Dynamic Adaptive Testing of Students in Learning English*

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Abstract. The article describes the computer dynamic adaptive testing of the educational activity of students with the Grammar Tenses of the English language. Dynamic adaptive test simulators, developed on the basis of the biological theory of human development by J. Piaget, make it possible to diagnose the procedural characteristics of students' learning Grammar Tenses of the English language. It is shown that the control actions on the students are due to the self-consistent interaction of two evaluative feedback loops. The presence of two types of cognitive learning of the subjects: stable, monotonically increasing, unstable, changing abruptly is experimentally revealed. Subjects with an unstable, spasmodic development of learning activity, as a rule, have a lower learning potential or learning ability than students of the first group.

Keywords: educational activity, adaptation, dynamic test.

1 Introduction

For the first time, dynamic adaptive testing of human learning activity as a test combining training with testing was conducted by A.R. Luria [1]. Traditional so-called static testing diagnoses learning or learning outcomes in the past [2]. Dynamic adaptive testing diagnoses changes in the subject's learning activity during the learning process, which extrapolate the learner's capabilities in future learning. That is, dynamic adaptive testing or dynamic assessment diagnoses learning ability as a learning potential that a student can realize in the future [3; 4]. Dynamic testing of the cognitive potential of learning is implemented by including an intermediary or mediator in the dynamic testing process [5]. In the process of development of the learning activity of the subject, there is a transition from external regulation, when the learning activity

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of the student is controlled by someone else − to regulation, when the student establishes self-control over his own activity.

Thus, traditional static testing is «a look from the past into the present», and dynamic adaptive testing «is a look from the present into the future» [6]. The basis of dynamic adaptive tests is the sociocultural theory of development of L.S. Vygotsky [7]. In this theory, the mechanisms of development are due to a change in the relationship between the actual and the nearest development zones, which occurs as a result of interaction with intermediaries − members of culture.

Attempts to computerize dynamic adaptive tests developed on the basis of the sociocultural theory of development by L.S. Vygotsky lead to the need for computer modelling of instructive feedback [8; 9]. This, as a consequence, leads to difficult-to-solve problems associated with the objectivity of diagnosing changes in the educational activity of the subjects. First of all, this is the problem of identifying the subject, whose efforts are due to changes in educational activity. To solve this problem, criteria must be identified for determining the contributions of the subject and the mediator to changes in learning activities. Another important problem that has not received a final solution is the problem of quantitative assessment of the qualitative characteristics of the learning process for solving problems.

2 Methodology

The biological theory of development by J. Piaget is used as a methodological basis for dynamic adaptive English language tests [10]. The basic principle of development in the theory of J. Piaget is to strive for the balance of two vital processes of the organism: accommodation and assimilation. These processes characterize human interaction with the environment in the process of purposeful activity. Assimilation is the process of acquiring information about the environment based on the organs and means of utilization (assimilation) of information available to a person, and accommodation is the process of adaptation (change, adjustment) of the information perception organs of the human body, aimed at increasing the efficiency of receiving signals from environmental objects. Signals coming from the environment play the role of reinforcing human actions to achieve the goal. Reinforcements can be represented as a numerical assessment of a person's actions. If the action leads to a decrease in the mismatch between the current and target states of human activity, then the reinforcement of the action is positive and, in the zero approximation, is equal to +1. If the mismatch between the current and target state of a person increases, then the reinforcement is negative − 1. In the first case, the action is correct, and in the second case, the action is incorrect. The numerical, evaluative nature of reinforcements allows the use of evaluative feedback, rather than instructive feedback, which simulates the activity of a mediator [9].

The interface of the electronic problematic environment, which provides the conditions necessary for the solution to the problem search for, is shown in figure 1.

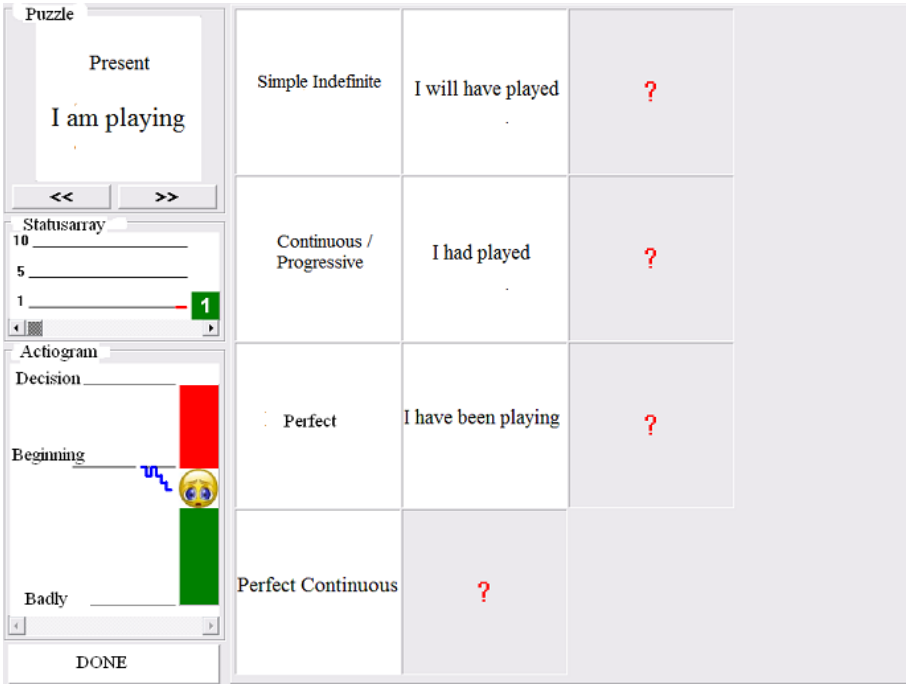

Fig. 1. Interface of the dynamic adaptive test simulator «Grammar Tenses of the English language»

The task consists in collecting from puzzles «Tables of the times of the English language» [8]. There are 12 empty squares on the working area, in which you need to place puzzles with the Grammar Tenses of the English language by taking them from the viewport located in the upper left corner of the interface. Below the window for viewing the puzzles, there is a sensor giving signals − reinforcing the correctness or incorrectness of the subject's actions «Distance to the target». Between the window for viewing the puzzles and the sensor «Distance to the target» is a second sensor, which indicates the level of independence of the learning activity of the subject. There are 10 levels of independent learning activity. The levels differ in the frequency of reinforcement of active actions (setting or cancelling a puzzle). The higher the level, the lower the frequency of reinforcements is. In the lower left corner is the «distance to target» sensor (see Fig. 2), which functions in a local feedback loop and acts as a reinforcement for the learner's learning activity.

At the beginning of learning to solve a problem, the relative frequency of reinforcements, that is, the sensor «Distance to the target" gives a signal about the correctness or incorrectness of each active action. After the completion of theith solution of the problem, the relative frequency of reinforcements for the i + 1 -th solution of the problem is determined, where, is the number of correct actions performed during the i - th search for a solution to the problem; is the total number of active actions in the i-th solution of the problem. As the subject learns, the relative frequency of reinforcements will approach zero, and the subject's activity will acquire an autonomous, independent character. The interface of the dynamic adaptive test «Dynamic puzzles

of the Grammar Tenses of the English language» reflects the two-circuit control system of the educational activity of the subject. The combination of external management and self-management of educational activities described in [11; 12], allows the subject to switch to autonomous activity.

At the beginning of learning to solve a problem, the relative frequency of reinforcements $\delta_1 = 1$, that is, the sensor «Distance to the target» gives a signal about the correctness or incorrectness of each active action. After the completion of thei-th solution of the problem, the relative frequency of reinforcements for the i + 1 -th solution of the problem is determined

$$\delta_{i+1} = 1 - \frac{n_{i(npaв)}}{n_{i0}} \qquad (1)$$

where, $n_{i(npaв)}$ is the number of correct actions performed during the i - th search for a solution to the problem; n_{i0} isthe total number of active actions in the i-th solution of the problem. As the subject learns, the relative frequency of reinforcements will approach zero, and the subject's activity will acquire an autonomous, independent character. The interface of the dynamic adaptive test «Dynamic puzzles of the Grammar Tenses of the English language» reflects the two-circuit control system of the educational activity of the subject. The combination of external management and self-management of educational activities described in [11; 12], allows the subject to switch to autonomous activity.

3 Results

Analysis of the change in the level of independence depending on the number of the task makes it possible to distinguish two groups of subjects. In the first group of subjects, accounting for 20% of the total number of subjects, the level of independence increases monotonically (see Fig. 2).

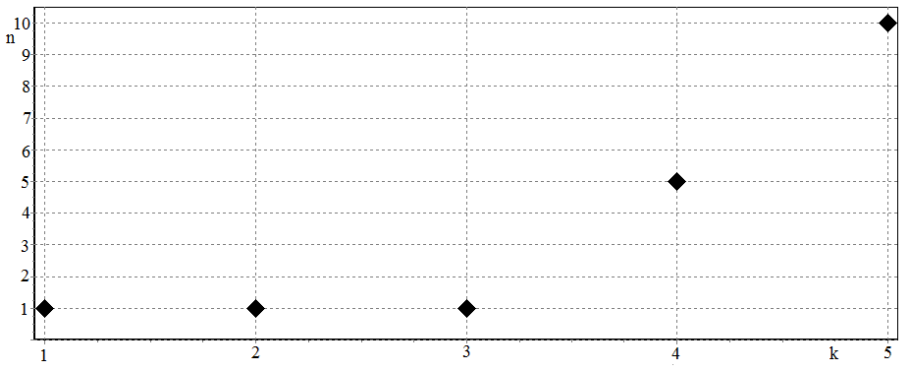

Fig. 2. Monotonous increase in the level of independence of subject No. 1 depending on the task number during the transition to autonomous activity

The change in the levels of independence for the subjects of the second group has a non-monotonous spasmodic character (see Fig. 3), depending on the task number. In percentage terms, this group is 80% of the total number of subjects.

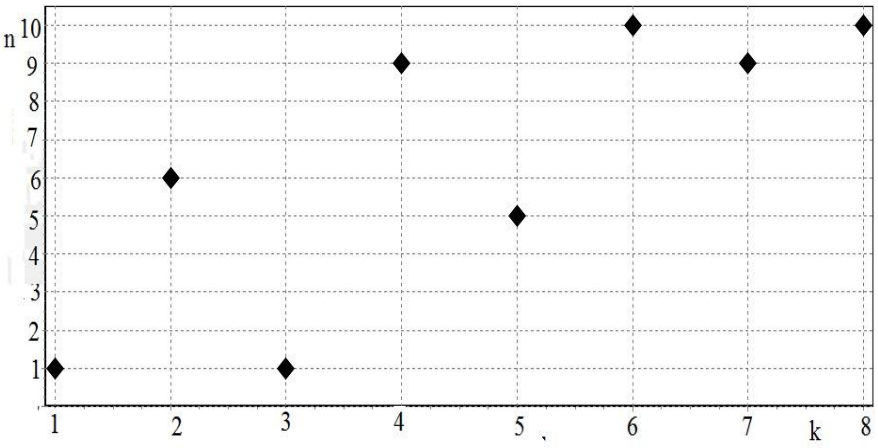

Fig. 3. Non-monotonous change in the level of independence n depending on the number of the task k for subject No. 2

Graphically, the trajectory of the educational activity of the subject or the actiogram of the search for a solution to the problem is represented by a graph of the time dependence of the numerical value of the sum of the actions' estimates [10]. In a zero approximation, if the action is correct, then the assessment of the action or reinforcement is +1, if the action is incorrect, then the assessment of the action is -1. The level of independence on the «statusogram» is self-consistently regulated by the relative proportion of correct actions of the subject (see formula (1)) in previous assignment.

After completing the first task (see Fig. 4), the control system transferred the subject No. 2 from the 1st to the 6th level of independence.

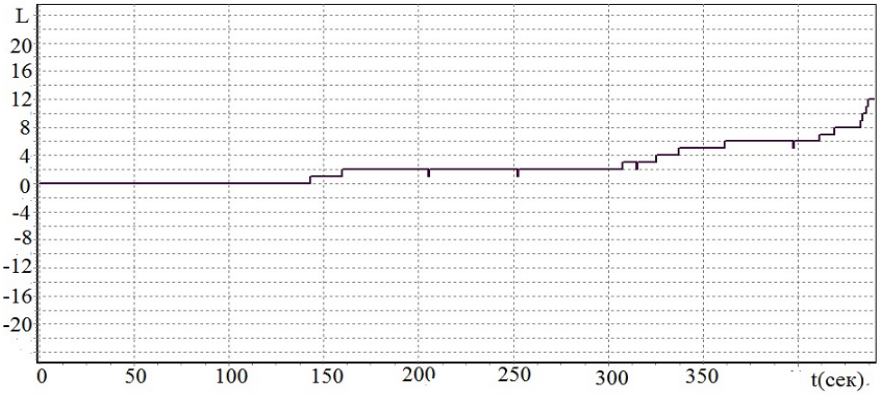

Fig. 4. Trajectory or actiogram of the search for a solution to the problem by subject No. 2 when performing the 1st task

After completing the second task, there was a decrease in the level of independence (see Fig. 3) due to the fact that subject No. 2, having passed to the 6th level of independence, was in a state of cognitive dissonance due to a decrease in the frequency of reinforcement of actions. This led to a sharp increase in the number of erroneous actions, as well as the time spent on the task (see Fig. 5).

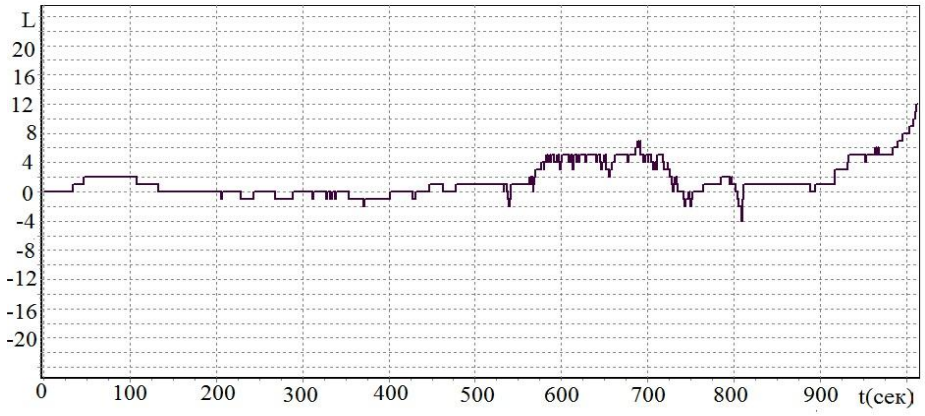

Fig. 5. Aktiogram of the educational activity of the subject No. 2 when performing the 2nd task

Therefore, the control system transferred the subject back to the 1st level of independence (see fig. 3). A sharp decrease in the number of errors and the execution time of the 3rd task is associated with the transition to conditions with less uncertainty of the electronic problematic environment (see fig. 6).

When performing the 2nd task, subject No. 2 was in a state of cognitive instability or bifurcation [13; 14], which arose as a result of an abrupt increase in the uncertainty of the problem environment. The resulting lack of external information when deciding on the next action has led to an increase in errors.

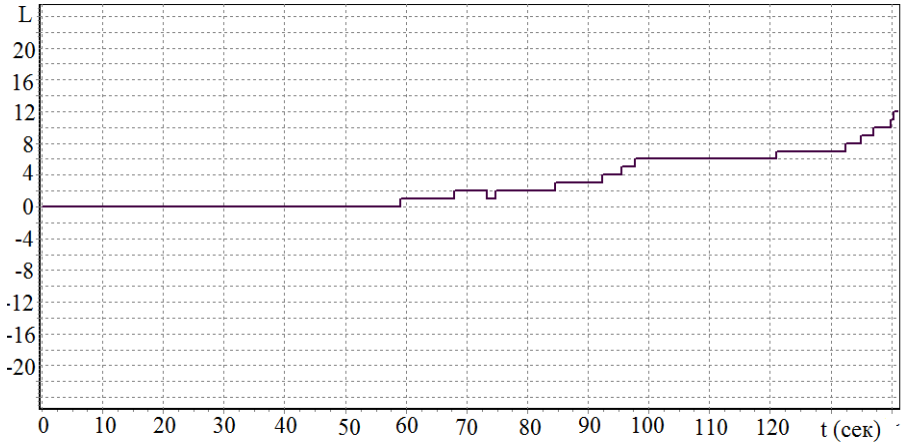

Fig. 6. Aktiogram of educational activity when performing the 3rd task

4 Conclusions

Analysis of the results of dynamic adaptive testing of learning activity with the times of the English language allows us to conclude that students experiencing breakdowns in the level of independence perform more tasks compared to students who do not experience breakdowns. At the same time, the final state − autonomous activity is the same for everyone. Hence, it follows that subjects with monotonous changes in the level of independence are characterized by cognitive stress resistance and have, on average, greater learning ability in comparison with subjects characterized by nonmonotonic changes in the level of independence.

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