence of the listener (flows) interact with each other forming a dynamic integrity. The indicator of the efficiency of such a system E can be quantified and obtained from the ratio of the level of actually obtained competencies multiplied by the effort expended (output) to a certain level of competencies multiplied by the estimated costs (input):

$$E = \frac{output}{input} = -\frac{J_e X_e}{J_i X_i} \ . \qquad (3)$$

Where J_e – the output flow, which characterizes the amount of acquired knowledge or actually obtained qualification upon completion of retraining or advanced training courses;
X_e – the amount of practical costs for training the student or the effort of the training cluster in accordance with the work plan-program expressed in man-hours or their monetary equivalent;
J_i – the flow at the entrance, which characterizes the expressed, for example, in the number of didactic units the amount of knowledge of students, which is set by the relevant combat training courses and training programs, or the expected level of competencies and qualifications that he must receive in retraining or advanced training;
X_i – the planned costs of the training system for retraining and advanced training of a specialist in the AP, expressed in man-hours or in cash or otherwise - the amount of material resources and the required training time according to the curriculum, which requires spending on the learning process.

Provided by regulations governing aviation activities, the process of retraining and advanced training AP, the so-called i process, launches a real e learning process. The flows and volumes of knowledge of the expected and real processes are interconnected by equations [19]:

$$J_i = L_{ii} X_i + L_{ie} X_e \ , \qquad (4)$$

$$J_e = L_{ee} X_e + L_{ei} X_i \ , \qquad (5)$$

where J_e – production function of the learning environment $J_e(X_i, X_e)$;
J_i – production function of the faculty $J_i(X_i, X_e)$, which is implemented in the form of requirements for relevant courses and training programs.

In the two-stream model of the learning system considered, the phenomenological basic direct and inverse relations are represented by the coefficients of elasticity of direct L_{ee}, L_{ii} and their L_{ei}, L_{ie} cross-processes, the meaning of which follows from equations (4) and (5). These coefficients can be interpreted as follows:

L_{ii} – the "need" ratio reflects the need for a qualified AP;
L_{ee} – the coefficient of "learning costs" reflects the ability of the educational system to provide students with knowledge on the course of disciplines to be studied, taking into account: first - the learning environment opportunities, second – individual abilities of students in mastering the amount of knowledge, and third - the ability of students to form the necessary knowledge and turn them into skills.

Phenomenological cross-coefficients L_{ei} and L_{ie} characterize the mutual influence of the process determined by normative documents i and the real educational process e for mastering theoretical and practical material. Cross-process coefficients determine the amount of feedback due to learning technologies, qualifications and skills of teaching and instructing staff, the abilities of students, and their level of individual training and so on.

To achieve the goal of retraining or advanced training, these coefficients must be equal to each other or be symmetrical, ie the ability of students, their level of individual training must meet the requirements of the educational system to master a particular specialty or obtain a certain qualification. This requirement for the values of phenomenological coefficients in equations (4) and (5) completely coincides with the reciprocity Lars Onsager theorem [19]:

$$L_{ei} = L_{ie} \ . \qquad (6)$$

Analysis of the efficiency of conversion of input parameters into output is convenient to perform if (3) is presented taking into account (4) and (5) in the form of:

$$E = -\frac{ax - b}{1/ax - b}, \qquad (7)$$

$$x = -\frac{X_i}{X_e}, \qquad (8)$$

$$a = \sqrt{\left|\frac{L_{ii}}{L_{ee}}\right|}, \qquad (9)$$

$$b = \frac{|L_{ie}|}{\sqrt{|L_{ii}L_{ee}|}}. \qquad (10)$$

Where x – the relative learning costs, a – the parameter that reflects the value of direct connections, b – parameter that determines the feedback. As in other similar synergetic models, x – the order parameter, a and b – the control parameters.

Graphically, the dependence $E(x, a, b)$ corresponding to (7) can be represented as a set of extreme curves (Fig. 1). Curves 1, 2, 3, 4 are constructed for feedback values equal to 0.7; 0.85; 0.94; 0.99.

With the help of the proposed model of efficiency it is possible to carry out a qualitative assessment of individual elements of the process of retraining or advanced training of AP. Such a model can provide a qualitative description of the impact on the effectiveness of the learning process of factors such as initial level of training, ability, various types of motivation of students to improve their skills or acquire new knowledge in a new specialty, socio-psychological atmosphere in the training cluster and so on.

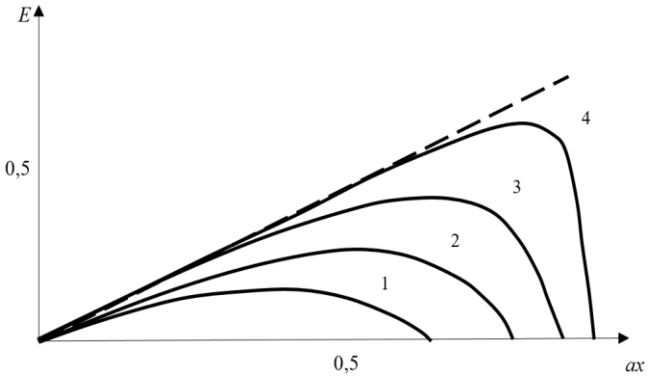

FIGURE 1 FAMILIES OF EXTREME EFFICIENCY CURVES OF ENERGY (ENTROPY) TRANSFORMATIONS FOR TWO-STREAM PROCESSES

The proposed model was used to qualitatively assess the effectiveness of the process of retraining and advanced training of AP, which was trained at Ivan Kozhedub Kharkiv National Air Force University, Faculty of Retraining and Advanced Training of Aviation Personnel in previous years and identify possible ways to improve it.

As the analysis of the obtained results showed, about 30% of students show increased interest in mastering the educational material of the course. For flight specialists, the percentage of such students increases by 2 – 2.5 times, for engineering specialties by 1.5 – 2 times, for specialists involved in flight management, the increase reaches 1.7 – 2.3 times during advanced training. When retraining, the percentage of students who show increased interest decreases and averages 30%. Such listeners have a relatively high level of motivation, they are focused on success. About 45% show insufficient interest, as indicated by their current assessments of "good", but for the most part such assessments are only "satisfactory". About 25% are unmotivated listeners with uncertain goals. They assimilate the material at a low level and receive, for the most part, grades at the level of "satisfactory".

One of the main tasks of teachers is to reduce the number of poorly successful students by transferring them to the category of active, interested in learning outcomes by increasing motivational factors.

Students with poor initial training and difficulties in mastering the material can successfully complete the learning process if the educational system is able to carry out "soft", non-linear management of the educational process, taking into account technical and intellectual capabilities, abilities, skills and level of training all participants in the learning process.

As part of the proposed synergetic model, effective management of the learning system should be done by changing the parameters discussed above: relative costs *x*, direct *a* and *b* feedback. At the same time, the parameters *a* and *b* take into account not only the socio-economic, but also the psychological and pedagogical conditions of the learning process.

From the analysis of (7) and (8) it follows that with constant feedback $b = const$ to increase the efficiency of the learning process *E* can be in two ways: first by changing the intensity of effort (relative costs) at the constancy of direct connections $a = const$, the second by changing the direct ties at a constant cost $x = const$.

Obviously, the first way to increase E by increasing time and labor costs x while not exceeding the established values ($x < x_0$) is the most justified way to increase the effectiveness of training in relation to passive students and those who have a low level of preparation for training. This category of students, as a rule, has weak skills of independent work and requires increased attention from teachers and, as a consequence, an increase in time spent on training in achieving the goal of retraining or advanced training. The implementation of such an extensive approach could be the organization of remote input control of the level of theoretical training of students and the results of the formation of study groups of students who have a similar level of training. For groups in which students have a low level of preparation to organize additional classes.

At the same time, as the experience of retraining and advanced training of AP shows excessive classroom and extracurricular work of teachers with students, the overload of the educational process with control measures (case $x > x_0$) does not contribute to the need for independent work and leads to the opposite effect which negatively affects the effectiveness of the learning process. This situation is reflected in the values of the efficiency of the educational process calculated according to the proposed model with the invariance of the feedback $b = const$ shown in Fig. 2.

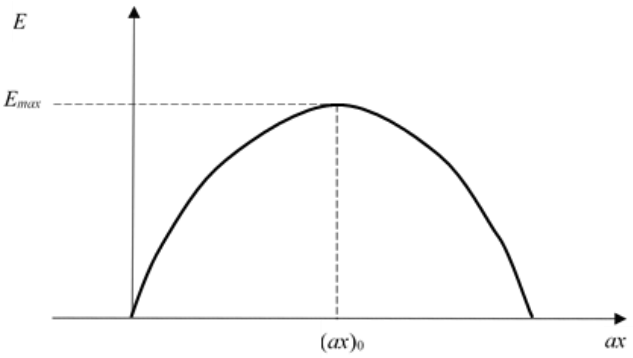

FIGURE 2 THE DEPENDENCE OF THE EFFECTIVENESS OF THE EDUCATIONAL PROCESS B = CONST ON THE RELATIVE COSTS X AT A = CONST OR DIRECT CONNECTIONS A AT B = CONST

It is advisable to consider the second way to increase the efficiency of the learning process that follows from the analysis of the proposed model, (7) and (9). The essence of this method is to intensify direct ties *a* at constant costs $x = const$ and feedback $b = const$.

Suppose that the factor of direct connections, assesses the psychological state of the listener, conditionally define it as a "level of discipline". This is a multifaceted systemic psychological indicator as shown, for example, in [19]. All other things being equal, the efficiency index *E* will reach its maximum value at the optimal value of the mobilizing factor of "discipline" a_0 (Fig. 2) which corresponds to a high degree of conscious component of motivation of the listener. Weak factor *a*, ie the case when $a < a_0$ (reduced level of responsibility for personal future, indifferent attitude to training, unclear consequences of insufficient level of personal qualification in aviation activities), reduces the level of effectiveness of training *E*. At the same time, the inflated level of the case when "discipline" turns into unconscious fear $a > a_0$ (excessive excitement caused by either one's own insecurity or a tense psychological climate in the team and other factors) reduces the importance of the effectiveness of the educational process.

The proposed synergetic model of (7) characterizes the most promising and productive way to intensify the learning process and increase the efficiency of the component of the learning system "teacher-listener", which is to strengthen feedback *b* at fixed costs $x = const$ and fixed direct ties $a = const$ (Fig.1). We will prove it by the following example.

Assume that the parameter that performs the control action *b* reflects the degree of cooperative, coordinated interaction of the listener and the teacher (instructor), their interrelated development that occurs in the learning process. This parameter not only determines the transfer of information from teacher to student in the formation of skills, but also characterizes the creation of a situation in which the possibility of converting information into knowledge by the listener (for example, in the formation of personal skills) [20–21]. In this case, the factor *b* is a reflection, an action that triggers and maintains a non-linear process of dialogue based on feedback between the teacher (instructor) and the listener. Such an action can be conditionally called "interest". It is also a complex systemic psychological indicator for the assessment of which there are various models, such as those given in [22]. For a student undergoing retraining or advanced training, the factor of "interest" is an expression of intrinsic motivation to acquire the necessary knowledge, ability to self-education, ability to supplement and improve personal knowledge structure, develop acquired skills and form the necessary skills. By educating and developing the listener's necessary internal motivation, the formation of personal goals aimed at achieving the goal of learning, the educational system is able to increase the effectiveness of training. In the considered model such situation is illustrated by Fig. 1, when the intensification of feedback reflecting, for example, “interest” (increasing the value of the factor *b*) increases the effectiveness *E* of the training system.

Consider another example of the influence of the level of initial knowledge on the effectiveness of the learning process. Assume that the results of the test tasks of the input control are in the range from 0 to 10 and reflect the level of knowledge of the listener before retraining or advanced training, so that 10 points indicates an excessive level, 8 and 9 points – high level, 5, 6 and 7 points – medium level, 3 and 4 points – low level, below 3 points – insufficient level of preparation for training. We will assume that an excessive level of training corresponds to a feedback value such as $b = 0.99$, a high level – $b = 0.85$, a medium level – $b = 0.7$, a low level – $b = 0.5$ and an insufficient level – $b = 0.3$, respectively. The direct costs of Xi for training are recorded in the relevant training programs, which set: the duration of training and a certain number of hours of theoretical, practical, training, independent components of training, as well as a certain number of hours of consultation – a value of direct communication. Also assume that the relative costs have reached the level of $x = 0.96$. Substituting the obtained values into (7) we obtain the curves shown in Fig. 3.

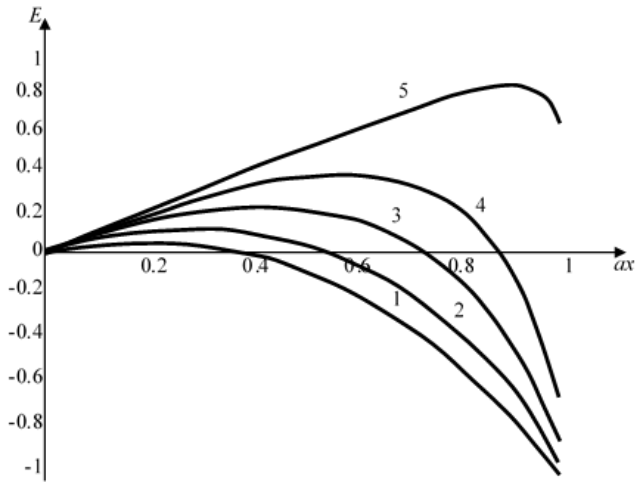

FIGURE 3 DEPENDENCE OF EFFICIENCY OF TWO-FLOW EDUCATIONAL PROCESS AT B = CONST, CURVE 1 – B = 0.3, 2 – B = 0.5, 3 – B = 0.7, 4 – B = 0.85, 5 – B = 0.99, ON DIRECT CONNECTIONS A AT THE FIXED RELATIVE EXPENSES X = CONST

Let's explain the results. At first glance, it seems that the higher the level of initial knowledge, the effectiveness of the learning process should increase, but this is not true. In the case when the level of preparation of the student for training was excessive, the costs provided by the training program become excessive, ie such that they exceed their need to achieve the ultimate goal of training, so the effectiveness of the learning process decreases.

In another extreme case, when the initial level of knowledge is low or insufficient planned resources (time spent) is not enough to achieve the goal within a certain period of time set aside for training. In this case, the value of the efficiency of the training system becomes below zero, the system wastes resources T_0 confirm this, we give an example from the experience of retraining forward air controller (FAC). Thus, during 2019-2020, the percentage of unmotivated students during retraining in the FAC specialty reached 73%. This situation is explained by the state in which Ukraine found itself at that time. In order to carry out effective measures to conduct an anti-terrorist operation in eastern Ukraine, the troops felt an urgent need for the FAC, so a large number of servicemen were sent to retrain in this specialty. At the same time, the preliminary selection for retraining courses was conducted at an extremely low level. This led to the retraining of servicemen who did not have a complete secondary education or had a humanitarian education, did not understand the impact of the FAC on the overall results of hostilities, were subject to dismissal from the ranks of the Armed Forces and so on.

Such factors did not motivate students to master this profession. Therefore, retraining did not achieve its goal in full.

To eliminate such situations and in order to increase the efficiency of the process of retraining and advanced training, it is proposed to conduct an extended study of the ability of future students and assess the ability of the educational system before training. Such a study for students can be organized remotely by conducting appropriate tests aimed at assessing the level of theoretical knowledge and practical skills, the ability to remember information (level of "short" or "long" memory), identifying the type of information perception (visual, auditory, verbal, logistical), the ability to self-study, the ability to translate knowledge into practical skills, the level of motivation and discipline and so on.

The capabilities of the training system are assessed by the comfort of the training course (living conditions, nutrition, training, training, cultural and physical education activities), providing classes with interactive tools, the availability of appropriate training facilities, providing special literature, Internet access and so on. The ability of the educational system also includes the assessment of teaching (instructor) main criteria which are: level of qualification, methodical skill, ability to change the form of teaching material (taking into account visual, auditory, verbal or logistical type of perception), ability to create socio-psychological atmosphere and so other.

The obtained study and evaluation data are presented in digital form, usually on a ten-point scale. Assume that the values of students' abilities are the coordinates of the general vector *b* that reflects the feedback, and the abilities of the educational system form a common vector of direct links *a* of the educational process and the total value of such vectors is a normalized sum of the form:

$$a = \frac{1}{a_{\max}} \sqrt{\sum_{i=1}^{N} (\alpha_i a_i)^2} , \qquad (11)$$

$$b = \frac{1}{b_{\max}} \sqrt{\sum_{j=1}^{M} (\beta_j b_j)^2} . \qquad (12)$$

where a and b – appropriate level of direct and feedback links of the educational process;

a_{max} and b_{max} – maximum level values that can take direct and feedback, respectively;

a_i and b_i – the results of testing and evaluation of the components of the educational process and future students, respectively;

N – the total number of components for which the assessment of the educational process;

M – the total number of components for which the study of future students;

α and β_j – weights.

Values and are obtained in accordance with the tests and methods selected to assess and study the components of the learning process and the ability of future students. The weights in (11) and (12) are determined by the methods of expert assessments [23]. Their values can differ significantly depending on the purpose of training AP (retraining, advanced training, training, etc.) and the profession in which the process is carried out.

Thus, having the results of assessment and testing of the components of the educational process and future students, respectively, you can assess the level of direct and feedback of the future educational process using (11) and (12). In the future, based on previous experience of retraining and advanced training of AP, an assessment of the relative costs of the training process (8). As a result, we obtain all the necessary data to calculate (7) to assess the effectiveness of the planned learning process. Changing the values ai of the coordinates of the general vector of direct a connections taking into account the existing limitations on their values (capabilities of the training system – the availability of time, training base, interactive learning tools, etc.) the search for the optimal, in terms of maximizing the effectiveness of training $\underline{E} \rightarrow E_{max}$, management decisions, ie the search for a rational version of the training program. The found variant of the plan of the program of carrying out training is submitted for the coordination and the statement.

This method of developing and adjusting curricula will enable the management of the educational process of AP to form appropriate study groups in accordance with the ability to prepare the AP, the level of training of students' personal abilities to perceive information and form the necessary professional skills and abilities. form of teaching educational material, which will improve the efficiency of the educational process of retraining and advanced training of AP.

The proposed approach to change in the organization of AP training will significantly increase the effectiveness of retraining and advanced training of AP and reduce the time of separation of personnel from their functional responsibilities, which in turn will encourage managers to increase the knowledge of subordinate AP, which is planned for retraining or advanced training.

CONCLUSIONS

Using the proposed synergetic approach to quantifying the impact of direct and feedback on the effectiveness of retraining or advanced training AP allows you to choose the appropriate teaching methods which can be: nonlinear dialogue, self-learning, training that stimulates self-motivation and so on. All this creates the preconditions for the adaptation of the learning process to the real conditions that are created during its implementation in order to save resources (costs) in achieving the ultimate goal - the acquisition of established competencies or a certain level of qualification.

The choice (definition) of the method of making the optimal decision (search for a rational version of the plan-program) for retraining or advanced training of AP can be a further area of research.

The application of a synergetic model to assess the effectiveness of the process of retraining and advanced training of AP is universal and provides a methodological basis for the analysis of many factors that affect the effectiveness of training. The considered approach allows to compare various modes of carrying out of training taking into account their maintenance and volume, to choose the most optimum technological or pedagogical innovations and the most favorable administrative decisions, to carry out monitoring of formation of necessary competences of AP.

The developed synergetic model can be further applied to the training of specialists for radio-technical troops (for example, [24]-[29])

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