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Evaluation of the effectiveness of simulator training by the method of target management

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Abstract: **The extensive use of educational processes of educational institutions and in the system of combat training determines the relevance of the development of methods for justifying training equipment, evaluating their effectiveness and the effectiveness of training provides. One of these methods may be the target management method, proposed in this paper and not previously used in this subject area. The method of targeted training management involves determining the goals of training and the re-quirements for its means, the structure, and content of training, and testing the results of training. The paper justifies the choice of different categories of students of different simulators and meth-ods for evaluating the effectiveness of training for different students' categories. Based on the func-tions of the students' activities, the authors propose and justify the activity classification of the trained operators and their division into three categories, three levels. Under the accepted classification, the authors define the requirements for training equipment and the organization of training equipment. Methods of forming assignments for students under the objectives of training and evaluation of its re-sults, including automation of training assessment, are fundamental in the organization of simulator training based on the method of target management. The paper suggests the following procedure for the development of mathematical software automate the assessment of the preparation: the choice of control parameters and the objective function devel-opment, the parameters and rating scales exercises development, the drafting of the algorithm and pro-vide recommendations. The target management method for evaluating the effectiveness of simulator training is developed because of over ten years of experience in using simulators in the educational process and the authors' personal participation in their creation and use.**

Keywords: **information model, target management, objective function, educational and cognitive activity, exercise, simulator, training, estimation, operator, the training, skill, the method, effectively.**

1. INTRODUCTION

The modern concept of training specialists involves the widespread use of various simulators in the educational process. However, although there are achievements in creating a system for designing and using training complexes in the educational process, the task of choosing the optimal composition of training equipment for training specialists remains relevant. The current state of this problem (despite a significant number of publications [1–4]) is characterized by the absence of a unified, scientifically substantiated and didactically oriented method for choosing the type of simulator depending on the purpose of its use in the process of professional training of specialists. Therefore, the development of a methodology for evaluating the effectiveness of simulators and the creation of software tools for its implementation are especially necessary.

The main tasks of training trainees are the acquisition and maintenance at the proper level of a set of knowledge, skills and abilities that ensure the performance of tasks with the greatest possible efficiency [5–7].

The functions of operators of different levels differ significantly from each other, which must be taken into account when creating simulators and special software (SMO) for them. This is especially true for the development of methods and algorithms for learning management.

Learning management methods should be different for different contingent of trainees [8]. This is due to the different nature of the activity. The more complex the system, the more branched the trainee's operations tree, which means the greater the uncertainty.

Depending on the functions performed, operators can be divided into groups (Table 1):

- operators controlling moving objects (drivers, helmsmen, etc.);

- process operators performing the functions of monitoring, controlling and regulating the course of various processes (controlling a power plant, weapons, technical equipment, etc.);

- operators of the collection and processing of information, whose main tasks are to obtain the most complete information about the environment, the state of their forces, about the enemy, as well as the processing of this information (operators of radar sonar complexes, automated information processing systems, etc.);

- operators-organizers of the system, that is, operators organizing the structure and operation of the system, making decisions about the directions of its activities based on the analysis of secondary information processed by other parts of the control system (ship commander, assistant commanders, commanders of combat units).

- operators-organizers of associations, that is, operators organizing the structure and work of an association, which includes a number of separate systems (a large system from the point of view of cybernetics), making a decision on the directions of the associations' activities based on the analysis of secondary information processed by other organizers of control systems (commander formations, groups of ships and above).

For Level III operators, the tree of operations is clearly defined by instructions and can be easily described by an algorithm. The algorithm of actions is rigid, clearly described by instructions. Management of the training of operators who control technical means can be carried out on the basis of the control of each operation. The system can be considered simple, since the sum of the elements of the operator's actions is equal to the final result, the performance of each operation in the best way leads to the best final result. In the case of a simple system, a step-by-step control method is used and strict recommendations and results of activities are issued.

When managing the training of operators-organizers of systems (level II), it must be taken into account that the trainee's function tree can be so branched that it is not possible to control all operations. The algorithm of actions is complex, partially determined by some framework, within which creativity and multivariance in solving the problem can manifest itself.

2. METHODS FOR THE FORMATION OF TASKS FOR THE STUDENT

When preparing students, one of the main tasks is to create, depending on the purpose and stage of training, a simulated model of the situation or its individual elements (conditions for performing the required actions), similar in its information impact on the student in a real environment [5].

The student needs to be presented with such an information model from which he would receive information about the spatial and temporal position of control objects and objects of the external environment, the conditions for performing the learning task.

In addition, for the psychological preparation of the trainee, it is necessary, along with the mentioned information model, to present information or work out special tasks that ensure the preparation of operators for actions in extreme conditions.

Analysis of programs and methods of training operators allows you to create a list of tasks for simulation.

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To assess the skills and abilities of operator activities, it is possible to use established standards. In this case, the standards are quantitative and qualitative indicators of the performance by individual operators or combat crews of tasks, techniques and actions related to the use of means in real conditions. The standard is a set of actions (operations) that determines

some end result of the work on the use of funds. With the help of the standard, the level of preparedness of each operator individually and of the entire calculation is controlled. At the same time, individual and collective standards are distinguished.

Quantitative values of the standards for operator actions in solving various training tasks are developed by the R&D executor to create a new tool based on (expected, desired, required) ergonomic properties and specific features of the information model of the designed tool. Under these conditions, the R&D performer can guarantee the fulfillment of the technical assignment issued to him only if the operator has a certain (high enough) readiness to fulfill his functional duties to manage the developed tool in the process of its use.

In the future, the estimated indicators (standards) proposed by the R&D contractor should be used in the development of a manual for the use of the tool, as well as in formulating goals and objectives and determining the organization of simulator training for operators.

When managing the training of operators-organizers of systems (operators of level II), it must be taken into account that the trainee's function tree can be so branched that it is impossible to control all operations.

The system is complex: the sum of the elements of the operator's actions is not equal to the total. The algorithm of his actions is vague. In this case, the evaluation should be based on the final result.

In a special group, it is necessary to single out operators-organizers of associations (operators of the first level), who not only control the system, but also determine the rules for its operation. In such a complex system (operator-manager), the algorithm of actions is indefinite. In this case, only the exploratory teaching method can be used: learning is controlled by presenting the results of various decision outcomes for comparison and, on the basis of this, changing one's actions in subsequent experiments, as well as the rules of the system. Recommendations are not issued. In fact, the simulator for the operators of this group degenerates into ASNI.

The basis for assessing level III operators is step-by-step control with fixing the time of execution by the operator of the operator's command of a higher level.

To solve the problem of assessing level III operators, it is necessary:

− to determine the criterion for the effectiveness of the activities of personnel in the man-machine system;

− formalize the activities of operators by describing the mathematical model of the functioning of the calculation;

− to simulate the process of the operator's functioning.

Based on the analysis of the results of modeling the functioning process, temporary normative indicators of operators' activity are substantiated, an assessment is made by comparing the achieved results and standards.

3. COMPLIANCE ANALYSIS CAN BE DONE IN SEVERAL WAYS

· Automatically, with the help of special software, the command of the superior operator is analyzed, decoded and recorded, the time from the moment the command is given to the moment the task is completed, as well as the correctness (incorrectness) of the action are recorded. With the right action, the results are evaluated and accumulated. This method of evaluation can be carried out by recognizing the speech of an operator of a higher level and its semantic analysis. It allows you to evaluate level III operators acting as part of the calculation. The disadvantage is that at present, speech recognition operations and its semantic analysis are not yet sufficiently developed.

· The head of training analyzes the command of the superior operator, detects the time from the moment the command is given to the completion of the task, as well as the correctness (incorrectness) of the action. The data is entered into a computer. With the right action, the results are evaluated and accumulated. This method allows you to evaluate the level III operators acting as part of the calculation. The disadvantage is that the application of the method is possible with a limited number of trainees, measurement errors are imposed, depending on the workload of the leader and on his preparedness.

· Automatically, with the help of special software, the command of the superior operator is generated by the program, the time from the moment the command is issued to the completion of the task, as well as the correctness (incorrectness) of the action, are recorded. With the right action, the results are evaluated and accumulated. This method makes it possible to

evaluate level III operators operating on an individual simulator. Advantages of the method: it is possible with an unlimited number of trainees, there are no measurement errors. At the present stage of development of computer technologies, this method is the most acceptable, provided that level III operators are trained on individual simulators, and after acceptable results in all tests (not lower than 4), they are allowed to work in the calculation.

To manage the learning process in the ACS by practical training, it is necessary to implement a closed control loop, consisting of direct and feedback lines and systems for issuing various information on them.

Through the direct communication lines, educational information is issued, on the basis of which the student makes and executes his decision. Feedback lines transmit information about the progress of assimilation and actions of the student, about the compliance of this process with the given one.

Obtaining information about the course of the assimilation process is not an end in itself. They are needed to make the necessary changes in this process to achieve the set goals in the shortest possible way, that is, to correct the learning process. Ensuring control offers, first of all, a solution to the problem of the content of control - determining the criterion for the effectiveness of the exercise.

The learner has the ability to goal-setting and self-assessment, he has internal and external performance criteria. The discrepancy between these criteria entails a conflict, leading to a decrease in the efficiency of knowledge assimilation. External performance criteria are formed as follows:

- the criterion for evaluating the effectiveness should be objectively determined and express the savings of the main factor of human activity - time, that is, be a physically measurable value through which time savings can be expressed;

- performance evaluation should go from the whole to the particular - from top to bottom;

- the effectiveness of the performance of one or another element of the exercise is evaluated in direct proportion to the effectiveness of the exercise as a whole, that is, the criteria for evaluating the exercise as a whole and its elements should be directly related;

- the criterion for evaluating the effectiveness should be understandable to the trainee, be the core for building an indicative basis for action in such a way that the external performance criteria turn into the internal criteria of the trainee.

The choice of an indicator of success in this case will consist in establishing a strict correspondence between the goal to be achieved as a result of hostilities and the chosen indicator of success.

In this sense, the success rate of an operation can be called an objective function. In the most general form, the choice of the best variant of a combat mission by a level II operator can be represented as finding the maximum (minimum) of the objective function (W):

$W = f(a1, a2, \ldots, b1, b2, \ldots, x1, x2, \ldots.)$,

where a are the specified parameters of the operation; b – controlled parameters; x – unknown parameters.

In this case, the problem of choosing the best solution for the trainee will be reduced to finding such values of the controlled parameters b1, b2, ..., which, given the parameters a1, a2, ..., taking into account the unknown parameters x1, x2, ..., provide the maximum of the objective function.

In an effort to get the highest result, the student will act in such a way as to achieve the optimal ratio of controlled parameters, that is, to master the skills of optimally solving various classes of tasks.

To assess the degree of compliance of the result of the exercise with the learning goal, it is necessary to develop standards, that is, the value of the result, relative to which the countdown is made. The creation of understandable and acceptable standards for the main parameters of the student's actions gives a number of possibilities for their use as:

- means for explaining to the student the requirements for his educational activities;

- criteria for assessing the achievement of the learning goal;

- means for self-assessment and self-improvement of the trainee;

- means for changing the level of complexity of the task and the level of depth of control, reinforcing the actions of the student;

- means for purposeful reassessment by the trainee of the orienting basis of action.

When choosing a starting point taken as an indicator of effective performance, it must be borne in mind that the main purpose of standards in the process of learning management is to be an indicator of the successful progress of knowledge acquisition. Failure to achieve a certain standard is a signal that the process of mastering knowledge is going badly and it is necessary to take certain corrective actions on the part of both the trainee and the ACS by practical training.

4. THE QUANTITATIVE VALUES OF THE STANDARDS ARE DETERMINED IN TWO WAYS:

- calculation method; the standard is calculated based on the optimal model of the student's actions; as a rule, it should be determined before the start of the exercise based on certain initial conditions (the capabilities of the means of detection and weapons of the ship and target, hydroacoustic conditions, etc.);

- statistical method; the standard is set on the basis of the best results achieved when performing exercises in certain typical conditions.

The score in points is the degree of achievement by the student of the standard. The most convenient and universal quantitative criterion is the percentage criterion for assessing knowledge. The object is the assimilation of the material as a fact of the didactic process, as its result. One of the varieties of the percentage assessment of knowledge is an assessment as a measure of the achieved and required results. It is set based on the ratio of the achieved result to the standard. We will call this ratio an estimated indicator. Moreover, the gradation of grades should be made on different scales depending on the level of requirements for the student, which, in turn, is determined by the stage of mastering knowledge. As pedagogical practice shows, three levels of requirements are enough: initial, average, high. Gradation of grades in this case is carried out according to the scales shown in Table 2.

5. TARGETED MANAGEMENT OF PRACTICAL TRAINING

Target management in the proposed interpretation requires a clear and precise definition of learning objectives, the formation of programs for their achievement and evaluation by measuring the quantitative characteristics of the learning process. Target management is focused on the final result of the student's actions. Purpose and result in this approach are inseparable.

If the selected indicator of success is expressed in terms of the parameters of the actions being worked out, then it will be an objective function. At the same time, the choice of the best option for performing an exercise can be represented as finding the maximum of this function [6].

In an effort to get the highest result, the student will act in such a way as to achieve the optimal ratio of the controlled parameters of the objective function. At the same time, it is obvious that at the stage of preparation for the exercise, the student must be familiar with the structure of the objective function. This will allow him to correctly determine the guidelines for performing the exercise on the simulator and mentally build a model of his actions.

The greatest effect from the use of targeted training management on simulators can be obtained by collecting and processing information about the course of the learning process. Clear, reasonably chosen quantitative evaluation criteria when using this method allow this process to be carried out using special simulator software.

Software development is carried out in three stages:

1) the choice of controlled parameters and the development of the objective function;

2) development of parameters and scales for assessing the exercise;

3) development of texts and an algorithm for presenting recommendations.

It is almost impossible to control all the factors affecting the achievement of the goal. Therefore, when choosing controlled parameters, they proceed from the principle of a minimum of causes (only a small number of process factors have a significant impact on the final result) and the principle of the control point (control is most effective at the point of application of effort).

For example, the purpose of a submarine attack is to destroy it. At the same time, the main task of the ship commander in training is to ensure the greatest number of hits on the submarine during training.

Since a hit in a submarine by one or another type of weapon is a random event, it is advisable to take a non-random characteristic of a random variable as an efficiency indicator - the mathematical expectation of the number of hits in a submarine. Since the selected indicator strictly corresponds to the task, it means that it is an objective function. In this case, the trainee's choice of the best course of action will be aimed at maximizing the objective function, and the evaluation of the exercise according to this indicator will allow, without delving into the mass of minor details of the attack execution process, to correctly reflect the degree of preparedness of the commander and thereby correctly orient him to further improve the skill.

The score in points is set based on the ratio of the achieved result to the standard. Moreover, the gradation of grades, as pedagogical practice shows, must be carried out according to three levels of requirements: high, medium and primary. This approach provides a positive motivation for learning at various stages of mastering the skill.

6. THE ATTACK RESULTS ARE DETERMINED BY THE FORMULA

$$MO[N] = K[PTZ] \times (MO[TO] + MO[BO]),$$

where MO[N] is the mathematical expectation of the number of hits on the submarine; K[ПТЗ] – coefficient for taking into account anti-torpedo protection measures; MO[TO] is the mathematical expectation of the number of torpedo hits; MO[BO] is the mathematical expectation of the number of bomb hits.

Due to failures, mistakes, incompetence of trainees in the process of performing the exercise, deviations accumulate, which are revealed through controlled parameters. Corrective actions are needed to improve the monitored parameters once the learning objective is achieved.

Corrective actions are presented as recommendations to trainees for further study of the subject. At the same time, all possible control outcomes and corresponding instructions on transitions to the study or re-elaboration of specific articles or sections of the main guiding documents are provided. At the end of the exercise, the trainee is given a computer printout, guided by which, he corrects his actions at the next stage of training.

The experience of using the method of automated target management of training of ship commanders on simulators of the Military Institute (additional professional education) of the VUNTS of the Navy "Naval Academy" allows us to draw certain conclusions.

The introduction of the target approach into training allows to improve the quality and intensity of training of level II operators. Evaluation of exercises by the value of the objective function directs the trainees to achieve the final result, gives them reliable guidelines in building a model of their actions. These actions are characterized by the speed and accuracy of mastering the skill.

With the transition to the use of computers to automate the control and correction of skill development, interest in classes increases sharply and it is the higher, the better the students are aware of the principles of constructing a learning management algorithm.

With the use of computers, it becomes possible to actively manage the process of mastering skills by trainees even in the absence of a leader. The short reaction time of the complex to the actions of trainees allows you to quickly adjust their learning activities.

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