

Vetrov A.N., Kotova E.E., Kuzmin N.N.

“The Saint-Petersburg state electrotechnical university "LETI"”

THE APPROACH TO THE SYNTHESIS OF THE INFORMATION-EDUCATIONAL ENVIRONMENT OF ADAPTIVE (REMOTE) TRAINING WITH THE USE OF METHODS AND TECHNOLOGIES OF COGNITIVE MODELING

The genesis of the ideas of automation of the process of training is monitored in the theory and practice of educational activity even before the emergence of the concepts of automatic control, cybernetics and artificial intelligence as the modern scientific-technical directions of the academic science. S. Pressi in the middle of 20th years of the last century directly creates the innovative training machine as the prototype of the system of training, and the development of the training devices and programs in the sphere of education gains further development in the works of B. Skinner, N. Krauder and G. Pask (the 50th years). In 1954 year B. Skinner directly enters the scientific concept and offers the various principles of the programmed training, which developed further such Russian scientists as A.I. Berg, L.B. Itelson, L.N. Landa, V.M. Glushkov, A.M. Dovgyallo, E.I. Mashbits, E.L. Yushchenko, P.Ya. Galperin, N.F. Talyzina, A.N. Leontyev, V.P. Bespalko and others.

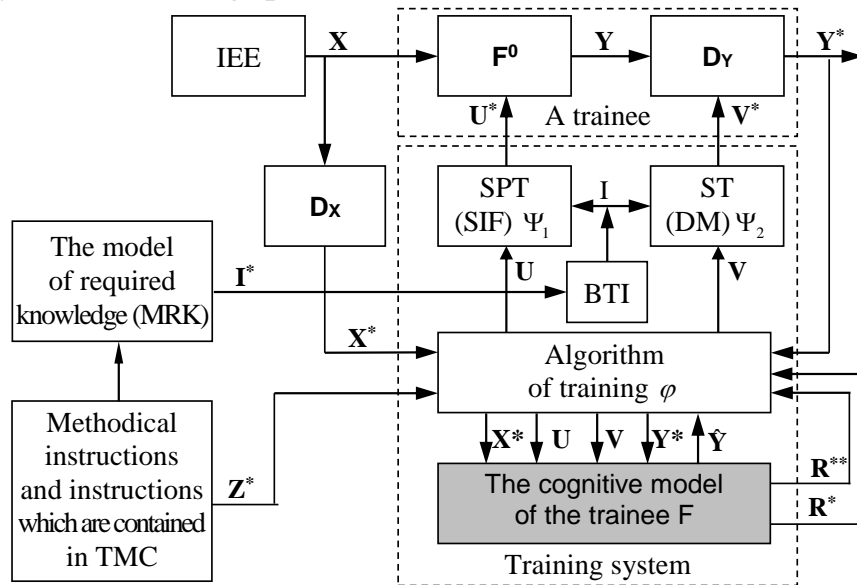
The development of the means of computational technics (personal computers) on the basis of information and communication technologies led to the fact, that the ideas of the programmed training began to be applied by the experts to support the (traditional) information-educational environments in the so-called automated training systems (at distance), which at present time are widely developed and operated as in our country (USSR and RF), so and abroad (Great Britain, USA and Japan).

The modern situation in the market of educational services is characterized by the dynamically changing needs of professionally differentiated representatives of the various segments of population, that has significant effect on the educational standards, policy, strategy, statement of purposes and tasks of training (at distance), organizational and methodical activity of the educational establishment (HEI), ergonomic compatibility of communicative interaction between the involved subjects and tool means of support of the admissible forms, methods of training on the basis of novations in the field of information and communication technologies, therefore the process of informatization of the educational environment needs to be understood as structurally difficult and continuous.

The remote education (education at distance) acts today as the specific aggregated form of education (is considered by the experts as the superposition of organizationally independent and mixed with “classical” diverse forms of education, - the division in the “traditional” educational establishment (HEI), the consortium of universities with the dealer / broker relations, the open “virtual” educational establishment or its representation), is oriented on granting the complex of educational services in a set of subject areas (subjects of studying) with the aid of the specialized information-educational environment, based on the means of representation of training information at distance (satellite, radio, optical, cable and post technologies).

When developing the modern information-educational environment of the certain hi-technological system of distance training and directly the realization of training process (at distance) in it the experts need to consider a row of scientific aspects (approaches): technical (level, kind, composition and specific features of the applied hardware and software means of automation), substantial (library of electronic methodical manuals), organizational-methodological (instructions to the trainees, psychology-pedagogical and mathematical methods of representation of information), allowing to carry out effectively the individual adaptation with taking into account the personal features of trainees (the subjects of training).

In the scientific community differentiates the essence of the scientific concepts “system of training” and “training system”, do not consider them identical. Under the system of training (pic. 1) understand the trainee and the training system.



Picture 1. The block scheme of the system of training with the cognitive model of the trainee

Considering the generalized structure of the automated adaptive system of training (at distance) it is possible to allocate a row of basic elements:

- the cognitive model of the trainee – directly describes the assessment \hat{Y} of the vector of condition of the trainee Y in the function of condition of environment X and the certain training (information) influence U : $\hat{Y} = F(X^*, U)$, and oneself the condition of the trainee of Y is defined by its operator F^0 : $Y = F^0(X, U)$, where the operator F of the model of the trainee is subject to definition and adaptation in the operated technological process of training (at distance);
- the algorithm of training (at distance) – carries the dual scientific basis, - at-first, it defines that, what should to teach the trainee (the training or information influence): $U = \varphi(X^*, \hat{Y}, Z^*, R)$, where φ – the algorithm of training (at distance), \hat{Y} – the estimation of condition of knowledge of the trainee, received with the aid of the model F , Z^* – the purpose of training, set by the tutor (the methodologist or the teacher), R^* – the external resource of training, determined by the opportunities of the system of training, R^{**} – the internal resource, allocated by the trainees F^0 for the training (for example, the necessary and sufficient time for the training); secondly, the algorithm of training (at distance) defines the tests V , answers on which bear the information about the cognitive model of the trainee F : $V = \Psi(X^*, \hat{Y})$, where Ψ – the algorithm of generation (synthesis) of the test V ;
- the bank of training information (BTI) – contains a set of information I , necessary for assimilation by the trainee in the process of training (at distance);
- the shaper of the portion of training (SPT) – defines the portion of information, transferred to the trainee for studying at this stage of training: $U^* = \Psi_1(U, I)$, where Ψ_1 – the algorithm of formation of the portion of training influence; let's notice, that a difference between U and U^* same as, for example, between the reference to some page of the text, i.e. its number, and the text (textual contents) of this page; in other words, U – the addresses in BTI, and U^* – their content;
- the shaper of tests (ST) works similarly: $V^* = \Psi_2(V, I)$ – the trainee in such system of training represents inside the “converter” of the condition of environment X and the portion of training information U^* into the condition Y ; the information about this condition of the trainee (the subject of training) can be obtained only with the aid of the test questions V^* : $Y^* = D_Y(Y, V^*)$, where D_Y – the operator of transformation of the test task V^* and the condition of the trainee Y in response to the control question Y^* (it is implemented by the trainee); let's notice, that in specific case directly possible $U=V$, what considerably simplifies the training system (at distance).

From all above follows, that the key elements are the model of the trainee F and the algorithm of training (at distance) φ .

The technological process of training in the information-educational environment by means of the automated training system (at distance) is directly typified and regulated (operated): there is shown to the trainee the portion of training information (the training influence), which he must to study by means of the means of automation (the electronic textbook), then for the determination of the quality of assimilation by him of the given portion of training information to him sets one or several control questions (as a part of the test). In various automated training systems (at distance) there is carried out the check of correctness of the answers the control questions and there is generated the next portion of the training information (the training influence), which is displayed directly to the trainee (the subject of training).

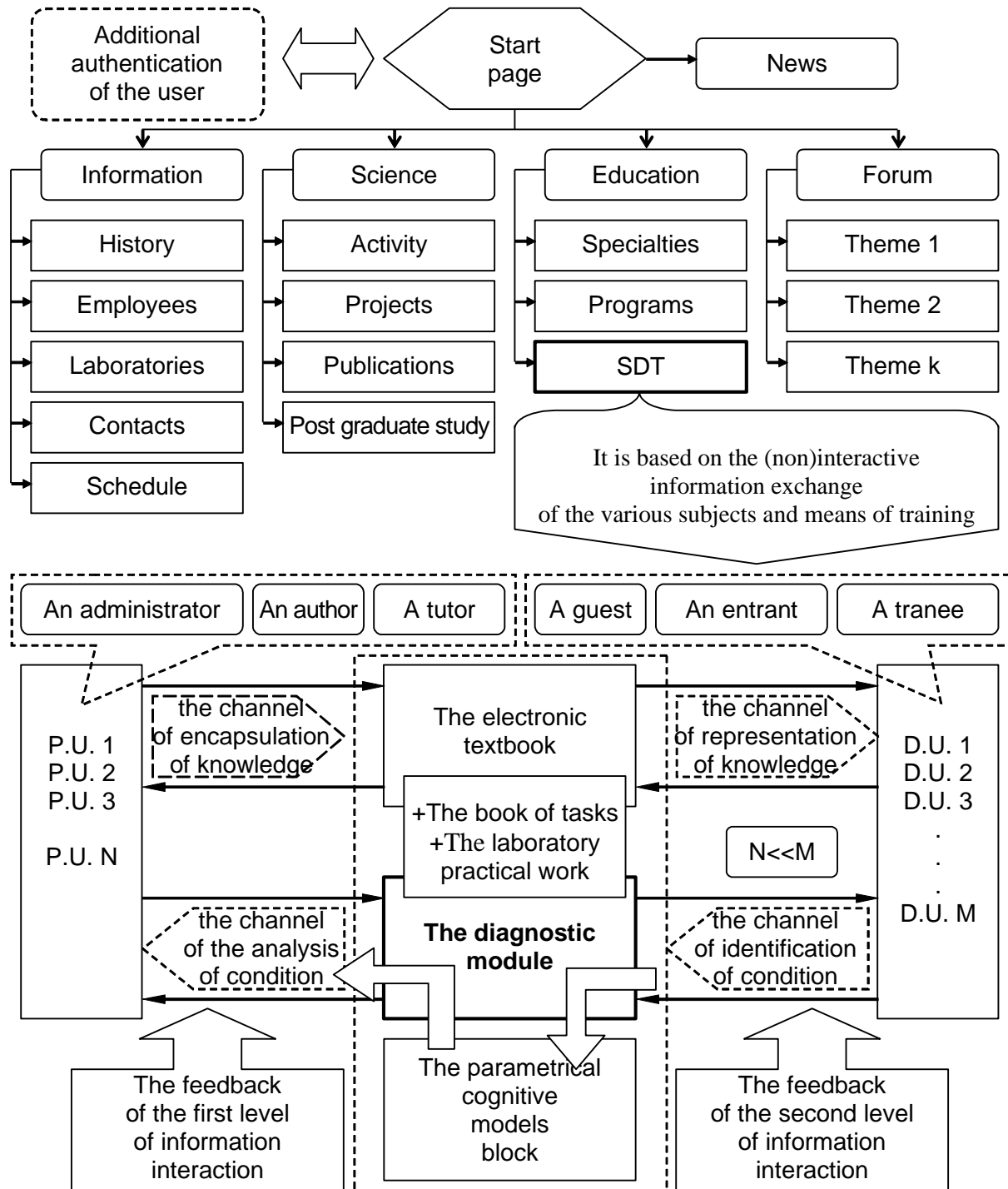
The algorithm of the training program directly defines the rules of generation (synthesis) and the sequence of presentation of the portions of training information (the training influences) to the trainee. The training program is constructing according to some algorithm of training, which represents the rule of generation (synthesis) of control V , or the rule of definition on each step of training (at distance) the next portion of the training information (the training influences). Wide circulation was received two types of the training programs – the linear training programs and the branched training programs. And among the branched training programs directly distinguish the internally and externally adjustable training programs (the means of automation).

The developed structure of the information-educational portal of the chair “Automatics and control processes” (“ACP”) of “The Saint-Petersburg state electrotechnical university "LETI"” provides the development of the high-technological Web application, segmented on a set of dynamically filled templates, at the same time directly the system of distance training acts as an integral part of the information-educational environment of chair.

The subjects of the system of distance training are directly differentiated by the rights of access and act in the various roles: the group of proficit units [administrator, author, tutor and others]; the group of deficit units [guest, entrant, trainee and others].

The limitation of communicative duplexity of the “virtual” dialogue between groups of proficit and deficit units (participants) is caused by the mediativity of information interaction (the subjects interact through the electronic textbook and the diagnostic module) and is the lack of any existing system of distance training, which needs to be investigated qualitatively and to eliminate technologically.

In the basis of the automated information-educational environment there is the computer system of distance training, realized directly by the modular principle (classically), but, along with the electronic textbook and the diagnostic module, structurally including the module of adaptation of the means of training (at distance) based on the parametrical cognitive models of the involved subjects (pic. 2).



Picture 2. The structural scheme of the (remote) training system in the basis of the developed information-educational portal of the chair "ACP" of "SPbSETU "LETI""

Program tools, along with the “rough” scale of estimation of the level of knowledge (it is based on the calculation of the summary weight coefficient of correct answers), contain the “expanded” (“exact”) scale of estimation of the level of knowledge (based on the calculation of the sums of gained points by each variant of answer the question), - in the result of the analysis of a posteriori data of diagnostics is established, that the accuracy of estimation of the level of residual knowledge significantly increases at the linear increase of quantity of the multiple answers.

In the electronic textbook the material on each discipline is stratified on sections, subsections, chapters and pages, to each stratum the block of control questions is associated, intended directly for the practical use in the diagnostic module of the remote training system, that allows to organize effectively the current, intermediate and total control of the level of awareness (residual knowledge) of the subject in a row of diverse subjects of studying (disciplines) with the application of a whole row of models of “pseudo”-adaptation. Many models of adaptation do not cover fully both levels of information interaction of the remote training system, and directly have only experimental character, as allow sometimes to lower individual time of the cycle of testing due to fine tuning of the sequence of questions which are subject to display (from the general selection of questions, which are in advance ranged on complexity) on the basis of the analysis of the answers of the certain examinee in time scale, which is brought closer to real (for the significant minimization of temporary expenses and the maximizing of the effect of synchronization of the virtual dialogue at the interactive interaction of the subjects of training and the means of training).

For the current processing of a posteriori results of research of the level of residual knowledge of examinees is applied the analytical-numerical method, which also allows to correct effectively the sequences of the question-answers structures in the database (knowledge base) of the diagnostic module for the organization of testing of the subsequent groups of examinees in the future period, includes the calculation of the following parameters (i – the index of the number of examinee, j – the index of the number of question in the task or the number of task in the block of tasks):

1. The complexity of the j^{th} task in the selection of question-answers structures (from the database):

$$K_j = \frac{N_j}{N}.$$

2. The summary result of implementation of all tasks by the i^{th} examinee:

$$y_j = \sum_{j=1}^M x_{ij}.$$

3. The summary result of implementation of the j^{th} task by all examinees:

$$x_j = \sum_{i=1}^N x_{ij}.$$

4. The average level of testing by the results of implementation of all tasks:

$$\bar{Y} = \frac{\sum_{i=1}^N y_i}{N}.$$

5. The average level of implementation of the j^{th} task by all examinees:

$$P_j = \frac{x_j}{N}.$$

6. The dispersion of the summary points of examinees (the subjects of training):

$$\delta_y^2 = \frac{\sum_{i=1}^N (y_i - \bar{Y})^2}{N - 1}.$$

7. The standard deviation of the summary points of examinees (the subjects of training):

$$\delta_y = \sqrt{\delta_y^2}.$$

8. The dispersion of the results of testing on the certain j^{th} task:

$$\delta_j^2 = \frac{\sum_{i=1}^N (x_{ij} - p_j)^2}{N-1}.$$

9. The standard deviation of the results of testing on the j^{th} task:

$$\delta_j = \sqrt{\delta_j^2}.$$

10. The estimation of connection of each j^{th} task with the sum of points on all test:

$$r_j = \frac{\frac{\sum_{i=1}^N (x_{ij} * y_i)^2}{N} - p_j * \bar{Y}}{\delta_j^2 * \delta_y} * \frac{N}{N-1}.$$

11. The average arithmetic of the independent expert estimates (marks):

$$\bar{Z} = \frac{\sum_{i=1}^N Z_i}{N}.$$

12. The standard deviation of the independent expert estimates (marks):

$$\delta_Z = \sqrt{\frac{\sum_{i=1}^N (Z_i * \bar{Z})^2}{N-1}}.$$

13. The coefficient of correlation of the results of testing of the examinees and the independent expert estimates (marks) (the validity of test):

$$V = \frac{\frac{\sum_{i=1}^N (Z_i * y_i)}{N} - \bar{Z} * \bar{Y}}{\delta_Z * \delta_y} * \frac{N}{N-1}.$$

14. The indicator of accuracy and stability of the results in time (the reliability of test).

The learning practice of the modern educational establishment, based on the innovative high-technological adaptive information-educational means and environments, assumes the periodic identification and the system analysis not only the level of awareness of the learning subject in the subjects of studying, but, also, and actualizes the consideration of the conceptual fundamental bases of engineering of knowledge (cognitive informatics, physiology of sensor systems, cognitive psychology and cognitive linguistics), which focus the essential attention of scientists and researchers on the physiological, linguistic and psychological aspects of information interaction of the subjects of training and the means of training.

For the system analysis of the efficiency of formation of knowledge of the trainees arriving directly from the electronic textbook (in particular) on the channel of representation of information of the remote training system of the information-educational environment is developed the structure of cognitive model, echeloned on a row of the diverse parametrized portraits: physiological (emphasizes the potential possibility of sensory perception of information in the signal form by the visual and acoustical analyzers), psychological (reflects the various convergent and divergent intellectual abilities, cognitive styles and learning ability) and linguistic (the natural-language aspects of virtual communication), for the filling of which is used the iterative cycle of the specially developed cognitive modeling technology (it is presented in the section 2.3 of the collective monography "The factors of success in the educational activity of modern HEI" edited by the member-correspondent of "IHEAS" Zakharov I.N.).

The intellectual (adaptive) training systems (at distance) belong to the new means of computer support of the process of training, therefore they can be used with success for the applied tasks of research of the information-educational environment of the adaptive training.

The developed software products are supposed to be used as a part of the unique information-computational complex of parametrical identification of the portraits of cognitive model, and the results received on its basis are supposed to be used in the further scientific-methodical and practical researches of the adaptive information-educational environments (at distance).

At present moment there is conducted the verification of databases (knowledge base) and productional kernels of the mechanism of conclusion of the program realization of modules of diagnostics of the convergent and divergent intellectual abilities of the cognitive model of the subject of training in the basis of the architecture of expert system with the application of the iterative cycle of the cognitive modeling technology.

The offered approach to the synthesis of the adaptive information-educational environment based on the use of the methods and technologies of cognitive modeling will allow to explain qualitatively the diverse reasons of difficulties at the forming of knowledge by the subjects of training (trainees) and adequately to correct the information-education influences, generated by the automated means of training (at distance).