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THE ADAPTIVE INFORMATION-EDUCATIONAL ENVIRONMENT OF THE AUTOMATED (REMOTE) TRAINING BASED ON THE PARAMETRICAL COGNITIVE MODELS

The approach to the creating, analysis and the improving in the efficiency of functioning of the information-educational environment of the automated (remote) training system based on the parametrical cognitive models is proposed.

The information-educational environment, the automated (remote) training system, the cognitive model, the parametrical cognitive models block, the cognitive modeling technology, the algorithm of formation of the structure of the cognitive model.

The informatization of the educational (scientific) establishments initiates the consideration of a wide spectrum of scientific aspects (approaches): regional, economic, organizational, technical, introduction, social, pedagogical, methodological, ergonomic, physiological, psychological, linguistic and others.

The genesis of the ideas of automated training has been traced since the middle of 20th y. of the last century is related with the appearance of classical models, used in the basis of educational means: the linear (B.F. Skinner), the linear with feedback (S.L. Pressey), the branched and branched multilevel (N.A. Crowder, G. Pask), which were further developed in the work of a row of the Russian scientists: A.I. Berg, V.P. Bespalko, P.Ya. Galperin, V.M. Glushkov, A.M. Dovgyallo, L.B. Itelson, L.N. Landa, A.N. Leontiev, E.I. Mashbitz, N.F. Talyzina, E.L., E.L. Yushchenko and others.

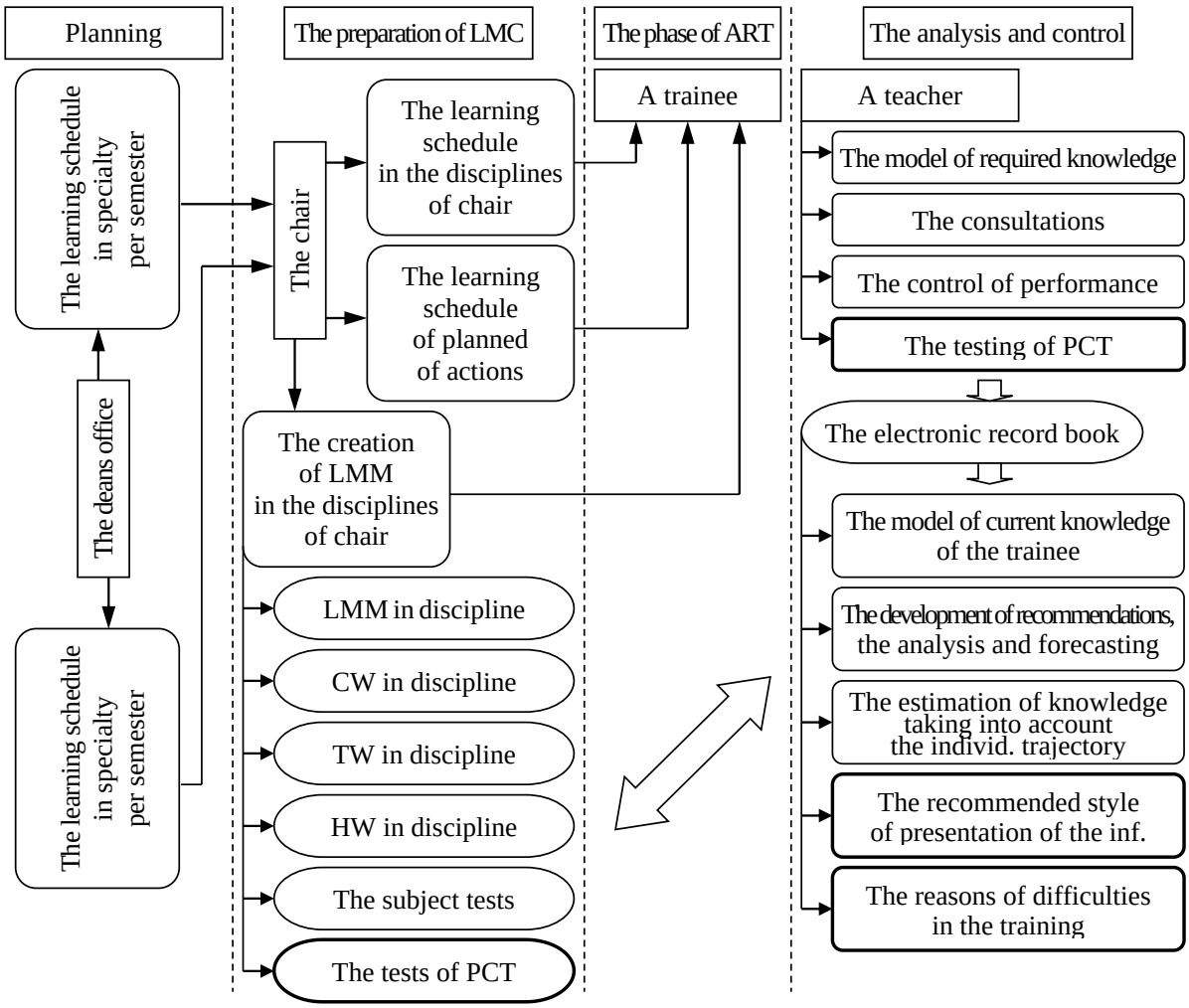
The classical and innovative information-educational environments (IEE) of the automated (remote) training systems (ART) created on the basis of the traditional models and technologies are practically do not take into account the individual features (characteristics) of personality of the subject of training (PCT). The significant exception is the branched multilevel model, taking into account the level of residual knowledge of the trainee and the level of statement in the subject of studying.

The modern level of development of the science and technology allows to realize the means of training of a new generation, taking into account PCT based on the hybrid and adaptive models, that significantly effect on the quality of (re)training of the qualified specialists.

The individual orientation of information interaction between the subjects of training and the means of training in IEE of ART system is achieved due to the use of a row of the modern technologies: the technology of individual training – realizes the scheme "the subject – the means of training", the technology of individualized training – provides the accounting of the individual features of personality, the technology of adaptive training – allows to generate the educational influences directly on the basis of the invariant (parametrical) cognitive model.

For the realization of the adaptive generation of the information-educational influences according to PCT in IEE of ART system proposes to use the cognitive model (CM), the structure of which directly meets a row of the modern requirements: the relevance – to form the model with a set of personal characteristics of the subject of training, taking into account by the means of training of IEE and the essential for the achieving of the purposes of training, the adequacy – the compliance of the obtained parametrical model to the original, the solvency – the support by the means of training of IEE of the quasi-dynamic system analysis and updating of the nominal values of parameters of the model due to the systematic accumulation of data about the condition of the subject of training.

The structure of training as a technological process of the formation of knowledge of the trainee (pic. 1), includes a row of the diverse technological gaps (the technological stages): the planning, the preparation of learning-methodical complex (LMC), the phase of training (at distance), the analysis and monitoring of condition of the subject of training.



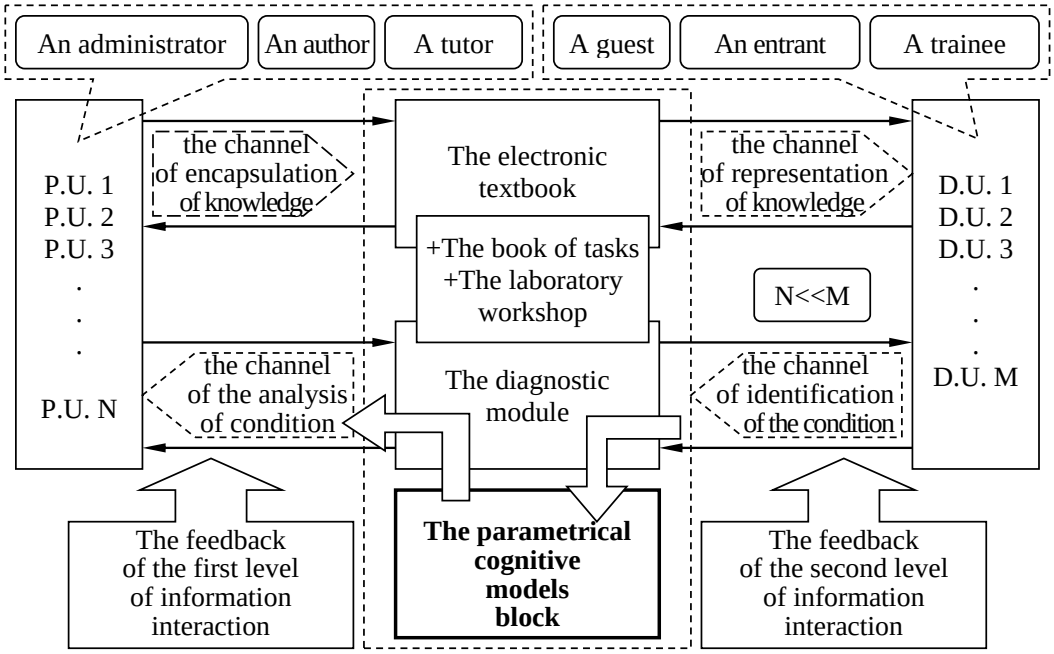
Pic. 1. The technological features at the organization
of the automated (remote) training
based on the parametrical cognitive models

The realization of IEE of the adaptive training based on the parametrical CM block attracts the modification of some technological stages of the educational process: the stage of preparing of the (electronic) LMC – it is necessary to prepare the tests of PCT, the stage of the (automated) analysis and control – it is required to test PCT, to reveal the preferred parameters of presentation of the information fragments, the reasons of difficulties of each trainee at their perception and processing, and then to put a posteriori results into the electronic record book (ERB).

The structure of ART system with the elements of adaptation based on CM block (pic. 2) represents a closed contour (with feedbacks), which includes the two levels of information interaction between the subjects and means of training: the first level is represented by the channel of encapsulation of knowledge and the channel of the analysis of condition, the second level contains the channel of representation of knowledge and the channel of identification of the condition of trainee.

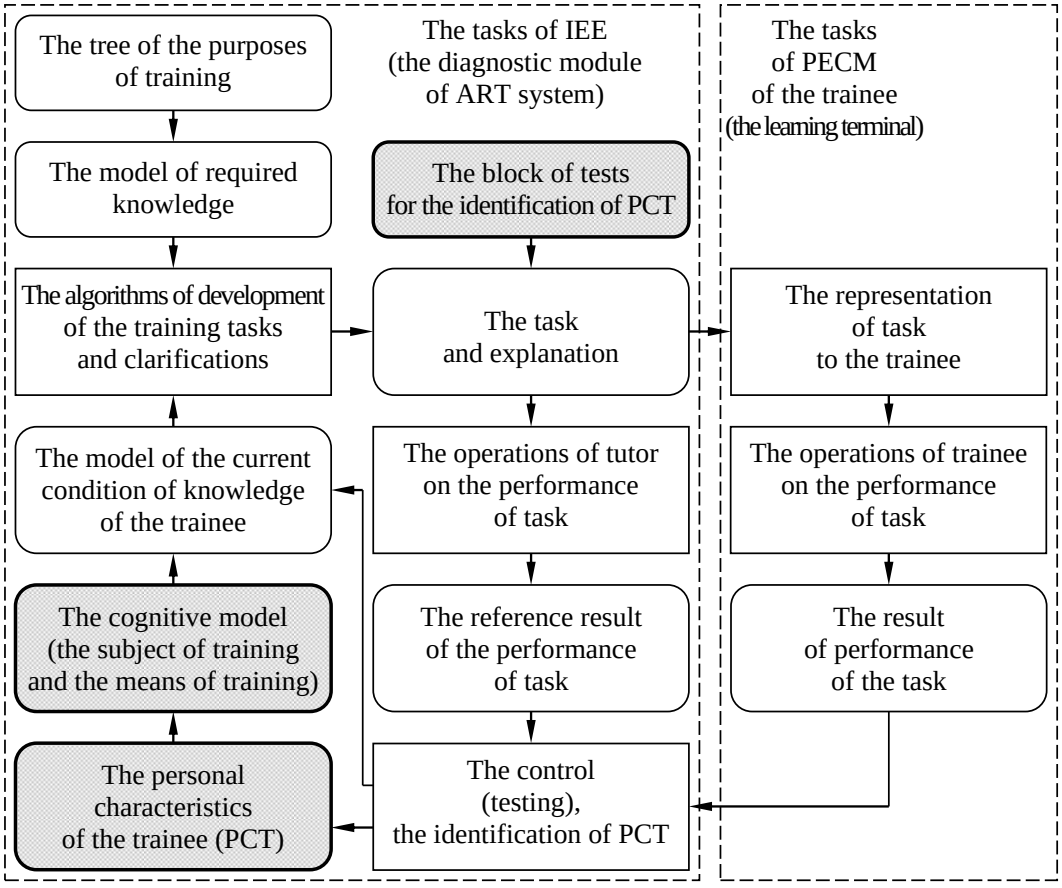
In relation to the technological process of knowledge formation (at distance), the subjects of IEE of ART system are differentiated by the level of access and act in the various roles: the proficit units (P.E.): an administrator, an author, a tutor and others, the deficit units (D.E.): a guest, an entrant, trainee and others. The virtual dialogue between the subjects of training is carried out by means of the means of training of IEE of ART system and therefore has a significant drawback – the limitation of communicative interaction (in a wide sense), which needs to be researched and technologically eliminated.

The training (at distance) is considered as a technological process of the controlled transfer of knowledge in the subject of studying into the consciousness of trainee and includes a sequence of technological stages of the processing of information (the visual representation, perception, understanding, the development of skills, the formation of skills and the aggregation of the received information into knowledge), therefore the level of residual knowledge of the trainee significantly depends on the quality of perception and understanding of the content of information fragments.



Pic. 2. The structure of the automated (remote) training system with the elements of adaptation based on the parametrical cognitive models block

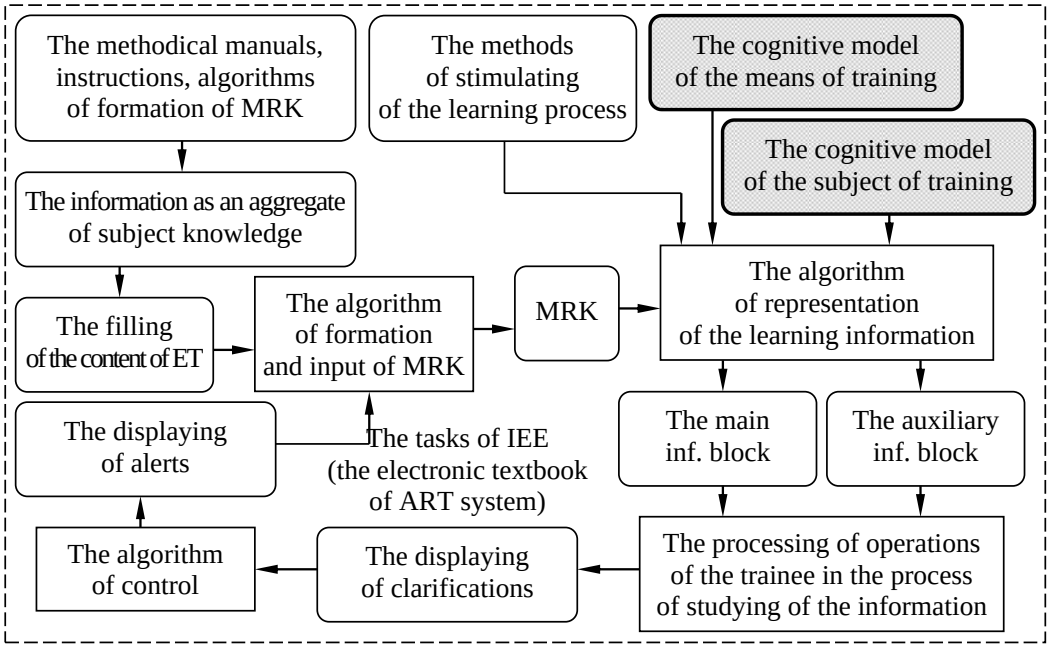
The diagnostic module (main and applied) of ART system (pic. 3) is intended for the initial, intermediate and final control testing of the level of residual knowledge of the trainee in a certain subject of studying, and also realizes the initial and quasi-dynamic research of parameters of PCT for the filling of nominal values of the parameters of the parametrical CM of the subject of training.



Pic. 3. The general scheme of training as a controlled technological process with the adaptation based on the parametrical cognitive models block:

the principle of functioning of the diagnostic module

The control of displaying of a sequence of diverse information fragments (the electronic textbook, section, chapter, paragraph and page) by the various ways realizes the adaptive representation of a sequence of information fragments processor, located directly in the structure of the adaptive electronic textbook (pic. 4) based on the structural (semantic) meta-model of the subject of studying and the innovative high-technological parametrical CM block. The structural (semantic) meta-model of the subject of studying is necessary and sufficient for the filling by the subject content in the cycle of disciplines (the subjects of studying).



Pic. 4. The general scheme of training as a controlled technological process with the adaptation based on the parametrical cognitive models block:

the principle of functioning of the electronic textbook

In the adaptive electronic textbook the material in each discipline (the subject of studying) is structured on chapters, sections, subsections, modules, paragraphs and pages, to each information fragment is associated the block of control questions, intended for the use in the diagnostic module of ART system, that allows to efficiently organize the current, intermediate and final control of the level of residual knowledge of the subject of studying in a row of the subjects of studying (disciplines) using a row of different methods of research (estimation) (tests).

For the automation of research of the level of residual knowledge of the subjects of training is developed the program toolkit (the main diagnostic module), allowing to directly conduct the estimation based on the two scales: "rough" – the calculation of the sum of valid answers to the questions of the method of research (test); "extended" or "accurate" – the calculation of the sum of the scored (penalty) points on each (in)valid variant of answer to the question of the method of research (test).

The processing of a posteriori data of testing is carried out using of a special technique (not presented in given scientific article), allowing to estimate the level of knowledge of the examinee and to carry out the analysis of the quality of test directly on the basis of a row of the analytical coefficients: the difficulty of task, the summary result of performance of all tasks by the i^{th} trainee, the summary result of performance of the j^{th} task by all trainees, the average level of testing based on the results of performance of all tasks, the average level of performance of the certain j^{th} task by all trainees, the dispersion of the summary points of examinees (the subjects of training), the standard deviation of the summary points of examinees (the subjects of training), the dispersion of the results of testing on the j^{th} task, the standard deviation of the results of testing on the certain j^{th} task of the method of research (test), the estimation of the connection of each j^{th} task with the sum of points on the whole test (the method of research), the average arithmetic mean of the independent expert estimations, the standard deviation of the independent expert estimations, the coefficient of correlation of the results of testing and the independent expert estimations (the validity of test) and the indicator of accuracy and stability of the results of testing (the reliability of test).

For the complex solution of the scientific problem of creation and subsequent system analysis of IEE of ART system with the elements of adaptation based on the parametrical CM block the innovative cognitive modeling technology (CMT) and the technique of use of CMT for the formation of the structure of the parametrical CM are proposed.

CMT acts as the universal in relation to the object of research and is the iterative cycle, including a sequence of technological stages, allowing not only to obtain the primary presentations about the object of research in the context of the spectrum of diverse scientific aspects of consideration the object of research, but also to carry out the structural (parametrical) system analysis. CMT includes the following technological steps (the technological gaps) of the system analysis: the identification (the obtaining of the primary presentations about the object of research), the conceptualization (the conceptual scheme of the object of research in the subject area), the structuring (the structured knowledge about the object of research in the subject area), the formalization (the construction of the first and second level of the structure of the parametrical CM), the structural analysis (the verification of the first level of the structure of the obtained parametrical CM), the parametrical analysis (the verification of the second level of the structure of the parametrical CM, its parameters), the realization (the placement of the obtained parametrical CM in the basis of the environment of research), the modeling (the cognitive modeling based on the holistic approach), the analysis (the statistical processing of data, obtained using the parametrical CM), the subject interpretation (the interpretation of the obtained tendences, dependencies, regularities and relationships), the synthesis (the accumulation of new knowledge about the dynamics of development of the object of research in the subject area). For the complex objects of research CMT provides the attraction of the consultants: the expert – the qualified specialist in the subject area (for IEE the methodist and others), the cognitologist – the qualified specialist in the field of knowledge engineering, the system analyst – the qualified specialist in the field of the system analysis and modeling, the programmer – the qualified specialist in the field of the languages of programming, knowing the methods and approaches to the realization of modern program means by means of the use of the highly-technological integrated environments of programming.

The technique of use of CMT and the algorithm of formation of the structure of CM (not presented in the scientific article) are developed for the formalization of a sequence of use of CMT with the purpose of formation of the structure of the parametrical CM for the tasks of the system analysis of IEE of ART system with the elements of adaptation based on the parametrical CM block.

For the system analysis of the structurally difficult objects of research it is recommended to use the representation of the parametrical CM in the view of the oriented graph, the vertices of which form a row of mathematical sets (pic. 5, above), that is significantly convenient for the subsequent system analysis.

It is recommended to use the schematic representation of the parametrical CM (pic. 5, below) for the system analysis of the structurally simple objects of research.

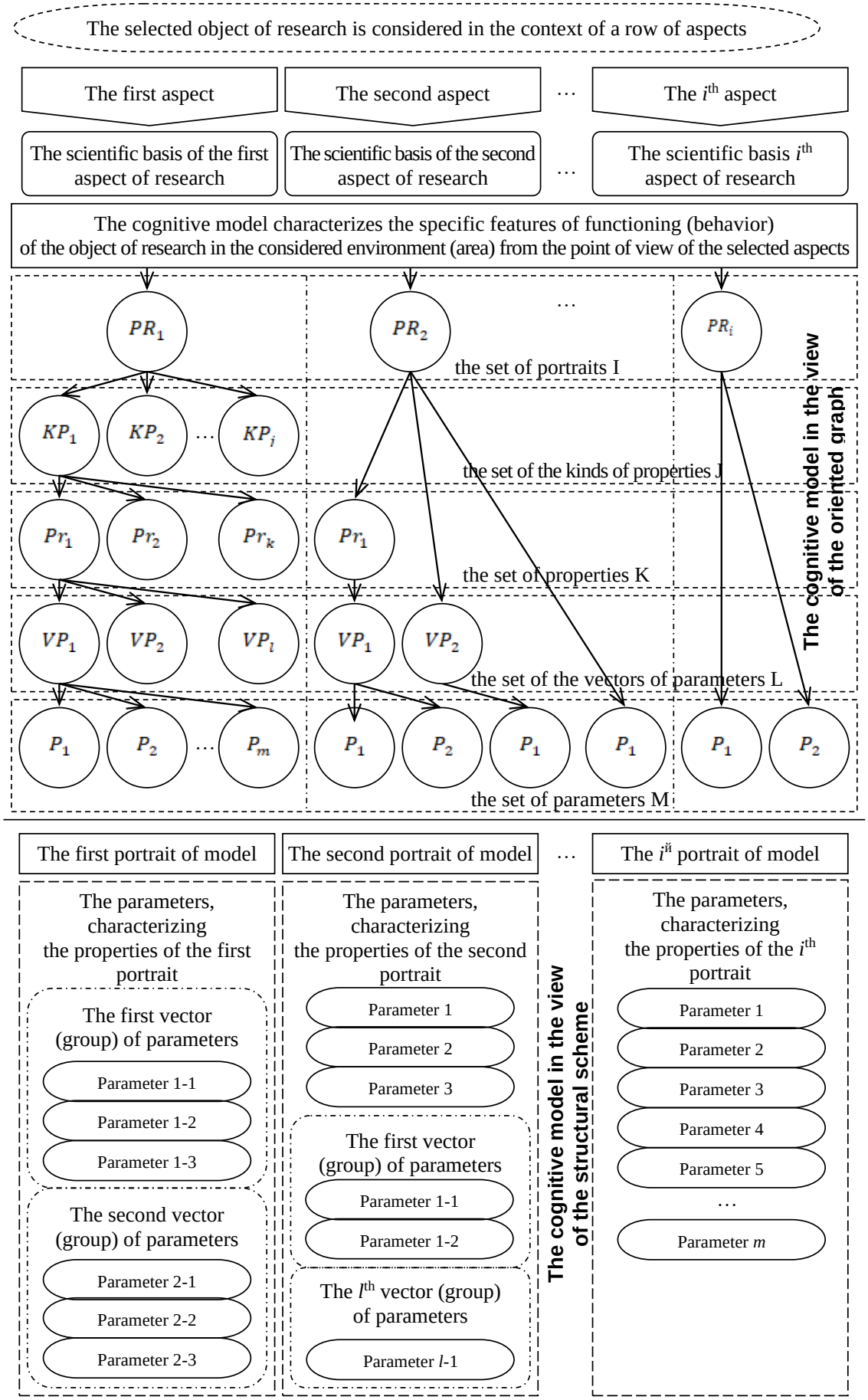
The parametrical CM – the repertoire of parameters, echeloned on a set of portraits and stratified on a row of mathematical sets (the presentation of CM in pic. 5, above). For IEE of ART system the parametrical CM reflects the most important scientific aspects (approaches) and the parameters of information interaction of the directly significantly diverse subjects of training and the means of training, providing the consistency of generation of a sequence of educational influences with the personal characteristics (features) of all subjects of training, and also allowing to reveal the causes of difficulties in the process of knowledge formation.

The contour of adaptation of IEE of ART system based on the parametrical CM block is technologically realized at the possibility of generation of the training influences based on CM of the means of training in coordination with PCT, contained in CM of the subject of training.

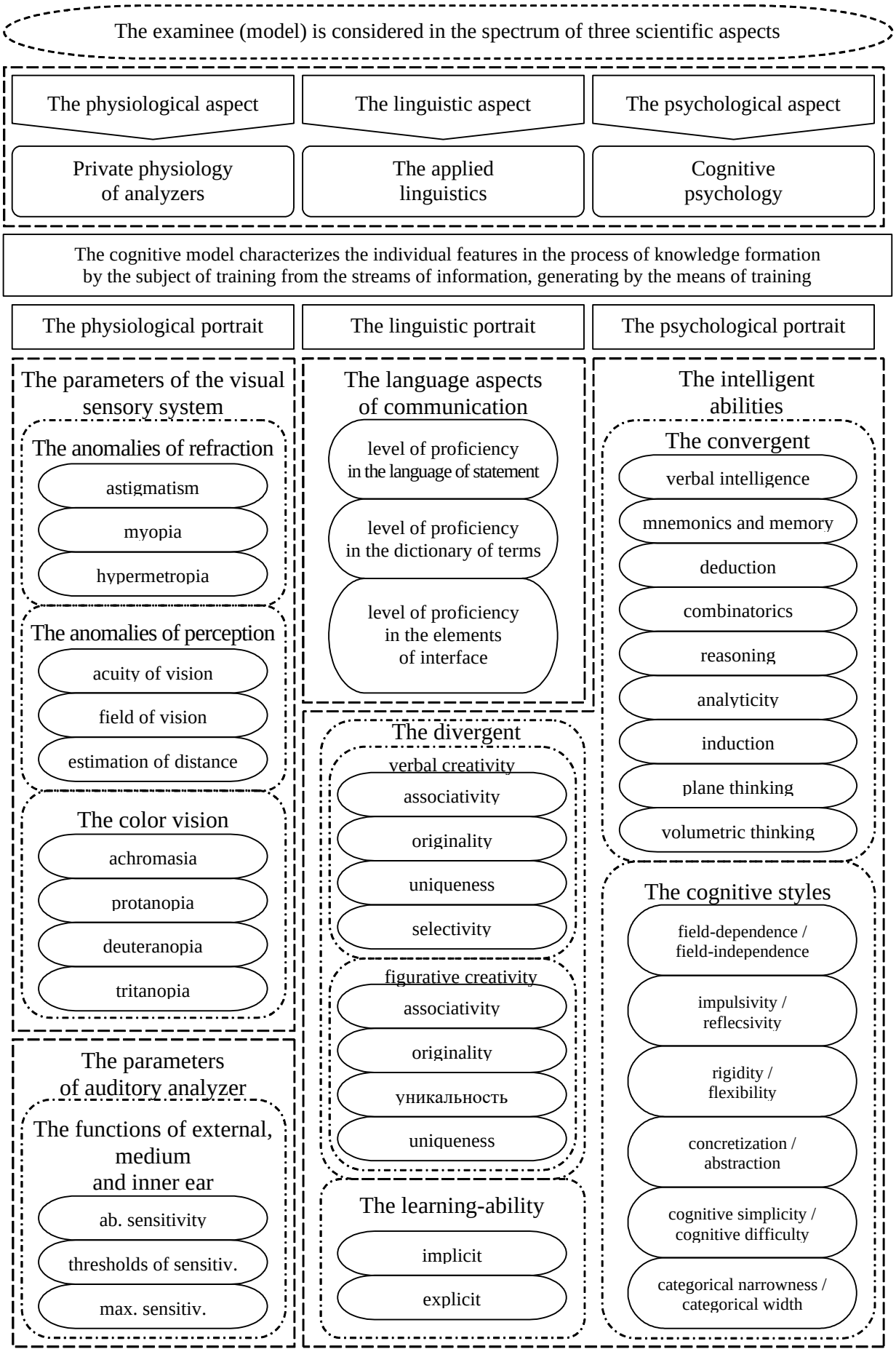
Accordingly the parametrical CM is directly differentiated on the parametrical CM of the subject of training (the parameters, characterizing PCT) and the parametrical CM of the means of training (the parameters, characterizing the potentially possible types and kinds of the generated diverse information-educational influences).

The parametrical CM of the subject of training (pic. 6) concentrates the parameters of the physiological, psychological and linguistic portraits, characterizing PCT.

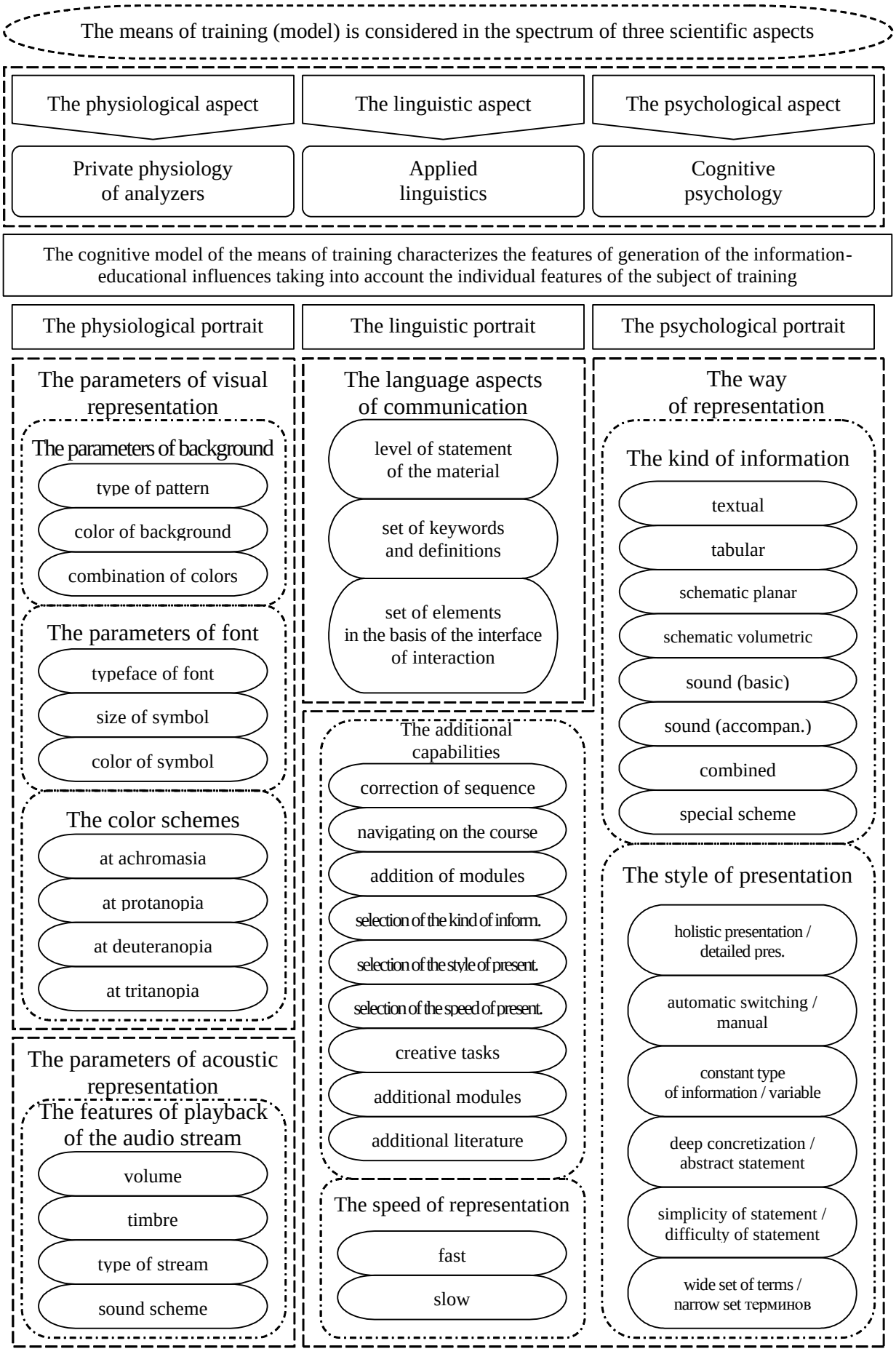
The parametrical CM of the means of training (pic. 7) contains the parameters, characterizing the potentially possible types, kinds and features of the generated diverse information-educational influences.



Rice. 5. The basis for forming the structure of the parametric cognitive model, represented in the form of an oriented graph (top) and a structural diagram (bottom)



Pic. 6. The parametrical cognitive model of the subject of training



Pic. 7. The parametrical model of the means of training

For the automation of the tasks of research of the vectors of parameters in the structure of portraits of the parametrical CM of the subject of training the program toolkit, developed directly on the basis of the architecture of the expert system and containing in the basis of the database (knowledge base) a set of applied methods of research (tests) on the scientific basis of the private physiology of sensory systems, cognitive psychology and linguistics.

The estimation of the efficiency of introduction of the scientific results of research was carried out using the generally-accepted indicators of the efficiency (resultativity) of IEE of ART system:

$$K = \{k_1; k_2; k_3\} = \left\{ Y_1 - Y_2; \frac{Y_1}{Y_2}; \frac{Y_1 - Y_2}{Y_2} 100\% \right\}$$

The coefficients directly denote respectively the absolute, comparative and relative indicators of efficiency, and the results of statistical processing of a posteriori data of a series of the diverse automated experiments are generalized in table 1.

Table 1. The results of statistical processing of data of the experiment

The name of indicator	The number of experimental group of examinees							
	1	2	3	4	5	6	7	8
The experiment №1 (without the use of CMT)								
The average point Y_1	3,850	3,414	3,224	3,678	4,036	3,643	3,790	3,645
ESD of av. point	0,867	0,178	1,958	0,879	0,577	0,783	1,679	1,047
The experiment №2 (with using of CMT, the personal adaptation)								
The average point Y_2	4,041	3,674	3,357	3,786	4,157	3,853	3,821	3,743
ESD of av. point	0,723	0,127	1,743	0,743	0,446	0,654	1,538	0,986
The results of research								
K_1	0,191	0,26	0,133	0,108	0,121	0,21	0,031	0,098
K_2	1,049	1,076	1,041	1,029	1,029	1,057	1,008	1,026
K_3	0,049	0,076	0,041	0,029	0,029	0,057	0,008	0,027
The change of ESD	-0,144	-0,051	-0,215	-0,136	-0,131	-0,129	-0,141	-0,061

The proposed approach allows to realize the additional contour of adaptation based on the innovative parametrical cognitive models block, and also to carry out the system analysis of the efficiency of functioning of IEE of ART system.

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