The influence of the adequacy of training simulators on simulator planning training

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Abstract. The analysis of the works with attempts to verify the adequacy of both simulation and simulators themselves was carried out. However, these attempts are limited by determining the facts of adequacy or inadequacy of checking systems that cannot be used to identify the skills acquired in accordance with the input of a generalized classification. Adequacy is a concomitant sign of inadequate use of simulators, however, the established base for assessing the adequacy of simulators does not allow presenting it in the form of the indicator of the accompanying sign of inadequacy of use of simulators. And the primary task is to determine its quantitative form, which would eliminate the disparity evaluations of teaching. This research paper presents the problems of the simulator training organization that regardless of the received ideas of flight missions planning, have the real objective, which is in conflict with an aircraft application, the essence of which is the presence of contradictions between the predicted and real necessary amount of forces and means to ensure the effectiveness. The paper aims at the adaptation of the content curriculum component for eliminating inadequate use of simulators, which should be focused on developing measures to compensate false skills in order to improve the accuracy of determining the flying skills in simulator training planning.

1. Introduction
The use of simulation models with limited adequacy is one of the major causes of inadequate use of simulators consisting in incorrect formation of training plans of simulator preparation (SP), namely, determining the number of training sessions on technical means of training (TMT) [1]. Due to the limited adequacy of simulators, there are interdependent events:
- the acquisition of the aircraft structure infidels skills on effective techniques and tactics of application of an aircraft (FM) and its systems;
- distorted evaluation of work-out of exercises and tasks by a flight personnel.

Distorted evaluation training tasks (TT) occur due to the existing discrepancies between the level of teaching pilots on simulators and standard equipment (SE) in a single exercise. The reason for inadequacy of teaching $^{3R(K)}$ means of simulating presents unrecorded skills that sometimes turn out
to be harmful, although perceived as desired.

From the theory of psychology and pedagogics [2], it is known that skills are the ability to perform purposeful actions brought as a result of conscious automatism of repeating the same movements or solutions in response to common challenges. With respect to SP, these are conscious repeated same movements or decisions of typical tasks carried out during workouts. However, it is also known that the actions can be classified as correct (positive) and incorrect (negative, erroneous) [3].

2. Theoretical classification of skills
The positive and negative actions are understood as action statement, which respectively provide positive (increasing function utility) and negative (decreasing function utility) effects of using technical means.

It is therefore advisable to introduce the notion of "skills" according to the classification of the action:

- positive skills (C) - positive action transmitted during workouts to automaticity;
- negative skills (E) - negative actions brought during workouts to automaticity.

With this in mind, the inadequacy of teaching $\mathcal{R}(K)$ is to identify any errors, as part of positive skills (C) perceived as negative (E), and vice versa – as part of negative skills (E) perceived as positive (C).

To formalize any errors, it is advisable to introduce the following concepts:

- false actions (error of the first kind) are actions that are identified as positive, although they are actually negative;
- missed positive actions (error of the second kind) are actions that are identified as negative, although in fact they are positive.

According to the given classification of errors of action identification that certainly are converted while practicing the action for second nature into errors of identification skills, let us use definitions of erroneous skills:

- false skills (F) - negative actions that are identified as positive ones practiced during workouts for second nature;
- missed positive skills (D) - positive actions that are identified as negative ones practiced during workouts for second nature.

In the light of the foregoing, Figure 1 presents a generalized classification of possible skills acquired by the pilots in the process of simulator training.

![Figure 1. Classification of skills](image-url)
It is evident that if the first three factors inherent to both trainers and SE due to their uniformity of origin, when assessing the level of skills, can be undone (they do not affect the variance of estimates of skills acquired on simulators and real technology when meeting the condition of their identity), the latter one manifests itself only on simulators and cannot be compensated in the same way as the first three.

It should be noted that false F and missed correct D skills serve as an objective reality, regardless of the lack of opportunities to observe them and are the consequence of the limited adequacy of simulators.

Due to the fact that there are now problems of the SP organization, therefore, regardless of the accepted views on flight planning jobs, the real objectivity is the conflict of LA use, the essence of which is the existence of contradictions between the predictable and indeed necessary quantity of forces and means of ensuring the guaranteed efficiency.

It is known that by using any simulator, one can achieve only quite certain, maximum possible level of preparedness. It is limited to the adequacy of the simulation processes occurring during the use of an aircraft and its systems [4, 5].

3. Mathematical model

Generalizing the notion of probability of adequacy of the simulator, we have nothing more than a chance that operators will not be sensitive to the difference between the output of the simulator settings information and standard equipment under the same influences on their control elements, and it will not lead to implementation of the simulator action by operators different from actions performed on real technology, which are positive for the latter case. That is, the value of γ, the probability of adequacy of the simulator, defines the potential level of positive skills acquired by operators on simulators. It is obvious that for standard equipment γ = 1.

A probability rate of acquiring positive skills by an operator is defined as:

$$\omega_C = \gamma \omega, \quad (1)$$

where $\omega$ is the assessment of the level of skills, defined by the analysis of operator actions:

$$\omega = \frac{N_C}{N} = 1 - \frac{N_E}{N}$$

here $N_C$ and $N_E$ are the number of correct and erroneous actions; $N$ is the total number of actions.

A true assessment of the level of other skills acquired on the Simulator is defined as:

$$\omega_E = \gamma (1 - \omega), \quad (2)$$

$$\omega_F = (1 - \gamma) \omega, \quad (3)$$

$$\omega_D = (1 - \gamma)(1 - \omega), \quad (4)$$

where $\omega_E$, $\omega_F$ and $\omega_D$ are assessing skill levels (E), (F) and (D).

Moreover, it should be noted that the assessment of skill levels (1) to (4) are the entire group of events, as:

$$\omega_C + \omega_E + \omega_F + \omega_D = 1. \quad (5)$$
It is obvious that for standard equipment: $\omega_C = \omega$, $\omega_E = 1 - \omega$, $\omega_F = 0$, $\omega_D = 0$, hence, $\omega_C + \omega_E + \omega_F + \omega_D = 1$. This confirms the validity of the (1) to (4) levels of evaluations.

In turn, the level of skills acquired during $N$ times of ST training is determined by (1), therefore, for assessment of C and E levels we have

$$\omega_C(N) = 1 - (1 - \omega_0)(1 - \xi)^N;$$

$$\omega_E(N) = (1 - \omega_0)(1 - \xi)^N.$$  

(6)  

(7)  

Due to partial or complete lack of imitation of some processes and effects in the Simulator, which are inherently distracting and scatter the attention of the operator, there might be a situation where the proportion of skills $S$ acquired on the Simulator may be higher than the percentage of skills acquired on standard equipment. Therefore, the assessment of the level of skills acquired on the Simulator for $N$ training, is:

$$\omega(n) = 1 - (1 - \omega_0)(1 - \xi_S)^n.$$  

(8)

If we substitute (8) into (1)-(4) and make some transformations, taking into account that the operator has not previously worked on a simulator, the initial assessment of the F – $(1 - \gamma)\omega_0$ level, being the result of its inadequacy, is zero, while the initial assessment of the C – $\gamma \omega_0$ level is $\omega_0$. Thus, we have:

$$\omega_C(n) = \gamma - (\gamma - \omega_0)(1 - \xi_S)^n;$$

$$\omega_E(n) = (\gamma - \omega_0)(1 - \xi_S)^n;$$

$$\omega_F(n) = \bar{\gamma} - \bar{\gamma}(1 - \xi_S)^n;$$

$$\omega_D(n) = \bar{\gamma}(1 - \xi_S)^n,$$

(9)  

(10)  

(11)  

(12)

where $\bar{\gamma} = 1 - \gamma$ is the probability of Simulator inadequacy.

4. Results

In Figure 3, there is curve $\omega^\%$ that corresponds to the standard schedule of skills mastering (in per cents) depending on $n$ - the total number of trainings, while curve $\omega_C$ is data obtained during its approximation at $\omega_0 = 0$, $\xi_S = 0.5$, $\gamma = 0.71$.

![Figure 3. Skills mastering depending on the number of trainings](image)

On this basis, we can state the following: as magnitude $\bar{\gamma}$ determines the potential level of correct skills the operator acquires on the Simulator, while value $(1 - \gamma)$ identifies the potential level of inappropriate skills, which reveals the inadequacy of the use of simulators, the latter can be used as an
indicator of an accompanying symptom of inadequate use of simulators.

In Figure 4, we may see graphic dependences of estimates of the skills levels acquired on simulators for \( n \) trainings for initial values \( \omega_0 = 0.25, \xi_s = 0.09, \gamma = 0.8 \).

![Figure 4. Evaluation of the skills level acquired on the simulators](image)

With this in mind, we can say that after a course of simulator training, a portion of skills \( \xi \), assimilated for regular training on SE, will be aimed at the acquisition of new, previously unknown, and the restoration of old, previously purchased, but forgotten or missed skills (because there are (E) and (D)), as well as to eliminate false skills F.

5. Conclusion
During the simulators training and because of their limited adequacy, the main danger lies with false skills which exist as an objective reality regardless of ability of their tangible perception or even selection of them from really observable skills. False skills cause a false prediction of effectiveness of aircraft combat use, which may be far from the true effectiveness, due to which the planned activities to fulfill combat missions may be untenable [6,7].

Based on the above-mentioned, we conclude that adaptation of a meaningful component of curricula to eliminate the inadequate use of simulators should be aimed at the elaboration of measures to compensate false skills.

Thus, to eliminate inadequate use of simulators, it is necessary to make assessment of the operators’ level of training, as well as evaluation of skills acquired during their training, taking into account simulators limited adequacy relative to SE and regulatory restrictions on their use. The developed method of adapting the substantive components of the curriculum not only allows calculating each version of the curriculum, but also selecting the sound option in accordance with disposable budget time and valid economic costs.

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