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Planning the use of educational and training applications

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Annotation. This paper presents a method for planning the use of educational and training applications, which intended to improve the training level of military specialists. This paper provides an algorithm for determining requirements to important professional qualities and competencies of a military specialist, an integral indicator of his training level for fulfillment of his functional duties, forecasting the process of improving professional qualities and competencies and drafting a rational plan for professional development.

1. Introduction

Nowadays, the level of professional training of military specialists is one of the most important factors that determine the effectiveness of the use of various types of weapons, military and special equipment [1]. Therefore, the tasks associated with improving the process of training military specialists are highly relevant.

A well-known direction of improving the process of training military specialists is the implantation of modern automated information systems, which include educational and training applications (ETA).

The Modern ETA are multitasking automated systems used to acquire new knowledge and improve existing skills and control the degree of their development. However, the tasks of optimal use are not fully worked out. Therefore, their effectiveness is insufficient to achieve aims, but this is especially important in the context of increasing military specialists' professional level directly in military units.

Further, a method for the formation of a plan for using the ETA is proposed, which includes the following stages:

- determination of requirements to professional important qualities (PIQ) and competencies of a military specialist;
- determination of an integral indicator of his training level for fulfillment of his functional duties;
- forecasting the process of improving professional qualities and competencies;
- drafting a rational plan for professional development.

2. Research materials and methods

The determination of the requirements for the PIQ and the competencies of a military specialist is based on a professional analysis [2]. For the correct compilation of a professional diagram, it is necessary to identify the characteristics of a person that will directly affect the quality of the fulfilment of duties.



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After determining the PIQ, competencies and functional tasks, it is necessary to express them in a quantitative and qualitative measure. This assessment is difficult to perform using the rules of classical mathematics or a scoring system, since these indicators are poorly formalized. In this case, it is optimal to use approximate human reasoning, applying linguistic variables, where fuzzy sets are the values of these variables.

For detecting connection between a set of the PIQ, competencies and successful execution of the functional tasks is proposed to use fuzzy correlation analysis [3, 4]. The values of the correlation coefficients can be interpreted as the weighting coefficients of the significance of individual qualities for the successful implementation of a particular functional task.

For the effective use of the ETA, it is also necessary to have information about the significance of a particular functional task of a military specialist. This requires the creation of an integral system for the classification of functional tasks. The use of this system makes it possible to determine a certain integral indicator of the level of a military specialist's skills for performing tasks. Focusing on the fuzzy nature of the initial data necessary to describe the features of the performance of their duties by military specialists, to build the proposed system, it is advisable to use a mathematical apparatus that allows to solve problems of classifying fuzzy and complexly structured figures [5, 6, 7]. In this case, the methods of fuzzy classification (which are based on the principles of conceptual clustering) are an effective tool for constructing a dividing surface in the space of all parameters of the objects under study, multidimensional scaling and reduction of heterogeneous parameters to a homogeneous form.

In general, the task of the integral assessment of the level of training of specialists is to transform the whole variety of different types of indicators into a single metric scale. The initial data are fuzzy, the most effective is the multidimensional fuzzy classification algorithm [8, 9, 10].

To predict the process of improving the PIK and the competencies of a military specialist, it is necessary to take into account that the process of improving the level of professional training depends on many factors, including individual abilities, forms and methods of training [11, 12]. In this case, in order to achieve the best results, it is necessary to focus on the features of the studied material and the characteristic portrait of the student both at the beginning and during the learning process, and on their basis to adapt the learning process.

In the research paper of the authors [13, 14], it is assumed that the learning process is exponential:

$$Q(t) = Q_I - (Q_I - Q_R) \cdot e^{-\alpha t}, \quad (1)$$

Q_I and Q_R – initial and required level of professional training of a specialist; α – learning rate indicator.

The exponential model for improving professional knowledge and skills has become widespread. But when examined qualitatively, the real process of holistic learning does not coincide with the monotonous exponential [15]. Therefore, it is advisable to use a more complex learning model based on the fact that the knowledge acquired by the student is capable of self-organization and is capable of creating new knowledge themselves.

The above provisions are fully consistent with the "transformational" theory set forth in the research paper [15]. As a result of using the presented provisions, it is possible to obtain an extensive class of models for calculating the adaptive dynamics of the professional development of a specialist [16].

In general, the model makes it possible to predict the process of professional development of a military specialist and to determine the expected time to reach a given level of training, depending on the individual abilities of each student [17, 18, 19].

After forecasting, it is necessary to draft a rational plan for the professional development of a military specialist. The plan of professional development is understood as a set of the PIQ and competencies that need to be improved, as well as the length of time to improve each of them.

For a drafting a rational plan, either algorithms are used that have high accuracy, but have limited capabilities for large dimensions of the initial data, or approximate algorithms that work fast enough, but do not always reach an optimal solution [20, 21, 22]. Approximate algorithms include a greedy algorithm that allows you to obtain an approximate solution (the accuracy of which can vary greatly) in polynomial time.

Evolutionary computation methods are an effective way to solve complex combinatorial problems, among which genetic algorithms (GA), based on evolutionary modeling, occupy a special place [23, 24, 25]. The GA advantage over classical algorithms consists in a wide variety of possible representations of the objective function, and optimization variables, the successful search for solutions in multimodal target functions in the process of the GA does not require any additional information, which increases the speed of the algorithm, as well as the use of probability and non-deterministic rules for finding solutions [26].

The task of drafting a rational plan for the professional development of a military specialist has the following informal setting: there is a certain declaratively defined time interval T , during which it is necessary to organize the process of raising the level of training, as well as the list of the PIQ and competencies $X = \{x_1, \dots, x_s\}$. The entire time period is divided into the smallest possible discrete intervals named Δt for working out specific questions of the lesson. The number of intervals is determined by $K_{\text{int}} = T/\Delta t$. Any the PIQ can be improved during the entire given period of time, therefore, the number of selected intervals for the development of the PIQ can take on the maximum value named $m = K_{\text{int}}$. The integral indicator of the predicted level of training named Q of a military specialist will be determined using a certain objective function. It is also necessary to draft such a plan, after which the integral indicator of the level of training will reach the highest value, and the total duration of the preparation time will not exceed a given period of time (named T).

The formal statement of the problem is to find a binary vector for a given set of the PIQ and competencies (named X), preparation time (named T) and also values (named q_{ij}):

$$X = (x_{11}, x_{12}, \dots, x_{sm}), x_{ij} = \begin{cases} 1, & t_j \uparrow \text{ the PIQs } x_i \\ 0, & t_j \downarrow \text{ the PIQs } x_i \end{cases} \quad (2)$$

and at the same time the following condition:

$$T' = \sum_{j=1}^m t_i \leq Tu \sum_{i=1}^s \sum_{j=1}^m q_{ij} \cdot x_{ij} = \max \quad (3)$$

The solution will be represented by a binary vector named $X = (x_{11}, x_{12}, \dots, x_{sm})$. GA with standard crossing and mutation operators is used when searching for a binary vector. However, at each step of the iteration, it is necessary to ensure that the new solutions obtained as a result of crossing or mutation satisfy the required restriction $T' \leq T$, since if the restriction is not met, the “wrong” potential solution must be modified.

Features of the use of GA for solving the problem are:

firstly, the number of genes contained in the chromosome is determined based on the number of the PIQs and competencies, as well as the number of minimum allowable time intervals that fit into the declarative interval allocated for training. The total number of genes in a chromosome will be determined as the product of the number of time intervals and the number of the PIQs and competencies considered in the research;

secondly, a complex functional that determines the value of the integral indicator of the level of training of a military specialist at the current time will be used as a fitness function (FF). The fitness function will be calculated on the basis of a hierarchical convolution of the values of the quality of performance by military specialists of their functional tasks, taking into account the weight coefficients of their significance. The possible level of quality in the performance of functional tasks is directly determined by the level of development of individual PIQs and the degree of development of competencies. The calculation of the degree of influence of PIQ and competencies on the quality of performance of functional tasks is carried out on the basis of a fuzzy correlation analysis. The issues of calculating the listed indicators were presented earlier. It is worth noting the nonlinearity of the process of increasing the level of specialist training in the learning process, which leads to polymodality of the FF;

thirdly, the quality of the GA work will largely depend on the initial data. The total number of the PIQs considered, competencies and preparation time will significantly affect both the chromosome size and the convergence rate of the algorithm. With a large number of PIQs and a short preparation time,

the number of units in the chromosome will be relatively small compared to the total number of genes, which will drastically reduce the speed of finding the optimal solution. Determination of the initial population size, the values of the probabilities of crossing and mutation must be determined depending on the specified conditions;

fourth, in the formulation of the combinatorial optimization problem when using GA, it is necessary to take into account the limiting condition on the maximum number of units in the chromosome, determined by the duration of the preparation time and the value of the minimum preparation time interval. Simple destruction of offspring with an unsuitable genotype will lead to a sharp increase in the time to find a solution, and to modify the genotype, a correct and effective algorithm is required, taking into account the degree of influence of individual genes on the value of the FF.

The developed method involves the following steps:

- Determination of the set of the PIQs and competencies (set X).
- Determination of the list of functional tasks performed by a military specialist for their intended purpose (set Y).
- The choice of the type of position (command and staff; command and control; engineering and management or engineering and technical), in which the specialist fulfills his duties.
- Determination of the initial level of training of a military specialist $x_i(t_0)$, (the degree of development of each of the considered the PIQs and competencies).
- Calculation of the coefficients of the learning rate α_i or each the PIQs or competence, depending on the activity strategy.
- Determination of preparation time T , calculation of $K_{\text{int}}=T/\Delta t$ for a value of Δt .
- Determination of the number of genes in the chromosome $E=K_{\text{int}} \cdot s$.
- Determination of the power of the initial population (N), which is calculated based on the processing of experimental data.
- Formation of representatives of the initial population directly $Z_l = (z_{l1}, z_{l2}, \dots, z_{lm})$: $s - \kappa$ the number of the PIQs and competencies, $m=K_{\text{int}}$, $l=1 \dots N$. The encoding itself takes place in a binary code, where each bit denotes a specific the PIQs or competency and its improvement or ignoring during a certain minimum learning interval Δt . To ensure the most representative population, each subsequent chromosome is formed on the basis of already formed ones, taking into account the condition of the maximum possible non-repetitive filling of genes with units.
- Calculation of the FF for each chromosome of the population (the FF is taken as the value of the integral indicator of the level of training of a military specialist at the end of the training time T):

$$Q = \sum_{j=1}^F \sum_{i=1}^S \frac{(x_i \cdot r_{ij}) \cdot \lambda_j}{\sum_{k=1}^S r_{ik}} \quad (4)$$

x_i – the level of development of the PIQs and competence; r_{ij} – the correlation coefficient of the i -th the PIQs or competence and the j -th functional task; λ_j – the value of the weighting factor of a specific functional task; F – the number of functional tasks/

- Calculation of the probability of selection for each chromosome by

$$P_{\text{sel}}^j = \frac{Q_j}{\sum_{j=1}^N Q_j}; j = 1 \dots N \quad (5)$$

- Random selection of rows based on probability P_{sel}^j .
- Crossing the chromosome with the maximum FF value (Z_i) and a random representative of the new population (Z_j). The probability of crossing (named P_c) is selected in the range from 0.8 to 0.9. The crossing operator assumes an element-wise comparison of the genes of the

chromosome (Z_i) and (Z_j) and the selection of alleles according to the following rule: genes with the same values are preserved in the offspring (they are inherited with a probability equal to 1). Genes with different meanings are passed on to the offspring with a probability of 0.5.

- A point mutation of the genes of the offspring is carried out with a probability P_m , equal to from 0.01 to 0.05.
- Determination of the correctness of the genotype of the resulting offspring by the number of units in the chromosome $K_{int} \geq \sum_{j=1}^E z_j$. If the offspring is incorrect, it is necessary to correct the genotype (reduce the number of 1 in the chromosome). The degree of influence of each gene on the FF is calculated based on the presented population

$$b_j = \frac{\sum_{j=1}^N Q_j \cdot z_{ij}}{\sum_{j=1}^N z_{ij}}; j = 1..E \quad (6)$$

- In the chromosome of the offspring obtained as a result of the crossing operation, the genes having the value of allele 1 take the value 0, depending on the number of excess units. The probability P_{cor} of correction of the gene value is determined by

$$P_{cor}^j = \frac{b_j}{\sum_{j=1}^E b_j}; j = 1..E \quad (7)$$

- Checking the rules for stopping the GA work by time, by the number of iterations and by the accuracy of the result.

3. Results

The method that was presented in this paper was tested in the process of training military specialists (for this, the PIQs of a military specialist were also grouped).

Further, the general structure of the competence of a military specialist was formed. The number of the military specialist's internal control complex was 60 units, and the competencies were 50 units. The formation of quantitative values of variables was obtained using expert estimates. All functional tasks that a military specialist need to solve in the course of his professional activity are divided into several logical groups. The number of functional tasks was 51 units.

Based on the training model, the dynamics of changes in the level of professional training was obtained on (figure 1).

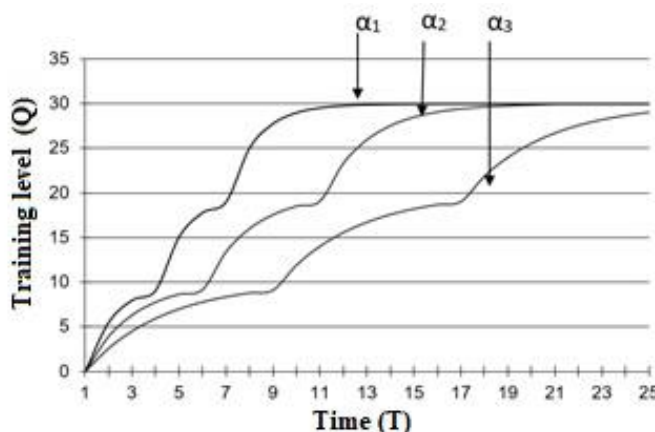


Figure 1. The process of changing the professional training of a specialist ($\alpha_1=0,8$, $\alpha_2=0,5$, $\alpha_3=0,3$) with an unlimited training time.

Based on the results of modeling, the volume of educational information transmitted at one step of learning to the learning object was determined, learning algorithms were selected, which are the basis for the ETA. The built-in training model made it possible to predict the dynamics of the development of professional qualities in a military specialist and to determine the most rational strategies for their

improvement, subject to time and cost constraints. As a result, the use of the proposed technique made it possible to increase the level of training of military specialists by an average of 9%.

4. Conclusion

Based on the above, it can be concluded that the proposed methodology for the formation of a plan for the use of the ETA takes into account all the variety of vaguely defined qualities necessary for a military specialist in the performance of his official duties and the degree of their influence on some integral indicator of the level of readiness. This method can significantly increase the efficiency of the training process for military specialists.

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