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DEPENDENCE OF TRAINING RESULT ON ALTERNATION OF THE EDUCATIONAL MATERIAL: COMPUTER SIMULATION

Abstract

The computer model of the pupil is analyzed; it considers the following: 1) transition of weak knowledge in strong which are forgotten much slower; 2) the nonlinear dependence of the student's efforts on his backlog of the teacher's requirements; 3) reduction of transmission coefficient of communication channel "teacher–pupil" with growth of the speed of new material presentation. It is shown that is desirable to alternate studying of theoretical and practical material.

Keywords:

Didactic system, imitating modeling, pupil, theory of training, teacher.

The development of the theory of training assumes application of methods of mathematical and computer (simulation) modeling [1]. The real pupil is replaced with some abstract model which behavior is described by one or several equations [2–4]. The particular interest is represented by the studying of various mathematical and computer models of the pupil for the purpose of their specification and development. The condition of didactic system is characterized to quantities of this or that type of the knowledge acquired by the pupil which is measured in conventional units. It is possible to assume that the model of didactic system describes training process better if the model takes into account: 1) transition of weak (poor) knowledge into strong which are forgotten significantly slower; 2) nonlinear dependence of the efforts F made by the pupil in unit of time on his backlog D of the teacher's requirements; 3) reduction of the transmission coefficient of the communication channel "teacher–pupil" K with growth of the speed υ of new material presentation.

Let us say the studied theme includes N elements of learning material (ELMs) which are connected with each other, and the teacher demands assimilation of all studied information, that is his requirements level L is equal to amount of the knowledge $I(t)$ told them. We will consider that complexity of i–th ELM S_i is proportional to expenses of time and the pupil's efforts which are required for assimilation of this ELM; then for simplest ELM $S = 1$, and for more difficult ELMs S more than 1. Level of requirements imposed by the teacher $L = S_1 + S_2 + ... + S_N$. If all N ELMs have complexity 1 then $L = N$. Speed of information transfer is equal to quantity of the knowledge reported by the teacher in the conventional unit of time (CUT): $\upsilon = dI / dt = dL / dt$; it is measured in CUT^{-1}.

We will formulate the basic principles for digital model of the pupil [4 – 6]: 1. If to neglect the forgetting, the speed of increasing of the pupil's knowledge dZ / dt is proportional to his efforts F spent in unit of time which depend on the difference D between the level of teacher's requirements L and the pupil's knowledge Z. 2. The motivation to learning and the efforts F spent by the pupil at the small backlog $D = L - Z$ at first increases, reaches a maximum, and at big D decreases, aspiring to some limit $b = 0{,}1$–$0{,}3$ (because the pupil realizes that he can't acquire the demanded material). 3. The communication channel "teacher–pupil" has a certain capacity. At the small speed of new material presentation by the teacher $\upsilon = dL / dt$ the coefficient of transmission K of communication channel is equal 1; at big υ the pupil doesn't manage to apprehend, understand and acquire the teacher's reasoning therefore K decreases to 0. 4. The condition of the pupil in each time moment is defined by amount of weak knowledge Z_1, quantity of abilities Z_2 and skills Z_3 (strong knowledge). Weak (or poor) knowledge is forgotten quicker than strong knowledge. 5. In the course of training ($k = 1$) the amount of the pupil's weak knowledge Z_1 increases, and part of weak knowledge transforms into stronger knowledge (at first in abilities Z_2, and after that in skills Z_3). 6. In the absence of training ($k = 0$) there is the forgotten: strong knowledge (skills) gradually turns into less strong, and the quantity of weak knowledge Z_1 decreases under the exponential law. The offered mathematical model of the pupil is reduced to the following system of the equations:

$$dZ_1/dt = k\alpha \cdot K(\upsilon)F(D) - k\alpha_1 Z_1 - \gamma_1 Z_1 + \gamma_2 Z_2,$$

$$dZ_2/dt = k\alpha_1 Z_1 - k\alpha_2 Z_2 - \gamma_2 Z_2 + \gamma_3 Z_3, \quad dZ_3/dt = k\alpha_2 Z_2 - \gamma_3 Z_3,$$

$$Z = Z_1 + Z_2 + Z_3, \quad K(\upsilon) = 1/(1+\exp(0{,}25\upsilon - 3)), \quad D = L - Z,$$

$$F(D) = 1{,}65k(1-\exp(-0{,}01D))\left(0{,}15 + \frac{0{,}85}{1+\exp(0{,}02D-4)}\right).$$

Here the forgotten coefficients is equal: $\gamma_Z = 10^{-3}$ CUT^{-1}, $\gamma_U = \gamma_Z / 2{,}72$ CUT^{-1}, $\gamma_N = \gamma_U / 2{,}72$ CUT^{-1}, the assimilation coefficients: $\alpha_Z = 14$ CUT^{-1}, $\alpha_U = 5 \cdot 10^{-3}$ CUT^{-1}, $\alpha_N = \alpha_U / 2{,}72$ CUT^{-1}. On the basis of those equations the computer program for modeling training was created [5, 6]. It contains the cycle on time in which the quantity of different types of the pupil's knowledge in the following time moment $t + \Delta t$ is defined and result is displayed in a text or graphic formats.

Situation 1. During the lesson, the teacher presents the material with some constant speed υ, so that $L(t) = \upsilon \cdot t$. Results of modeling of training at 9 UEV are presented in fig. 1.1. At a small speed υ the pupil acquires all information given by teacher. If the speed of transfer of new knowledge is big, the pupil isn't in time for the teacher, his backlog D increases and at some moment t' he "comes off" or gets behind the teacher, understanding only part of the studied material. If speed υ is even more, the pupil "comes off" the teacher earlier, acquiring even less.

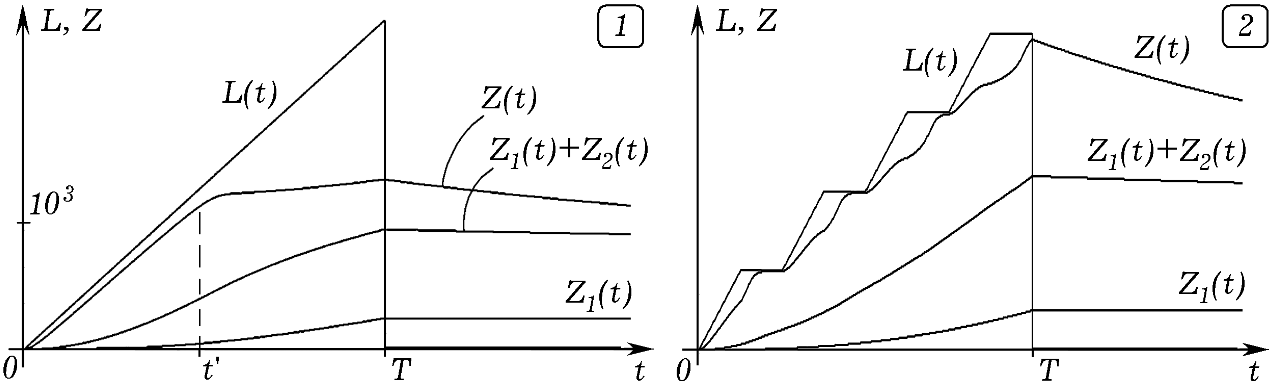

Fig. 1. Continuous and stepwise ($s = 4$) increase in level of requirements L.

Situation 2. Half of the training time is spent on studying of theoretical material (L grows), and another a half – on remembering by repetition and fulfilling of practical tasks (L remains to a constant). The teacher divides the theoretical material on $s=4$ parts and alternates them to practical tasks so that total values of time of studying of the theory t_T and practice $t_П$ were identical and equal $T/2$. Graphs in fig. 1.2 correspond to the maximum speed of the presentation of new material υ_m at which the pupil still acquires practically all information. Modeling shows that at increase in quantity of portions s the maximum speed υ_m at which the pupil is still capable to acquire all new material, becomes more; also the total knowledge reported by the teacher, and acquired by pupils by the end of training (at the moment $t=T$) increases. This result can be interpreted so: if in the class there are 20 pupils with various coefficients of assimilation α, alternation of the theory and practice at the same speed υ of the statement of theoretical material will provide assimilation of the reported knowledge with a large number of pupils.

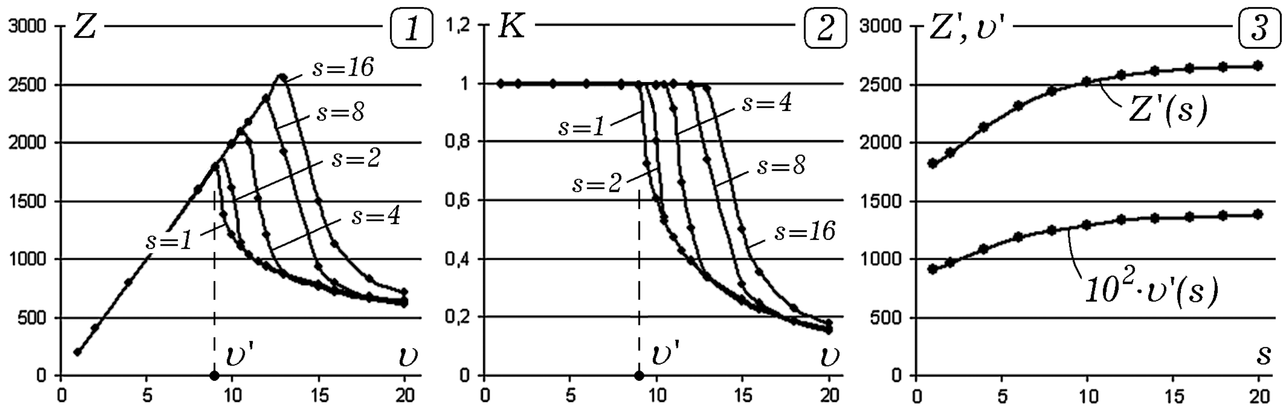

Fig. 2. Graphs $Zn(\upsilon)$, $K(\upsilon)$ at the various s; graphs $Zn_m(s)$, $\upsilon_m(s)$.

In fig. 2 graphs of following dependences are shown: 1) amounts of the acquired knowledge $Z(T)$ and coefficient of proficiency of the pupil $K_L = Z(T)/L(T)$ from the speed υ of reporting of information at various $s=1$, 2, 4, 8, 16 (fig. 2.1 and 2.2); 2) the maximum quantity of the acquired knowledge Z_m and the corresponding speed of the statement υ_m from s (fig. 2.3). From graphs $Z_m(\upsilon)$ and $K_m(\upsilon)$ it is also visible: 1) at $\upsilon > \upsilon_m$ value $Z_m(\upsilon)$ and $K_m(\upsilon)$ sharply decrease: the pupil ceases to acquire information; 2) at increase in s value Z_m, υ_m grow, striving for limit values. The sharply reduced character of the assimilation level of the educational material in dependence on the speed of its statement near critical value υ_m corresponds to border between two pupil's states when he understood and acquired the studied material and when he couldn't make it. So, the offered computer model of the pupil allows to prove that when studying the new theme the teacher has to alternate the statement of theoretical material to performance of practical tasks and consideration of examples of the studied theories using in the concrete cases.

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