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The approach to the synthesis of the information-educational environment
of the adaptive remote training
with the usage of the cognitive modeling methods and technologies

“It is correct to formulate the problem –
m e a n s h a l f i t t o s o l v e ”
(Einstein A.)

“The science begins then,
w h e n b e g i n t o m e a s u r e ”
(Mendeleyev D.I.)

The scientific community in the process of the analysis of the stages of formation of civilization on a threshold of the third millennium allocates the essentially new, mutual-caused “difficult” processes, problems and concepts, in particular,- the influence of globalization on the various spheres of public activity (social, economic, political and others); the emergence of “information (post-industrial) society”, in which the exponential increasing flows of diverse information and scientific knowledge on a range of subject areas represent inside the most important strategic resource of development of mankind, that, in turn, initiates the synthesis of the necessary high-technological ways (approaches) and means sufficient for the collecting, processing, storage and distribution of information (information resources, products and services) in the information environment.

There is emphasized the inevitability of redistribution of priorities among the diverse subjects (labor resources) in the relation of technologies of material production and information technologies: the considerable part of able-bodied population (the consumers of information) is involved into the information industry (the information branch), there are appeared the specific (innovative) professions relevant to processing of the flows of information in the concrete subject area. Significantly increases the social role of information, noted more in the 70th years of last century, and at the present moment its appearance is characterized in the high rates of expansion of the sphere of use (the inter-disciplinary consumption) of the streams of scientific-technical, economic, technological and other kinds of subject-oriented information (the information storages), which circulate in world, state, regional and local levels,- academicians of “RAS” Yershov A.P. and Arsky Yu.M. specially entered the new concept “infosphere” as the sphere of information of planetary scale, created for the communicative information exchange of subjects with use of technical means on the basis of modern achievements in the field of information and communication technologies.

The concept “informatization” (in a wide sense) of the various spheres of universal human activity is directed on the optimization of process of the creation, distribution and use of diverse information resources, products and services between the diverse subjects of information interaction in the different subject areas (problem spheres), therefore it is carried out by the local (address) creation and introduction of the problem-oriented high-technological information and communication infrastructures, which are directly directed on the satisfaction of dynamically changing information needs of the post-industrial society.

The emergence and continuous evolution of information “hyper-highways” on the basis of communication technologies (World Wide Web – The world wide web) initiates the reconsideration of opportunities of the new information technologies, their location in the modern society and the system of education, demand the elaboration of institutional approach at the international level. By Vetrov A.N. in the monography “The factors of success in the educational activity of modern HEI” edited by the memb.-corr. of “IHEAS” Zakharov I.N. (the section 2.3), gives the priorities of the international state educational politics of development of the system of education (the global purposes, defining directions, problems and tasks of formation of the perspective system of education offered by “The institute on information technologies in education”, operating in the context of the agreement between The Government of RF and “UNESCO”).

The modern situation in the market of education services is characterized by the dynamically changing needs of professionally differentiated representatives of the various layers of population, that has the influence on educational standards, politics, strategy, the statement of purposes and tasks of training, the organizational and methodical activity of HEI, the 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.

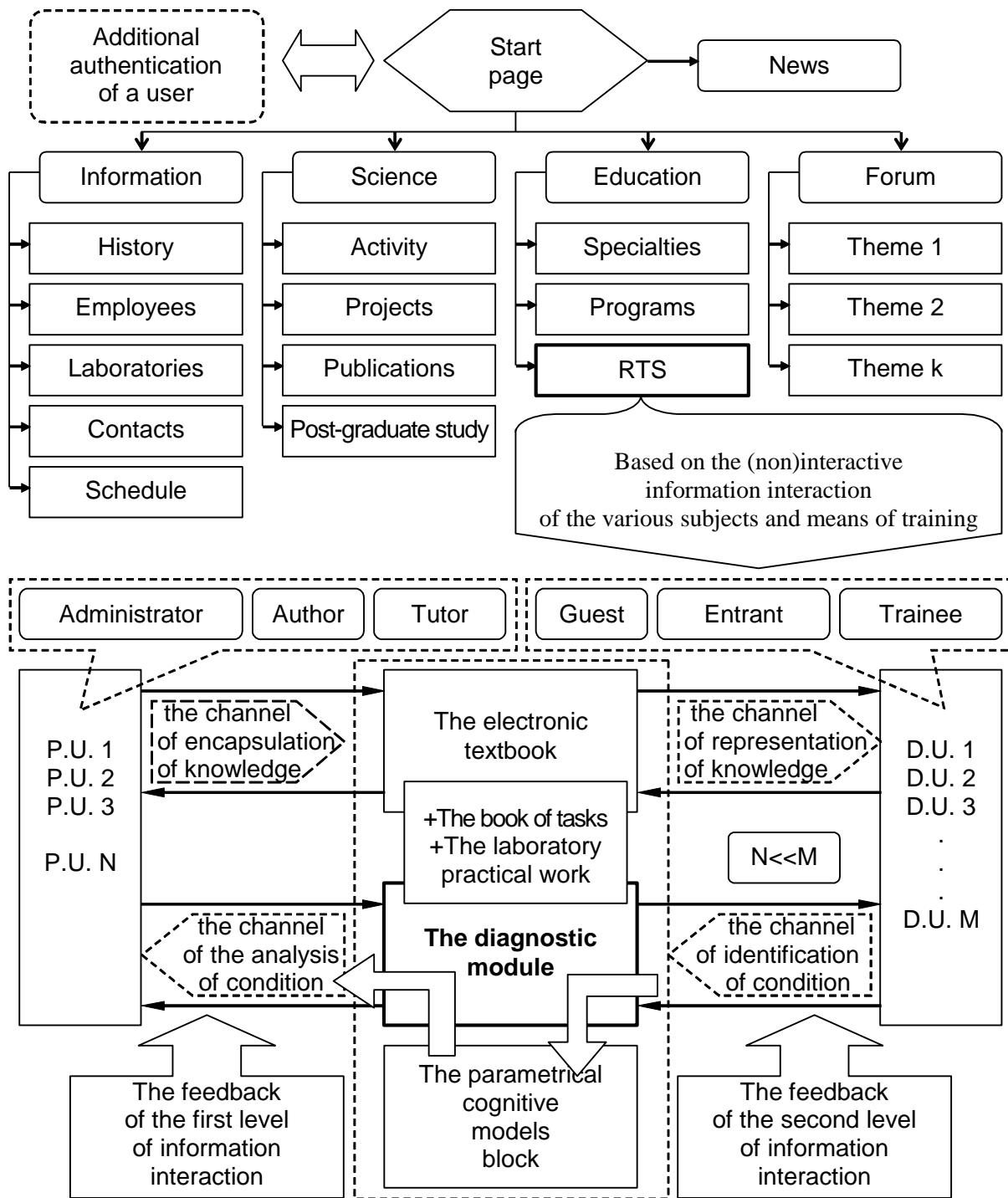
The informatization (in a narrow sense) of problem environment of the educational activity of modern educational establishment (HEI) causes the need of the purposeful analysis and introduction of information and communication educational technologies (classification is considered by Vetrov A.N. on the page 59 of the monography) for the providing of support of the existing or newly created classical or innovative information-education environment.

The federal target program of The Government of RF “The development of the unique educational information environment” (2006-2009 y.) acts as the adequate answer of modern society on the exponential increase of the cumulative aggregate of knowledge on a range of subject areas: on the one hand,- emphasizes the need of association of the local (regional) and internationalization of the distributed (international) information-educational environments; on the other hand,- it is oriented to the potential possibility of the synthesis of the unique (planetary)info-sphere in the near future.

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

The developed structure of the information-education 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 the remote training system (RTS) acts as the integral part of the char information-educational environment.

At the basis of the automated information-educational environment there is the computer system of remote training, realized 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 on the basis of the parametrical cognitive models of the involved subjects. The general structure of the developed remote training system (pic. 1) includes 4 channels and 2 levels of information interaction (there are investigated the direct and return connections of the first and the second levels): the first level (the channel of encapsulation of knowledge and the channel of the analysis of condition), the second level (the channel of representation of knowledge and the channel of identification of condition).

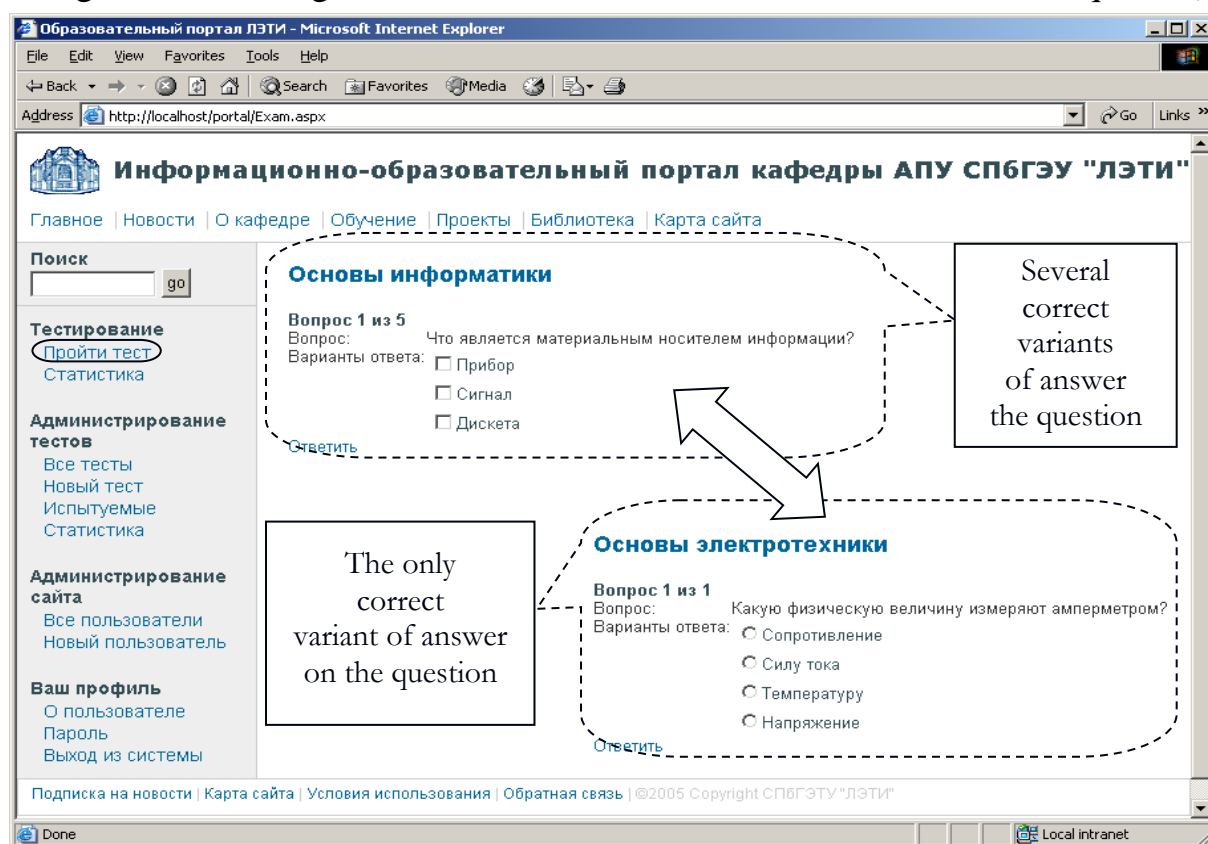


Picture 1. The structural scheme of the (remote) training system in the basis of the developed information-educational portal of the chair “ACP” of “SPbSETU “LETI””

The subjects of RTS are differentiated by the rights of access and act in the various roles: the group of proficit (surplus) units [administrator, author, tutor and others]; the group of deficit (scarce) units [guest, entrant, trainee and others].

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

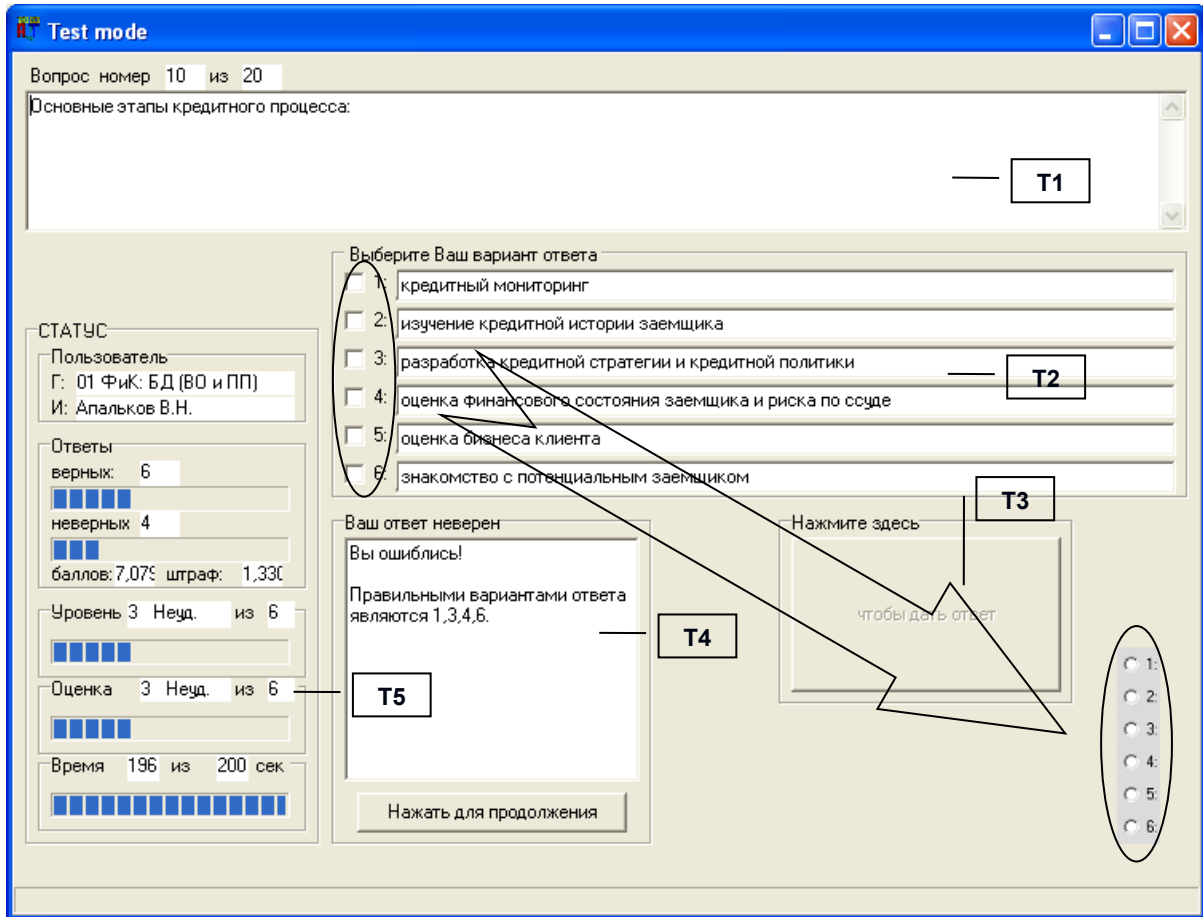
In the pic. 2 there is presented the interface form of program realization of the module of diagnostics of RTS of the information-educational portal of chair in the mode of diagnostics of the level of residual knowledge of trainees with the use of the chosen test on the certain discipline (the end user underwent the authorization of access, in the context-dependent panel made active “To pass the test”, there is carried out further the display of textual content of the formulation of question and the wording of the variants of answers, taking into account single-variant on correctness or the multi-variant answer the question).



Picture 2. The interface form in the mode of diagnostics with the use of the chosen test on the certain discipline

The module of diagnostics of RTS of the open educational portal as the environment of program surroundings uses “Internet information services” – “Inf. services of Internet” (“Web-server” – “Web-server”) under the control of the operating system of the family “Windows 200 Professional / Server / Advanced server / Data warehouse server / XP” and it is realized in the professional environment of programming “MS ASP.Net” for the tasks of “World Wide Web” (“The world wide web”) in the language “C#”, and the database is developed on the basis of “MS SQL Server”.

There are in addition realized the program toolkit (pic. 3) in the integrated environment of RAD programming of “Borland C++ Builder”, which are technologically mobile and quickly developed.



Picture 3. The interface form in the mode of diagnostics with the use of the chosen test on the certain discipline

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

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

In the basis of the developed adaptive means of training (the electronic textbook) directly is located the developed innovative adaptive representation of the sequence of information fragments processor, which is executed by the principle of parallel architecture and the traditional block-modular principle (for modernization): includes three diverse modules of control of processing of the physiological, psychological and linguistic parameters CM of the subject of training and CM of the means of training for the providing of the individual-based generation of information-educational influences to the contingent of trainees.

For the current processing of a posteriori results of research of the level of residual knowledge of examinees there is applied the analytical-numerical method, which also allows to correct the sequences of 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 difficulty 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 performance of all tasks by the i^{th} examinee:

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

3. The summary result of performance 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 performance of all tasks:

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

5. The average level of performance 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 correlation of each j^{th} task with the sum of points by 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 independent expert marks:

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

12. The standard deviation of independent expert 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 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).

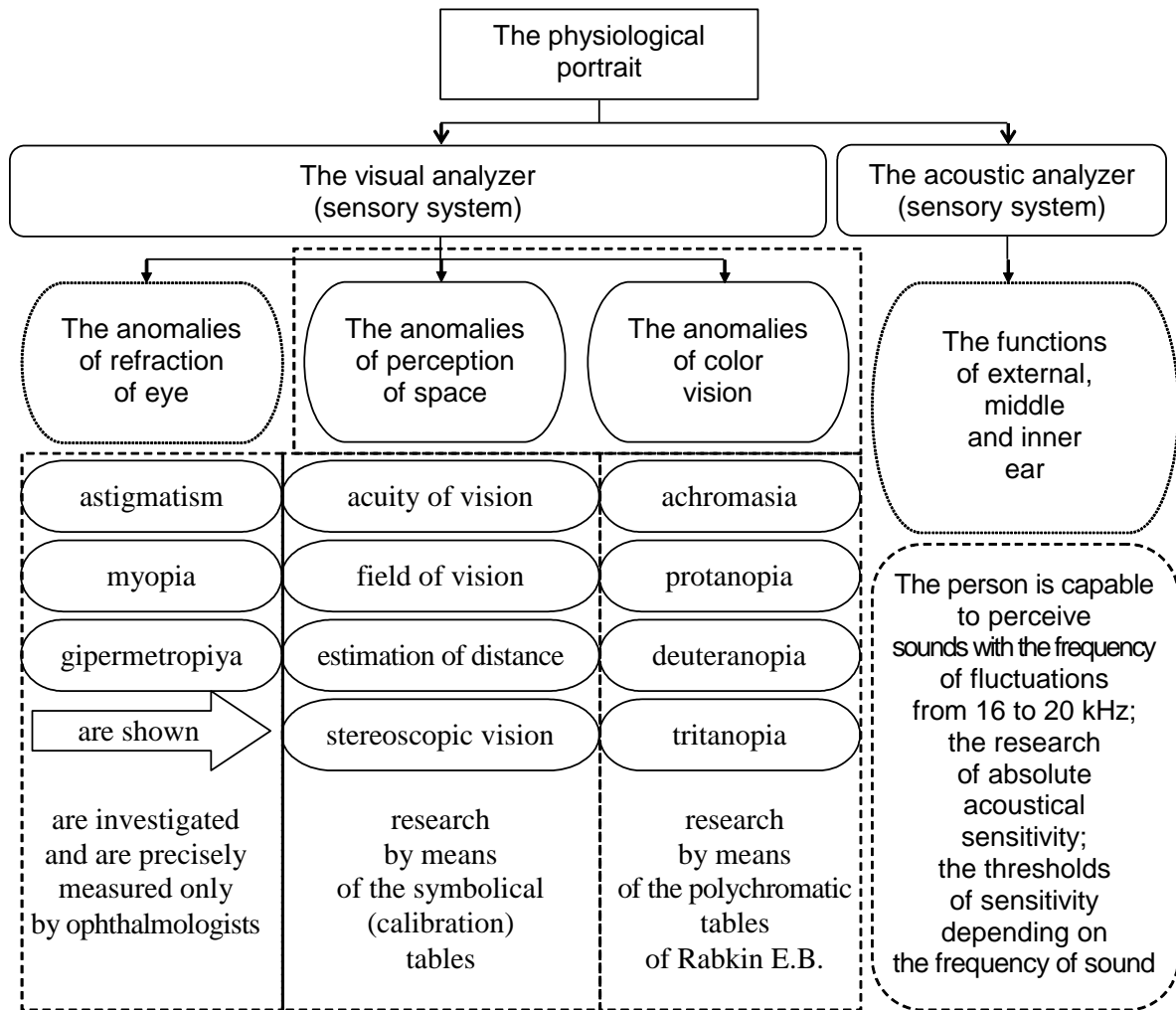
The models “pseudo”-adaptation and the considered analytical-numerical method will not allow to make the qualitative conclusion about the reasons of difficulties of the examinee in the process of cognitive sorption of structured data (knowledge) from the flows of learning information generated by the means of training.

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 conceptual 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 physiological, psychological and linguistic aspects of information interaction of the subjects of training and the means of training.

In the context of the information (training is derivative of a set of elementary processes of the processing of information expressed in data) and educational (the final product of training is the accumulated knowledge expressed in the structured data) scientific approaches to the research of the remote training system as hybrid (natural on the involved subjects of training and artificial on the used means of training), - the system analysis of the process of training structurally decomposing to the research of the sequence of the (process of) cognitive sorption. At the same time the knowledge is adsorbed from the flows of information of the educational environment, and the psycho-physiological construct of head brain of the learning subject acts as the sorbent (in particular the intelligence as its latent property).

For the system analysis of the efficiency of cognitive sorption of knowledge arriving from the (adaptive) electronic textbook (in particular) on the channel of representation of information of the remote training system of the educational environment was developed the structure of the cognitive model (pic. 6), 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 convergent and divergent intellectual abilities, cognitive styles and learning ability), linguistic (the natural language aspects of virtual communication) for the filling of which there is used the iterative cycle of the specially developed cognitive modeling technology (it is presented by Vetrov A.N. in the section 2.3 of the collective monography "The factors of success in the educational activity of modern HEI" edited by the memb.-corr. "IHEAS" Zakharova I.N.).

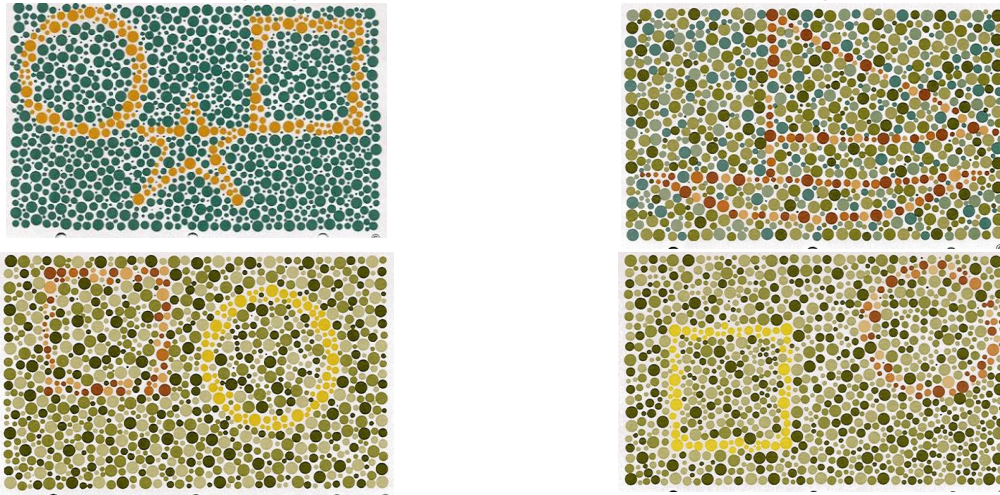
The formed physiological portrait is presented in the pic. 4.



Picture 4. The physiological portrait of the cognitive model of the examinee

The physiological portrait is created on the scientific base of private physiology of analyzers, concentrates the individual features: the visual sensory system (about 90% of information are registered, “the modified model of "the reduced eye"” (Vetrov A.N.) is used, come to light the anomalies of refraction, perception of space and color vision); the acoustical sensory system (the functions of external, middle and inner ear: the absolute acoustical sensitivity of the examinee and the thresholds of sensitivity depending on the frequency of sound).

In the pic. 5 there are given the examples of polychromatic tables of Rabkin E.B. for the research of anomalies of perception of the polychromatic range by the visual sensory system of the examinee (the subject of training).



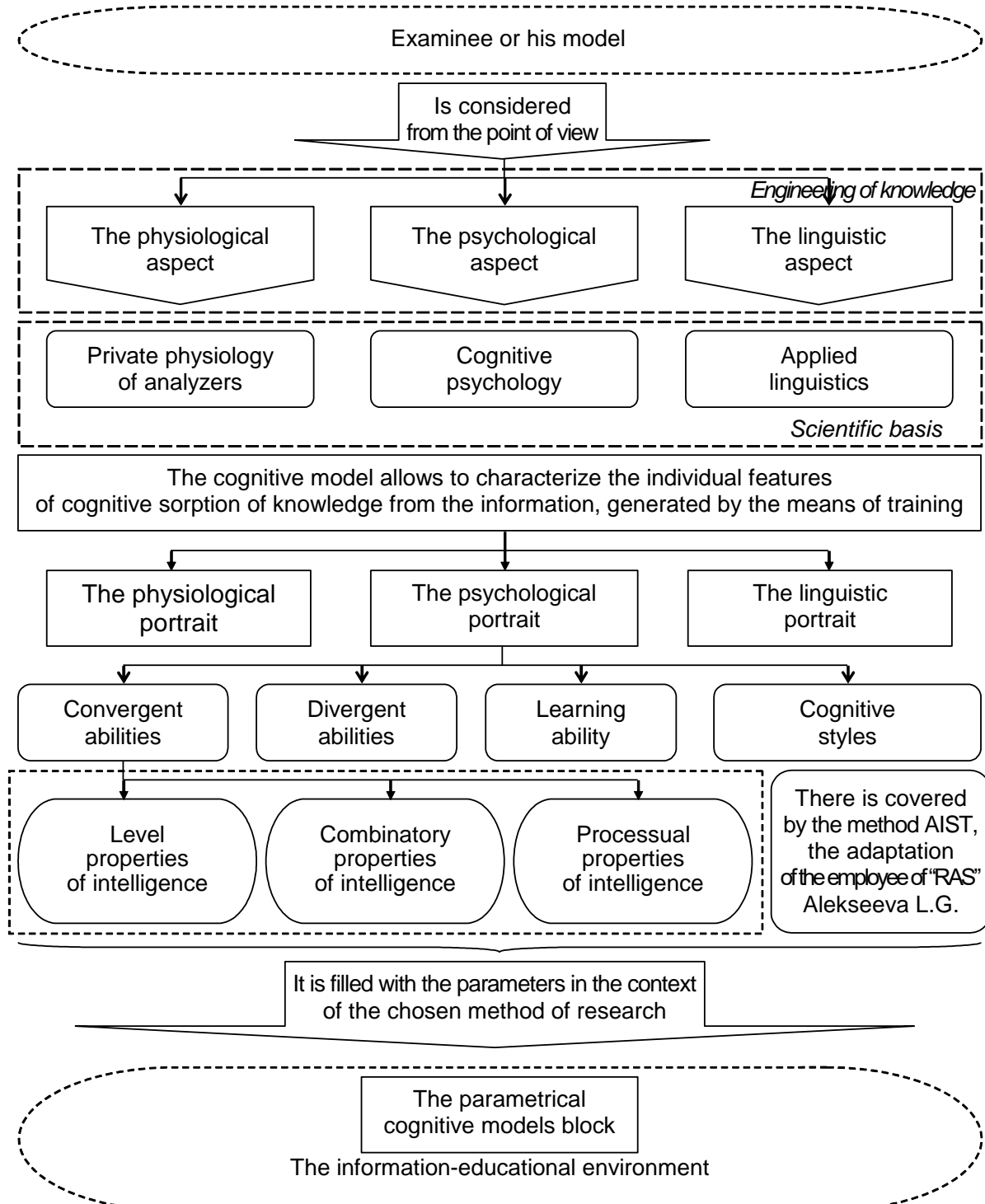
Picture 5. The polychromatic tables of Rabkin E.B.

for the identification of the anomalies of color vision (color perception)

The polychromatic table of Rabkina E.B. – a set of pigmentary spots of the certain (shade) of color and various size, the visual perception of which by the visual sensory system allows to identify one-to-one the digits and geometrical figures, and also to diagnose trichromatia (the absence of the pathology of color perception) or the certain dichromatia (the presence of the pathology of color perception): protanopia – the full or partial absence of sensitivity at the perception of red color or shades of red color, deuteranopia – the full or partial lack of sensitivity at the perception of green color or shades of green color, tritanopia – the full or partial absence of sensitivity at the perception of blue and violet colors or shades of blue color.

The threshold (polychromatic) table of Yustova E.N. – a set of squares of the certain (shade of) color and the identical size, the visual perception of which by the visual sensory system allows to identify one-to-one the place of gap in the geometrical figure, and also to diagnose trichromatia (the absence of pathology of color perception) or the certain degree of dichromatia (the degree of pathology of color perception): the degree of protanopia – the degree of full or partial absence of sensitivity at the perception of red color or shades of red color, the degree of deuteranopia – the degree of full or partial absence of sensitivity at the perception of green color or shades of green color, the degree of tritanopia – the degree of full or partial absence of sensitivity at the perception of blue and violet colors or shades of blue color.

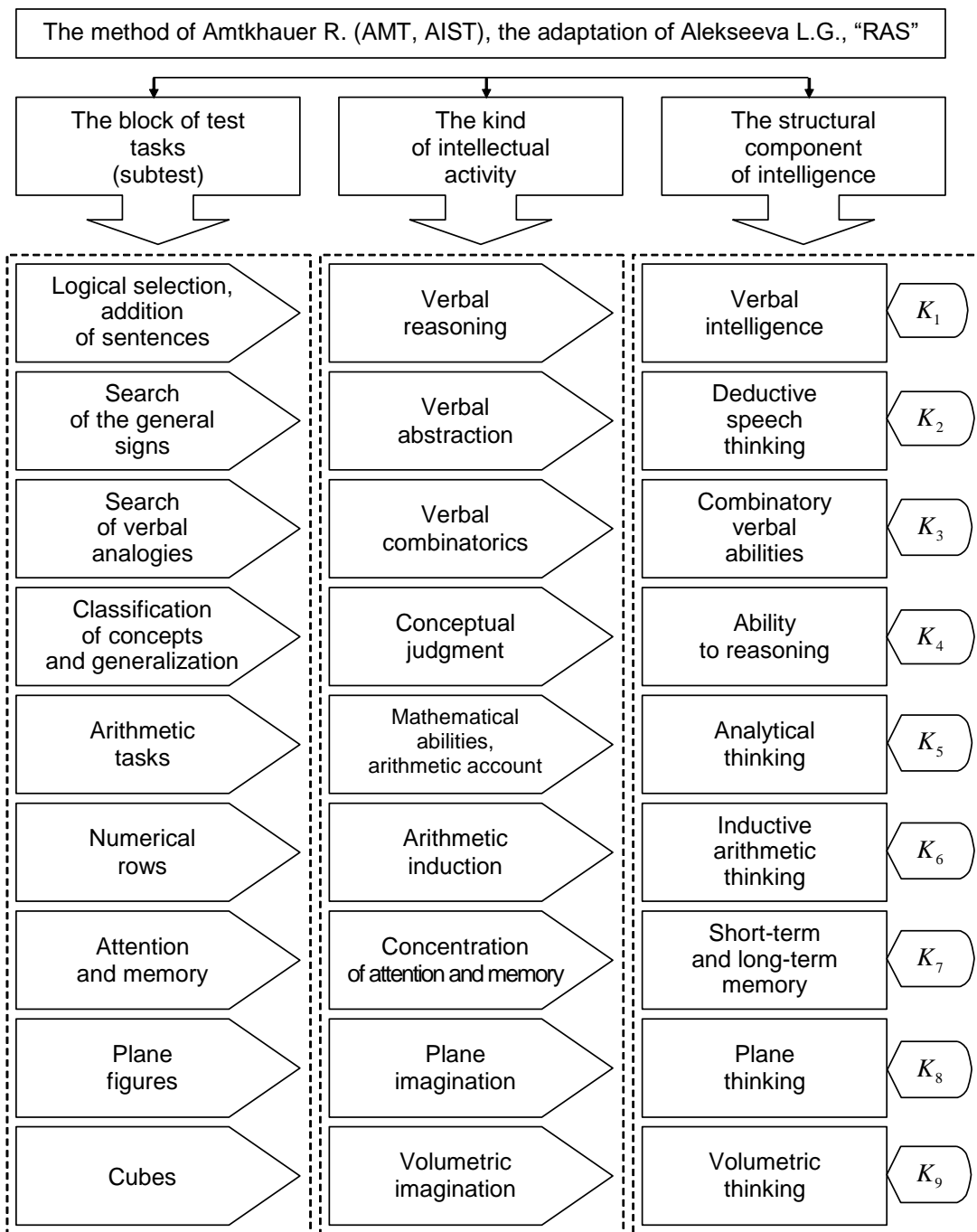
The formed psychological portrait is presented on the pic. 6, and for its filling there were used the conceptual scientific bases of cognitive psychology as the modern direction in psychology, includes: the convergent and divergent intellectual abilities, cognitive styles and learning ability (implicit and explicit).



Picture 6. The structural features of the cognitive model of the examinee for the tasks of the information-educational environment of the adaptive training

The vector of the convergent intellectual abilities is the structural component of the psychological portrait of the developed cognitive model, acting as one from the manifestations of the psycho-physiological construct of head brain of the learning subject of training (examinee), defines the individual productivity of deductive thinking (it is connected with the speed of search of the normative-only correct variant of answer according to the regulation of situation, requirements of tasks and time restrictions on the development of the correct decisions). The research is scientifically reasonable,- Holodnaya M.A. and Druzhinin V.N. in coordination differentiate the given vector on a row of different properties: level (the reached level of development of cognitive functions), combinatory (the potential ability to identification of diverse tendencies, ratios, dependences, regularities and relations) and processual (the elementary processes of processing of information).

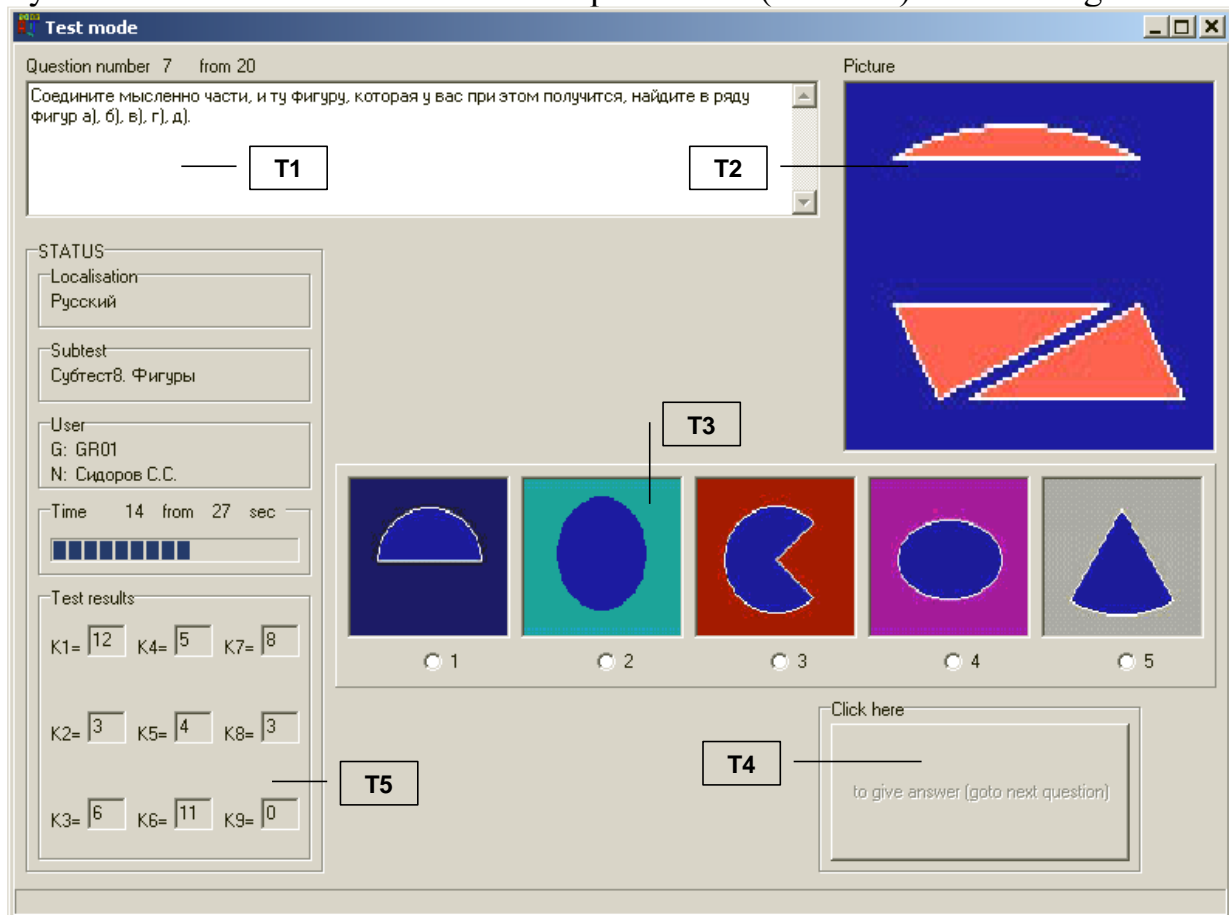
In Russia by the scientific community ("RAS") was recognized the method of Amthauer R. (AIST – Amthauer Intelligenz-Struktur-Test or Amthauer Intelligence Structure Test): has a set of localizations (also author's) and adaptations, and the validity is checked on the wide professional-differentiated selection of examinees from 13 to 60 years. The essence of the method consists in the consecutive presentation to the examinee of the continuum of question-answers structures of test tasks (pic. 7), grouped by the subtests (the blocks of homogeneous questions): "Logical selection, addition of sentences", "Search of the general signs, the exception of word", "Search of verbal analogies", "Classification of concepts, generalization", "Arithmetic tasks", "Numerical ranks", "Attention and memory", "The choice of figures" and "Cubes", which make active the certain kinds of intellectual activity (verbal reasoning, verbal abstraction, verbal combinatory, conceptual judgment, arithmetic accounting, arithmetic inductive conclusion, concentration of attention and mnemonics, plane imagination and volumetric imagination), and is dynamically made the measurement of manifestations of the structural components of intellectual activity (verbal intelligence, inductive speech thinking, verbal combinatory abilities, ability to reasoning, analytical thinking, inductive arithmetic thinking, short-term and long-term memory, plane thinking and volumetric thinking).



Picture 7. The essence of the method of research of the vector of convergent intellectual abilities

The development of the program diagnostic module was carried out on the basis of the architecture of the expert system with the use of the technology of fast prototyping and the methodology of RAD in the integrated environment of programming Borland C++ Builder, and in the basis of the knowledge base is structured and formalized the adaptation of the method AIST executed by the employee of "RAS" Alekseeva L.G.

In fig. 8 is presented the interface of the developed program toolkit of research of the convergent intellectual abilities in the mode of diagnostics at the stage of identification of plane imagination of the examinee by means of use of the block of questions (subtest) “Plane figures”.



Picture 8. The interface form of program toolkit of research of the convergent mental abilities in the mode of diagnostics at the stage of identification of the plane imagination of the examinee by the subtest “Plane figures”

The correlation of the values of indicators of different constructive components of intelligence also has practical interest at the research of the convergent and divergent abilities (there is presented by Vetrov A.N. in the section 2.3, table 2.1 of the collective monography “The factors of success in the educational activity of modern HEI” edited by the member-corr. of “IHEAS” Zakharov I.N.). Among a set of the testological methods of the structural research of intelligence used for the differentiated selection of the subjects of training on the different kinds (forms) of professional training (at distance), AIST can be used in the combinatory combination with other methods, in particular, at the system analysis of the individual predisposition to the certain kinds of professional activity, that allows to use the developed tool in relation to the wide spectrum of applied and scientific-methodical researches of the (automated) information-educational environment.

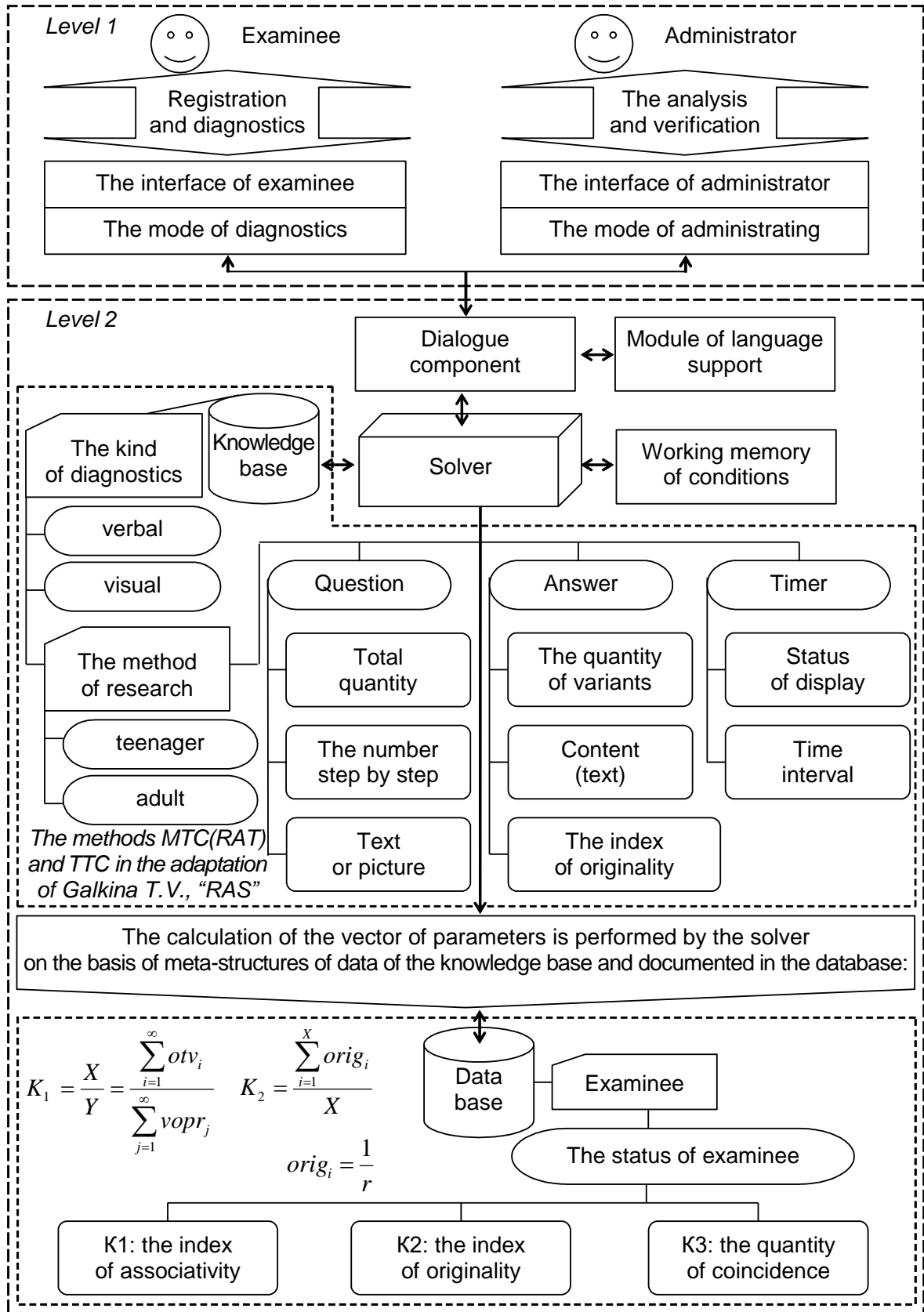
The vector of the divergent intellectual abilities is the structural component of the psychological portrait of the developed cognitive model, acting as one from the manifestations of the psycho-physiological construct of head brain of the learning subject of training (examinee), defines the individual productivity of the inductive thinking, characterizes directly the creative potential of the personality.

As the basis of research were used the several author's methods for the various age groups of examinees (so-called the teenage and adult variants): the verbal creativity – the method of research of Mednik S.A. (RAT – Remote Associations Test – the research of the remote associations); the figurative creativity – the method of research of Torrance E.P. There were used the adaptations of the employees of “RAS” Alekseeva L.G. and Galkina T.V.

The method of research (test) of the verbal creativity of Mednik S.A. is based on the consecutive presentation to the examinee (the subject of training) of the certain visual verbal incentives (questions with words), on each of which the examinee must to develop normatively a set of the remote verbal associations (answers in the view of words).

The method of research (test) of the figurative creativity of Torrance E.P. is based on the consecutive presentation to the examinee (the subject of training) of the certain visual graphic incentives (questions with images), on each of which the examinee must to offer normatively a set of the remote graphic associations (the finished drawing images), and then to develop normatively a corresponding set of the verbal names of the received graphic images (answers in the view of words).

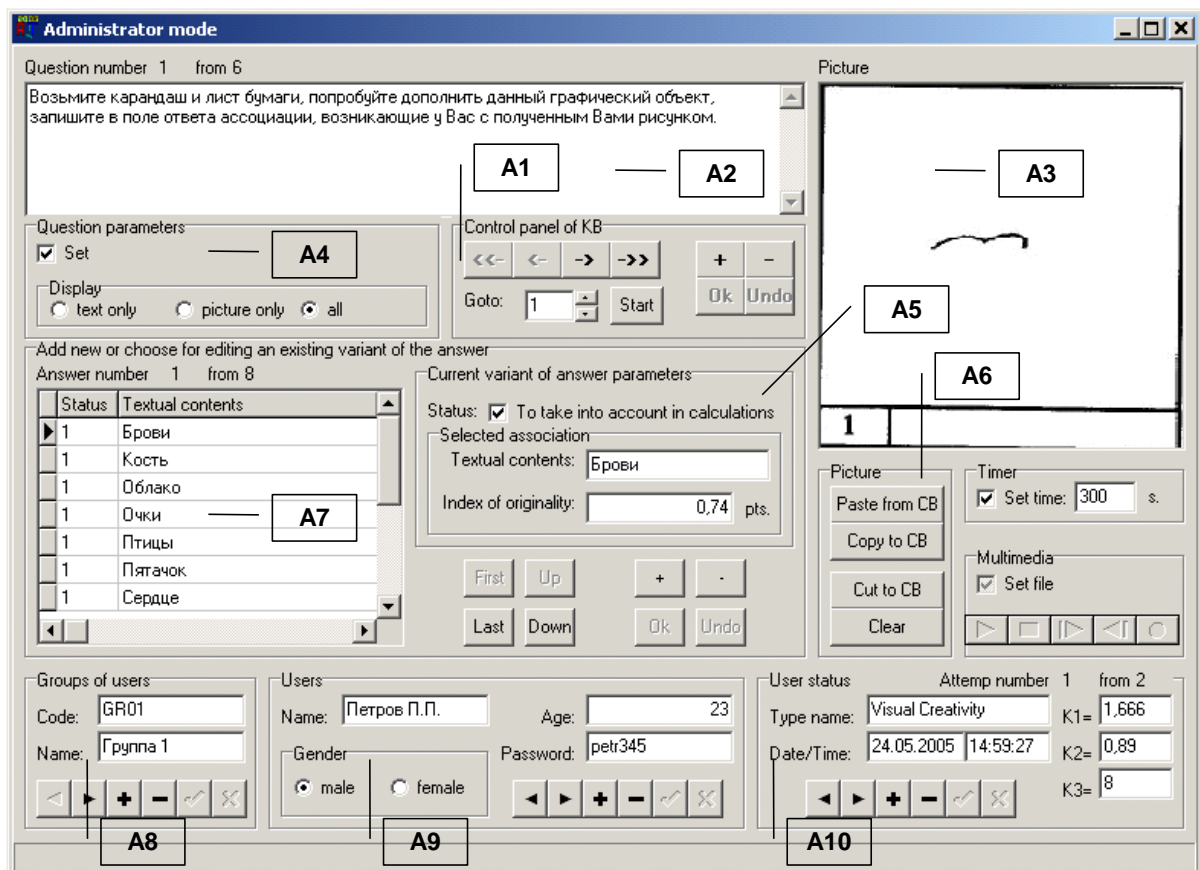
The realization of the program product was carried out by Vetrov A.N. in RAD (Rapid Application Development)-environment of programming Borland C++ Builder, the methods of research were structured and encapsulated in the basis of database (knowledge base) of toolkit (the diagnostic module), the algorithm of the mechanism of reference provides the calculation and documentation in the database of the following parameters in real scale of time: the quantity of coincidence of selections of the variants of answer, the index of originality, the index of associativity and the index of selectivity of the process of divergent thinking of the examinee (pic. 9).



Picture 9. The structurally-functional scheme of the program toolkit of research of the vector of divergent abilities

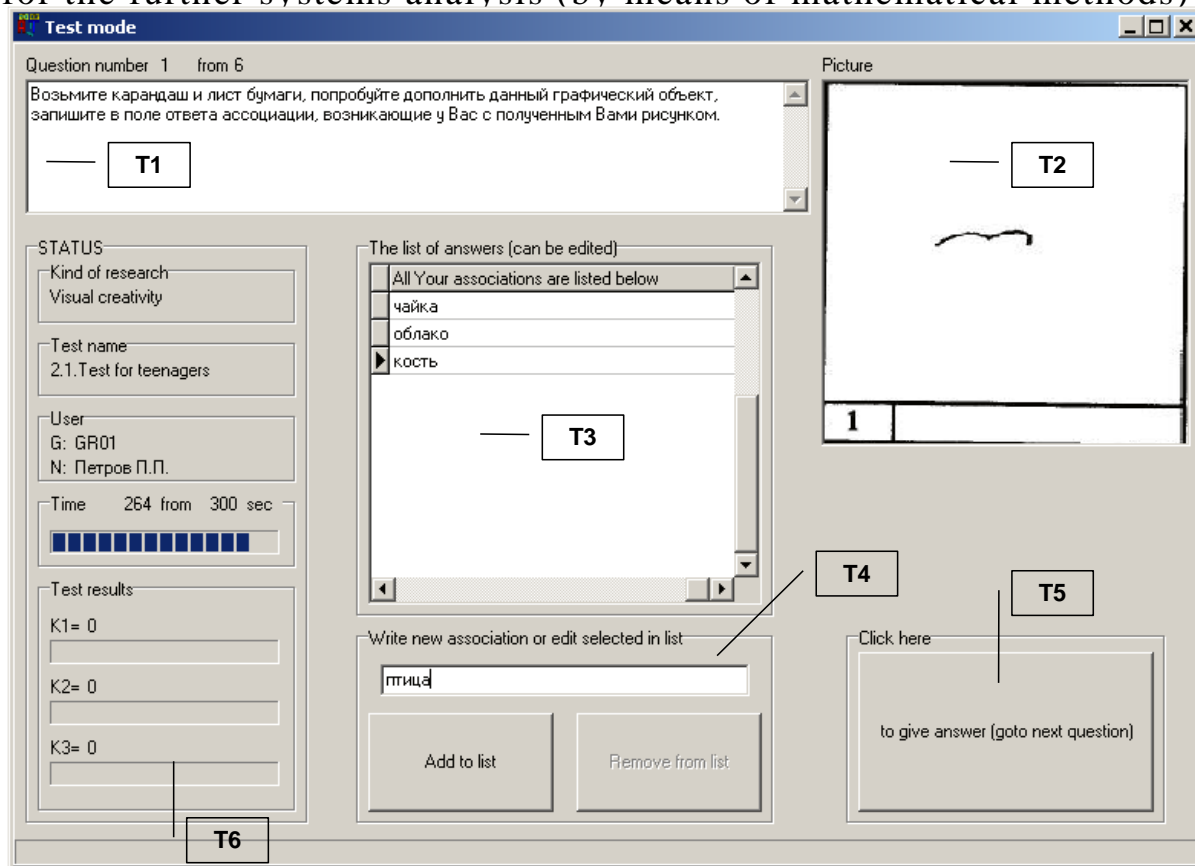
After the start and loading of the program diagnostic means the final user is offered to do 3 steps (each step is illustrated by flickering banners): to select the kind of research and the name of the method of research (test), to undergo the procedure of the automated authentication (if it is necessary, then to be registered in the database of the system) and to select the mode of operation (administrating, diagnostics and the analysis).

In the mode of administrating (pic. 10) is provided the constructing of the sequence of the question-answers dialogue structures (including the installation of all parameters of diagnostics according to the method of research), editing the list of groups of users and the final users, the viewing of date and time of attempts and results of passing of research.



Picture 10. The interface form of the program toolkit of research of the divergent intellectual abilities in the mode of administrating

The mode of diagnostics (pic. 11) is intended for the identification and calculation of parameters in the process of interactive interaction of the examinee and the system, and also the documentation in the database of the results of research for the further systems analysis (by means of mathematical methods).



Picture 11. The interface form of the program toolkit of research of the divergent intellectual abilities

in the mode of diagnostics at the stage of identification of the visual creativity

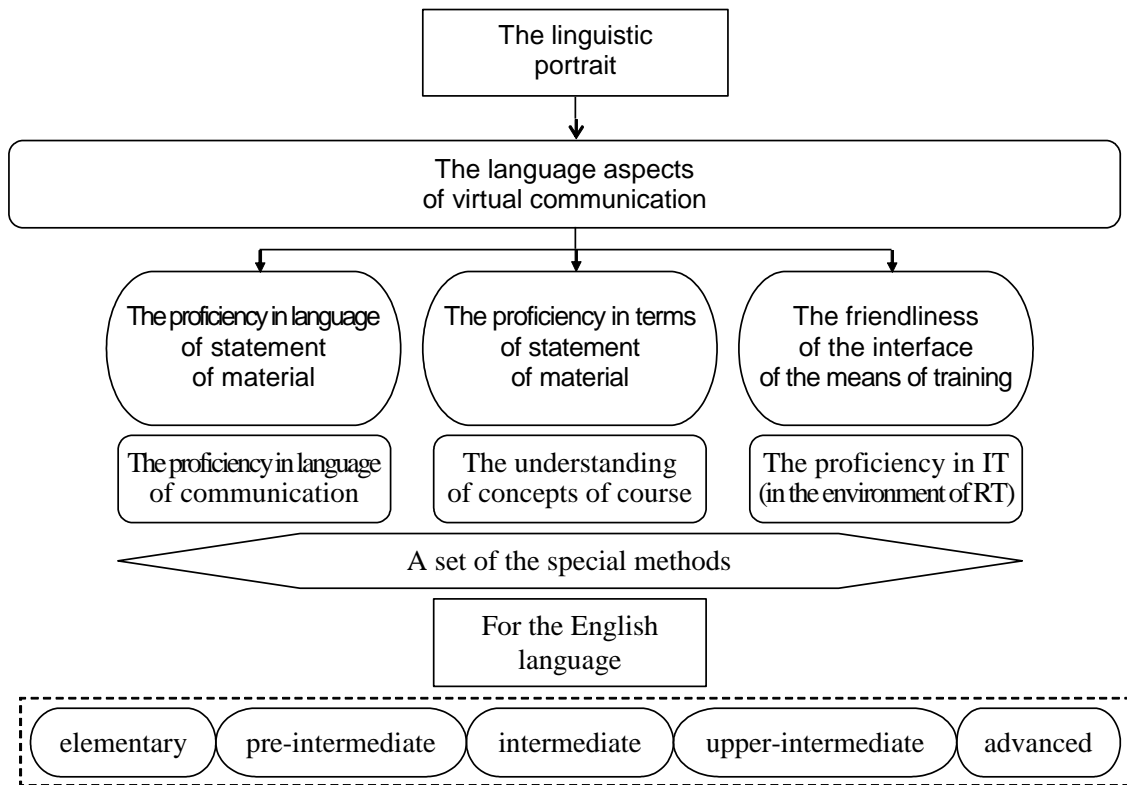
In the mode of the analysis there is the technical opportunity to compare the variants of reference answers of the independent expert (on the basis of the statistical analysis of a posteriori results of research, received in the previous periods of time) with the associations, entered by the certain examinee.

The interface of the program product was developed in such way, as much as possible to simplify the work of the final user who is not the specialist in the field of information technologies (both at the filling of the database (knowledge base) and during diagnostics).

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

The developed program products are supposed to be used in a part of the unique information-computational complex of parametrical identification of the portraits of the 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).

The developed linguistic portrait is presented in the pic. 12, based on a row of the special methods of applied linguistics, revealing the individual level of proficiency in language and key words and definitions of statement of material, defines the friendliness of the elements of interface of the program product.



Picture 12. The linguistic portrait of the cognitive model of the examinee

At present moment is conducted the verification of databases (knowledge bases) and productional kernels of the mechanism of output of the program realization of the modules of diagnostics of the convergent and divergent intellectual abilities of the cognitive model of the subject of training on the basis of the architecture of expert system with the use of the iterative cycle of the cognitive modeling technology. The developed program products and results received with their help are going to be used in the further scientific-methodical researches of the information-educational environment (at distance), and also in the improvement of the structure of RTS of the portal of chair.

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-educational influences, generated by the automated means of training (at distance).