Qualimetric Approach to Dynamic Evaluation of Educational Activities According to Facet Classification of the English Language Tenses*

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Abstract. On the basis of the developed facet dynamic adaptive tests-simulators, there were obtained protocols of educational actions numerical evaluation on facet classification of English language tenses, for a random sample of 150 students. Testees are taught the facet classification of puzzles with sentences in English in a randomized puzzle electronic problem environment, in the conditions of numerical reinforcements of the actions of a testee: + 1 correct; - 1 incorrect actions. A self-consistent change in the relative frequency of reinforcements helps to adapt and increase the level of autonomy of testees. The qualification approach to the dynamic evaluation of the educational activity protocols made it possible to specify three groups of testees: those who have achieved the state of autonomous educational activity; approaching the state of autonomous educational activities; with insufficient training in foreign languages or with "trained" helplessness to bilingual activities

Keywords: qualimetry, educational activity, adaptation, dynamic assessment, procedural characteristics, actiogram, entropy, labor intensity

1 Introduction

The problem of the qualimetry of the dynamic evaluation of the procedural characteristics of educational activities is topical and still not completely solved [1]. Dynamic assessment refers to a procedure that combines testing and training into a single procedure aimed at simultaneous understanding and advancing the abilities of students through indirect interaction in the zone of immediate development [2]. The idea that the student's learning potential is determined by the zone of immediate

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development is fundamental in the sociocultural theory of human development of L.S. Vygotsky [3].

As stated in work [4], "teaching with a teacher is teaching by examples presented by some informed external authority." The student's feedback to the mediator or teacher is instructive [5; 6]. It consists of instructions, recommendations, regulations, advice, etc., which the teacher gives to the student, contributing to the student's development. Under the conditions of instructive feedback, the dynamic evaluation involves the interactive interaction of the testee with the intermediary or mediator [7]. Dynamic assessment allows the diagnosis of learning potential, which is determined by the nature of the change in the academic activity.

Despite the complexity and hardness of computer simulations of mediator activities, electronic systems for dynamic assessment of the learning process are developed in various subject areas [8; 9]. The most successful is the attempt of computerized dynamic assessment development of teaching a second foreign language [10]. However, the interactive interaction of the mediator or teacher with the student is so complex that its modeling is often reduced to a rigid scenario of the mediator's reactions to the difficulties of the testee. The procedure of dynamic evaluation with a rigid scenario of intermediary reactions is called the interventionist one [11]. A dynamic evaluation procedure in which there is no rigid scenario of intermediary reactions, and interactivity is situational in nature and is called the interactionist one [11].

In our study, we used the ideas of reinforcement learning [6] to dynamically evaluate the learning process of problem solving of the facet classification of the English language tenses. Following the dictionary of Vishnyakov S.M. [12], we define facet classification as a classification system, which basis is the objects or concepts division in one aspect, by one characteristic.

2 Methodology

Learning of facet classification, based on ideas of reinforcement learning, is fundamentally different from the traditional approach of learning with a teacher. Feedback on reinforcement learning is evaluative. That is, the actions of the student receive reinforcements in the form of a numerical assessment. The evaluative nature of feedback determines the search activity of trainees in an electronic problem environment. Receiving reinforcements from the problem environment for his actions, the testee must learn to perform tasks. The complexity of the problem environment is determined by the changing uncertainty of tasks and reinforcements. A testee adapts to the problem environment in the course of educational activity when learning how to solve problems based on the experience of his interaction with the problem environment. In the process of adapting a student to a problematic environment, autonomous educational activity is formed.

In the process of learning how to solve problems, two components of the educational activity of the subjects can be distinguished: the first is the study of the problem states space; the second is the application of the obtained information about the task state space. As a result, two distinctive characteristics of the interaction of the

testee with the electronic problem environment are determined - the ability to conduct search by trial and error and delayed incentives [14].

The learning with evaluation feedback includes the interaction of the student with the problem environment, which contains uncertainty, undefined factors. The testee searches for a solution to the problem, despite the presence of uncertainty in the training environment. He makes the decision to choose the action himself. At the same time, he can evaluate the nature of the progress towards the desired goal, based on a direct perception of the current state of the task. The student uses the accumulated experience to improve his characteristics over time. The knowledge that students bring to the task at the beginning of the process of its solving has an impact on how useful or simple the process of self-teaching will be. But the decisive factor that ensures the adjustment of the student's behavior taking into account the specific features of the problem being solved is his interaction with the problem environment based on evaluative feedback.

According to the law of influence of Thorndike [15], actions leading to good (rewards) or bad consequences will respectively be repeated or rejected. The law of influence combines search and memorization processes. At the same time, the search is interpreted as a test of various options for actions in relation to each of the situations with the choice of one of these options, and memory - as a way of saving actions that made it possible to get the best result, associating them with those situations or states of solving the problem in which they gave this result. The combination of search and memory in the conditions of evaluative feedback characterizes the adaptation of the student to educational activities when learning how to solve problems. The evaluative feedback assumes that the current problem solving states are matched with the value of the task state equal to the total reward that the student will receive when performing actions that transfer him from the initial to the current problem solving state.

For self-management of educational activities, it is important for a student to have alternative options for finding solutions to problems and multitude of actions (operations). Since the information, according to the definition of Quastler H, " is a random and memorable choice of one option from several possible and equal ones," the student should have the opportunity to independently make decisions about choosing an option from the formed set [14]. According to the sociocultural theory of development of the Vygotsky L.S., the zone of actual development [3] of the student should allow him to form many options for actions and ways to find solutions to problems. Choosing an option gives the student information of value to achieve the goal. The area of actual development (its thesaurus) of the testee should contain elements (information) corresponding to the level of complexity of solving problems.

In dynamic evaluation computer systems, conditions must be created so that the testee can show creative independence in converting the original information into new messages. The factor of semiotic diversity is a prerequisite for adaptation of the subject to educational activities in electronic problem environments. Semiotic diversity allows the subject to realize the potential of learning, develops the ability to operate with numerical and sign symbols, as well as formal structures, structures of relations and connections [17].

As noted above, learning with reinforcements in dynamic learning potential assessment systems is based on the fact that the testee attempts to maximize the remuneration received by operating in an electronic problem environment with a high level of uncertainty. Uncertainty of problem environment is defined by changing conditions of solving problems, introduction of elements of randomness of parameters of problem environment and problems, as well as setting of many alternative options for selection of training actions and ways of finding solution of problems. Uncertainty causes an imbalance between cognitive needs and cognitive capabilities, initiating bifurcation [16] of the study activity of the subject (see Figure 1).

The qualimetry complexity of the procedural characteristics of the educational activity is due to the fact that they are usually qualitative characteristics of the ability of the student to produce and absorb new information during the training process. Search of a solution to the problems of classifying sentences in English by facets of English tenses consists in recognition of mismatch between the current and target states of solving the problem and execution of actions that reduce this mismatch to zero.

Sentences in English are located on the puzzles, which a testee must relate to facets. If the action is performed correctly, then a testee will receive positive reinforcement in the form of a numerical estimate of + 1. If the action is incorrect, then the testee receives reinforcements in the form of a numerical estimate - 1.

The qualimetric approach in the dynamic evaluation of the sentences classification process in English by English language tenses in facet dynamic adaptive tests-simulators [19] is implemented by:

- tracking and recording of educational activities of the trainee in real time;
- recognition of the mismatch value between the current and target status of the task solution and its correction through local feedback mechanisms in the form of information about the "distance to the target" in on-line mode;
- self-consistent adjustment of relative frequency of learning actions reinforcements during the current task performance depending on relative frequency of correct actions during performance of the previous task.

The procedural characteristics diagnostics qualimetry is based on a numerical assessment of the educational actions of a testee, which play the role of reinforcements. Computer tracking of target task state search is performed in on-line mode. For example, the sequence of single rewards and fines is: 1; 1; 1; 1; -1; -1; 1; -1; 1; 1; 1; 1; -1; -1; -1; 1; 1. The total win is + 5. The total gain is equal to reducing the distance (in actions) to the target. Sequences of educational actions and reinforcements form time series of events recorded in the protocol. In zero approximation, educational actions have three numerical estimates of 1, 0. -1. The correct action reduces the mismatch between the current state and the target state, and has a numerical estimate - reward + 1.

№	time	true	learned information	level	data processed	individual choise	action
1	83	1	0,22	2	1	0	14(0)--->poz 6
2	13	1	0,22	2	1	0	15(0)--->poz 7
3	42	1	0,22	2	1	0	7(0)--->6(0)
4	21	1	0,22	2	1	0	6(0)--->11(0)
5	11	1	0,22	2	1	0	11(0)--->4(0)
6	7	1	0,22	2	1	0	4(0)--->2(0)
7	7	1	0,22	2	1	0	2(0)--->8(0)
8	10	1	0,22	2	1	0	8(0)--->10(0)
9	7	1	0,22	2	1	0	10(0)--->12(0)
10	30	0	0.22	2	1	0	12(0)--->poz 8

Fig. 1. Activity protocol fragment of a test

An educational activity that does not explicitly change the mismatch between the current and target status of the task (e.g., browsing, listening, etc.) has a numerical value of 0. The wrong action has a numerical rating - fine - 1. It increases the mismatch between the current and target states.

The time series of events - educational actions presented in the protocols (see Figure 1) form the qualimetric basis for the procedural characteristics of training activities. Figure 2 shows a graph of the dependence of the level number n of the educational activity independence of a testee on the task number i. The graph analysis shows that the level of independence increased monotonically to level 10, which corresponded to the autonomous activity of a testee. However, a testee was not ready for autonomous educational activities and as a result of this bifurcation, there was a regression of educational activities, and a corresponding decrease from the 10 to the 7th level of independence.

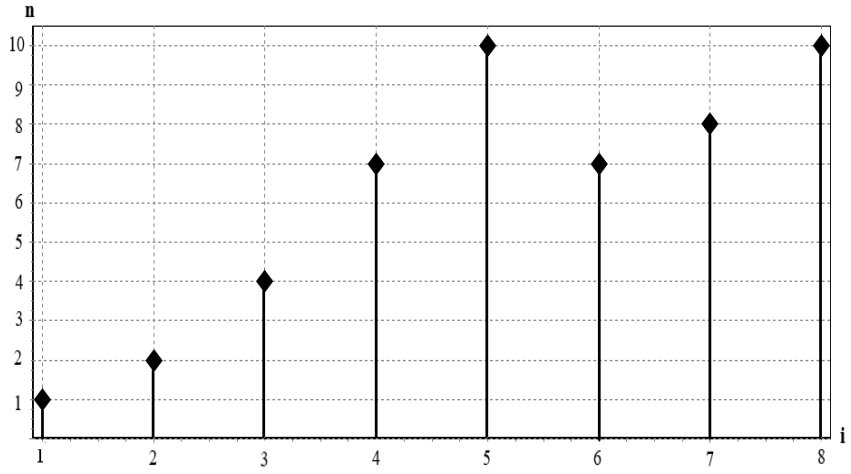


Fig. 2. Level n dependence on task number i

Figure 3 shows an actiogram of the activity of a testee on the task performance. The actiogram represents the mismatch value change graph of the current and target states of the problem solution [20]. The mismatch value between the current and target problem solving states at the start time is 12.

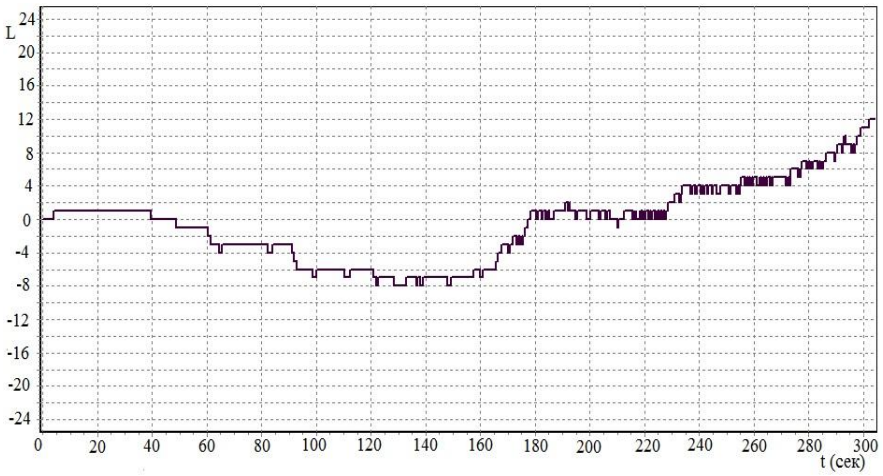


Fig. 3. Actiogram or task solution search trajectory

The actiogram shows that when solving the problem, a testee first uses the trial and error method, and spends a lot of time on each action, but this does not give a result. Then, a testee proceeds to a systematic search, which consists in sorting out all options until there is the right action. This leads to a loss of the time pace of the task and an increase in labor intensity. A testee spent more than 300 seconds to find a solution to the problem.

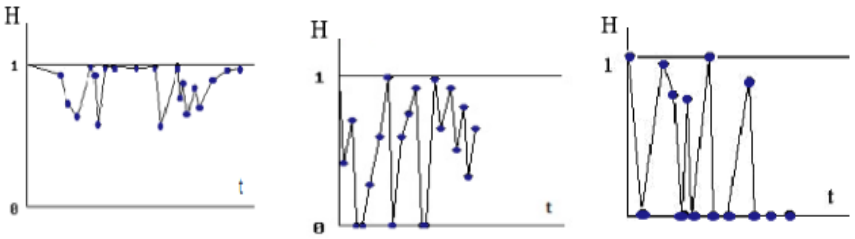
3 Results

Quantitative processing of the time series of educational actions allows making a numerical assessment of the information received by a testee from the reinforcements of his actions. By searching for a solution to the problem, the student receives after each action reinforcements that carries information ΔI . A numerical evaluation ΔI can be obtained using the Shannon-Claude formula

$$\Delta I = 1 - H = 1 - \frac{n_1}{n}\log_2\frac{n_1}{n} - \frac{n_2}{n}\log\frac{n_2}{n} \qquad (1)$$

Where $n = n_1 + n_2$ - the total number of actions taken to solve the current task , $n_1 -$ number of right actions, $n_2 -$ number of wrong actions. In formula (1), instead of the probability of choosing the right and wrong actions, the relative frequency of

the corresponding actions is used. Figure 4 shows graphs of entropy H dependence on time t.



a) b) c)

Fig. 4. Dependence of entropy H of educational activity on time t for three levels of the independence of students: low – a); middle – b); high - c)

4 Conclusions

The maximum entropy value is 1 and the minimum entropy value is 0. The graph in Figure 4 (a) shows that the entropy of the weak student's activities fluctuates steadily near 1. Of the sample, the proportion of such testees is about 27%. They usually use random or systematic search for the right solutions. Without flexibility of thinking and sufficient operative memory, a testee cannot solve the problems of facet classification of English language tenses without constant reliance on external information reinforcements from the problem environment. Such testees may be expected to lack foreign language education [21].

Testees who successfully solve the problems of facet classification of English language tenses, but cannot switch to autonomous activity mode, are represented by a characteristic graph of entropy dependence on time in Figure 4 (b). For such testees, the conditions of educational activity are more energetically comfortable, when it is possible to make mistakes and compensate for them with external reinforcements. The proportion of such testees in this sample is 41%.

Testees who reach zero entropy of educational activities (see Figure 4 c) have abilities for autonomous educational activities. They are characterized by thinking flexibility, developed operational and long-term memory. The percentage of such testees is 32%. They achieve the state of autonomous educational activity, moving from finding a solution by trial and error to intelligent decision-making.

Thus, the qualimetric approach to the dynamic evaluation of learning to solve the problems of facet classification of English language tenses allows you to obtain meaningful diagnostic information about the procedural characteristics of the educational activities of the testees.

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