THE SAINT-PETERSBURG STATE UNIVERSITY

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# THE COGNITIVE MODELING TECHNOLOGY FOR THE SYSTEM ANALYSIS OF THE INFORMATION-EDUCATIONAL ENVIRONMENTS

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V-39 Vetrov A.N. The cognitive modeling technology for the system analysis of the information-educational environments: the dissertation (tech., phys.-math. and med. sciences) (spec. 05.13.01, 05.13.10, 19.00.02 (19.00.03)) (3 volumes) / A.N. Vetrov; “The S.-Petersburg.st.un-ty”. – SPb.: “SPbSETU "LETI"”, 2006, M.: “RAS”, 2007, SPb: “SPbSU”, 2023. – 240 (240, 232, 416) p.: 310 (44, 89, 177) pic., 327 (2, 154, 171) tab. – Bibliogr. 499 (299) (499, 0, 0) nom. – Eng. – Dep. in “RAS”, 2007.

In the dissertation the research and the system analysis of the information technologies for the support of the information environment of automated training is conducted, the features of the structure of the adaptive information-educational environment of the automated (remote) training based on the cognitive models are presented, the cognitive modeling technology and the structure of the parametrical cognitive models for the adaptive intelligent automated training systems (at distance), and also the experimental checking of parametrical cognitive models for the system analysis and the increasing of efficiency of the information interaction of the diverse subjects of training and the various means of training of a new generation.

As the subject of research acts the cognitive modeling technology for the system analysis of the information-educational environment of the automated (remote) training system (environment) with the properties of adaptation based on the innovative parametrical cognitive models block.

The system analysis of the structure of the adaptive information-educational environment of the automated (remote) training based on the cognitive models was carried out, in particular the organization and technological stages of the automated (remote) training with taking into account of the individual features of personality of the subjects of training, the software of automated training as an information process, the features of the structure of the technological process of automated training (at distance) and the levels of presentation of the structured data in the information-educational environment, the algorithms (principles) of functioning of the various classical and innovative components of the automated training system (at distance) (in particular the adaptive electronic textbook, the laboratory workshop and library, the basic and applied diagnostic modules and electronic dean's office), the structure of the adaptive representation of a sequence of information fragments processor based on the parametric cognitive models, the specifics of the channels of information interaction of the subjects and means of training.

The cognitive modeling technology and the structure of the parametrical cognitive models for the adaptive systems of automated training (at distance) are presented.

The experimental checking of cognitive models for the system analysis and the increasing of efficiency of the information interaction of the subjects and means of training was carried out, in particular the primary statistical processing of a posteriori data assumed the searching of the anomalies of sequences of the nominal values in the samples with a posteriori data (the revealing of anomalous emissions and artifacts in the values, the formation of primary descriptive statistics, the calculation of the critical values of indicators and the displaying of graphs), and also the secondary statistical processing of a posteriori data was carried out by the means of use of the dispersion, regression, discriminant, cluster analysis, multidimensional scaling and the factor analysis.

It is intended for the scientists and employees of SRI, teachers of technical HEIs and students in spec.: 05.13.01 – “The system analysis, control and information processing”, 05.13.05 – “The elements and devices of computer equipment and control systems”, 05.13.06 – “The automation and control by the technological processes and manufactures”, 05.13.10 – “The management in the social and economic systems”, 05.13.11 – “The mathematical and program support of computing machines, complexes and computer networks”, 05.13.17 – “The theoretical foundations of informatics”, 01.01.05 – “Theory of probability and mathematical statistics”, 01.02.01 – “Theoretical mechanics”, 19.00.02 – “Psychophysiology of perception”, 10.02.21 – “Applied and mathematical linguistics” and others.

# The table of contents

# The list of reductions and symbols

| | | |
|---|---|---|
| ATS | – | automated training system (environment) |
| ART | – | automated (remote) training |
| AWP | – | automated workplace |
| (K)DB | – | database (knowledge base) |
| PCMB | – | parametrical cognitive model block |
| AT | – | additional task |
| DM | – | diagnostic module |
| DE | – | distance education (training at distance) |
| I(C)T | – | information (and communication) technologies |
| IFPST | – | individual features (abilities) personality of the subjects of training (trainee and tutor) |
| IEE | – | information-educational environment |
| IC | – | information centre |
| CC | – | computerized course |
| CM | – | cognitive model |
| CW | – | course work |
| LAN | – | local area network |
| LW | – | laboratory workshop |
| MATP | – | model of adaptive training program |
| MRT | – | model of remore training |
| MRK | – | model of required knowledge |
| TI(EI) | – | training information (educational influence) |
| EE | – | educational establishment |
| SW | – | software |
| BC | – | boundary (intermediate) control |
| IW | – | independent work |
| CMT | – | cognitive modeling technology |
| TRM | – | theoretical-reference module |
| LMC(M) | – | learning-methodical complex (manual) |
| LMD | – | learning-methodical department |
| LRKT | – | level of residual knowledge of trainees |
| EL | – | electronic library |
| ED | – | electronic deanary (dean's office) |
| ERB | – | electronic record book |
| ET | – | electronic textbook |
| IEEE | – | "The institute of electrical and electronics engineers: leaning technology task force" («Институт инженеров по электротехнике и радиоэлектронике: комиссия в области образовательных технологий») |
| IPX / SPX | – | intranet packet exchange / sequence packet exchange (the protocol for the internetworking exchange of packets of data) |
| TCP / IP | – | transmission control protocol / "Internet" ("Intranet") protocol (the protocol of transmission of data for the networks "Internet" ("Intranet")) |
| WWW | – | "World wide web" ("The world wide web") |

# The introduction

The scientific community throughout the formation of modern civilization allocates the problem of human in a changing world and researches it in the various angles. The processes of globalization, having influence on the evolutionary development of the economic and social formations of society, actualize the task of adaptation of the structure and content of education to the requirements of diverse entrants in the conditions of real validity.

In the course of the process of evolutionary development of society the transition from the industrial stage to the information causes the significant increasing of the role and degree of participation of the intellectual kinds of activity of the specialists in the various subject areas, actualizes the growing necessity of informatization (automation), accenting the special attention from the side of many (foreign) countries, the national and international organizations and enterprises (corporations) to the potential possibility of widespread introduction and practical use of the various information and communication technologies (ICT) in the education. The level of technological development of the different global information systems and tele-communication networks lays the bases of a new planetary infrastructure – "the infosphere" (the new scientific term was introduced by the acad. of "RAS" Ershov A.P.), in which the information and scientific knowledge present the most important strategic resource and the acting factor of development of the mankind on the threshold of the third millennium.

The information interaction between the sources and consumers of information is complicated and acts as a measure of participation by the degree of inclusion into the difficult processes of creation, distribution and use of the information resources, products and services: in the artificial systems (from the local regulators to the global computational networks), in the natural systems (from the molecular-genetic to the level of community and society), the significant attention is accented on the hybrid (combined) systems ("person – machine", "natural – artificial intelligence") [1, 2, 3, 23, 33, 37, 39].

The development of the systems of education of the different countries at the international level poses the increased requirements to the quality of preparation of the qualified specialists. From the modern establishment of the system of education and science requires the introduction of the new (information) technologies and the methods of (adaptive) training (at distance), providing the fundamentality of preparation of the diverse specialists (experts) with the observance of various existing "The state educational standards", the development of communicative, creative, professional and other abilities, the needs in the self-education due to the potential multivariability of content and the development of different kinds of support of the (automated) educational process [19, 67].

The informatization of educational establishments (EE) involves the automation of information-educational environments (IEE) by means of the introduction of ICT [80, 88, 129].

The emergence and continuous evolution of information "hyper-highways" (in particular directly "WWW" ("World wide web") – "The world wide web") initiates the rethinking of capabilities and position of the system of education in the society, as the traditional (simple) and innovative (difficult) ICT develop quicker, than the potential capabilities of their practical use in IEE [151].

The commission on educational technologies at the international organization "IEEE" (""The institute of electrical and electronics engineers leaning technology task force") emphasizes the special actuality of development and use of IT of training, offering the following directions: the automated training systems (ATS), IEE based on the virtual reality, the intelligent and adaptive models, the methods and means of training, the structuring and representation of knowledge (meta-data), the multimedia and hypermedia of technology, cognitive informatics and computer graphics, the object-oriented paradigm and high-technological environments of programming.

Directly in the worldwide declaration about higher education XXI$^{st}$ century, adopted in Paris city in 1998 year, emphasizes the active influence of various ICT on the acquisition of knowledge (the structured data) and skills by the trainees by the means of support of the quality in the sphere of higher (professional) education. The compliance of existing educational preparation to the various modern requirements and actual needs of the personality, society and country acts as the priority task of politics of The Government of RF in the sphere of education [42, 43].

The traditional education is oriented for the most part on the acquisition of the knowledge, abilities and skills by the trainee, necessary for the chosen specialty. The fundamental scientific principle acts "the education for all life", at which the obtained knowledge in the course of the educational process directly improved by the way of the improving of qualification of the diverse subjects of training. The scientific principles "the education for all on lifelong" and "the open training" acts as the highest priority of many educational and scientific centres. The purpose of reforming of the system of education and science at the level of country – the accumulation of unique knowledge by means of the searching of actual information and the dynamical updating of information resources in the information storages, allowing to motivate the significant interest and necessity of the subjects of training to the continuous independent training (at distance) by the means of introduction of the technologies of automated (remote) training (ART) [41, 56, 57, 105].

At the modern stage it is necessary to take into account the individual features of the subjects of training, for example, the development of the convergent and divergent abilities (creativity), the features of the individual cognitive style of cognitive activity, and also the ability independently to form, deepen and update of knowledge. The theory and practice of creation of IEE of the different EE actualizes the need of development of the organizational, methodical and technical support [7, 8, 14, 20, 22, 34, 36, 47, 61, 91].

To the priority scientific aspects of the informatization of education today include [119]:

- the social aspect – the revealing of the main functions of the various means of ICT for the intensification of productive activity of the diverse specialists in the various spheres of social activity of the society, including in the education, the prediction of possible social consequences of the informatization of education [9];
- the regional aspect – taking into account the territorial features of functioning of EE in the various regions of country as the elements of the system of education and science according to the existing various requirements and existing support: the legal, administrative, economic, technical and other [12];
- the organizational aspect – initiates the synthesis of the organizational structure of IEE and the realization of the control of training as the technological process [80, 148];
- the technical aspect – the analysis of approaches to the introduction of the various achievements of ICT and the determining of the directions of automation of the processes in the sphere of education [85, 128];
- the program aspect – the selection of perspective technologies and tool environments for the realization of the means of automation of training of a new generation in IEE [12, 52, 67, 70, 77];
- the introduction aspect – the questions of introduction of the means of automation in the learning process and the selection of criteria for the estimation of efficiency of their use [90, 125, 127];
- the pedagogical aspect – the analysis of different conditions, facilitating to the realization of purpose installations at the using of IT in IEE [62, 124, 136, 137, 178, 197];
- the linguistic aspect – the systematization of scientific approaches to the research of the processes of understanding of the content of information in the subject of studying (discipline), presented on a certain national or foreign language, the development of the various methods of the modeling of communicative interaction and the algorithms of the automated analysis of text [46, 114, 115, 171, 140, 153];
- the psychological aspect – the providing of regulation and self-regulation, activity and motivation of the subject of training with the taking into account of mental processes, properties and the individual features of personality [59, 60, 63, 68, 69, 81, 98, 134];
- the physiological aspect – the studying of regularities of the sensory perception of information at the realization of the (adaptive) training based on ICT [64, 130, 131, 139, 154, 175];
- the ergonomic aspect – the determination of various conditions, requirements and restrictions, providing the protection of health in the process of labor activity of the subjects of IEE [28];
- the economic aspect – the calculation of profitability of the introduction of the different of ICT in IEE.

The considered nodal aspects can be the subject of separate scientific researches, therefore each from them has its own specifics and causes the emergence of various traditional and innovative approaches, methods and technologies.

The complex scientific approach with the taking into account of the various applied researches to the constructing and use of the holistic computerized courses (CC) will allow to create and introduce the means of the automation of training of a new generation, and also the organizational, technical, program, methodical and other support, in which designates the role, place, functions and tasks of the subjects and means of training in IEE.

**The actuality of the theme of research** is explained by the evolution of priorities from the side of the state and international bodies, regulating the politics of development of the system of education and science and the informatization of the educational and scientific spheres, the expanding of a set of various requirements to the creation and use of IEE of EE, the imperfection of the existing scientific-methodical and technological apparatus for the system analysis and the estimation of the efficiency of information interaction between the diverse subjects of training and the different means of training in IEE, the lack of the universal scientific approach (technology, method or algorithm) to estimate the quality of the formation of knowledge as the controlled technological process, developed in the context of the applied bases of physiology, psychology and linguistics and so on, and also the continuous dynamic development and the emergence of significant novations in the area of IT and the integrated environments of programming in the languages of high level, the emergence of a row of problems in the various spheres of social activity of the society, influencing on the consumer preferences of educational resources, products and services:

- the globalization of information environment of the post-industrial (information) society and the high rates of scientific-technical progress (the information revolution) cause the exponential growth of the diverse flows of information as the aggregative aggregate of accumulated knowledge in the various subject areas, determining the specifics of controlled educational technological process, covariant to a limited time and the different individual features (physiological, psychological, linguistic and others) of the subjects of training, directly the consumer (subjective) preferences (requirements) of which indirectly influence on the organizational-methodical and technological bases of the controlled process of the formation of knowledge of the trainees in the automated IEE;
- according to the principles of automated training and open education, the learning process of the modern EE is based on the practical use of wide capabilities of the automated (open) IEE of ART system, for the formation of which requires the active work of specialists (experts) in the preparation and support of the information-educational resources, but insufficiently developed the technologies of creation of such learning-methodical materials of a new generation, taking into account the individual features of subjects.

There is the essential necessity of creation of the new approaches, methods and technologies for the research of capabilities of IEE and the estimation in the efficiency of functioning of the adaptive means of training, allowing to generate the educational influences (EI) based on the individual features of personality of the subjects of training (IFPST).

**The characteristics of the degree of development and the recognition of actuality of the problem in the scientific community** traced in the scientific researches of the Russian scientists (Andreev A.A., Apatova N.V., Gein A.G., Gershunsky B.S., Ershov A.P., Lapchik M.P., Matros D.Sh., Mashbitz E.I., Polat E.S., Robert I.V., Skibitsky E.G. and others).

The organization, technical and methodical support of the technological process of ART in the sphere of higher education is reflected in the works of domestic and foreign scientists (Zhafyarov A.Zh., Ivannikov A.D., Krivosheev A.O., Sovietov B.Ya., Tikhonov A.N., Knight R. and others).

The important theoretical direction in the studying of problem of the informatization of education is the conception of realization of the personally oriented training based on IT (Bim-Bad B.M., Bondarevskaya E.V., Petrovsky A.V., Yakimanskaya I.S. and others).

The questions of application of IT in the education are researched on a row of the main directions: the psychological-pedagogical aspects of the formation of knowledge based on the modern of IT (Dillon A., Jonassen D.H., McKnight C., Hawk P.P., Wilson B.G. and others), the programmed training and development of various training systems (Briggs L., Elkerton J., Furlong M.S., Harrison N., Kearsley G., Seidel R.J. and others), the technologies of RT (Bradford L.P., Knowles M.S., Moore M.G., Solomon E.D. and others), the perception of electronic information (Dillon A., Norman D., Salomon G. and others).

The mathematical methods and models of analysis and synthesis of the automatic control system (Andronova A.A., Eiserman M.A., Besekersky V.A., Gantmacher F.R. and others), the theory of open systems (Haken H., Sauermann H., Uemov A.I. and others), the theory of the modeling of learning process (Bespalko V.P., Clarin M.V., Mashbitz E.I. and others), theory of (intellectual) systems (based on knowledge) and the languages of the presentation of knowledge (Andreev V.P., Ivashchenko K.I., Popov E.V., Pospelov G.S., Pospelov D.A. and others), the theory of algorithms (Gorelik A.L., Gurevich I.B., Efimova S.M., Zhuravlev Yu.I. and others), the object-oriented paradigm in the high-technological environments of programming (Davies S.R., Gates B., MacAlistair J., Stinson K., Thompson K.L., Zikhert K. and others).

The problem of IT in the "adaptive" training not yet been widely solved, although its applied tasks, important due to their fundamentality, were developed by the teachers, physiologists, psychologists, linguists and specialists in the area of IT: the problems of the theory of pedagogical systems and the innovative processes in the education (Halperin P.Ya., Zagvyazinsky V.I., Zinchenko V.P., Makhmutov M.I. and others), the personal-oriented training (Amonashvili S.A., Bondarevskaya E.V., Yakimanskaya I.S. and others), the technologies of programmed training (Bespalko V.P., Gershunsky B.S., Talyzina N.F. and others), the fundamental provisions of the psychological-pedagogical bases of use of the new IT (Akhutina T.V., Gein A.G., Ershov A.P., Leontyev A.A., Talyzina N.F. and others), the modeling of IEE and the programmed training (Bespalko V.P., Gershunsky B.S. and others), the psychophysiology of perception (Izmailov Ch.A., Krol V.M., Smirnov V.M. and others), cognitive psychology (Druzhinin V.N., Zinchenko TP, Kholodnaya M.A. and others) and cognitive linguistics (Gik M.L., Kobrina N.A., Potapova R.K. and others).

The analysis of the modern stage of development of the traditional approaches to the creation of IEE and the technologies of ART allows to reveal **the most significant contradictions:**

- the new IT offers a wide potential possibilities for the organization of the process of training, but the level of their application in HEIs is not large enough;
- the existing technologies of creation of the automated means of training and learning-methodical complexes (LMC) practically do not take into account the individual features of information processing by the trainee as the subject of the process of training;
- the improvement of organization and the technologies of the process of ART cause the necessary of analysis of the efficiency of functioning of IEE with the taking into account of IFPST (physiological, psychological, linguistic and others);
- the requirements to the modern IEE initiate the realization of accumulation of the operative processing of data, characterizing the individual dynamics of changing of the indicators of efficiency of the formation of knowledge of the trainees, but the potential of introduced IT of monitoring of the educational process is insufficient.

**The object of research** is the technologies, methods and algorithms of IEE of ART system of EE.

**The subject of research** is the cognitive modeling technology (CMT) for the system analysis of IEE of ART system (environment) with the properties of adaptation based on the innovative parametrical cognitive models block (PCMB).

The research is directed on the possibility of analysis of the automated IEE and the realization of individually-oriented learning process with taking into account of the physiological, psychological and linguistic features of the subject of training.

**The hypothesis of research** is based on the assumptions about the continuity of development of a new IT and the expansion of sphere of their use in the education, providing the possibility of realization of the means of adaptive training in the automated IEE, taking into account the physiological, psychological, linguistic and others the features of the subjects of training (of the educational process), which, in the end account, will allow to provide the controlled formation of knowledge of the trainee with the minimal various loads, transactional and time costs (expenses), and also withstand the required level of preparation (the professional competence).

**The purpose of research** is the increasing in the efficiency of functioning of IEE of ART due to the means of realization of the individually-oriented formation of knowledge of the subject of training with using of the adaptive generation of a sequence of EI based on PCMB and the complex of programs for the automation of the tasks of research.

According to the hypothesis and purpose **the following tasks of research** are solved:

1. The analysis of the theoretical bases of building of IEE of the adaptive training (at distance) with the model of the subject of training on the basis of the theory of automatic control, the features of organization of IEE of ART and the technologies of information interaction of the diverse subjects of training with the various means of training, and also the main actions (the technological gaps) at the organization of technological process of the individually oriented formation of knowledge: the models of representation of EI, the (adaptive) algorithms of training (at distance), the specifics of realization of the continuous (dynamic) monitoring of academic-performance and the estimation of the level of residual knowledge of trainees (LRKT) in IEE of ART system.
2. The research of the structure of IEE of ART system with the properties of adaptation based on PCMB: the features of the structure of the communicative duplex (bidirectional) channel of information interaction of the subjects of training and the means of training, the organization of IEE and the main technological stages (gaps) of ART as the difficult controlled technological process of the formation of knowledge and the (program) realization of different components of ART system; the revealing of the physiological, psychological and linguistic parameters of information interaction between the subjects of training and the means of training, and also the ways of increasing of the efficiency of the formation of knowledge of the contingent of trainees with using of the adaptive means of training, functioning on the basis of PCMB.
3. The development of CMT, including directly the technique of its use, the algorithm of formation of the structure of the cognitive model (CM), the techniques of research of the parameters of CM of the subject of training and the means of training and the algorithm of processing of a posteriori results of testing of IFPST and LRKT, and also the ways (models) of representation of the structure of the parametrical CM.
4. The development of CM of the subject of training and CM of the means of training in the basis of IEE of ART (the multi-level structural scheme, combining the theory of mathematical sets).
5. The development of the complex of programs for the automation of the tasks of research, including:
    - the adaptive electronic textbook (ET) – the adaptive means of training of the first generation, providing the individually-oriented generation of EI based on PCMB;
    - the laboratory workshop (LW) – the adaptive means of training of the second generation, providing the individually-oriented generation of EI based on PCMB;
    - the basic diagnostic module (DM) – the means of diagnostics of the first generation, realizing the automated estimation of LRKT in the subjects of studying with using of the rough scale of estimation based on the quantity of valid answers and the exact scale of estimation based on the sum of scored points for each valid answer to the question of the method of research (test);
    - the applied DM – the means of diagnostics of the second generation, realizing the automation of research of the parameters of CM of the subject of training;
    - the electronic deanery (ED) – the means of control by the technological process of ART, providing the automated saving and displaying of the estimations of LRKT in the certain subjects of studying (disciplines) and the values of parameters of the physiological, psychological and linguistic portraits of the parametrical CM of the subject of training and CM of the means of training;
    - the adaptive electronic library (EL) – the adaptive means of training, allowing to provide the individually-oriented (open) access to the information resources and services of IEE of ART system based on PCMB.
6. The development of the scientific-educational consortium, including the scientific organizations.

To **the main methods of research** the following should be included:

- the theoretical – the theory of systems, informatics, the system analysis and modeling, the structuring and representation of knowledge, engineering psychology and pedagogics;
- the experimental – the applied methods of private physiology of analyzers, cognitive psychology, applied linguistics and mathematical statistics.

**To the main scientific provisions, submitted on the defence** are following:

In the context of the system and model approaches the structure, characteristics and interrelationship of the elements of IEE of ART system are defined, including the organizational-methodical and program-technical resources, and also are developed:

1. The generalized structure of the adaptive IEE of ART system of EE based on the innovative PCMB:

- the generalized topological structure of the territorially distributed IEE: on the example of the geographically distributed (countries), regions and areas [225, 268];
- the typical scheme of information interaction of the information centre (IC) of EE and the various automated workplaces (AWP) of the subjects of training (at distance) [226];
- the typical scheme of remote information interaction of the different AWP of the diverse subjects of training of IEE of ART system of (the various) EE [226];
- the classification of the diverse subjects of training of IEE of ART system [226];
- the transformation of information in the technological process of the formation of knowledge [226];
- the classification of the practical methods of extraction and transmission of information (as the aggregate of knowledge) in the various subjects of studying (disciplines) [226];
- the modifications in the organization of IEE of ART system of (the modern) EE for the providing of taking into account of IFPST directly [226];
- the modifications in the technological process of the controlled formation of knowledge at the realization of the automated personally-oriented training [226];
- the generalized scheme of comparing of the modifications in the organization of IEE and the technology of ART for the realization of the contour of adaptation based on the innovative PCMB [226];
- the structure of the information-educational portal of the scientific (educational) centre: on the example of the information resources of “The scientific-educational consortium "System and financial analysis based on cognitive modeling technology"” [235-244];
- the structure of the information-educational portal of the teacher (the scientist): on the example of the information resource – the scientific-educational portal of “"the author of the unique technology" of cognitive modeling for the system, financial and difficult analysis” (“AUT CMT SFA”) Vetrov A.N. [262];
- (the recommended formal description – the calculation of) the structure of ART system with the properties (elements) of adaptation based on the innovative PCMB (by means of the apparatus of the classical theory of automatic control) [226];
- the information scheme, reflecting the algorithm (principle) of functioning of the main (basic) and applied (extended) DM in IEE of ART system [271, 272];
- the information scheme, reflecting the algorithm (principle) of functioning of the innovative adaptive means of training (ET and LW) in IEE of ART system [269];
- the innovative architecture of the adaptive means of training (ET and LW) based on PCMB [290];
- the branched information structure of the subject of studying (discipline), displayed at the level of presentation of data by the means of using of the innovative adaptive means of training (ET and LW) based on PCMB [226];
- the recommended schemes of the realization of branching for the linear and branched model of controlled process of the formation of knowledge of the contingent of trainees [226];
- the algorithm of processing of the events, initiated by the user (the subject of training) in the innovative adaptive means of training (ET and LW) based on PCMB [226];
- the semantic (structural) model of representation of the diverse information (a sequences of diverse information fragments by the different way) in the innovative adaptive means of training (ET and LW) based on PCMB [226];
- the structural-functional scheme of the adaptive representation of a sequence of information fragments processor in the subject of studying [226].

2. CMT for the system analysis and increase in the efficiency of functioning of IEE:
   - the generalized iterative cycle of CMT for the system analysis of IEE of ART system [203];
   - the technique of use of CMT for the tasks of the system analysis of IEE of ART system [281];
   - the recommended bases for the building of the structure of CM of a zero generation;
     - the formal models for the presentation of procedural data (the algorithms and procedures);
       - the representation of the structure of the parametrical CM by means of the logical model [226];
       - the representation of the structure of the parametrical CM by means of the production model [226];
       - the representation of the structure of the parametrical CM by the means of use of the (difficult) calculus of the theory of sets and the corteges on domains [226];
     - the nonformal models for the representation of declarative data (data and knowledge);
       - the representation of the structure of the parametrical CM in the view of the frame model [226];
       - the representation of the structure of the parametrical CM in the view of the semantic network [226];
       - the representation of the structure of the param. CM in the view of ontology (the field of knowledge) [226];
       - the representation of the structure of CM in the view of the multi-level structural scheme [226];
       - the infological scheme of database (DB) for the representation of the structure of CM [226];
     - the hybrid models for the representation of data in the poorly formalized areas;
       - the representation of the structure of the parametrical CM by the means of use of the (difficult) classical calculus of the theory of sets and the theory of graphs [226];
       - the representation of the structure of the parametrical CM by the means of use of the multilevel encapsulated pyramids, combining the theory of graphs and the theory of sets [226];
   - the recommended bases for the building of the structure of CM of the first generation;
     - the hybrid models for the representation of data in the poorly formalized areas;
       - the representation of the structure of the parametrical CM in the view of the cognitive ring [313];
       - the representation of the structure of the parametrical CM in the view of the cognitive disc [313];
       - the representation of the structure of the parametrical CM in the view of the cognitive cylinder [311];
       - the representation of the structure of the parametrical CM in the view of the cognitive cone [313];
       - the representation of the structure of the parametrical CM in the view of the cognitive sphere [311];
   - the recommended bases for the building of the structure of CM of the second and third generations;
     - the hybrid models for the representation of data in the poorly formalized areas;
       - the representation of the structure of the parametrical CM by the means of use of the one-, two-, three-, four-, five- and more-cognitive ring, cognitive disc, cognitive cylinder, cognitive cone and (or) cognitive sphere [311-315];
   - the algorithm of formation of the structure of CM for the system analysis of IEE of ART system [226];
   - the technique of research of the parameters of the innovative CM of the subject of training [226];
   - the technique of research of the parameters of the innovative CM of the means of training [226];
   - the algorithm of processing of a posteriori data of testing of the contingent of trainees [226].

3. The innovative PCMB for the system analysis of IEE of ART system:

- the innovative structure of the parametrical CM of the subject of training (the multilevel structural scheme, combining the theory of mathematical sets) [the theoretical structure of CM with the wide scientific justification: cognitive informatics, psychophysiology of perception, cognitive psychology and applied (mathematical) linguistics] [221-224];
- the innovative structure of the parametrical CM of the means of training (the multilevel structural scheme, combining the theory of mathematical sets) [the theoretical structure of CM with the wide scientific justification: cognitive informatics, psychophysiology of perception, cognitive psychology and applied (mathematical) linguistics] [221-224];
- the structure of the modified model of the reduced eye of human (CM of the optical and biological construct of the reduced eye of human) [the theoretical and experimental structure of CM with the wide scientific justification: cogn. informatics, psychophysiology of perception, ophthalmology and micro-surgery of eye] [226];
- the structure of the modified model of the reduced ear of human (CM of the optical and biological construct of the reduced ear of human) [the theoretical and experimental structure of CM with the wide scientific justification: cognitive informatics, psychophysiology of perception, otology and micro-surgery of ear] [226];
- * the structure of CM of the difficult chemical element (the nuclear polymer) with the one, two, three, four, five or more nucleuses (the plasmatic formations) in the view of the one-, two-, three-, four-, five- and more-cognitive sphere [the experimental structure of CM with the narrow scientific justification: cognitive informatics, physics of atomic nucleus, physics of plasma and physical chemistry; it was developed by the means of use of the modeling and scientific visualization before the official decision about the recognition of fact of the synthesis of nuclear polymers with the one, two, three, four, five or more nucleuses (or the areas of plasma) of "The international association of theoretical and applied chemistry": at-first,- for the purposes of the potential possibility of realization of the difficult analysis of the structure of the difficult chemical elements (the nuclear polymers) as the plasmatic formations with the clearly (not explicitly) expressed one, two, three, four, five or more nucleuses (the areas of plasma); at-second,- for the providing of the potential possibility of studying (modelling) of the difficult physical phenomena of the nuclear convergence and divergence (at the micro-level)] [312];

4. The complex of programs for the automation of the tasks of research of IEE of ART system, which includes the innovative adaptive means of training (ET and LW), the basic and applied DM, and also the innovative ED and EL:
   - the generalized structural-functional scheme of the complex of programs for the automation of the tasks of research of IEE of ART system [226];
   - the algorithm of primary initialization of DB and switching of the modes of functioning of the complex of programs for the automation of the tasks of the system analysis of IEE of ART [226];
   - the algorithm of authentication of the user in the automated training system [226];
   - the interface of the complex of programs in the mode of main button form: the basic DM [226];
   - the structural-functional scheme of the adaptive means of training (ET and LW) [226];
   - the infological scheme of DB of the adaptive means of training (ET and LW);
   - the algorithm of filling of the content of the adaptive means of training (ET and LW) based on the information (semantic) model of the subject of studying;
   - the algorithm of extraction of the information fragments of the adaptive means of training (ET and LW) based on the adaptive representation of information fragments processor;
   - the algorithm of functioning of the adaptive ET together with DM (the clarification of the level of statement of the material of the subject training is realized);
   - the interface of the adaptive ET (LW) in the mode of administrating: the viewing and modifying of parameters of the subjects of studying (disciplines);
   - the interface of the adaptive ET (LW) in the mode of administrating: the viewing and modifying of parameters of the sections of the subject of studying;
   - the interface of the adaptive ET (LW) in the mode of administrating: the viewing and modifying of parameters of the modules of section of the subject of studying;
   - the interface of the adaptive ET (LW) in the mode of administrating: the viewing and modifying of parameters of the page of module of the section of the subject of studying;
   - the interface of the adaptive ET (LW) in the mode of administrating: the viewing and modifying of parameters of the page of module of the section of the subject of studying;
   - the administrating of DB with the values of parameters of PCMB: the viewing and modifying of parameters of CM of the subject of training;
   - the administrating of DB with the values of parameters of PCMB: the viewing and modifying of parameters of CM of the means of training;
   - the interface of the adaptive ET (LW) in the mode of adaptive training: the textual representation of information fragment (text);
   - the interface of the adaptive ET (LW) in the mode of adaptive training: the graphical representation of information fragment (the flat scheme);
   - the structural-functional scheme of the basic DM in IEE of ART system;
   - the infological scheme of DB of the basic DM in IEE of ART system;
   - the algorithm of functioning of the mode of administrating of the basic DM;
   - the algorithm of functioning of the mode of diagnostics in the form of testing of the basic DM;
   - the interface of the basic DM in the mode of administrating;
   - the interface of the basic DM in the mode of diagnostics (the version for the carrying out of express diagnostics without the using of images);

- the structural-functional scheme of the applied DM in IEE of ART system;
- the infological scheme of DB of the applied DM in IEE of ART system;
- the algorithm of functioning of the applied DM in the mode of administrating of the question-answers structures of the methods of research (tests) of the individual features of personality of the contingent of examinees;
- the algorithm of functioning of the applied DM in the mode of diagnostics of the individual features of personality of the contingent of examinees;
- the interface of the applied DM in the mode of administrating of the question-answers structures of the method of research of the color-perception of Rabkin E.B.;
- the interface of the applied DM in the mode of diagnostics of the color-perception by means of the method of research of Rabkin E.B.;
- the interface of the applied DM in the mode of administrating of the typical question-answers structures of different subtests of the verbal reasoning, verbal abstraction, verbal combinatorics, conceptual judgment, arithmetic counting, arithmetic inductive output, the concentration of attention and mnemonics, planar imagination and volumetric thinking by the means of use of the various blocks of questions "The logical selection, the addition of sentences", "The searching of general signs, exclusion of words", "The search of verbal analogies", "The classification of concepts, generalization", "The arithmetic tasks", "The numerical rows", "The attention and memory (mnemonics)", "The flat figures" and "The cubes" of the method of research of Amthauer R.;
- the interface of the applied DM in the mode of diagnostics by the means of using of the different blocks of questions of the method of research (test) of Amthauer R.;
- the interface of the applied DM in the mode of administrating of the question-answers structures of the subtest of verbal creativity and figurative creativity by the means of using of the method of research of Mednik S.A. and Torrance E.P.;
- the interface of the applied DM in the mode of diagnostics of the verbal and figurative creativity by the means of use of the method of research (test) of Mednik S.A. and Torrance E.P.;
- the mathematical model of the spherical perimeter of Forster K.F.R., and also the features of representation of a posteriori data of research of the achromatic and chromatic field of vision of the examinee;
- the interface of the applied DM in the mode of administrating of the question-answers structures of the method of research of the achromatic and chromatic field of vision of the examinee by means of the computer perimetry: the parameters of the method of research;
- the interface of the applied DM in the mode of administrating of the question-answers structures of the method of research of the achromatic and chromatic field of vision of the examinee by means of the computer perimetry: the parameters of displaying;
- the interface of the applied DM in the mode of administrating of the question-answers structures of the method of research of the achromatic and chromatic field of vision of the examinee by the means of use of the computer perimetry: the parameters of DB;
- the interface of the applied DM in the mode of diagnostics of the achromatic and chromatic field of vision of the examinee by the means of use of the computer perimetry;

- the structural-functional scheme of the innovative ED based on PCMB;
- the infological scheme of DB of ED of ART system with the properties of adaptation based on CM;
- the interface form of the innovative ED in the mode of administrating of DB: the basic parameters of account and the estimation of knowledge of the trainee (the examinee);
- the interface form of the innovative ED in the mode of administrating of DB: the nominal values of parameters of CM of the subject of training and CM of the means of training;
- the interface form of the innovative ED in the mode of viewing of the content of DB: the main parameters of account and the estimation of the trainee (the examinee);
- the interface form of the innovative ED in the mode of viewing of the content of DB: the nominal values of parameters of CM of the subject of training and CM of the means of training;
- the semantic model of saving, extracting and searching of the information for the innovative adaptive EL based on the innovative PCMB;
- the structure of the information model of information resource of the adaptive EL;
- the structure and connection of information elements of the adaptive ET in the adaptive EL.

5. The statistical justification of practical use of the obtained results by means of the preliminary (primary) processing of a posteriori data, the secondary mathematical processing of samples of a posteriori data: some results of the dispersion, regression, discriminant, cluster analysis, multivariate scaling and the factor analysis (*):
   - the scheme, reflecting a sequence of actions (stages) for the support of researches of the cycle of adaptive ART [226];
   - the summary results of mathematical processing of a posteriori data;
   - the results of regression analysis: the equations of multiple regression;
   - the results of discriminant analysis: the eigenvalues for the formed canonical discriminant functions and the position of the centroids of classes in the space of two discriminant functions;
   - the results of multidimensional scaling of a posteriori data;
   - the results of factor analysis of a posteriori data;
   - the dynamics of the indicators of efficiency (resultativity) of the technological process of the controlled formation of knowledge of the contingent of trainees (examinees).
6. The structure of “The scientific-educational consortium "System and financial analysis based on cognitive modeling technology"”, including the scientific organizations:
   - the structure of “The state international organization "Academy of cognitive natural sciences"” (“SIO "ACNS"”) [324];
   - the structure of “The scientific-research institute "System and financial analysis based on cognitive modeling technology" of “The Russian academy of (natural) sciences" named after Veniaminov V.N.” (“SRI "SFA CMT" of "RA(N)S" n. a. Veniaminov V.N.”) [325];
   - the structure of “The scientific fund "System and financial analysis based on cognitive modeling technology" named after Prokopenko N.A.” (“SF "SFA CMT" n. a. Prokopenko N.A.”) [330];
   - the structure of “"Saint-Petersburg exhibition centre named after Brezhnev L.I." at "Exhibition of achievements of science and technology named after Sobchak A.A."” (“"SPbEC n. a. Brezhnev L.I." at "EAST n. a. Sobchak A.A."”) [334];
   - the structure of “The scientific-educational centre "System and financial analysis based on cognitive modeling technology" of "The Russian academy of (medical) sciences" named after academician Burdenko N.N.” (“SEC "SFA CMT" of "RA(M)S" n. a. acad. Burdenko N.N.”) [456].

**The novelty of the scientific results** of the dissertation research:

1. It allows to realize the additional contour of adaptation based on IFPST, providing the increasing in the efficiency of functioning of IEE of ART system.
2. It allows to carry out the complex system analysis of the efficiency of functioning of IEE of ART system directly in the context of a series of selected scientific aspects.
3. It accumulates respectively the various parameters, characterizing IFPST and potentially possible kinds and types of EI in IEE of ART system.
4. It provides the possibility of the adaptive (individually-oriented) generation of a sequence of information fragments (EI) by the means of using of the developed adaptive representation of information fragments processor, and also the automated estimation of LRKT, the research (diagnostics) of parameters of CM of the subject of training and the analysis of a posteriori data of testing.
5. It reflects the justification of increasing in the efficiency of functioning of IEE of ART system.
6. Acts as the innovative organization in the sphere of science and education.

**The theoretical significance** of the dissertation research is consisted:

1. The reorganization of IEE with taking into account of the realization of adaptation to IFPST is proposed: the structure of ART system with the properties of adaptation based on PCMB; the specifics of the formation of knowledge as the controlled technological process; the features of the structure and algorithms of functioning of the components of ART system; the bases of the extraction of subject knowledge for the construction of theoretical-reference modules (TRM) of the adaptive means of training of a new generation and the parameters of their estimation; the specifics of use of the multimedia (hypermedia) in IEE of ART system.
2. The features of modification of IEE and the principles (algorithms) of functioning of the components of ART system at the realization of the contour of adaptation based on PCMB are allocated.
3. The channels of communicative duplex information interaction of the diverse subjects of training and the various means of training in IEE of ART system with the properties of adaptation based on PCMB, the key parameters (factors), influencing on the efficiency of technological process of the formation of knowledge of the trainee in IEE of ART system.

**The practical value** of dissertation research is consisted:

1. CMT provides the complex system analysis of IEE of ART system.
2. The obtained structures of CM of the subject of training and CM of the means of training by means of using of the algorithm of formation of the structure of CM allow to provide the generating of information fragments adequately to IFPST and the potential technical capabilities of the means of training (ET and LW).
3. The developed techniques of research of the parameters of CM of the subject and means of training and the algorithm of processing of a posteriori data of testing formalize a sequences of carrying out of the experiment and processing of a posteriori data.
4. The complex of programs (the means of automation) provides the automation of the adaptive generation of information fragments in the subject of studying (discipline) based on the previously diagnosed parameters of CM and the subsequent estimation of LRKT.

**The reliability of scientific results** is provided by the system approach to the description of the object of research, the correct use of the fundamental provisions of (cognitive) informatics, private physiology of sensory systems, cognitive psychology, applied linguistics, pedagogy and ergonomics, the adequacy of the obtained models to the real processes, the justified application of the approved methods of research, the strict logic of carrying out of research, the results of statistical processing of a posteriori data, obtained at the using of the specially developed software (SW), the approbation of the main scientific provisions (theoretical and practical) of dissertation on the national and international seminars and conferences of various level, the introduction of the results of dissertation research into the learning process.

**The introduction (practical use) of the scientific results of dissertation research** was carried out independently directly in "The Saint-Petersburg state electrotechnical university "LETI" named after V.I. Ulyanov (Lenin)" ("SPbSETU "LETI"") and "The international banking institute" ("IBI"), RF, Saint-Petersburg city, that is confirmed by the personal cards of the examinees for the registration of a posteriori data and the corresponding acts about the practical use (introduction) of scientific results.

In the course of the dissertation research the scientific-methodical work was carried out, in the result of which the course of lectures on the discipline "Informatics" was developed.

**Publications.** On the theme of diss. was publ. 44 on 2006 y., 52 on 2007 y. (106 on 2012 y.) [314 on 2023 y.] s. works: 01 textbook and 03 methodical manuals to the lab. works in the discipline "Informatics", 01 textbook (10 volumes) on the discipline "Finance, monetary circulation and credit"; 02 sections in 01 coll. scientific monography of "IHEAS" (with form. co-authors-teachers); 04 (10) learning manuals and scientific monographies (with co-authors-diploma-students); 12 (29) [54] learning manuals and scientific monographies (without co-authors); 01 (02) report(s) on the individual initiative SRW (2003-2005 y. and 2006-2008 y.); 01 appendix to the report on the individual initiative SRW (2003-2005 y.); 05 (09) [14] scientific articles in the scientific journals, recommended by "HAC of RF", from which 00 (05) scientific articles were deposited in ""VINITI" of "RAS""; 22 (48) [226] scientific reports in the materials of 11 (24) [46] international scientific conferences, and also 04 copyright certificates about the deposition and registration of works – the objects of intellectual property in "RAS" (RF, Moscow city) were received.

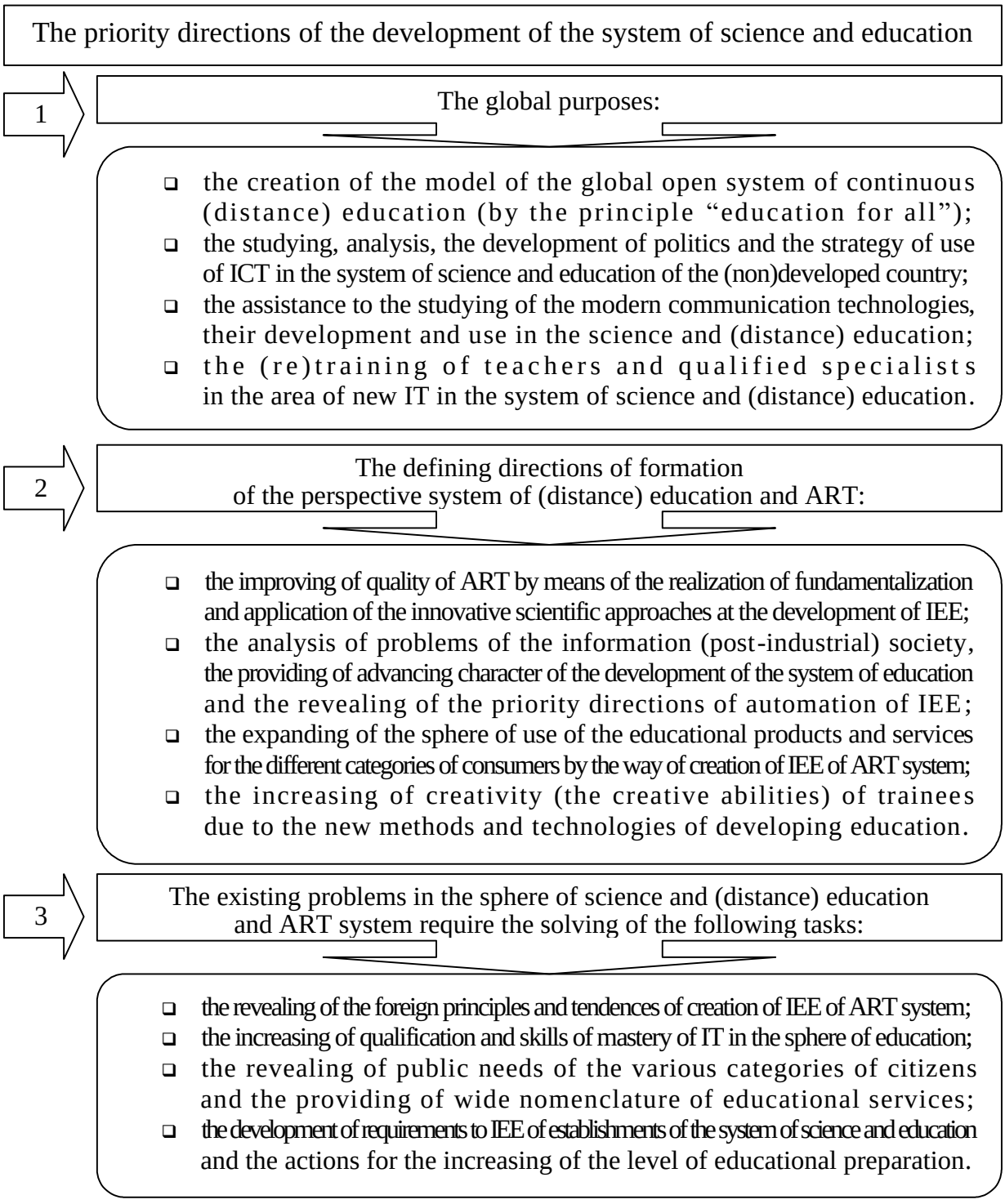
In 2005-2007 y. (2012 y.) [2023 y.] the norm for the candidate (doctor) of techn. sciences (02 (10) scientific articles in the scientific journals from the list of "HAC of RF" were required).

**The structure and volume of my doctoral dissertation in the form of manuscript:**

- volume 1 (the main part, 2006 y.) – the introduction, four chapters (sections), conclusion, the bibliographic list, including 499 names, stated on 240 p. of typewritten text, including 44 pictures and 2 tables (with appendices) are presented;
- volume 2 (the appendices, 2006 y.) – contains 14 appendices on 232 p. of typewritten text, including 89 pictures and 154 tables;
- volume 3 (the appendices, 2010 y.) – contains 1 appendix on 416 p. of typewritten text, including 177 pictures and 171 tables.

# 1. The analysis of information technologies for the support of the information environment of automated training

The many international scientific and educational organizations and state bodies, regulating the development of the unique scientific-research and educational space, are interested in the problems of creation, introduction and use of ICT in the sphere of education and science, therefore directly provide the development of the global purposes and directions of the process of informatization of the various traditional and new scientific and EE (pic. 1.1).




Picture 1.1. The priority directions of development of the system of education

## *1.1. The concept of information technologies in the science and education*

*Under the educational (information) technology* in a wide scientific sense is understood the way of realization of the learning plans, working and educational programs, representing the system of forms, methods and the means of training (at distance), providing the achievement of the set didactic (methodical) purposes. The educational (information) technologies are differentiated in dependence from the applied (information) technologies, methods and the means of training (at distance).

*Under the educational IT* in a narrow sense is understood the educational technologies based on the modern (innovative) means of automation and computer technics, supporting the controlled process of training (at distance) by the means of use of the traditional or innovative IEE, which includes the various components: the technical – the kind of hardware and the means of communication, used in IEE; the program – a set of various SW for the supporting of realized technology of ART; the methodical – LMC, the instructions to the subjects of training (trainees and teachers); the organizational – the organization and planning of the technological process of ART.

*Under the educational (information) technologies* in The high school understands the system of fundamental and applied scientific knowledge in the subjects of studying (disciplines), and also the diverse approaches, technologies, methods, algorithms and means (of automation), which are used for the creation, searching, storing, processing and transmitting of information in the various subject areas (the problem spheres) in the context of the subjects of studying, providing the support of a certain educational activity (trajectory) in the various traditional and new scientific and EE (the scientific-educational centres).

The problem of informatization of the establishments of science and higher professional education causes the essential necessity of development of the complex scientific approach and is achieved by means of the realization of rationalization of the process of distribution of the different intellectual kinds of activity of the interested scientific community, directed on the expanding of the sphere of creation, dissemination and use of a new IT in the various subject areas and the spheres of social activity of the modern society, providing the increasing of efficiency of the controlled process of training (at distance) and the quality of preparation of the diverse qualified specialists (experts) to the level of information culture, achieved in the certain (not) developed countries.

The process of informatization of IEE of ART system is achieved directly due to the creation, introduction and use of the innovative means of automation based on the diverse hardware, software and brainware.

### *1.2. The appointment of the information technologies of educational environment*

The appointment of IT is shown in the sphere of their practical use (introduction), and their specifics is caused by the features of various information processes, which are observed in the various subject areas (the problem spheres) of ART.

IT plays the important role in the different spheres of social activity of the modern society, as it optimizes and automates the various information processes. The modern stage of development of the civilization causes the formation of information society, in which the most diverse social subjects are involved into the processes of creation, distribution and use of the information resources, products and services of the information industry (on the various sectors of information market), therefore they are forced to use the different IT for the searching and processing of information.

The application of IT in the sphere of education and science is directed directly on the solving of some global problems of the XXI$^{st}$ century, as it orients on:

- the significant increasing of efficiency of the controlled technological processes, accompanying the educational activity in IEE of ART system of each EE, and the significant reduction of the various kinds of costs at the creating and introducing of the different information resources, products and services of information industry;
- the relative reduction of the value of proportional ratio between the public needs in the receiving of (distance) education and the capabilities of the system of education and science of a certain country at the providing of a diverse set of educational resources, products and services;
- the integration of productive activity for the joint creative process of territorially distributed scientific communities and individual specialists, dealing by the problems of creation, introduction and use of the different IT in the system of education and science with the minimal costs of various resources.

The modern scientific-technical level of development of IT allows the capability of their use for the automation of the various processes of the processing of educational information. The modern IEE of ART systems and their various elements at the introduction of different IT allows to perform a part of the excessively spent intellectual work of the teacher (the preparation of diverse tests, the control of academic-performance and the testing of LRKT). The basic skills and techniques are quickly algorithmized and transmitted to the trainees by the means of use of the diverse automated means of training.

The modern ICT and global computing networks cover the surface of The Earth and provide the open access to ART system to the diverse contingent of trainees.

## *1.3. The classification of the information educational technologies*

The educational IT are differentiated into the two main (basic) categories: *the non-interactive* – the printed and multimedia data on the various carriers of information; *the interactive* – the linear, reactive and multiple or dialog interaction between the different information resources and products in the communication environment (tele-bridges, seminars and conferences on a certain channel of data transmission: the wired – the (coaxial) cable and twisted pair and wireless – the electromagnetic radiation).

*The interactivity* – the principle of organization of the given information system, at which a certain purpose is achieved by the means of information exchange of the information elements between the diverse subjects and (or) objects (the ability to trace the condition and to form the reaction on the actions of user).

The carriers of information in the context of the various IT of non-interactive group are dynamically updated and concentrated in the special warehouses, banks and DB. The interactive ICT provide the qualitatively new capabilities to DE and are rapidly developing on the basis of the information interaction by means of the global network "Internet". In ET of a new generation the modern technological novations are integrated, providing the dynamical representation of information fragments in the discipline.

In the practice of ART directly use the various high-technological automated means of tele-communications (a new turn in the evolution of ICT), allowing to transmit the compressed video-information in the real scale of time, but not used early in the automated IEE by the reason of high cost of the terminal equipment of data transmission and the rent of segments of the satellite networks.

The traditional hardware, software and brainware are directly used in the basis of the various IEE of ART systems for the support of the controlled technological process of the formation of knowledge.

The hardware of IEE of ART systems is divided into the two groups:

- the internal components of computer for the processing of various information;
- the external components of computer for the input and output of different information;
  - the input devices of information (including from the different carriers of information);
  - the output devices of information (including from the different carriers of information);
  - the device of displaying of information about the current condition of the computer;
  - the devices of support of functioning and uninterrupted power supply of the computer.

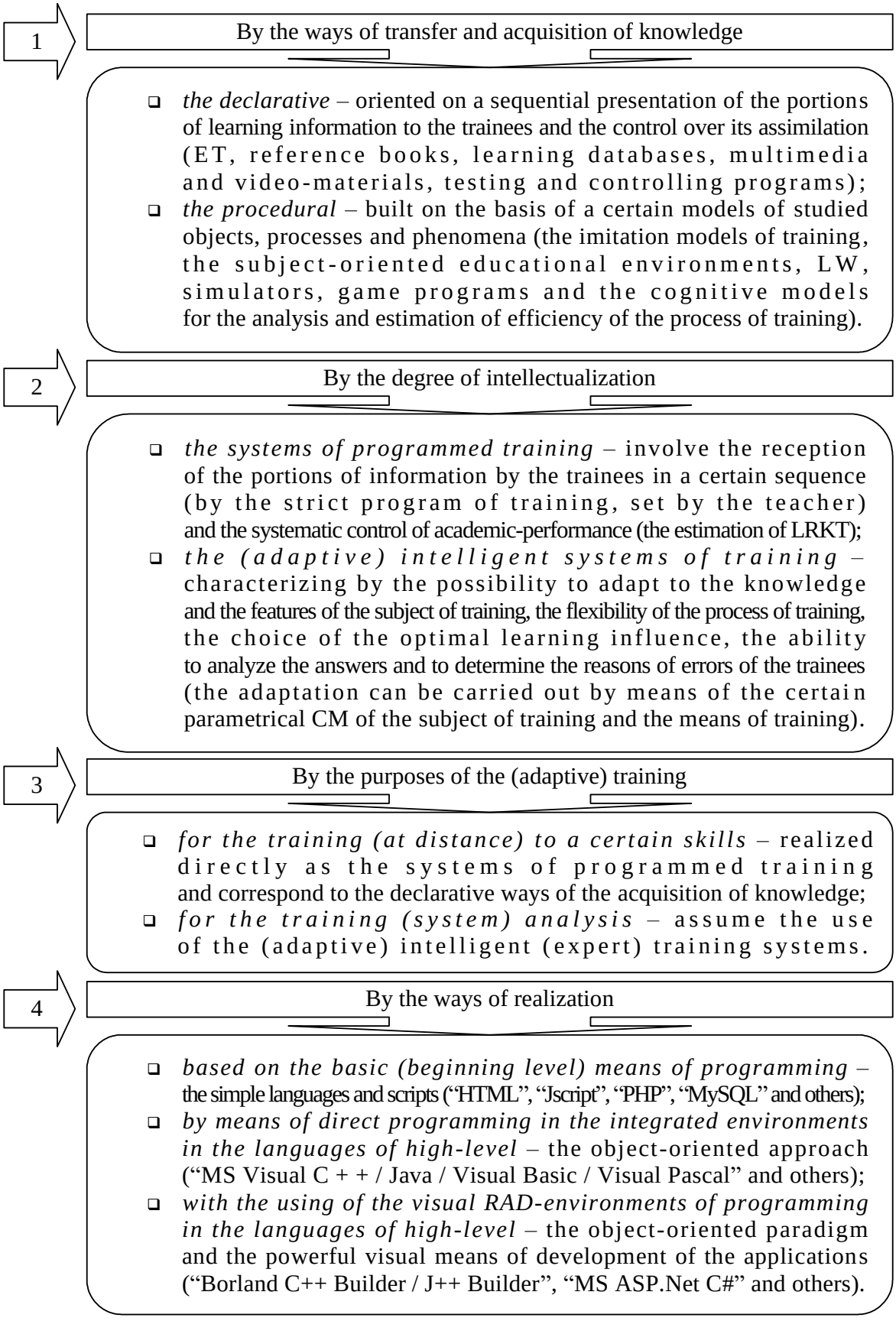
The software of IEE of ART system is divided into the two groups:

- the system – the local (non-interactive) and network (interactive) operating systems, supporting the command and dialog interface of interaction with the user;
- the application – the programs and packages of the applied programs for the user.

The brainware of IEE of ART system is divided into the two groups:

- the linear algorithms – the linear sequence of operations (actions);
- the branched algorithms – the branched sequence of operations (actions).

There are a large quantity of the criteria of classification of the educational IT in the basis of IEE of ART system, among of which a row of main can be distinguished (pic. 1.2).




Picture 1.2. The classification of information technologies in the information-educational environment

## 1.4. The kinds and tasks of the automated means of training

IT directly significantly increases the information and didactic value and the efficiency of developing of the different components of IEE of ART system, aggregating the basic (main) IT and IT of applied appointment (advanced): the textual editors ("MS Word") and the system of electronic spreadsheets ("MS Excel"), the graphical editors ("Adobe Photoshop") and the means of animation ("MM Flash"), the control systems of DB ("MS Access", "Oracle", "Informix", "SQL", "MySQL" and others), the hypertext technologies ("HTML", "XML", "Perl", "PHP" and others), the multimedia technologies ("Sound Forge" and others), the technologies and means of development of the expert systems (the fast prototype technology), the technologies of creation of the open (network) (educational) systems ("ASP.NET" and others), the technologies of the system analysis of the efficiency of IEE of ART systems (CMT and CM) and others.

The program means of training in the basis of (the innovative) IEE of ART system have the different functional appointment and the (didactic) potential capabilities.

*The electronic textbook* – the (automated) (program) means of training (a certain automated learning-methodical manual (LMM)), allowing directly independently to master the learning course or section, including the properties of traditional textbook, handbook, the book of tasks and LW.

*The diagnostic module* – the (automated) (program) means of training, designed directly for the revealing of the estimation of LRKT (the identification of IFPST), and also the abilities and skills by means of a set of the special methods of research (tests).

*The laboratory workshop* – the (automated) (program) means of training, allowing to research the tendences, dependencies and regularities of objects, processes and phenomena, their relationships and properties, the applied areas of their practical use, to process a posteriori data and to reflect graphically the statistical dependencies.

*The simulator (the book of tasks)* – the (automated) (program) means of training for the development of various practical skills and the accumulating of a certain experience, includes the means of automation for the estimation of the achieved level of experience, corresponding to the changes of the intensity of training (educational) influences (the simplicity and difficulty, the time of execution, the speed of reaction and other parameters).

*The game programs* – the (automated) (program) means of training, providing the additional didactic capabilities in relation with the simulators.

The experts note the significant efficiency of the diverse business games, oriented directly on the obtaining of the best results of solving of the difficult similar (typical) tasks (test. tasks) by the competing groups of trainees.

The dialogue acts directly as the information interaction of the subjects of training and the means of training (it acts as the form of expression of personality).

*The subject-oriented environments* – the various SW for the modeling objects, processes and phenomena, their properties, tendences, dependencies and regularities, demonstrating the different processes and relationships in them at the micro- and macro-level.

The trainees in the course of independent research operate by the objects of environment, performing the operations and tasks on the achievement of didactic purpose, set by the teacher.

The imitation modeling causes the increasing in the level of understanding due to the visual interpretation of behavior of the object, process or phenomenon of research in dynamics, the motivation of interest of the trainees to the independent creative work in IEE of ART system.

## *1.5. The main stages of development of the automated training systems*

The world practice of practical use of the modern educational IT in the basis of IEE of ART systems allows to distinguish a row of historical stages in the course of their development.

The 1st stage (60s years). *The specialized packages of training programs* – ATS, allowing to create directly the (automated) CC in IEE: the definition of the technique, content and types of EI is delegated to the teacher (tutor), and the technological process of training and the estimation of the academic-performance is realized by the means of training.

The 2nd stage (70s years). *The intelligent and branched (hierarchical) ATS*. In this historical period the main efforts of the theoretics of ART are directed on the creating and improving of the models of training based on the achievements of knowledge engineering. The scientific approaches, technologies, methods and algorithms of the representing of knowledge, developed directly in the area of artificial intelligence and knowledge engineering are actively developing. In a large extent the models of the presentation of knowledge (the structured data) are developing, the selection and creation of which are linked with the problems of collecting and structuring learning material, and also the optimization and control of organization of the technological process of training. One from the main tasks of didactic programming (the programmed training) – the synthesis of the purposeful system of optimal control of learning operations, at the performance of which the condition of knowledge and skills of the trainee comes nearer to the required ones. In the present time the actuality of solving of the listed scientific problems is saved by the many developers of ATS – the domestic and foreign scientists and specialists.

The 3rd stage (80s years). *The knowledge engineering and the tool means of creation of ATS.* The deep scientific researches is carried out in a row of the fundamental and applied areas: the modeling of reasoning and explanations (clarification) for the realization of different ATS, the development of the intelligent technologies of structuring and representation of knowledge in the subject areas (the problem spheres) in the context of the subjects of studying (disciplines), the creation of strategies of training (at distance), the methods of research of IFPST and the estimation of LRKT. There is a tendency to the development and introduction of the integrated educational environments, allowing to use the information resources and products with the different-type information (texts, tables, static schemes and dynamic images, audio- and video-streams), including the analytical and imitational models of researched objects and processes, DB and knowledge bases (KB), the systems of supporting of the making of decision and the performing of calculations: the scientific and engineering-technical, medical, statistical, economic and others.

The various fundamental and applied scientific works is developed in the field of psychophysiology of perception, cognitive psychology and applied (mathematical) linguistics, cognitive computer graphics and the representation of knowledge (the structuring of data). The using of computer animation in the different new training programs contributes to the development of the convergent and divergent intellectual abilities, as it activates the associative, planar and volumetric thinking (memory), the originality and selectivity of the process of cognitive activity of the psyche, that allows to introduce the innovative methods of research (tests) and correction.

The 4th stage (90s years). *The innovative computers and ATS of a new generation, the optical-fiber and satellite channels of communication, multimedia, hypermedia, the communication and network technologies of (distributed) data transfer.* The changes in the principles of constructing of the architecture of the (distributed) information systems and the technologies of realization of the hardware, software and brainware of computers cause the realization of ATS of a new generation – the adaptive ATS.

*The multimedia-technologies* provide the support of the technological process of creation, introduction and practical use of the multimedia-resources and products: the electronic books (textbooks), the multimedia-encyclopedias, animation and others. The characteristic feature of these new information resources and products is the uniting of textual, tabular, graphical, audio- and video-information. The technologies of multimedia and cognitive computer graphics provide the potential possibility of creation of IEE of ART systems of the type "virtual reality", and also allow to introduce and approbate the innovative methods of research and the personally-oriented (adaptive) training (at distance), assuming the displaying of the specially prepared audio- and video-streams.

The technologies of multimedia turned the computer into a full-fledged interlocutor and allow to the contingent of trainees, without the leaving from the classroom (home), to attend on the lectures of the outstanding scientists and qualified specialists, to become witnesses of the important historical events of past and present, to attend the well-known conferences, seminars, exhibitions, museums and cultural centers, located directly in the various geographical places of the globe.

The multimedia-technologies provides the emergence of the innovative book of a new generation – the electronic book (textbook, dictionary, encyclopedia, reference book and book of tasks), containing, along with the ordinary texts, tables and graphical images, the animation, allowing to increase significantly the level of the perception of information due to the parallel reproduction of information fragments with the audio- and video-streams.

*The hypermedia-technologies* – the way of the creating and formatting of electronic documents, including the texts, tables, graphical images and computer animation, the transition between the diverse information fragments in which is carried out by the means of using of the cross-references, located in the table of contents and content.

Practically all modern reference and information-search systems are realized on the basis of the innovative Web-technologies and computer animation. The hypermedia-resources and products of learning appointment allow to the subjects of training (trainees) to work with a large volume of diverse material (information), presented in the view of texts, graphical images, active (dynamic) schemes, including the audio accompanying (audio-streams) and video-clips (video-streams), that allows not only to read them, but and to listen, watch and sort the information, to make extracts, to prepare the necessary documents (monographies, scientific articles and abstracts).

The hypermedia-technologies initiates the development of geo-information systems, which began to applied in IEE of ART systems and allow to present complexly the information about the structure and principles of functioning of the difficult objects and systems.

*The network (communication) technologies* – the rapidly developing scientific direction, providing the improvement of the ways of exchanging of the diverse information and opening up a new possibilities of communication between the subjects of training in IEE of ART system. The working in the local and global networks meets the information needs of trainees, and also increases the level of computer literacy due to the tele-communication communication, widens the outlook and motivates the interest to the obtaining of a new knowledge in the subjects of studying.

The open access to banks and D(K)B allows to the trainees to familiarize with the scientific problems, the researches of which has not yet completed (on the ongoing scientific-research works), to work by the small (mobile) scientific-research collectives (groups), to share by the obtained scientific results with the representatives of scientific community. The scientific information, systematized and stored in the data banks, DB and KB, allows to find the new scientific approaches, to verify the own scientific hypotheses, to form the skills and techniques of the system analysis of the objects, processes and phenomena, the comparing of the various fundamental knowledge and the using of applied knowledge.

By means of use of the local and global computing networks and tele-communications the teachers not only improve their information culture, but also have a unique possibility of communication with their colleagues around the world. This creates the ideal conditions for the professional relations (communication), the conducting of joint scientific, practical and methodical activity (at distance), the sharing of knowledge, experience and the fundamental and applied scientific results.

*The electronic mail (Email)* acts as the cost-effective way of the automation of delivery of the various learning materials (the information expressed in the form of data) at the existence of communication equipment at the diverse subjects of training. In last time the given communication technology has become the distribution as the additional high-technological way of communication at the traditional and ART. The support of the learning process in IEE of ART system by means of the electronic mail causes the beginning of the period of introduction of the tele-communications in the sphere of education and science. The specifics of realization of the technological process of training (the formation of knowledge) require the specific organization and coordination of the diverse flows of information, having the complex influence on the efficiency of functioning of IEE of ART system.

"The electronic messaging association" was conducted the complex scientific researches, reflecting the tendences to the expansion of the sphere of practical use of Email: in 1994 y. the number of consumers amounted 23 million users, and in 2000 y. – 72 million.

*The virtual conference* – allows to (the remote from each other on the considerable distance) the subjects of training (teachers and trainees) to organize the learning process, which is directly the analogous of the traditional learning process in EE, and also to coordinate the collective work of territorially distributed trainees and to realize the active interaction (round table, business game, brainstorming and others). This is possible due to the realization of a virtual class based on the tele-conference.

There are the two main ways (modes) of the organization of tele-conference, which differ in the speed and regulation of exchange of the diverse information between the involved subjects (participants) of given virtual communication:

- *off-line* – there is directly a certain interval of time between the translation of the author's replica in the conference and the reading of it by other participants, wherein the answer of each from the participants (subjects) of conference is not known in advance;
- *on-line* – the virtual dialogue is carried out in the real scale of time and the trainee in the process of training (at distance), similar to the traditional, has the possibility of selecting and receiving of the necessary information on his computer.

*The remote access to DB* – allows to the users to operate by the information, stored in the different DB on the territorially distributed servers of the network "Internet".

*"WWW"-technology* – acts as the open system of hypermedia-resources, providing the transfer of hypertext, graphics, animation, audio- and video-streams between a certain set of diverse servers (the information warehouses), located in the various segments of the global computational network "Internet" ("Intranet"), acting as the most perspective way (means) of virtual communication for the social, military, technical, economic, educational and scientific purposes.

The network "Internet" is the progressive distributed information system, realized directly on the basis of the innovative advanced "WWW"-technology and acting as a set of regional information systems (the segments of network), providing the interactive access by means of the communication technologies to the information resources, containing the information in the various subject areas: science, education, medicine, economics, politics, religion, jurisprudence and others.

According to the forecasts, the informatization of establishments of the sphere of education and science directly at the fourth stage of the historical development of the educational IT causes the tendence to the progressive evolution of the methods and technologies of development of the organizational, methodical and technical support of educational process for the realization of the support of functioning of the highly-technological IEE of ART systems, using in their basis a set of the technical means of automation of the information processes, which are characteristic for the educational activity.

*The technologies of nonlinear audio- and video-editing* – support the all difficult technological process of creation, distribution and use of the different audio- and video-streams (files, DB, KB and computer programs), located on the various types of carriers (magnetic, optical and electronic), containing the diverse information, expressed in the form of different data, in particular the educational (the interactive training courses, lectures, LW and others), intended for a wide contingent of consumers (the specialists and experts), differentiated by the age, the professional status and the kind of activity.

## 1.6. The essence and the basic principles of distance education

*Under the distance education (DE)* understands the complex of educational services, provided to a wide layers of population in a certain country and abroad by the means of use of the specialized (innovative) IEE of (ART system), based on the various ICT of the exchange of diverse learning information at distance (the satellite, radio and cable local and global computational networks), providing the open access to the educational resources of various kind and appointment. In the developed countries DE acts as the one from the form of continuing education, which realizes the rights of human on the obtaining of education and the access to the information.

*The remote training* – a set of IT (ICT) in the basis of IEE (ART system), providing the delivery to the trainees of the main volume of studied material, their interactive information interaction with the teachers in the learning process, the providing to the trainees of the possibilities of independent work (IW) in the mastering of material, and also the (automated) estimation of their knowledge (LRKT), abilities and skills (qualification).

The form of DE has the important value for the countries with the large territories and the unevenly located different educational and scientific centres, at the same time RF is no exception (the geographically distributed location). The feasibility of introduction of DE in RF is confirmed by the development and carrying out of "The federal target program of The Government of The Russian Federation "The creation (development) of unique educational information environment" (2001-2005 y. (and later))".

The essence of the fundamental theories of DE is detailed stated in the appendix 1.

ART as the component of DE is directly constructed on a certain theoretical provisions and the principles of organization of training at distance. At their development taking into account the traditional didactic principles of training (at distance), the content of which is based on the diverse scientific achievements in the area of pedagogics, physiology, psychology, linguistics and (cognitive) informatics, and also the experience of use of ICT in the establishments of the system of education and science.

To such important traditional didactic principles include: the scientificity and visibility, motivation and activity, the independence in training, systematics and consistency, the training at the high level of difficulty, the deep and wide mastery of diverse knowledge, abilities and skills, the unity of traditional and automated forms of organization of the educational process at the introduction of various high-technological novations in IEE of ART system.

The given scientific principles are described in detail in the different pedagogical literature and are not the subject of consideration in the given work, but it is important to note two contradictions:

- the existing didactic principles define the various requirements to the components of the process of training (tasks, content, methods, technologies and other);
- in the traditional (classical) scientific principles, either completely absent, or there is a weak relation with the possibility of taking into account of IFPST in IEE of ART systems.

There are the significant difficulties at the solving of scientific-research tasks, related with the expansion of the sphere of use of the approaches, methods and technologies of ART, accenting the attention of scientists on the need of the complex solution of problem as a whole.

At the same time the controlled process of training (at distance) should be considered as:

- the element of high rank at the level of the system of education and science of the country;
- the independent element of the autonomous IEE of ART system at the level of EE.

Accordingly the set of scientific principles is ranked and divided on a row of blocks, each of which includes the several scientific levels according to the priority purposes, problems, tasks, features of developing of algorithms and mechanisms of solving:

1. The social-pedagogical principles – are regulated by the state politics in the area of the process of informatization of the sphere of education and science include:
   - the systemality – the creation of the system of education, meeting to the modern requirements, providing the training (at distance) on the basis of the complex of scientific knowledge and realizing the effective management and control of all its different links;
   - the continuity – the providing of (re)training according to the modern requirements in the course of all life of a certain subject of training (trainee), the creation of flexible conditions for the consumers of educational products and services at the transition from one (simple) level of education to the another (difficult);
   - the regionality – the analysis of the territorial features of functioning of the system of education and science: the national-ethical factors, types and levels of EE;
   - the nationality and historicism – the orientation on the identity of national pedagogics and the history of development of the national system of education and science, its roots and traditions;
   - the adaptability and accessibility – the providing to the trainees of the open (convenient) access to the educational space (the individual in content and result);
   - the scientific-character and standardization of education – the development of diverse content of the various educational programs adequately to the modern achievements of science and the requirements, presented in "The state educational standards".
2. The psychological principles – the development of personality in the process of ART, include:
   - the ergonomics – the protecting of condition of the health of human with the taking into account of IFPST and the level of development of the various abilities (the physiological and psychological);
   - the humanism – the socialization of the technological process of training (at distance), the taking into account of the social needs, personal interests and the properties of personality, the revealing of the factors of negative influence on the trainee in IEE of ART system;
   - the development of personality – the creation of conditions and the development of the methods of research, providing the physical and psychical development of each trainee;
   - the openness and flexibility – the providing to the subjects of training (at distance) the freedom of choose of the form of training and the providing of flexibility of the educational trajectory, which cause the self-actualization, self-education and self-development;
   - the complexity – the integration of scientific knowledge in the adjacent areas (including the science-study, IT, physiology, psychology and linguistics), providing the research of the psychophysiological and other features of personality, influencing on the increasing in the efficiency of functioning of IEE of ART system.

3. The organizational- technological principles – the features of organization and technology of the controlled process of the formation of knowledge (at distance) in EE include:

- the specifics of activity – the technological process of training (at distance) is organized proceeding from the features of activity of the subjects of training, creates the conditions of realization of their interests, the ways of achievement of the purposes and others;
- the regulation -- the providing of controllability and observability of training (at distance), the development of the algorithms of controlling and the monitoring of process of the formation of knowledge, the revealing of factors (the physiological, psychological, linguistic and others), influencing on the increasing of efficiency of the formation of knowledge of the trainee directly in the traditional or innovative IEE of ART system;
- the reflection – the analysis of performed operations at the stages of educational trajectory and the estimation of their influence on the resultativity of the process of training (at distance).

The greatest effect at the development and practical use of the means of training in the basis of the diverse traditional and innovative IEE of ART systems is achieved, when the specified principles work as a unique (unified) system.

The specifics of DE involves the organization of information interaction of the diverse subjects of training by the means of use of the different means of training directly in the traditional or innovative IEE of ART system, at the same time the important value has the personal initiative of the contingent of trainees, therefore the priority is given to IW in the various individual programs with the potential possibility of modification of a certain educational trajectory, and also the additional potential possibility of approbation of the innovative (high-technological) models, algorithms, methods and technologies of the presentation of the diverse information fragments in the subjects of studying is opened.

Among many organizational, methodical, technical, pedagogical, ergonomic, physiological, psychological and linguistic principles can distinguish the adaptability, flexibility, controllability (observability), the personal orientation (the individual orientation) and complexity, which are characteristic not only for the traditional (classical) education, and also directly acquire the significant actuality in the context of ART.

Many scientists in some works [12, 43] distinguish a row of private principles.

The private principles, characteristic for ART systems, include the following:

- the expediency – the substantiation of possibility, justifiability and a set of requirements and limitations to the sphere of practical use of ART systems, providing the quick solution of various didactic tasks and problems;
- the interactivity of interaction and personal initiative – the improvement of interfaces in the basis of the program realization of the various means of training, the updating of the content of disciplines and the creation of conditions, contributing IW of trainees;
- the stimulation of creative activity – the development of the means and methods of stimulating of the cognitive interest and the activity of the contingent of trainees, and also the improvement of the models and technologies of ART, used in IEE;
- the purposeful and advance education – the creation of optimal conditions for the independent formation of knowledge, abilities and skills of the trainees adequately to their future profession (a certain direction and specialization);
- the modularity and individualization – the providing of modular organization of the learning-cognitive activity of the diverse contingent of trainees, the core of which is a certain personality of the subject of training (trainee) with its different individual inclinations, features and abilities;
- the complexity and economic efficiency – involves the comprehensive accounting of the specifics of all different components of ART system, the requirements of consumers and the providing of profitability of the provision of educational products and services.

On the basis of the proposed branched system of diverse principles the general and private tasks and problems, characteristic for IEE of ART systems are solved.

The results of the theoretical and practical scientific researches of many specialists [14, 17, 18, 54, 56, 67, 79, 90, 134, 135] emphasize the need of scientific research of the information interaction between the subjects and means of training in IEE, the search of the ways of improving in the efficiency of functioning of the various ART systems, and also directly the creating and providing of various optimal conditions for the realization of the formation of knowledge and the development of the personality of each trainee.

The informatization of different of IEE of EE causes the need of consideration a wide spectrum of various scientific (theoretical and practical) aspects and initiates the selection and development of the special methods and technologies of the system analysis at the realization ART systems and the modernization of the traditional (classical) IEE.

In the given scientific work it is proposed directly the creation of IEE of ART system with the properties of adaptation based on PCMB and CMT for its system analysis, providing the increasing of efficiency of the formation of knowledge of each trainee based on IFPST (the physiological, psychological, linguistic and others).

## *1.7. The conclusions on the first chapter*

On the basis of the carrying out analysis of problem the conclusions on the first chapter is formed:

- the level of development of the modern ICT causes the potential possibility of their use in the sphere of education and science for the realization of the scientific principle of individually-oriented education (at distance) in IEE of ART system;
- the social needs in the information (post-industrial) society actualize the revision of some classical scientific provisions and bases, which are used at the creation of the innovative IEE in the modern EE;
- the rates of development of ICT is ahead the possibilities of its use in the basis of IEE, that causes the necessity of conducting of the additional scientific researches;
- the diverse priority scientific directions of the creation and development of the perspective system of education and science at the modern historical stage are allocated, according to the various social needs of the members of information society;
- the structure of the classical IEE and the essence of ICT in the science and education is considered, and also the main components, determining the specifics of the process of training are allocated (the technical, program, organizational, methodical and others);
- the appointment, the potential capabilities of the automated means of training and the ways of increasing of efficiency of IEE in the introduction of ICT are justified;
- the main historical stages of the development of ATS based on ICT, and also the kinds and tasks of the diverse automated means of training, providing the improvement of quality of the educational products and services to a wide contingent of trainees (in the various directions and specializations) are allocated;
- the essence and main scientific principles of ART, and also the innovative models and technologies of realization of the means of training are directly considered;
- IEE of a new generation are designed on the basis of the modern technologies of ART with the use of the diverse scientific principles of personally-oriented (the individually-oriented) and adaptive training (at distance), providing the potential possibility of taking into account of the various IFPST;
- the system analysis and the estimation of the efficiency of functioning of IEE of ATS system of EE initiate the necessity of carrying out of the complex scientific researches, oriented on the development of a new special approaches, methods and technologies.

## 2. The features of the structure of the adaptive information-educational environment of the automated (remote) training based on the cognitive models

The existing IEE of ART systems are practically not provide the taking into account of IFPST, that has a significant influence on the level of quality of the (re)training of specialists, therefore the significant scientific interest to the potential possibilities of the individually-oriented and adaptive training (at distance) is increased [67, 91, 121].

At the realization of the automated means of training in the basis of IEE of ART systems it is necessary to take into account a row of scientific models, algorithms, technologies and approaches, the emergence of which is caused by the evolution of purposes, tasks, requirements, presented to EE at the stage of historical development of the system of education and science [41, 56, 57, 62, 67, 90, 105, 116, 129].

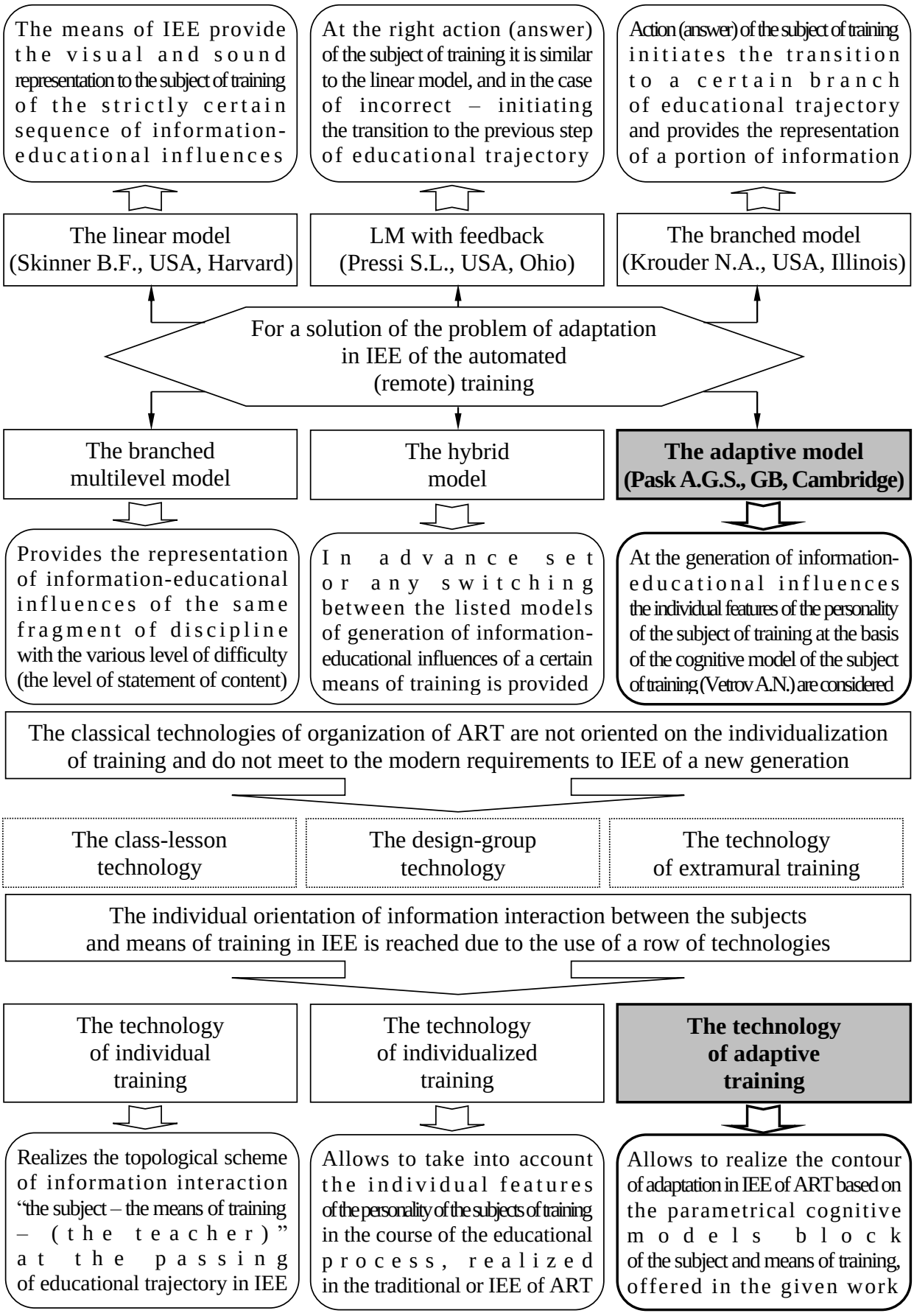
In the scientific perspective of the personally-oriented training the classical models (the linear model, the linear model with feedback and the branched model) and the principles of functioning of the means of training are losing of their actuality (pic. 2.1, above). For the solving of the scientific problem of creation of the means of training of a new generation appears a row of the new models (the branched multilevel, the hybrid and adaptive), which directly allow to provide not only the accounting of LRKT, but and IFPST.

The individual orientation of (half-)duplex information interaction between the subjects of training and the means of training in the various IEE of ART systems is achieved directly at the using of a row of new technologies (pic. 2.1, below): the individual, individualize and adaptive training (at distance).

The development and introduction of technologies of the personally-oriented training initiates the accounting of IFPST: the physiological, psychological, linguistic and others.

The creation of the contour of adaptation in IEE of ART system initiates the addition of PCMB, containing CM of the subject of training (the parameters, reflecting the various IFPST) and CM of the means of training (the parameters, characterizing the potentially possible set of types and kinds of EI, generated by a certain adaptive means of training). At the same time the application of the traditional (classical) models and technologies of organization (the class-lesson and project-group models) in the basis of IEE of ADO system with the properties of adaptation based on PCMB acquires the special scientific interest, therefore they allow directly to introduce and approbate the innovative approaches, methods, models and technologies of realization of the different kinds of support of ART.

The realization of ART with the properties of adaptation based on the innovative PCMB causes the modification of the existing (classical) IEE of ART system of EE (the addition and changing of the components, increasing the efficiency of functioning) or the creation of a new (high-technological) IEE of ART system of EE (the creation and addition of the components, increasing the efficiency of functioning), that is reflected directly on the existing or new structure of the organizational, technical, methodical and other kinds of support.

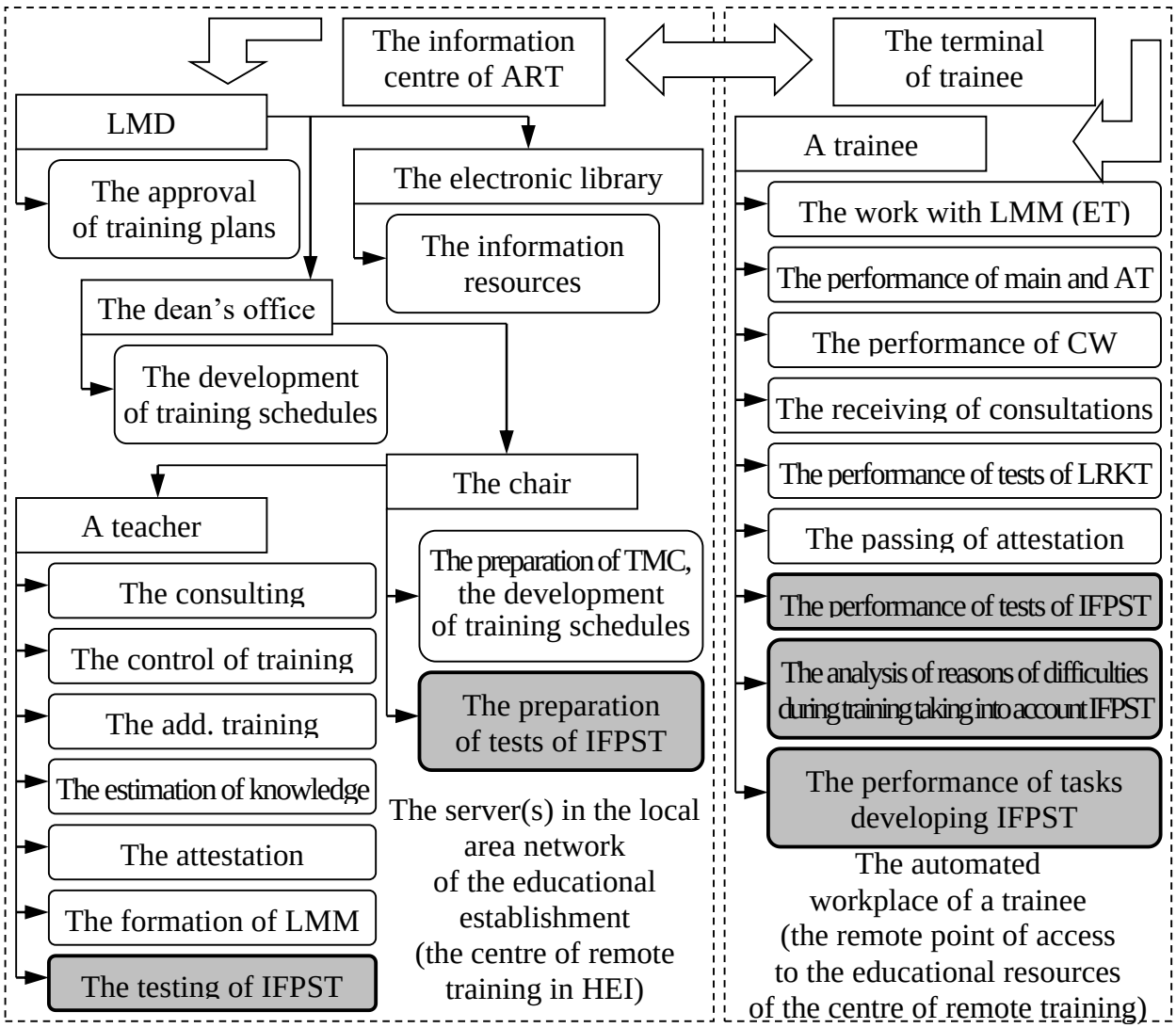



Picture 2.1. The organizational models and technologies of information interaction of the subjects of training and the means of training for the solution of the scientific problem of adaptation in the information-educational environment

## *2.1. The organization of the automated (remote) training with the taking into account the individual features of personality of the subjects*

Under *the automated (remote) training (ART)* understands the controlled process of the formation of knowledge by means of the means of training of IEE based on ICT, realizing the interactive remote dialogue (the information interaction) of the diverse subjects of training (the teacher and trainee) on their AWP with IC of EE according to a defined (re)constructed individual schedule of training, allowing directly to control the various results of IW, to change the mode of automated training (at distance) according to IFPST.

The general scheme of IEE at the organization of the controlled technological process of the individually-oriented (adaptive) ART is presented in pic. 2.2.




Picture 2.2. The features of organization of the information-educational environment of educational establishment at the realization of the individually-oriented (adaptive) automated training (at distance)

IC of a certain EE (of higher education) serves directly: the learning-methodical department (LMD), the library (EL), the denary (ED) of faculty, the chair, providing the technological cycle of automated training (at distance) on the developed complex of the various subjects of studying (disciplines) according to the approved developed (re)constructed learning plan, using for this purpose of LMC in the subjects of learning and attracting the teachers, possess of the various modern achievements of IT of training (at distance). IC of a certain EE contains AWP of the subjects of training (the teachers and trainees), DB with the details about the trainees and the results of their systematic IW in a set of disciplines, and also EL and the different means of communication with the contingent of trainees (examinees).

AWP are equipped by the means of automation of access to the educational resources IC of EE (EL) and the main (basic) components of IEE of ART system (ET and DM).

The practical use of this form of training (at distance) allows to trainees:

- the purposefully and systematically work over the studying of a certain discipline;
- the systematically controlling (testing) of LRKT and work over its increasing;
- to communicate and consult in the interest questions with the teachers by the means of use of the diverse ICT in the basis of IC of a certain EE, providing the intensification of IW at the studying of content in the cycle of disciplines.

The introduction of this form of training (at distance) will allow to the teacher (tutor):

- regularly to receive the information about the trainee and his work over the discipline, using directly his electronic record book (ERB), and also individually to consult each trainee (examinee);
- timely to correct the technological process of training (at distance), changing the algorithm of generation of the tasks in the view of information fragments (EI) with the taking into account of the current level of knowledge of the contingent of trainees (LRKT) and IFPST;
- to form the learning plans of individual classes of the contingent of trainees according to the previously determined (specified) purposes of training (at distance).

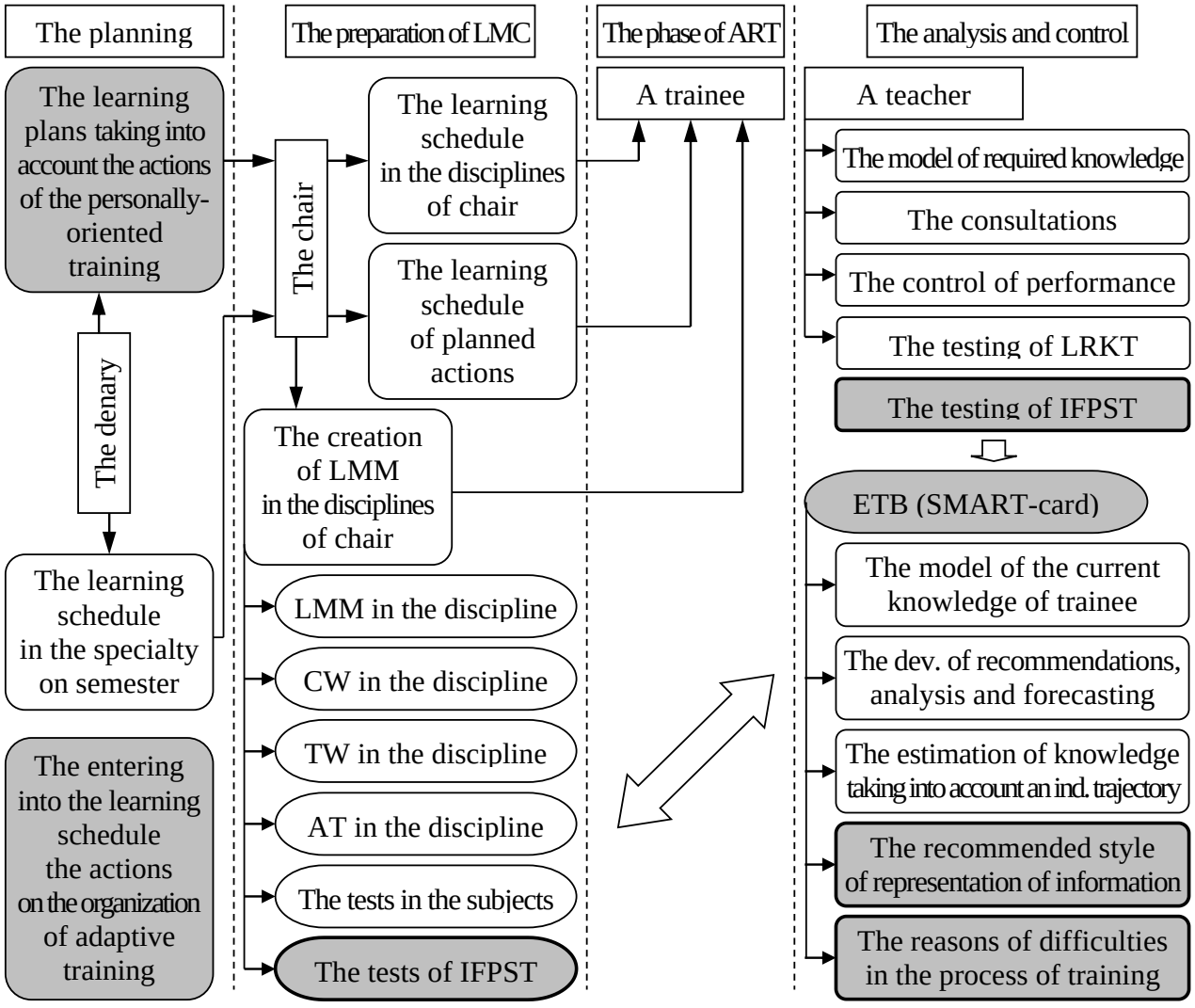
For the realization of IEE of the additional contour of adaptation based on IFPST the organizational (administrative) units need to performance a row of actions:

- IC – to provide the preparation of the methods of research (tests) of IFPST (a certain chair or a separate special subdivision of EE), to carry out the automated research (the computer diagnostics) in the form of automated testing of the different IFPST (teacher);
- AWP (terminal) of trainee – at the initial stage to perform the tests of IFPST and at the necessity the tests, developing the certain IFPST (trainee).

## 2.2. The main technological stages of the automated (remote) personally-oriented training

The process of ART – the information process, building by the principle of feedback and including a sequence of technological steps of information processing (pic. 2.3):

- the planning of the process of training on the semester – carried out by the denary (ED);
- the preparation of LMC in the subjects of studying – the formation of LMC in the chairs;
- the phase of ART in the disciplines -- realizes SW of support of the cycle of training (at distance) and the innovative adaptive means of training (ET) with taking into account of IFPST, carrying out the control of technological process of ART based on LRKT and IFPST directly in the process of IW of each trainee over the complex of disciplines, using the developed defined LMM on the paper and electronic carriers;
- the analysis and control – the teacher systematically communicates with the contingent of trainees by means of a set of the technical means of automation in IEE of ART system, and also at the personal (individual) contact with each trainee: conducts the consultations, the additional training (at distance) and the estimation of LRKT.




Picture 2.3. The modifications in the technological process of the formation of knowledge at the realization of the personally-oriented (adaptive) automated (remote) training

Further it is proposed to consider the essence of the existing stages of training (at distances) as the controlled technological process of the formation of knowledge of the trainees in IEE.

The stage of planning

The purpose of the stage – the development of the working programs in the disciplines and the learning schedule of preparation of the contingent of trainees on a semester based on the learning plan in the specialty.

It is provided by the denary (ED) of faculty, realizing the training in the specialty. For ART the learning schedule on the semester is presented the main document, in which indicate directly the deadlines of reporting-documentation on all kinds of IW of the trainee: the reception of LMM and all kinds of tasks on IW, the presentation of the results of performance of the final additional tasks (AT), the boundary controls (BC), the course works (CW) and other, and also the personal turnouts of the diverse contingent of trainees in EE in the course of semester. The learning schedule directly reflects (for the subject of training – the trainee) the typical or individual plan of the preparatory and reporting actions in the cycle of disciplines, which is awarded to each trainee in EE or sent from its IC by the channels of communication.

The stage of preparation (formation) of the learning-methodical complex

The purpose of the stage – to form LMC in all disciplines of chair and to preparate the learning schedule of IW (for the trainee) for the systematic studying of the content of disciplines.

The realization of the given stage is provided by the chair, including into IEE of ART system. The learning schedule of work of each trainee in the disciplines of chair is developed directly on the basis of (re)constructed learning plan in the specialty and contains the deadlines of presentation of the results of IW of the trainee in each discipline: the studying of diverse information fragments, reflecting the main content of parts, sections, chapters, modules, blocks, paragraphs and subparagraphs of discipline (the subject of studying) and the realization of AT, the passing BC (the current, intermediate and final control), and also the conducting of planned consultations of the teachers with the trainees by the means of use of the channels of communication (the transfer of data) between IC of EE and AWP.

LMC in the cycle of disciplines of the chair includes the special set of materials:

- the unique registration number (for the purposes of systematization and search);
- LMM on the various carriers of information (the classical and electronic);
- CC, made on the electronic (magnetic) carrier of information;
- the intermediate and final AT for the presentation to the contingent of trainees;
- a set of the different methods of research (tests) of LRKT for the basic DM, providing the capability of BC in the subjects of studying (disciplines) by means of the automated (computerized) testing of LRKT, formed at the studying of ET or LW (LMM) and the performance of AT by the trainees;
- a set of the different methods of research (tests) of IFPST for the applied DM, allowing to research IFPST (the parameters of CM of the subject of training) for the subsequent realization of the individually-oriented generation of the diverse EI at the studying of the content of LMM directly by the means of use of the adaptive means of training (ET or LW);
- the audio-visual materials (multimedia) in the subject of studying (discipline) are presented directly the different audio- and video-streams and the files with the records of lectures on the various carriers of information, in which (by the means of sounds and images) accenting the attention on the content and increasing the level of perception of the final trainee.

AT (materials) provide the formation of skills of the solving of typical exercises and tasks, and also allow to study in depth each trainee the theoretical positions, which difficult to perceive directly by the diverse contingent of trainees. The various audio-visual materials in the process of training (at distance) provide the presentation of information to the trainee in a visual and accessible form for the perception. However, only CC, are compatible directly with the adaptive representation of information fragments processor in the basis of the adaptive means of training (ET and LW), allow to realize the various methods of computer training (at distance), modeling the actions of teacher and taking into account IFPST based on the innovative PCMB.

The phase of the automated (remote) training

The purpose of the stage – to form a certain required level of knowledge of the trainees in the subjects of studying (disciplines) of the chair, using ICT of training (at distance). The technological process of ART is carried out sequentially (headway) and involves the achievement of a row of the important results: the basic and additional.

At-first, the formation of knowledge of the trainee in the course of his controlled IW with LMM and CC in the discipline by means of textual, graphical and audio-visual materials, revealing the different setting of solved tasks in the subject area, the concepts and definitions, the formulations of theorems, the algorithms of solving of the typical tasks and directly the various possible situations of their practical use. The information resources of (the adaptive) EL provide the possibility of selecting and searching of the information interest to the trainee (examinee) by the key concept, by the typical affiliation (by type), by the alphabetical index (by letter), by the table of contents (by structure), acting as the structural model of discipline, determining the optimal order of studying of the diverse information fragments.

The work of each trainee with CC on the basis of LMM is provided directly by the means of using of the innovative adaptive means of training (ET and LW), functions on the basis of the adaptive representation of information fragments processor, taking into account of IFPST and stipulates the quantification of the content of discipline on a row of information elements (part, section, chapter, module, block, paragraph and subparagraph).

At-second, the achieving of the required level of understanding of the information in the disciplines directly causes a row of significant skills of each trainee: to answer to the various questions in the theoretical part of studied material, to develop the different algorithms of solving of the typical tasks based on the studied theory and to apply them in practice in the diverse applied areas of activity.

Directly IW of each trainee on the mastering of diverse information in the volume of a certain chapter of the learning course is completed by the controlling (testing) of LRKT and him is given the recommendations on the further work with the information based on IFPST. The control results of automated testing with AWP of trainee are transmitted by the channels of communication to IC of EE and entered into ERB (in the appendix 2).

For the achieving of various purposes of ART each subject of training (trainee) operates with the means of training in IEE of ART system, performing a sequence of tasks:

1. The formation and filling by the nominal values of parameters of CM of the subject of training by means of the automated diagnostics of IFPST with the using of the applied DM:
   - the preliminary analysis of technical capabilities of the adaptive means of training, providing the adaptive generation of diverse information fragments by the various ways (methods) based on the parameters of CM of the means of training;
   - the revealing of the various nominal values of parameters of CM of the subject of training with the help of a row of different specialized methods of research (tests) directly in DB in the basis of the developed architecture of the applied DM.
2. The training (at distance) due to the using of the adaptive means of training (ET and LW), combining directly the various (hybrid) functions of ET, the book of tasks and LW:
   - the studying of the theoretical material of discipline in the process of IW of trainee with the obtaining of different explanations (clarification) and hits at the necessary;
   - the studying of scientific approaches, methods and principles of the solving of typical tasks;
   - the formation of various skills in the process of solving of the applied tasks with the step-by-step analysis of the different results of actions of each trainee.
3. The automated testing of LRKT by the means of using of the basic DM:
   - the systematic BC of the level of understanding of a set of information fragments, reflecting the content of a certain of the subject of studying (discipline) by means of the linked with it samples of questions of the method of research (test), providing directly the automated testing of LRKT;
   - the controlling of understanding in the various information elements of a certain CC, the results of which are recorded directly in ERB on the carrier of information, and the trainee is given the recommendations on the further work with the learning course;
   - the revealing of a certain level of proficiency in the various developed skills at the solving of the typical and applied tasks by the means of using of the book of tasks and LW.

The work of each trainee with the adaptive means of training (ET and LW) provides the formation of a certain model of required knowledge (MRK) in the special mode of adaptive training (at distance) according to the conceptual-essential model of discipline and the algorithm of training (at distance), specifying directly a certain sequence of displaying of the information elements of discipline, clarifications, the causes of difficulties and the presenting of the prepared (in advance) samples of questions of the method of research (test) for the realization of the automated current (intermediate) and final BC.

Simultaneously with the studying of diverse material of LMM by the means of using of the adaptive means of training (ET and LW), the trainee fixes the acquired knowledge, performing AT according to the working program of the subject of studying (discipline) on a semester. The results of execution of the main program of preparation and AT in each discipline, and also the results of work with the different information resources of (the adaptive) EL reflect the ability of trainee to use the accumulated knowledge in the practical activity. The final BC allows to define LRKT in each subject of studying (discipline) by the means of using of the basic DM and to record the result into ERB (in the appendix 2).

At the stage of BC the automated analysis of the understanding of information at the level of various information elements of the subject of studying (discipline) is carried out. ERB contains the results, allowing to judge about the achieved level of understanding of the information fragments (part, section, chapter, module, block, paragraph and subparagraph) of LMM. The control of understanding of the information elements of the subject of studying (discipline) is realized directly by the basic DM at the automated testing of LRKT or directly by the teacher on the examination in the subject of studying (discipline).

The adaptive means of training (ET and LW) provides the support of the cycle of training, combines the functions of the book of tasks and LW, including the setting of tasks and the methodical manuals to the performance of laboratory works, developed on the basis of LMC with the taking into account of MRK.

At-third, the rational organization of IW of each trainee increases the efficiency of developing of the abilities and skills of solving of the typical tasks, applying the accumulated knowledge in the adjacent subject areas, causing the potential possibility of creation of the mathematical models of diverse studying objects, processes and phenomena, the formation of various formal description and the setting of the different tasks of research, the development of algorithms with the using of a new methods of solving of the diverse tasks, the iterative analysis of the obtained results of solving of tasks with the purpose of formation of the recommendations on the refining of the mathematical model and the selecting of actual parameters, accenting the essential attention on the specified requirements and limitations at the solution.

The adaptive means of training in the given case is acted ET and LW, realizing the displaying of information and the forming the task to the laboratory work in the process of the (adaptive) interactive information interaction with the trainee, the performing of which is directed directly on the solving of different applied tasks and requires the providing of the making of local (secondary or auxiliary) decisions.

The estimations of the results of performance of the laboratory works in LW are added into ERB.

In the process of automated studying of the subject of studying (discipline) each trainee according to the individual schedule of classes can send (by the electronic mail) the messages to the teacher with the purpose of receiving of the recommendations for the increasing in the efficiency of formation and the using of the obtained knowledge in practice.

The teacher by means of the systematic testing of LRKT and IFPST reveals the causes of difficulties in the perception, processing and understanding of information fragments in the discipline, that allows to modify LMM and the algorithms of ET, to improve the organization and technology of ART, and also to recommend the possible directions of professional activity of the contingent of trainees.

At-fourth, the development of the different abilities and skills of solving of the applied tasks in the problem environment by means of the performance of various practical tasks and CW allows each trainee to study the diverse (innovative) scientific approaches to the research of objects, processes and phenomena in the subject area (the problem environment), to select a certain method of research and to develop the algorithms of solving of tasks, to apply a variety of SW for the statistical, mathematical and engineering calculations.

The individual learning plan and the technical task to CW (issued to the trainee) cause the necessity of studying with the available methodical manuals, the selecting of the special and reference literature in the (adjacent) subject area.

At this stage the work of trainee is supported by the methodical manuals to CW, the list of necessary literature in the adjacent subjects of studying (disciplines) and the various automated (adaptive) means of training (ET and LW). The results of performance of the different CW are formed according to the presented requirements, are submitted for the consideration (control) directly to a certain EE personally (in person) or are forwarded by the means of use of ICT in IC of EE, and the various obtained estimations of trainee are recorded into ERB on the carrier of information.

The conclusion stage

The purpose of the stage – to form the combined presentation about the academic-performance of trainee at his IW in IEE of ART system and to help him to eliminate the academic debts.

At the conclusion stage the appearance of trainee in EE completes the cycle of training (at distance) according to the individual learning plan of preparation and the learning schedule of training.

The aggregative presentation about the achieved LRKT is formed directly on the basis of the following details, located in ERB of trainee (in the appendix 2):

- the general information, contained in ERB (L.F.P., age, gender and other);
- the results of research of IFPST, acting as the parameters of CM of the subject of training and the formed conclusions on their basis about the features of each trainee;
- the estimations, obtained in the course of testing of LRKT in the subjects of studying (disciplines);
- the comparison of MRK, formed directly by the various teachers by the means of use of LMM and LRKT in the cycle of the subjects of studying (disciplines);
- the results of performance of AT and the protection of CW with the using of the means of automation of ART;
- the other results of passing of the individual learning plan of trainee and the performance of diverse planned actions included in it (the work of trainee with EL, the performance of BC with DM, LW, the book of tasks and other).

On the basis of this information LRKT is considered satisfactory, if:

- the results of performance of BC, AT and the final testing by the contingent of trainees at least then in 70% of cases are estimated directly as positive;
- the results of proficiency and understanding of the diverse information fragments in the information elements of discipline are estimated as positive;
- the results of performance of the practical tasks and LW are estimated as positive;
- CW is protected by each trainee with the estimation at least satisfactorily.

The information about the time, spent by the trainee on the performance of each AT is secondary and is taken into account at the giving him the recommendations by the teacher on the consultations for the preparation to BC and the final (automated) testing (examination).

If in accordance with the formulated above criteria (requirements), LRKT is estimated directly by the basic DM as unsatisfactory, then making the management decision in relation to a certain trainee, should be taken into account and all rest (other) indicators of his work in the course of semester, including the compliance of the deadlines of reporting-documentation, the quantity of working (learning) time, spent on the studying of discipline, the using of computer consultations and others.

If a certain trainee diligently worked by the approved learning plan, and the automated diagnostics (in the form of testing) of IFPST reveals his inability to concentrate the attention, the lack of a constructive way of thinking, the poor preparation in the various main subjects of studying (disciplines), then, it is obvious, that an attempt should be made to the additional training (at distance) with a subsequent (automated) estimation of the achieved results by the trainee. The positive resultativity of training (at distance) is characterized directly by the estimation not lower, than "satisfactory" and indicates about the admission of trainee to the examination, and otherwise the denary (ED) makes the decision about the repeated training or expulsion.

## 2.3. The software of the automated training

IC of a certain EE provides the support of the personally-oriented model of the controlled technological process of training (at distance) directly with taking into account the existing specifics of organization (pic. 2.2) and technology (pic. 2.3) of ART based on the practical use of a wide set of various CC, LMM, the automated means of training (at distance) and the auxiliary SW based on IEE.

SW in the basis of IEE of ART system are differentiated into four main groups:

- SW of planning and control (in relation to the educational trajectory);
- SW of support of the controlled technological process of training (at distance);
- SW of the support of functioning of the equipment of data transmission by the channels of communication between the diverse subjects of training and the means of training in IEE of ART system;
- the (adaptive) EL, which contains the various information resources.

The first group of program means – SW of planning and control

The given group of the means of automation provides the support at the organization of IEE, the planning and control of the technological process of training (at distance). The necessity of storage, ordering and processing of a large volumes of information of the various type initiates the creation of (the distributed) data bank in the basis of ART system.

The (distributed) data bank acts as the information warehouse of different data, structured in dependence from its purpose appointment (the practical application):

- the (individual) calendar and learning plans in the discipline (specialty);
- the structured material by a teacher in the discipline (MRK) – LMM;
- the methodical manuals to the performing of different laboratory and practical works;
- the information about the used means of training (ET, DM, LW and the book of tasks) and the packages of applied programs of the special appointment ("SPSS" and "ArchiCAD");
- the model of the current knowledge of trainee, formed in the result of training;
- the information about the resultativity of training (at distance) in the complex of disciplines.

The presented diverse information allows to choose directly the organizational, methodical and technical support of the technological process of ART.

The distributed architecture at the realization of the data bank of ART system of EE is caused by the consumer needs of users of the different categories, which are acting the diverse subjects of training in IEE of ART system and the various divisions of the basic EE and its regional representative-offices: LMD, the dean's offices (ED) of faculties, the chairs, the teachers, the trainees and entrants.

Each division of EE provides the solution of assigned functions and tasks, by processing a part of the information, expressed in the form of data from the common data bank, using the distributed mechanism of access to the various information resources and directly the control system of the different (main and reserve) DB.

In the basis of the architecture of data bank of ART system is based on the distributed principle: it includes the main data bank of the basic EE and the data banks, located in IC of the territorially remoted regional representative-offices and consulting centres. IC of each regional representative-office of EE contains a certain data bank, consisting from DB of the dean's offices (ED) of faculties, DB of chairs, DB of teachers and the corresponding to them AWP, including directly into the unique IEE of ART system.

Consider the appointment of the components of data bank and the functions of divisions, included in IEE of ART system of EE (the regional representative-office) on the example of HEI.

DB of faculty is formed and modified directly in the denary (ED) on the basis of the acting educational standards in the disciplines (specialties) and contains the (individual) learning plans for the entire period of training (at distance), approved by LMD, the basic accounting information about the trainees and their ERB, reflecting the personal details, the estimations of LRKT in the subjects of studying (disciplines), and also IFPST, allowing to carry out the scientific researches of IEE of ART system for the introduction of new IT for the support of the technological process of training (at distance).

The knowing of IFPST provides the adaptation of the models and algorithms of functioning of the automated means of training in the basis of IEE with the taking into account of the specifics of the subjects of training. The automated diagnostics of IFPST is realized by means of the applied DM on the basis of the specialized methods of research (tests) after the entering of trainee into EE, and the nominal values of parameters are taken into account by teachers in the process of training.

DB of chair contains the calendar learning plans of training (at distance), built directly on the basis of the (individual) learning plan, the (individual) semester schedules of work and the programs of the subjects of studying (disciplines). On each discipline, assigned to the chair, the following information is formed: the purposes and tasks of discipline, the thematic plan of lectures, the description of interdisciplinary relations, the plan of laboratory works, the plan of practical lessons, the details about BC and CW, the plan of individual work of trainees with the means of training and teachers, the list of the recommended sources of literature, the basic and additional LMM and CC. The listed information-educational elements act as the important basis for the formation and estimation of MRK in the existing cycle of the subjects of studying (disciplines).

ERB acts as the expanded model of the current (residual) knowledge of trainee, formed by means of the data transmitted to IC of EE from AWP of trainee, reflecting the results of work with the means of training and the performance of BC, AT, CW and other.

The data of ERB is available for the viewing in the various divisions of EE.

DB of teacher contains the schedule of IW of the subjects of training with the means of training and the conducting of scheduled consultations by means of the exchange of information messages, transmitted by the channels of data transmission (communication) between IC of EE and each AWP. At the same time the subjects of training receive a row of the basic and additional possibilities: the trainees as the subjects of training – ask the questions on the extend of performance of AT, CW and BC, the teachers as the subjects of training – carry out the monitoring of IW of trainees and send the various typical variants of solution of the previously given out AT and CW.

DB of teachers provides the access to the information on AWP of teacher, which provides the monitoring of obtained estimations of LRKT in the disciplines, saved in the course of the period of time of the studying of each discipline.

DB of denary (ED) and DB of chair are conditionally static (do not change), and the information of DB of teacher dynamically changes in the process of training (at distance). AWP of teacher and trainee act as the main links of the learning process.

The data banks, located in IC of the territorially distributed representative-offices of the basic EE mutually duplicate (reserve) a part of information at the level of various DB.

DB in the structure of the main data bank of IC of EE provide the transfer by the channels of communication and the storage of content of the various information resources of IEE of ART system: the elements of LMC, the learning schedules, the schedules of planned consultations with the trainees.

AWP of trainee provides the saving of the local variant of ERB of trainee, in which registering the list and result of all passed BC and the reporting actions, provided by the typical (individual) plan of training (at distance).

Periodically the data of ERB is transmitted into IC of EE and entered into DB of teacher, which can control and correct the technological process of training.

The special procedures carry out the support of data bank of IEE of ART system, provide the processing of diverse information in the local (subordinated to it) DB, realize the generation of individual plans of training and the formation of AT and CW, and also support the registration in ERB of trainee of the achieved results of training.

The internal procedures of the means of IEE of ART system have the intellectual basis:

- the automated layout of the (individual) learning plans;
- the automated preparation of the (individual) semester plans;
- the (individual) selection of LMC and the development of the methods of research (tests) of LRKT.

The second group of program means – SW of support of the cycle of training

The automated training (at distance) – the stage of IW of trainee over the discipline with the using of the different automated means of training (ET, LW and DM) and LMC.

The most important component of IEE of ART system is directly the adaptive ET, functioning on the basis of the adaptive representation of information fragments processor, including the means of automation of the filling of MRK in a row of the subjects of studying (according to the (individual) learning plan, the working programs of disciplines and the schedule of working of each trainee from the contingent of trainees with ET) and the controlling of the technological process of training by the principle of feedback (the generation of diverse information fragments with the tasks of trainee, the control of LRKT with the formation of the model of current knowledge and carrying out of ERB of trainees). The saving and extracting of information is realized by means of the data bank of ART system.

The paramount importance at the same time has the quality of LMC, used in ET, LW and DM, created on the basis of technologies, modelling the teacher and the methods of estimation of LRKT, providing the direct control of the technological process of ART, creating the effect of presence of the teacher in the course of IW of a certain trainee. The automated means of training give to DE some average position between the intramural and extramural form of (the automated) training (super-position). IW of trainee at this stage is underpinned by the planned and unplanned consultations with a certain teacher by the tele-communication channels of data transmission. The details about the results of work of trainee at the stage of training (at distance) is entered into ERB.

The third group of program means – SW of interaction of the subjects and means of ART

For the support of ART to the trainee needs to provide a row of possibilities:

- the delivery of the main and additional material by the channels of data transmission;
- the interactive informational interaction with the teachers in the process of ART;
- IW of trainee with the various information resources of the basic EE, in particular the access to the global information warehouses through IC of EE.

These capabilities are created by the means of realization of the following network information services:

- the reception and transmission of messages by the electronic post (Email) realizes the mode "OFFLINE" at the exchanging of information messages between the subjects of training in the process of information interaction by means of the means of training based on ICT;
- the exchange of informational messages in the mode of real time "ONLINE";
- the remote access to the information resources of IC of training (at distance);
- the work of the terminal points (AWP) of the subjects of training with the distributed information resources, provided by IC of training (at distance).

The organization of DE proposes the creation and use of the distributed system of information resources of the educational appointment, available by means of ICT. This causes the connection of the internal (local) computational network of IC of ART to one from the existing external (global) tele-communication networks. The connection of IC of (the innovative) EE to the computational network is carried out in the context of the informatization of (the traditional) IEE. The open access provides the operative receiving of necessary information for the support of the technological process of training and scientific-research work, and also allows to use directly the video-conferences (tele-conferences). The use of high-speed highways realizes the exchange of video-information in the real time, which is the most effective for the perception by the human.

The fourth group of program means – SW of support of the electronic library

EL acts as the specific (distributed) data bank, located directly on "WWW"-server and containing the various catalogs, the descriptions of information materials, including the name, authors, short annotation, the electronic variants of learning manuals, CC, ET, LW and the blocks of the methods of research (tests).

DB of (the adaptive) EL are realized as the diverse important components of the common (distributed) data bank directly in the basis of IEE of ART system, and the open access with the information elements of differentiation of the rights of users allows to use a wide nomenclature of various information resources.

For the introduction of the technologies of ART is needed to execute a row of basic conditions:

- the development and realization of the given technology of support of the process of training;
- the creation of the developed system of learning-methodical and computer support of the process of ART by means of the various means of training (at distance) in IEE;
- the creation of data bank in IEE of ART system and the flexible control system of DB;
- the availability of internal (local) computational network of EE, connected to the various local, regional and international computational networks, providing the open access to the various information resources.

## 2.4. The automated training as the information process

The developing (in the present time) IT of training (at distance) is intended for the support of IW of trainee and obeying to the regularities of educational process.

The training (at distance) is considered as the difficult information process of the controlled formation of knowledge of the subjects of training by means of the means of training. The subjects of training as the controlled technological process can acts: the individual (person), the group of individuals or the system of artificial intelligence, imitating a certain model of activity of the subject of training of IEE of ART system. The knowledge is considered as the derived active information (the form of information), capable to generate a new information in the process of thought activity of the subject. The knowledge is based on the declarative and procedural (algorithmic) part of information, located in some environment (brain and the model of brain), capable to activate both components.

The information process includes a sequence of information operations. The information operation is based on the algorithm, the input and output information. The various information operations are distinguished: the difficult and simple (trivial). The difficult information operations can be decomposed into the other less difficult and a row of simple information operations (logically not decomposed). In the information process allocate the stages as a set of information operations, having a certain general purpose appointment in the information process.

In the process of functioning of the digital machine the processing of discrete information is carried out, the logical or arithmetic operations are realized, that causes the necessity of temporarily storage of the intermediate and resulting values of the various operands in the period of execution of the operation.

In the combination schemes with the memory of condition the resulting condition after the arrival of some input influence (value) changes and then is stored until to the moment of arrival of a new input combination, at the same time the response of scheme on the input influence is determined by the internal condition, which is characterized by a set of the values of several variables (operands).

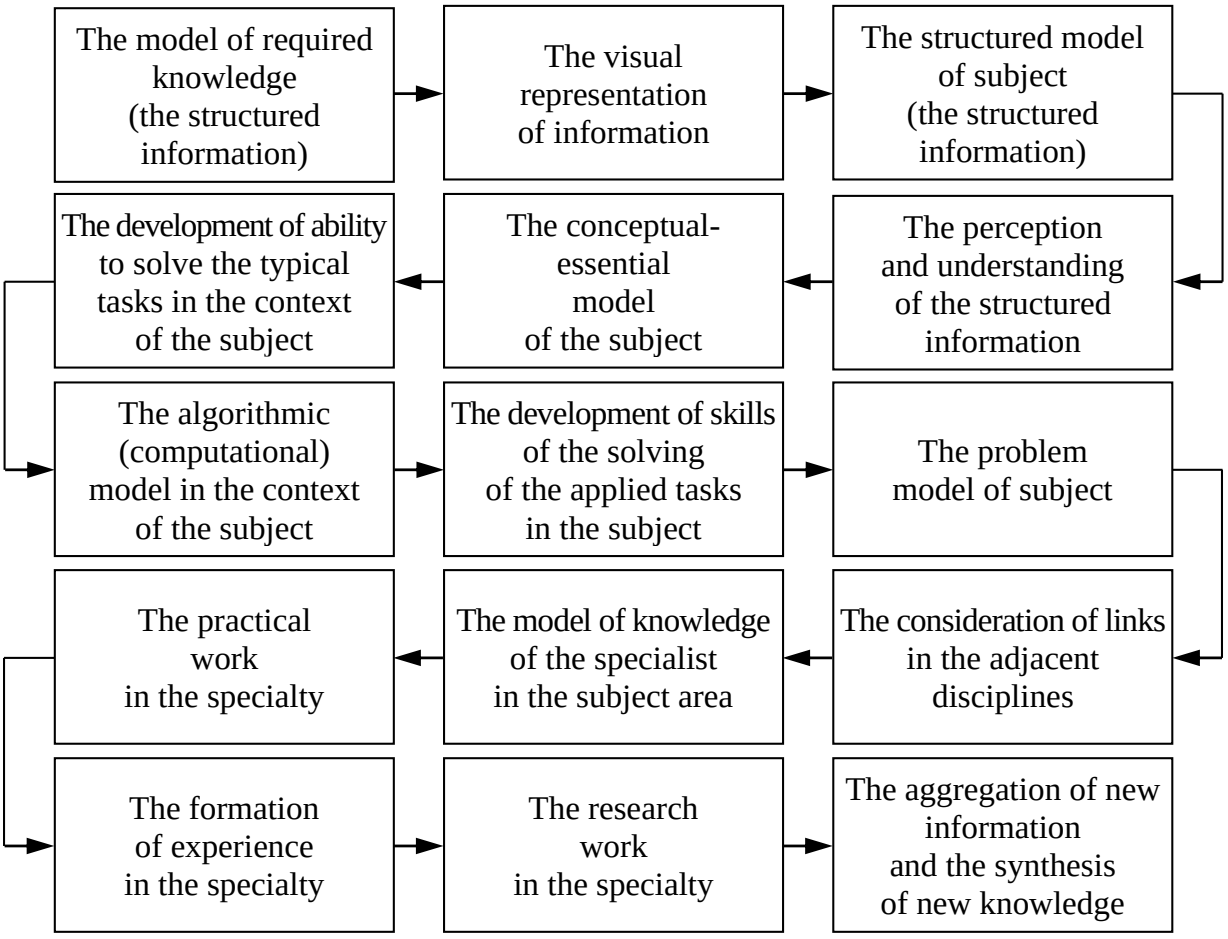
The mathematical model of the combinatorial scheme with the memory of condition is the digital machine, which is described by the system of logical functions.

The time diagram reflects the dynamics of changes of conditions of the levels of signals on the outputs of the arithmetic or logic device in dependence from the combinatorial combinations of the levels of signals on its inputs, at the same time a certain hardware realization of the device is represented in the view of the electrical principial circuit or the functional scheme.

Each time diagram contains in its basis the several various graphs of functions of the continuous or discrete time, which reflect the dynamics of the switching of conditions on the outputs of a certain arithmetic or logic element (device) in dependence from the levels of signals on its specified inputs.

### 2.4.1. The features of the structure of the technological process of training and the levels of the representation of knowledge in the information-educational environment

The formation of knowledge of the trainee as the subject of training (at distance) is the significantly difficult controlled technological process of transfer of the previously structured knowledge by the teacher into the consciousness of trainee by the means of use of the components of the automated IEE of ART system, the structure of which is presented directly in pic. 2.4 [101, 102, 103, 30, 31, 32, 100].




Picture 2.4. The stages of the processing of information
in the process of the formation of knowledge of the trainee

The process of the formation of knowledge includes a row of stages of information processing by the trainee, and the presented structural scheme contains the several its main levels (formations):

- the visual representation of information (the displaying of the content of the subject of studying);
- the perception, understanding and formation of the theoretical and practical skills to solve the typical and applied tasks in the subject of studying (discipline);
- the ability to select the interdisciplinary relationships in a cycle of the different subjects of studying;
- the development of experience of the conducting of scientific-research work in the specialty.

Here also can allocate a row of different semantic (sense) models, formed in the consciousness of each trainee in the process of training (at distance):

- the structural and conceptual-essential model of the subject of studying (discipline);
- the algorithmic (computational) model of the subject of studying (discipline);
- the problem model of a certain subject of studying (discipline);
- the model of the knowledge of specialist and the various expertise in the area of specialty;
- the new knowledge as the final result of scientific-research work.

The quality of perception and understanding of the diverse information influences on LRKT, causes the potential ability of determining of the purpose appointment and the search of actual information in the content of the subject of studying (discipline). The understanding is the level of knowledge, consisting in the potential ability to explain the relationships between the concepts of the subject area and their properties.

The ability to solve the diverse typical tasks is the level of knowledge, consisting in the ability to build the computational scheme of solving of the typical task.

The ability to solve the applied tasks in the subject of studying is the level of knowledge, consisting in the ability to decompose the applied task into the typical tasks, forming their mathematical statements (the correct formal descriptions), to interpret the final results of solving of a certain applied task proceeding from the main purposes of the initial setting of task in the subject area, that allows to the trainee to form the practical skills of solving of the applied tasks.

The ability to the system analysis of the interdisciplinary links depends from the level of knowledge, allowing to use the diverse adjacent subjects of studying (discipline) for the solving of the various applied tasks in the given subject area, providing the complex scientific approach to the solving of problems (the complex tasks).

The formation of the high level of theoretical knowledge and practical skills is achieved on the basis of the different scientifically-justified methods and technologies of ART, allowing to introduce the new ways of representation of the material with taking into account of IFPST by the means of use of the structural (semantic) models of the subject of studying.

### 2.4.2. The structural (semantic) models of the representation of knowledge and the semantic programming in the automated training

*The structural (semantic) model of the subject of studying* is oriented on the presentation of the sense content in the context of a certain level of statement and realized outside the consciousness of a certain subject of training (trainee) by some formal apparatus (the model of presenting of the structured data).

The technological process of training (at distance) presents the controlled transfer of the content of the structural (semantic) models of the subject of studying from the consciousness of teacher into the consciousness of trainee as the diverse subjects of training.

The computer support of this process involves the creation of the models: from the side of teacher – MRK (the structured information in the discipline), and from the side of trainee – the model of current knowledge (characterized by the estimation of LRKT).

*The semantic programming* – the procedure of creating and using of the various structural (semantic) models of the subject of studying (discipline), the structure of which describes the diverse concepts by means of a row of frames: the purpose, classification, sense (semantic), directive and others.

The purpose frame – aggregates a set of source and current purposes of training (at distance).

The classification frame – arranges the key concepts of subject area under the basic concept, which acts directly as the identifier of frame.

The sense (semantic) frame – the blank for the describing of diverse concepts in the natural language, containing the various input and output arguments.

The directive frame – the specifying to the subject of training (at distance) on the carrying out of action by the means of displaying of the terminal text (the information fragment).

The elementary frames are located at the various level of allocated hierarchy, a set of which presents the structural (semantic) model of the describing of concepts on a limited subset of a given natural language, which is represented in the view of the oriented graph or the structural scheme.

The task of teacher or the system of the extraction of knowledge is respectively in the possibility of statement of the material in the certain language and the level of difficulty and the saving of it by means of the semantic model, including a set of frames.

## 2.5. The structure of the automated adaptive training as the controlled process of the formation of knowledge of the trainee

The process of the formation of knowledge of the trainee (presented in pic. 2.4) includes a row of stages (the technological gaps) and is characterized by the purpose of control (training).

By the input of the controlled technological process of the formation of knowledge is MRK, formed directly on the basis of the tree of the purposes of training (at distance), and the output – the model of current knowledge in the consciousness of a certain trainee in fact of the completion of tasks and clarification of the teacher (the means of training). The diverse learning tasks and clarifications perform the specific role of the various information-educational and control influences.

The control of the formation of knowledge is occurred by the principle of feedback: the learning tasks and clarifications are developed by the teacher (the means of training) directly proceeding from a certain purpose of training (at distance), based on the comparison of MRK of teacher and the model of current knowledge of trainee. The last is formed in the consciousness of teacher (the system of artificial intelligence) on the basis of the control of the results of performance of the learning tasks by each trainee by the way of their comparing with the correct (reference) results of teacher, which are generated by the teacher (the model, reflecting the method of estimation of LRKT) in a certain subject of studying (discipline) in the subject area.

The control by the means of providing of the estimation of LRKT realizes the feedback in the closed contour of control by the technological process of training (at distance) and provides direct the achievement of the stated purposes of training (at distance).

The adaptation to LRKT on the basis of the principle of feedback allows at the necessity to return the trainee at the previous stages (the technological gaps) in the course of studying of a formed sequence of information fragments.

### 2.5.1. The features of the components of the automated training system at the various stages of educational process

The formalization of the process of training (at distance) allows to form reasonable the principle of functioning of the automated means of training (ET and LW), in which a row of functions are realized in coordination with the main and applied DM.

The considered structure with the features is the block-modular (pic. 2.5): each module supports a certain stage of the process of training (at distance), has a necessary set of diverse procedures and algorithms (of control), realizing the various operations of training (at distance) and their semantic filling.

| | | | | | | |
|---|---|---|---|---|---|---|
| The stages of the process of training | The formation of the theoretical knowledge in the discipline | The development of abilities to the analysis and understanding | The development of skills of the solving of typical tasks | The development of skills to solve the applied tasks | The control of the level of residual knowledge | The research of the individual features of personality |
| The component of the structure of RTS | The theoretical-reference module (ET and LW) | The question-explanatory module (ET and LW) | The book of tasks (ET and LW) | The laboratory workshop (ET) | The basic diagnostic module | The applied diagnostic module |
| The models of representation of knowledge | The frame and OOR model | The frame and OOR model | The frame and OOR model | The frame and OOR model | The frame and OOR model | The frame and OOR model |
| The iterations of the process of training | The fixed order of presentation of the information | The concepts and examples of the solving of tasks | The setting of tasks with the recommends of performance | The statement of experiments and the modeling of processes | The performance of tests for the revealing of the level of knowledge | The performance of tests for the research of IFPST |
| | The possibility of selection of the information by the trainee | The questions with the alternative answers | The entering of mathematical formulas | The monitoring for the phenomena, objects and processes | The estimation of LRKT based on the weight coefficients | The diagnostics of parameters of the cognitive model of the subject |
| The table of contents, pointers, the entered concept and highlighted word | | The providing of control of the performance of tasks | The entering of the algorithms of solution and graphics | The registration and analysis of a posteriori data | The formation of sheet in a set of disciplines | The revealing of the features of the perception of information |

Picture 2.5. The functional features of components of the automated (remote) training system at the different stages of the technological process of training

For the realization of filling in the subjects of studying of the information elements of disciplines makes the structural (semantic) models of the subjects of studying (disciplines), describing the purposes of the corresponding stages (the technological gaps) of training (at distance), the procedures (algorithms) and means of their achievement, the structural (semantic) models and the elementary frames (the terminal text – the information fragment).

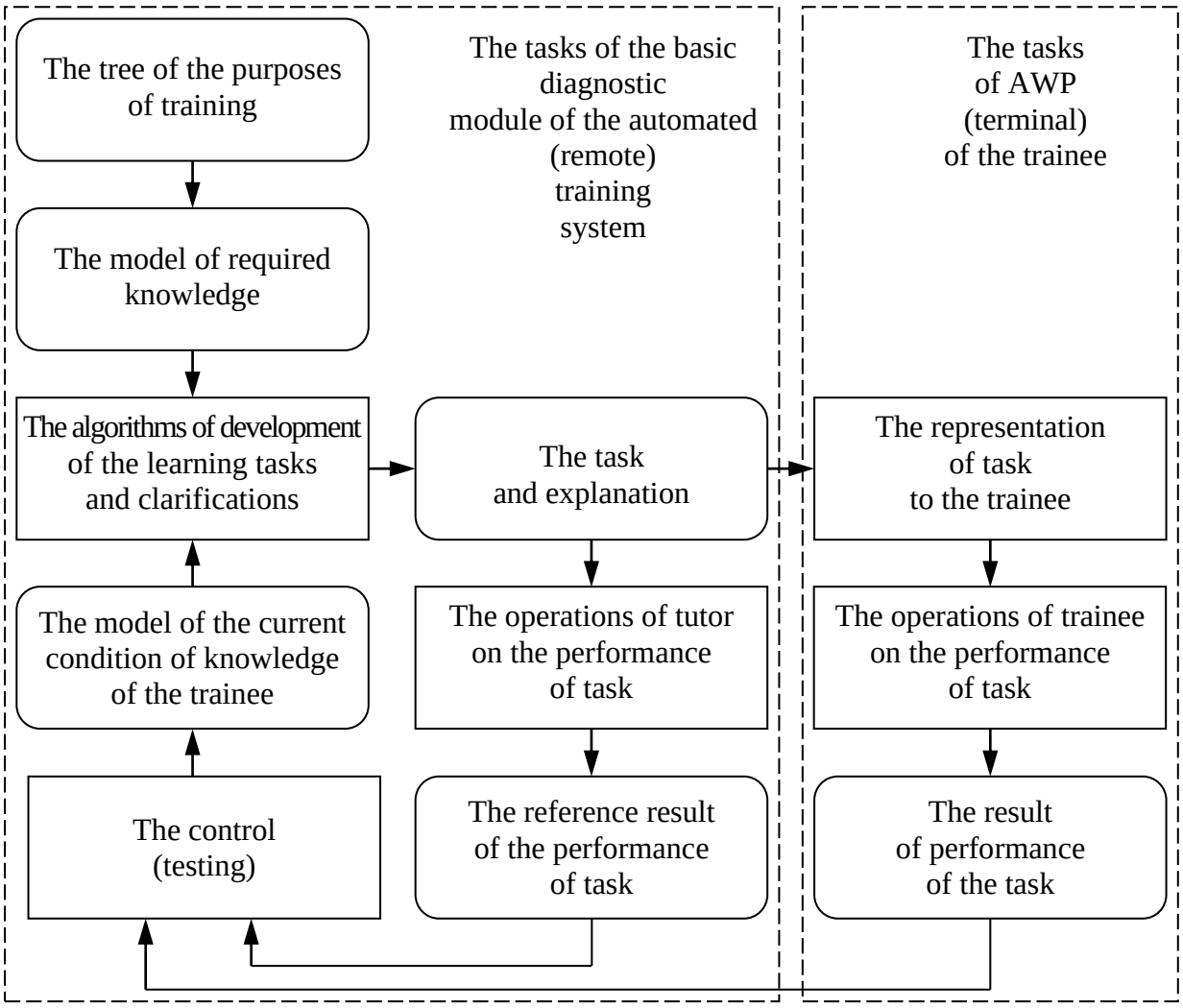
The filling by the diverse information is individually for each discipline and is realized by the means of using of the various structural (semantic) models as the specific language of the representation of knowledge (the structured data).

The structural (semantic) models of the certain subjects of studying (disciplines) together with the algorithms (procedures) in the basis of the automated means of training realize the control by the technological process of training (at distance).

Further the algorithms (principles) of functioning of the main components of IEE of ART system (the adaptive ET, LW and DM), operating on the basis of PCMB are proposed, providing the possibility of realization of the individually-oriented model of training.

### 2.5.2. The algorithms (principles) of functioning of the components of the automated training system (at distance)

The scheme in pic. 2.6 – the algorithm (principle) of functioning of the basic DM for the estimation of LRKT.



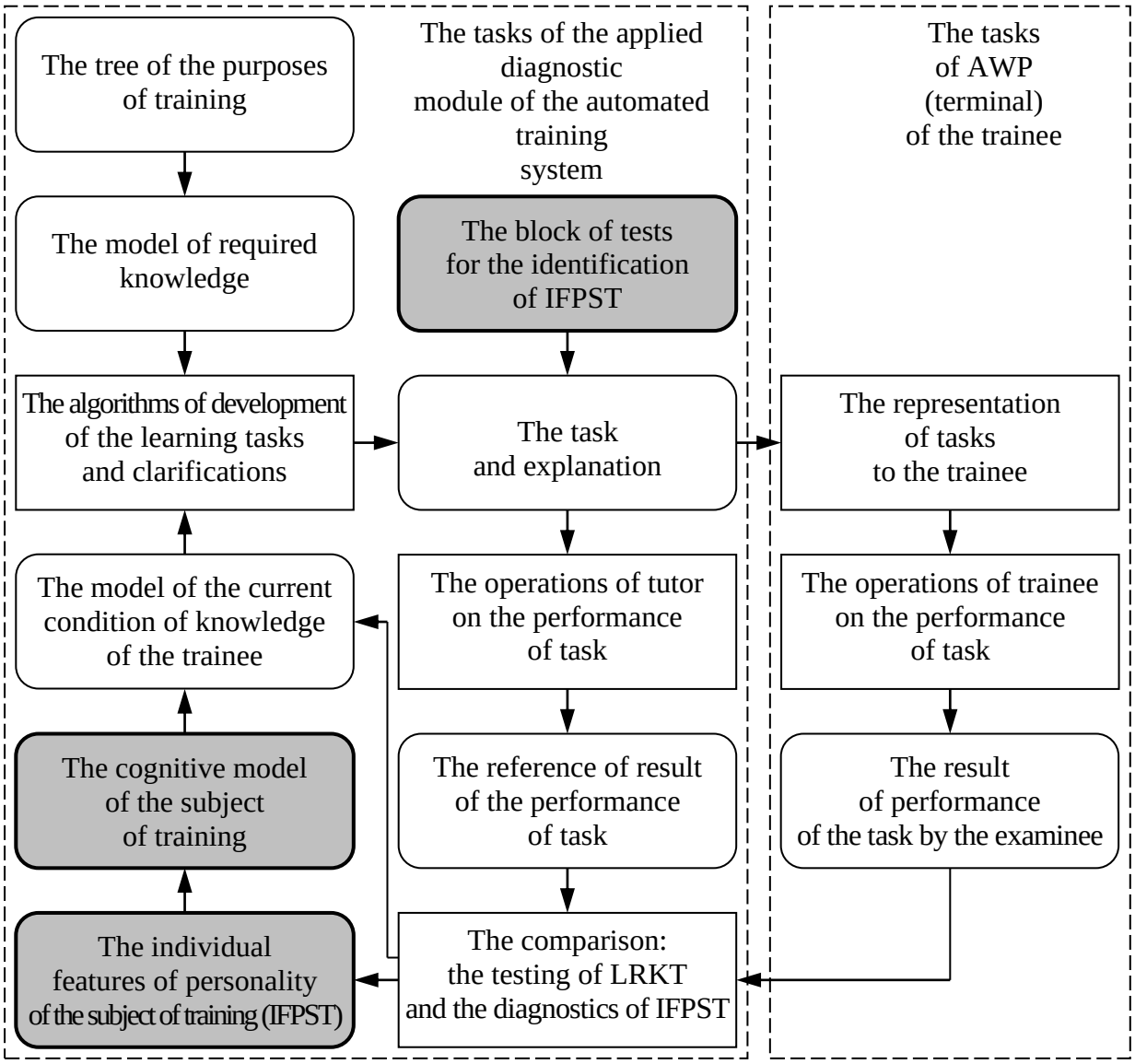

Picture 2.6. The scheme, reflecting the algorithm (principle) of functioning of the basic diagnostic module for the automated testing of the level of residual knowledge of the trainee

The training (at distance) as the controlled technological process by the principle of feedback consists from a separate operations (algorithms) and has the difficult dual character: in the course of training (at distance) the knowledge of each trainee is not only formed, but and the technological process of training (at distance) is realized according to the requirements, presented to the knowledge (LRKT) of the contingent of trainees, their initial condition, the features and abilities of each trainee (IFPST).

For the accounting of IFPST CM of the subject of training and a set of different methods of research (tests) are introduced into the structure (closed contour) for the parametrical identification of IFPST directly by the means of using of the developed applied DM (pic. 2.7).

The algorithms of control of the technological process of training (at distance) are oriented on the development of learning tasks and explanations (clarifications) and hints and depend from the used technologies, methods and techniques of training (at distance).

Orienting on the psychophysiological possibilities (the individual limitations), the trainee in each moment of time works with a limited portion of information, locating at a certain stage of the technological process of training (at distance), organized directly under the control of the teacher (the means of training). The algorithm of control in the basis of the certain (adaptive) means of training transfers the trainee to the previous stages of educational trajectory.




Picture 2.7. The scheme, reflecting the algorithm (principle) of functioning of the applied diagnostic module for the automated diagnostics of parameters of the cognitive model of the subject of training

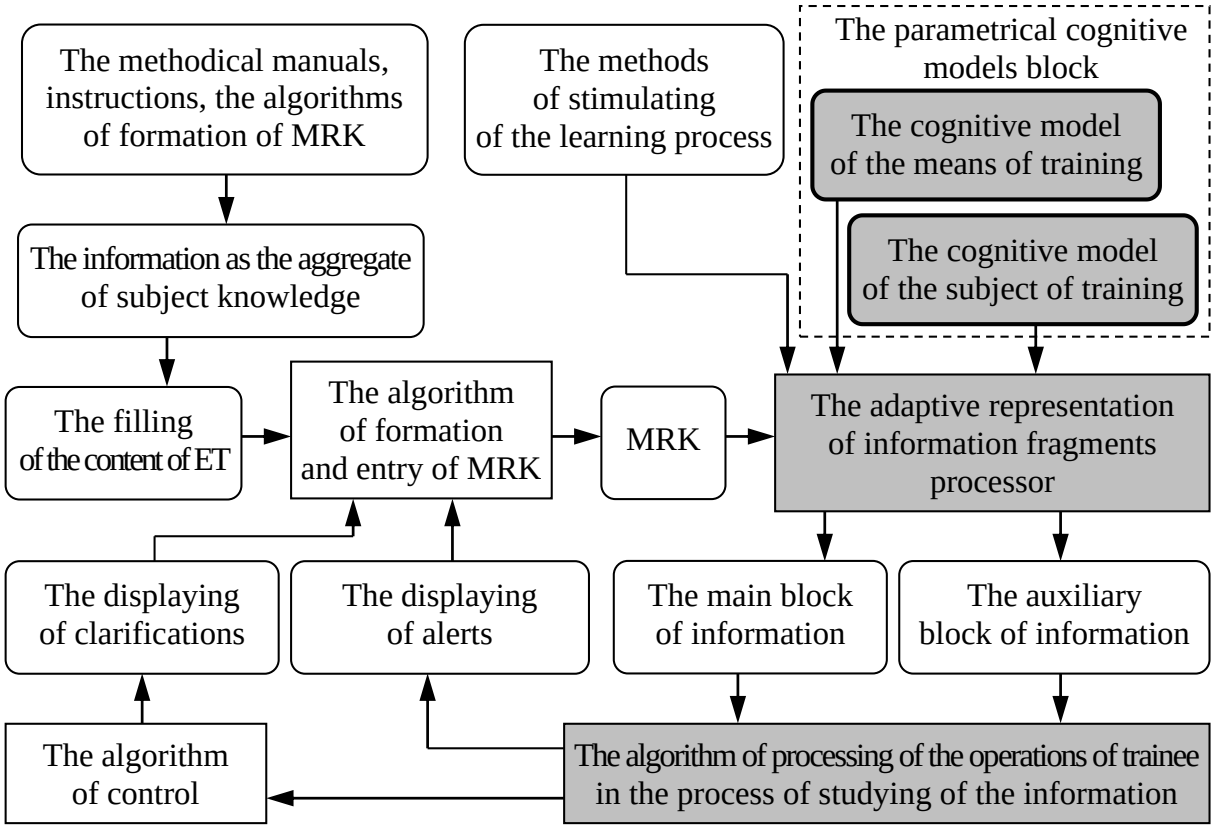
ET – the key component of IEE of ART system with the properties of adaptation based on PCMB, providing the individually-oriented formation of knowledge of each trainee.

The adaptive representation of a sequence of information fragments processor (pic. 2.8) in the basis of the architecture of the adaptive means of training (ET and LW) functions in the context of a limited subset of kinds and types of EI (the parameters of CM of the means of training), at the generation of which takes into account IFPST (the parameters of CM of the subject of training).

In the view of the internal closed contour of control the scheme of information interaction between the subjects of training and the means of training is shown directly (pic. 2.8). The input for this contour of control serves MRK in the subject of studying (discipline). This contour provides the control of IW of trainee with ET (LW) on the basis of the formed MRK.

The setting up of the adaptive ET (LW) as the means of training in the subject of training (discipline) consists in the formation of the project and the subsequent filling of the adaptive ET (LW) by the content of MRK in the accepted language of knowledge representation (the structured data).

Using by the method of constructing of the structural (semantic) models of disciplines, the teacher forms MRK, passing the entire technological chain of training, which is later offered directly to the contingent of trainees.




Picture 2.8. The scheme, reflecting the algorithm (principle) of functioning of the adaptive means of training for the automation of the individually-oriented generation of information fragments

The teacher can acts on the organization of the process of training (at distance) and directly stimulate of IW of each trainee as the subject of training, setting up the algorithms of generation of learning tasks before the session of the formation of knowledge. It seems actual to support the taking into account of IFPST at the generation learning tasks (the physiological, psychological, linguistic and other parameters). At the same time the adaptive representation of a sequence of information fragments processor, controlling by the process of the formation of knowledge of the trainee on the basis of the principle of feedback, provides the full or partial adaptation of training (at distance) to IFPST.

At the detection of gaps in the proficiency of material of the subject of studying (discipline) the adaptive representation of a sequence of information fragments processor returns the trainee to the previous stages of the technological process of training by means of the access to the information fragments of information elements of the course.

### 2.5.3. The adaptive representation of a sequence of information fragments processor based on the cognitive models

The innovative adaptive representation of a sequence of information fragments processor (pic. 2.9) acts as directly the control part of ET and LW (pic. 2.8) and is linked with DM, therefore is the universal innovative basis of ART system, providing the coordinated functioning of its diverse components. As the means of control, the adaptive representation of a sequence of information fragments processor functions on the basis of the principle of feedback by the innovative scheme of inclusion (integration) with taking into account of the diverse IFPST, but as a universal shell (the interface of interaction) it is able to process the structural (semantic) models of the certain subjects of studying (disciplines) and contains the typical (recommended) and new algorithms of training (at distance), realizing the various supported techniques of training (at distance).

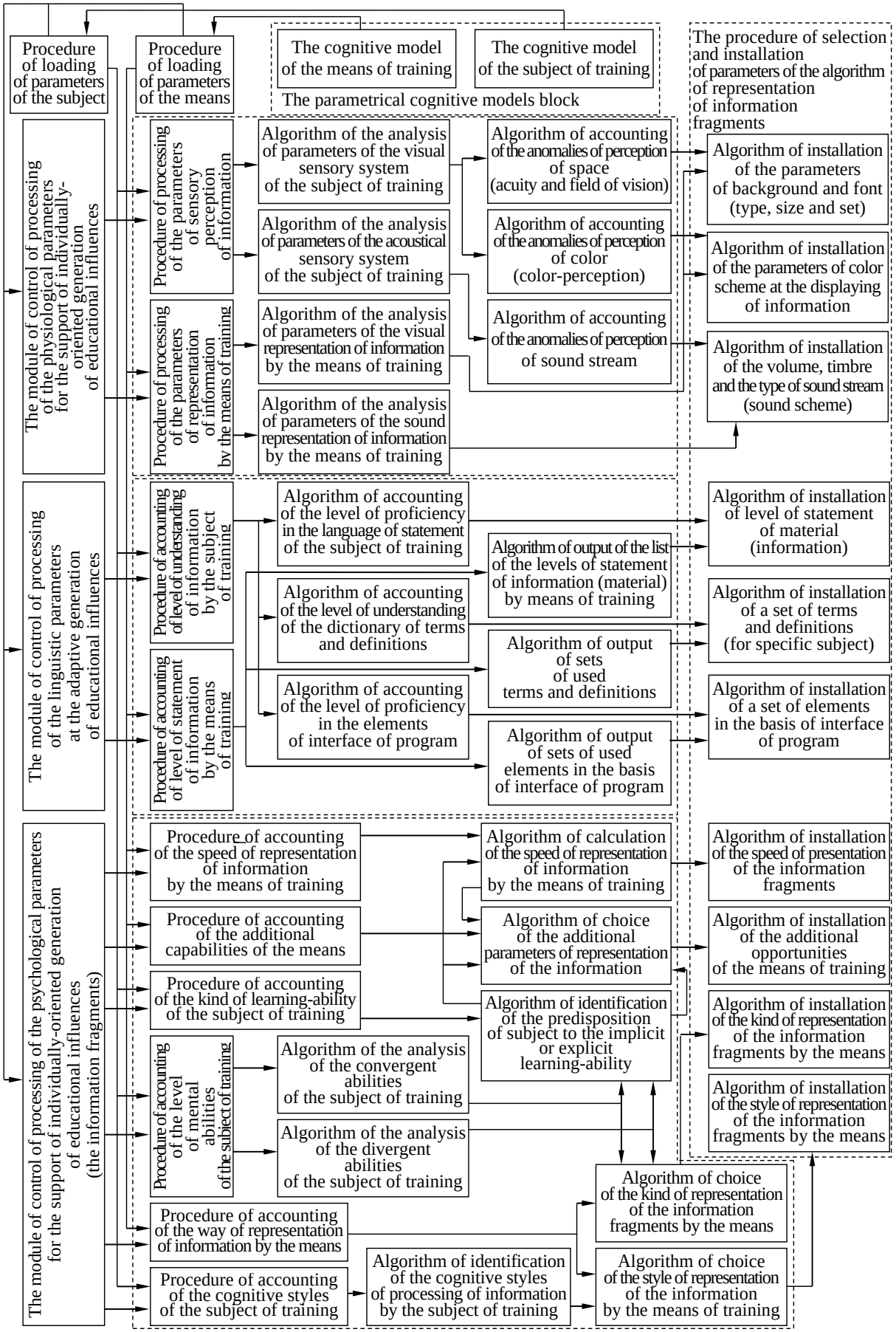
The adaptive representation of a sequence of information fragments processor is developed by the principle of parallel architecture and block-modular principle:

- the module of control of the processing of the physiological parameters – the features of the primary sensory perception of information by the subject of training and the generation of a sequence of educational influences by the means of training;
- the module of control of the processing of the psychological parameters – the features of processing of the information by the head brain of the subject of training and the generation of information fragments of a certain kind by the means of training;
- the module of control of the processing of the linguistic parameters – the features of understanding of the information fragments by the subject of training and the statement of content in a certain language by the means of training.

The procedure of loading of the parameters of the subject of training provides the loading of the nominal values of parameters of CM of the subject of training in the structure of PCMB.

The procedure of loading of the parameters of the means of training provides the loading of the nominal values of parameters of CM of the means of training in the structure of PCMB.

The adaptive representation of a sequence of information fragments processor effectively functions directly on the basis of the innovative PCMB, taking into account the diverse IFPST, and its structural scheme is presented in pic. 2.9.




Picture 2.9. The structure of the adaptive representation of information fragments processor

### 2.5.4. The bases of the technology of the extracting of knowledge of the teacher for the purposes of building of the theoretical-reference modules of electronic textbooks

The technology of the extraction of knowledge of the teacher for the purpose of building TRM of ET and LW is based on the theory of intelligent systems of training (at distance), but with taking into account:

- the formalization of training (at distance) as the difficult information process, including a sequence of stages of the formation of knowledge of each trainee, providing the achievement of the various levels of knowledge and abilities (skills): the possession of information in the subject of studying (discipline) in the subject area, the development of understanding of the essence and content of the subject of studying (discipline), the development of abilities and skills of the solving of typical tasks in the subject area and other;
- the sense description of entities (objects, processes and phenomena) in the subject area for its structuring and modeling with using of the achievements of IT;
- the organization of the technological process of training by the principle of feedback.

CMT provides the support of the technological process of training (at distance) at the stage (technological gap) of representation and mastery of the diverse information.

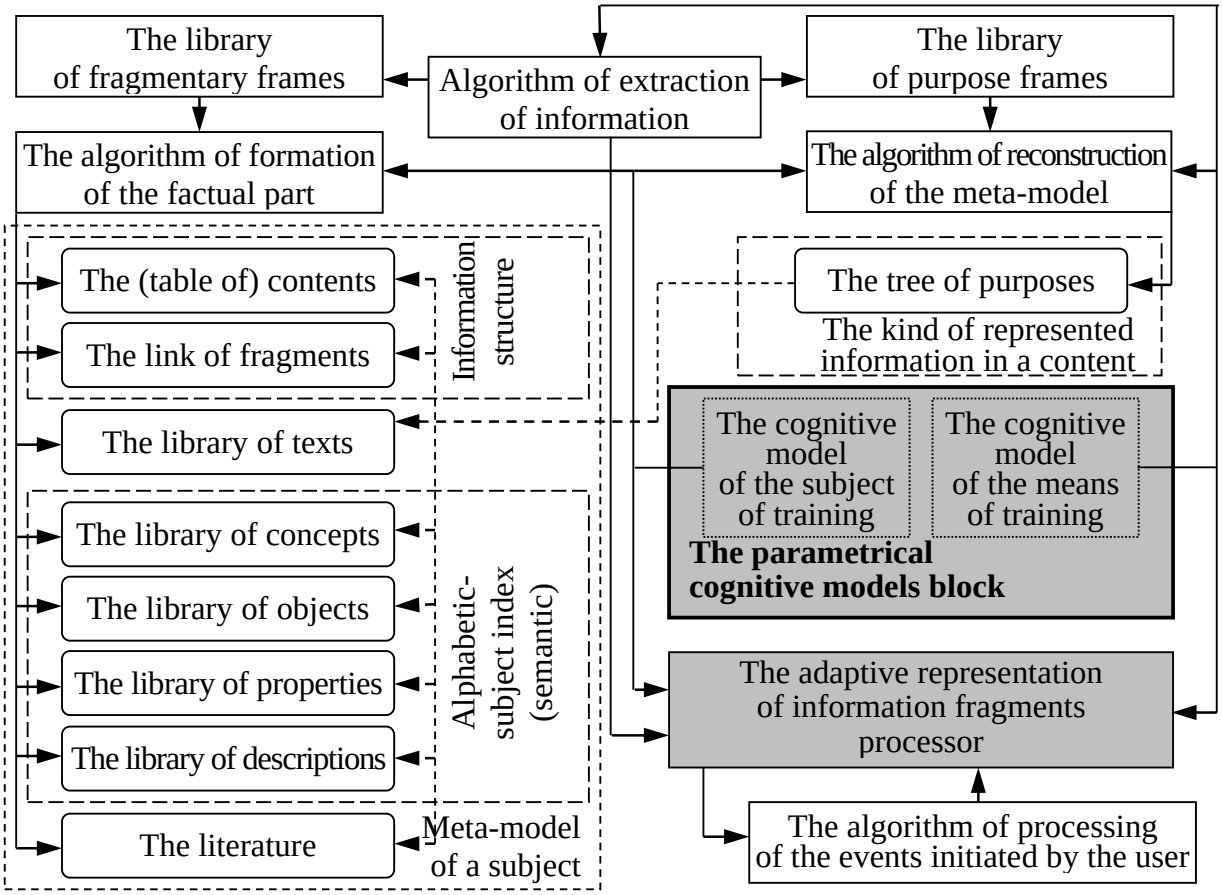
The task of creating of TRM of ET and LW can be presented as the task of building of MRK at the stage of "the mastering of information" on the basis of the structural (semantic) model. The task of extraction of knowledge (the structured data) for the purposes of creating TRM of ET and LW includes the automatic construction of the structural (semantic) model of the subject of studying based on the results of the natural-language dialogue (the information interaction) with the teacher and the automatic formation of the algorithms of training (at distance).

The structural (semantic) model of a certain subject of studying (discipline) is formed in the two coordinated between themselves iterative information processes on the formation of the factual part of the structural (semantic) model of the subject of studying and the meta-model of the subject of studying (discipline) with the tree of the purposes of training (at distance).

The factual part of the structural (semantic) model of discipline (pic. 2.10) consists from:

- the information structure of a certain subject of studying (discipline), presenting the (deeply) structured table of contents (contents), supplemented by the relations (links) between the information fragments;
- the structural (semantic) alphabetical-subject index of discipline, including the alphabetical-subject index, the classification of (scientific) concepts, the library of properties of the (scientific) concepts (objects) and the library of theorems;
- the libraries of terminal texts, reflecting the content of the subjects of studying.

In the basis of the structural (semantic) model of the subject of studying (discipline) of ET and LW is leaned the meta-model of the subject of studying (the universal structure is necessary and sufficient for the encapsulation of information in a row of various disciplines). The meta-model of the subject of studying (discipline) (pic. 2.10) presents the tree of purposes, each vertex of which – the purpose appointment of a certain information fragment.




Picture 2.10. The structural (semantic) model of the representation of information in the adaptive means of training (the electronic textbook)

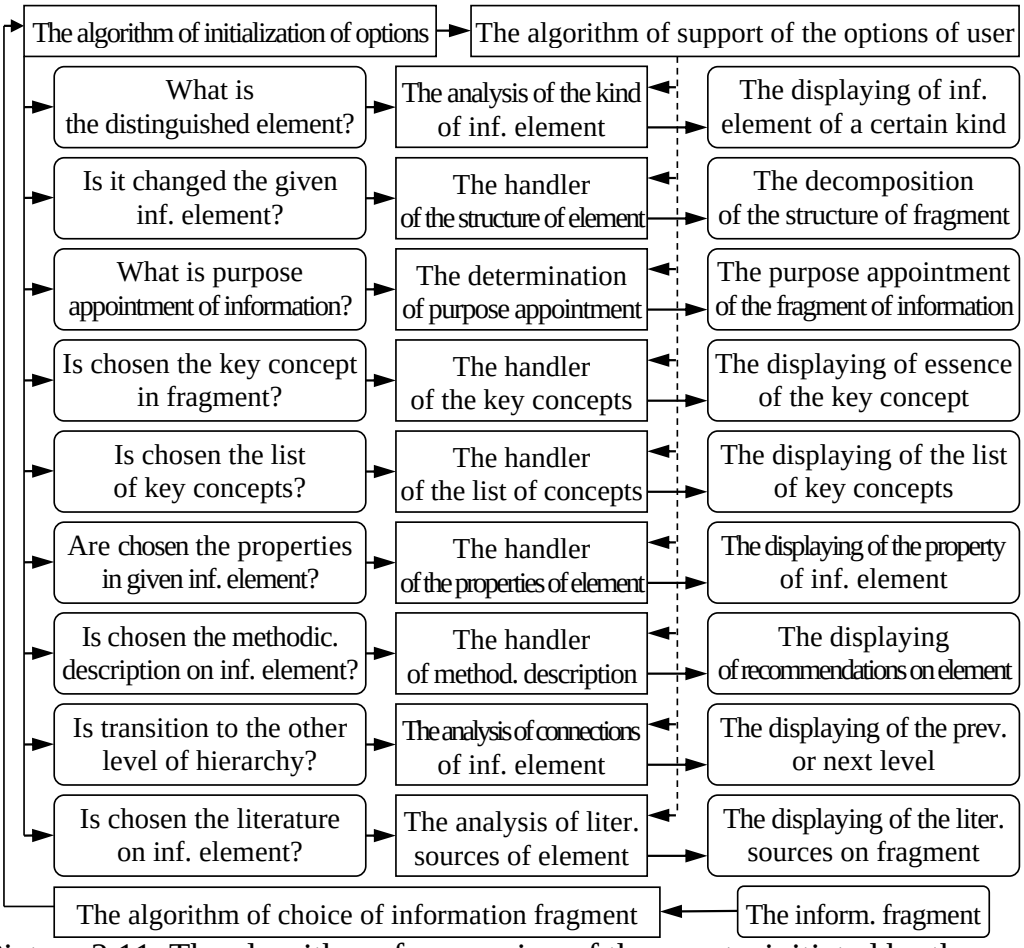
*Under the information fragment* understands directly the electronic book, its part, section, chapter, module, block, paragraph, subparagraph and item (the terminal text), that is the block (quantum) of information, having a certain sense content, the structural (semantic) decomposition of which is impossible (inexpedient), represented in the context of one elementary displayed page on the screen.

The work of teacher, accompanied by the extraction of his knowledge (the structured data), presents a directly the difficult iterative information process, on each iteration of which filling the various slots of a certain frame, corresponding to the current information fragment in the subject of studying (discipline). The operations of teacher (the system of artificial intelligence) are reduced to the answers to the questions, formed from the sense links (the information links) of derived frames. The procedure of the extraction of knowledge begins from the work over the information fragment of the upper level and a sequentially proceeds on the consideration of its different components.

The formation of parts of the structural (semantic) model of the subject of studying (discipline) takes place directly on the basis of the corresponding various derived frames: the frame, containing the factual part of the structural (semantic) model of discipline (the frame of the information fragment or the fragment frame – in the appendix 2) and the frame, containing the tree of the purposes of training (the purpose frame – in the appendix 2).

The technology of formation of the tree of the purposes of training (at distance) includes the selection of the different purpose appointments of information fragments from the factual part of the structural (semantic) model of a certain subject of studying (discipline), in the result of which the list of various purpose appointments is directly formed, the selection from the list of purpose appointment and filling a certain purpose frame for it (the formation of classifications, the allocation of concepts and categories in the purpose appointment, the decomposition of the purpose appointment, the analysis of the purpose appointment and information fragment), the formation based on the received information the current condition of the tree the purposes of training; and also the selection of the next purpose appointment for the work of the means of training (ET and LW).

The algorithm of processing of the events, initiated by the user (pic. 2.11), provides the support of the work of teacher on the formation of fragmented frames and the tree of purposes.




Picture 2.11. The algorithm of processing of the events, initiated by the user in the adaptive means of training

The algorithm of support of the working of user controls by the activity of teacher at the processing of the existing fragment frames and the modifying of the tree of the purposes of training. It includes the algorithms of information support of the operations of user, the initialization of the various operations, the extracting and saving of diverse information at the working of teacher with the structural (semantic) model of the subject of studying (the frames of information fragments and the frames of the purposes of training (at distance)).

The algorithm of initialization of the operations of user displays the information fragments (the modules and questions for the testing) to the teacher, which he can modify.

The algorithm of information support of the different operations of the final user, functioning together with the adaptive representation of a sequence of information fragments processor and the algorithm of extracting of information in the form of data from the structural (semantic) model of a certain subject of studying (discipline), provides (to the consumer of educational services) the necessary information about the current condition of the actual tree of the purposes of training (at distance) and the factual part of the structural (semantic) model of the subject of studying.

The algorithmic support of the working of teacher is organized analogously at the automating of formation of the branched tree of the purposes of training (at distance). The created model is subject to be automatically checked on the completeness and inconsistency.

CMT can used by the trainee for IW in the mode of "uncontrolled reading", and also in the mode of controlled acquisition of information by the principle of feedback. In this mode the various fragment and purpose frames, filled by the author, are the basis for the generating of questions to the trainee and the control of correctness of his answers.

The use of given technology facilitates the working of teacher at the creation of ET and LW. The system, realizing the given technology, can considered as the expert system. The structure of the expert system best way allows to embody in ET all the above mentioned innovative algorithms (principles) of functioning. So, for example, the generation of questions to the trainee and the automatic construction of a dialogue with him can be fully realized directly in the expert system.

The main parameters (criteria) of estimation of the means of training (ET, LW and the book of tasks) as the intelligent systems (based on knowledge) are presented in the appendix 3.

### 2.5.5. The specifics of the practical use of the means of multimedia in the creation of the electronic textbooks and the laboratory workshops

Under multimedia is understood the modern IT, allowing to unite the text, sound, video, graphical images and animation in the information system. The scientific interest in the technologies of multimedia causes by a row of significant reasons:

- the emergence of the powerful and accessible (personal) computers and complexes, capable to support the graphical interface of interaction with the user, and also the functioning of the modules of capture and playback of audio- and video-stream;
- the availability of diverse hardware and SW for the realization of support of the multimedia, realizing a certain set of national and international standards;
- the creation of the various author`s (difficult) information systems and complexes, giving the potential possibility of different final users to make the various own (simple) applied multimedia programs, without having much practical experience of programming in the languages of high level.

The multimedia – the violently developing IT, including a row of scientific principles:

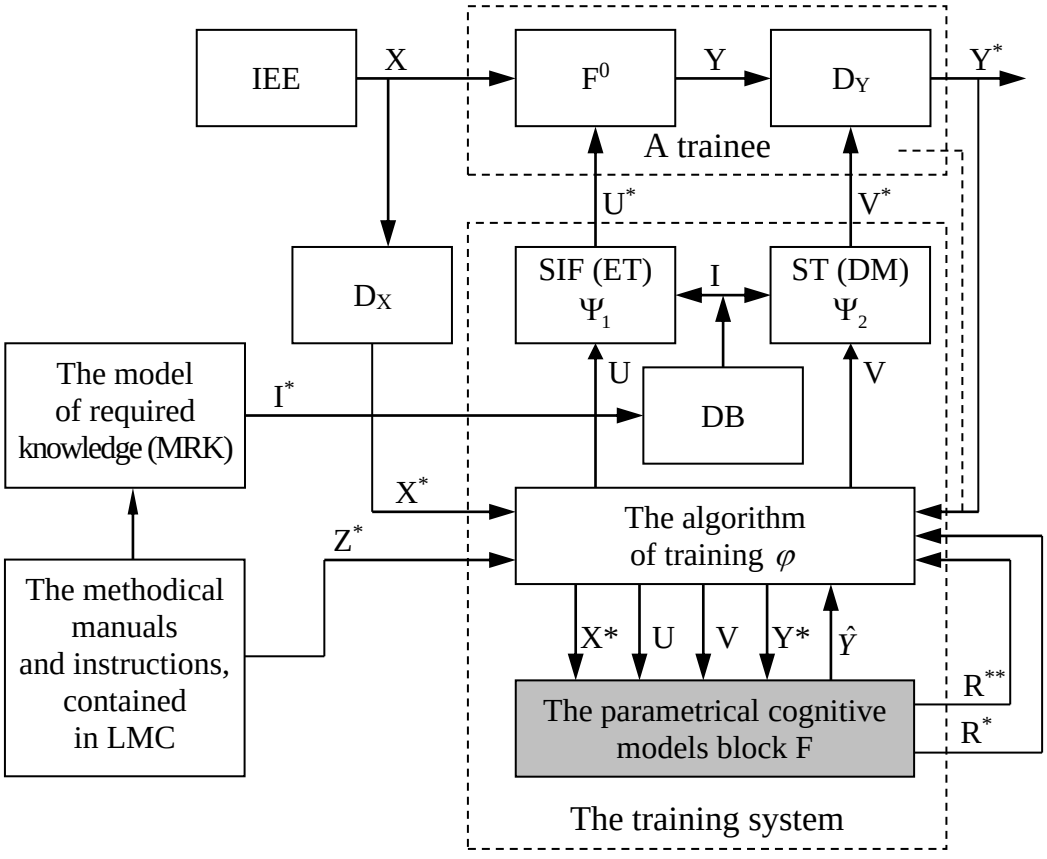
- the integration in the one program product of the different kinds of information: the static (text, tables, graphical images and other) and dynamic (speech, music, the fragments of video-films, tele-frames, animation and other);
- the processing of static and dynamic information in the scale of real-time;
- the interactive information interaction "the subject of training – the means of training", at which the final user receives in the process of (virtual) dialogue more extensive and versatile information in the subject of studying (discipline), that contributes the improving of the conditions of training (at distance), work or rest;
- the automated processing of the diverse streams of audio- and video-information.

The features of use of the (adaptive) means of training based on the multimedia at the creation of ET and LW in the basis of IEE of ART system are considered in the appendix 4.

## *2.6. The theoretical bases of building of the adaptive training systems based on the parametrical cognitive models block*

It is purposeful the consideration of the general scientific principles of building of the adaptive (intelligence) training systems (based on knowledge) (at distance) with the parametrical CM of the subject of training (trainee or examinee) and the parametrical CM of the means of training (for the adaptive ET and LW), and also the specifics of synthesis of PCMB for the realization of adaptive training (at distance).

Many believe, that the concepts “the system of training” and “the training system” are not identical scientific concepts in the context of the theory of automatic control. Under the training system means the subject of training (trainee) and his training system. The training system as the element of the system of training (at distance) is shown in pic. 2.12.




Picture 2.12. The block scheme of the adaptive training system (at distance) based on the parametrical cognitive models block (including the parametrical cognitive model of the subject of training and the parametrical cognitive model of the means of training)

The system of training is formed by the subject (trainee) and the means of training in IEE (the sensor $D_X$).

To the structural elements of the training system include directly:

- *CM* – describes the estimation $\hat{Y}$ of the vector of condition *Y* of the subject of training (trainee) in the given mathematical function of the condition of IEE *X* and EI *U:* $\hat{Y} = F(X^*, U, V, Y^*)$, and the condition *Y* of the subject of training (trainee) is determined by the operator *F°*: $Y = F^0(X, U^*)$, the operator *F* of the analytical model of the subject of training (trainee) is directly is subject to the determination (the parametrical identification) and the adaptation in the controlled technological process of training (at distance);
- *the algorithm of training (at distance)* has the dual functional appointment: at-first, it forms the addresses (links) and the parameters of EI: $U = \varphi(X^*, \hat{Y}, Z^*, R)$, where $\varphi$ – the algorithm of training (at distance); $\hat{Y}$ – the estimation of the condition of knowledge of the trainee, obtained with using of the analytical-numerical (parametrical) model *F*; $Z^*$ – the purpose of training (at distance), set by the tutor (methodist or teacher); $R$ – the resource of training (at distance), consisting from the two analytical components: $R = (R^*, R^{**})$, where $R^*$ – the external resource, determined by the capabilities of the system of training, $R^{**}$ – the internal resource, allocated by the subject of training (trainees) $F^0$ on the training (in particular the time and transactional costs on the training (at distance)); at-second, the algorithm of training (at distance) $\varphi$ forms the methods of research (tests) $V$ the answers to the questions of which characterize the results of performance of tasks $Y^*$ and carry the information about the estimation of the current condition of the trainee $\hat{Y}$: $V = \varphi(X^*, Z^*, \hat{Y})$;
- *the (distributed) data bank of training information (DBTI)* contains a set of diverse information fragments $I$ in the subject of studying (discipline), necessary for the studying by the trainee in the technological process of training (at distance);
- *the shaper of the portion training (SPT)* determines the directly defined EI, displayed to the subject of training (trainee) as the final user for the studying on a certain technological step of training (at distance): $U^* = \Psi_1(U, I)$, where $\Psi_1$ – the algorithm of formation of a certain information fragment, $U$ – the address (link) and the parameters of EI in DBTI, and $U^*$ – the content of information fragment;
- *the shaper of tests (ST)* determines the content of the method of research (test): $V^* = \Psi_2(V, I)$, where $\Psi_2$ – the algorithm of synthesis of the method of research (test) *V*.

The subject of training (trainee) in the (adaptive) system of training (at distance) is presented "the one-to-one converter" of the condition of IEE $X$ and the portions of training information (TI) $U^*$ into the condition of the subject of training $Y$ (LRKT). The information about the condition can be obtained by using the questions of the method of research (test) $V^*$: $Y^* = D_Y(Y, V^*)$, where $D_Y$ – the operator of conversion of task of the method of research (test) $V^*$ and the condition of the subject of training (trainee) $Y$ into a certain answer (reaction) $Y^*$.

The key are the analytical model of the subject of training (trainee) $F$, the algorithm of training $\varphi$ and the algorithms of formation of EI ($\Psi_1$) and the tasks of test ($\Psi_2$). For the simplicity $U \Leftrightarrow V$ and $\varphi \Leftrightarrow [\Psi_1, \Psi_2]$ (the one-to-one compliance is introduced).

### 2.6.1. The algorithms of training in the automated training systems

The ideas of the automation of training (at distance) are tracked in the theory and practice of training before the emergence of informatics (cybernetics) as the new scientific direction [44]. In the middle of 20th years of the XXth century Pressi S. was created the first training machine. The training devices and programs are developed in 50th years of the XXth century directly by a row of outstanding scientists: Skinner B.F., Crowder N.A., Pask A.G.S. and others. The concept and term "the programmed training" were introduced in 1954 y. in the work of Skinner B.F., who outlined the basic principles of the conception of programmed training. In our country the works in the area of programmed training were began in the 60th years by a row of the outstanding scientists: Berg A.I., Itelson L.B., Glushkov V.M., Dovgyallo A.M., Mashbitz E.I., Yushchenko E.L., Halperin P.Ya., Talyzina N.B., Leontiev A.N., Bespalko V.P. and others.

The development of informatics (cybernetics) and computer technics has led to the fact, that the ideas of programmed training have begun to be applied in the various ATS, which in present time widely developed and exploited both at all territory of our country (USSR and RF) and abroad. ATS – a set of organizational actions, the means of computational technics, the methodical materials, the psychological-pedagogical and mathematical methods, allowing to carry out the individualization of the technological process of training. ATS includes the diverse computer means of training (at distance) with the appropriate terminal equipment (the terminal equipment of data transmission), the packages of the applied programs of educational and other functional appointment, ET and LW for the (adaptive) training, DM for the control of LRKT and EL in IEE of ART system.

The technological process of training (at distance) in ATS is carried out by the typical scheme: the subject of training (trainee) is presented the different information fragments, which he must study by means of the various means of training (ET and LW), and then for the determination of the quality of assimilation of the content of material a row of questions is asked. In ATS carries out the automated check of the correctness of answers to the questions and considers the next portion of EI, rendered on the subject of training (trainee).

The sequence of presentation of the portions of EI is determined by the training program. The training program is built on the basis of the algorithm of training (at distance), which is presented the rule of the synthesis of EI and the control of training (at distance) and the determination on each step of the technological process of training of the next EI. The two types of training programs have gained the distribution – the linear and branched. Among the branched programs the internally and externally regulated programs are distinguished.

In the linear training programs the presentation of a certain portions of EI is carried out sequentially, invariant to the answers of the trainee to the various questions. In this case the individualization of training is not realized – the difference between the trainees is expressed only in the duration of passing of the educational program – all trainees move along the same path regardless from the degree of assimilation of the portions of EI by them.

Analyzing the linear training programs with the positions of the theory of control, the hard (program) control of the technological process of training is distinguished, which is provided without the realization of the classical principle of feedback. The training (at distance) is built regardless from the condition of the subject of training (trainee), wherein the model of the subject of training (trainee) is supposed to be known in advance (without this it is impossible the programed control by the technological process of training). The subject of training (trainee or examinee) receives the next portion of EI regardless of the level of assimilation of the previous TI, and the result is fixed into ERB.

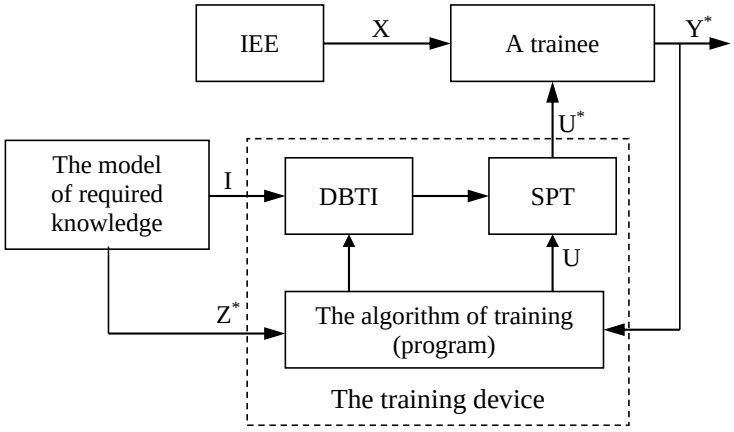
In the linear program there is no the explicit model of the subject of training (trainee), but it is implicitly present in the model of control of training (at distance). The portions of TI are built on the basis of the experience of teacher in assuming, that the trainee, perceiving the portion of EI, necessarily assimilates it and can proceed to the next portion. On this principle the television learning actions are held: lectures, seminars and conferences.

The all TI breaks on $N$ portions, renumbered (named) from 1 to $N$:

$$I = < U_1^*, U_2^*, ..., U_N^* >,$$

which are given sequentially to the subject of training (trainee) in the moments of time $t_1, ..., t_N$ (in this and consists directly any algorithm of programed training). However can enter the feedback $Y^*$ into the linear program (it is shown in pic. 2.13), which informs about the fact of assimilation of the next portion of TI by the subject of training (trainee):

$Y^* = \begin{cases} 0 \\ 1 \end{cases}$, if a certain portion of information is not acquired and acquired respectively.




Picture 2.13. The block-scheme of the training system with the linear program of training

In this case in the moments of times $t_i (i = \overline{1, N})$ the fact of assimilation of the portion of EI is determined by the algorithm of training and is reflected by the single level of signal ($Y^* = 1$) in the feedback.

The model of the subject of training (trainee) $F(X, U^*)$ must reflect directly its time capabilities (the limitations by time) for the assimilation of information (EI):

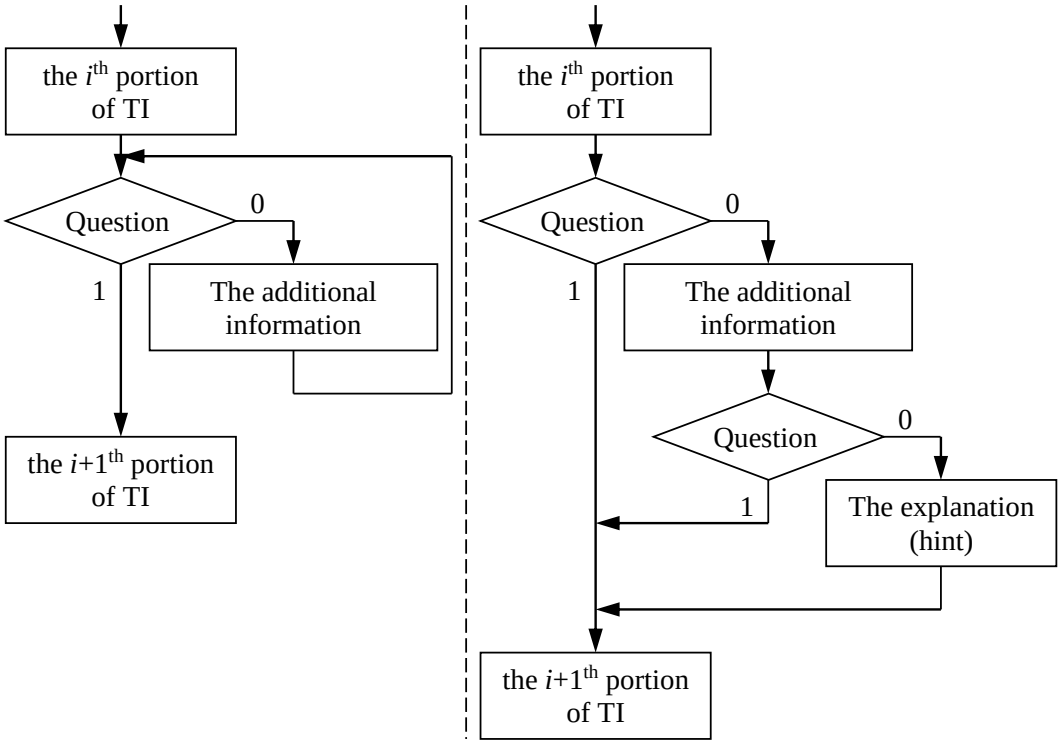
$$F(X, U_i^*) \Leftrightarrow t_i - t_{i-1}$$

that is to specify the time, needed for the assimilation of the portion of EI $U_i^*$ in the conditions of IEE $X$. Then the signal of feedback $Y_i^*$ on $i^{\text{th}}$ stage of training (at distance) is defined as:

$$Y_i^*(t) = \begin{cases} 0 \\ 1 \end{cases}, \text{ at } t_i \le t \le t_{i+1}.$$

The purpose of training (at distance) directly in the linear training program: to the subject of training (trainee) it is needed to inform (display) consistently all $N$ portions of information (EI) by means of the means of training and to diagnose LRKT.

The branched internally regulated training programs work by the extended (complemented) scheme of the automation of training (at distance): the subject of training (trainee) is generated a certain portion of EI, then a row of questions are asked for the check of LRKT after the assimilation of given information, then, in dependence from the answers of trainee, in the case of incorrect answer the following is given: either the additional information (clarification) and a certain question is asked again, or the hint (the valid answer to the question) and the next portion of TI is formed. In case of the valid answer to the question the next portion of TI is given immediately. In pic. 2.14 shows the examples of the possible schemes of branching of the algorithmic structure.

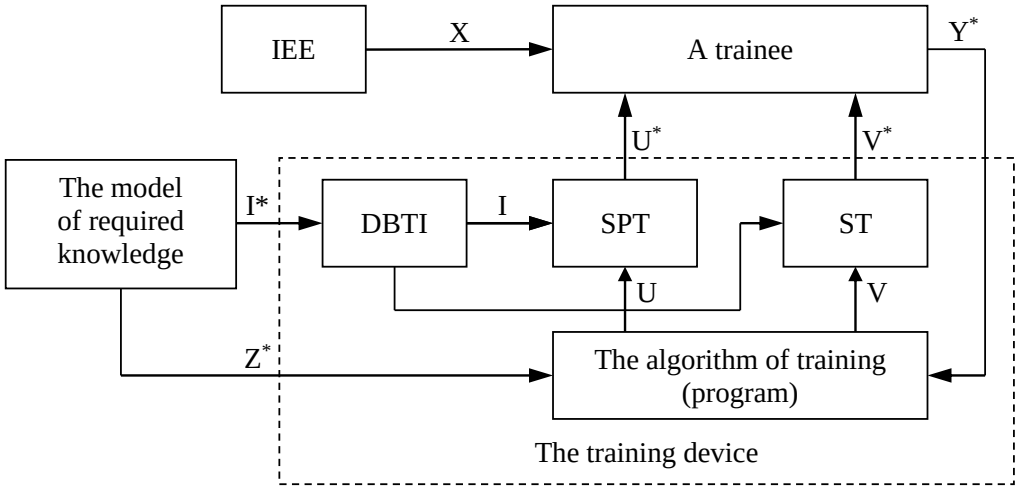



Picture 2.14. The schemes of the realization of branching (1 – valid answer, 0 – incorrect answer): on the left – the linear model; on the right – the branched model

The training by the branched program (as opposed to the linear) is built in dependence from the fact of assimilation of the next EI by the trainee, that is determined by his answers to the questions.

In pic. 2.15 the shaper of portion of TI provides the forming of the portion of additional information for the $n^{th}$ main portion $U_n$. Denote them directly through a certain sequence $U_{n1},U_{n2},...,U_{nl}$, where $l$ – the number of portions of the additional TI directly for the main portion TI.

Each portion of OI (including the main) is accompanied by the test (question), formed automatically directly by the block of ST (the shaper of tests). In the scheme the channels of displaying $U$ and $V$ work simultaneously with division in time, therefore the portions of TI contain the previously selected tasks of test for the estimation of LRKT.




Picture 2.15. The block-scheme of training system with the branched internally regulated program

The quantity of portions $q_n$ of the additional information, given to the trainee, depends from his answers to the questions of test on this the $n^{\text{th}}$ portion of TI ($0 \le q_n \le l$). The technological process of training (at distance) is realized by the different algorithms of a certain automated (adaptive) means of training (ET and LW), formalizing the set sequence of pairs: $< U_{ni}, y^*_{ni} >$ $(i = 0,1,..., q_n)$, where $i$ – the number of portion of the additional information (at $i = 0$ – the main portion), $y^*_{ni}$ -- the estimation of answer to the $i^{\text{th}}$ question, presented in the information block:

$$y^*_{ni} = \begin{cases} 0 \\ 1 \end{cases}, \text{ if the answer on the question is incorrect and valid respectively;}$$

At $y^*_{ni} = 0$: $q_n = q_n + 1$ that is $q_n$ is equal to the number of incorrect answers to the question consecutive. At $y^*_{ni} = 1$ and $q_n = \max$ the additional information is not given and the system proceeds to $U_{n+1}$.

The quality of assimilation of the material (the information fragments) is linked with the number $q_n$. It characterizes the level of knowledge of the trainee of the $n^{\text{th}}$ portion of information (EI). But on the determination of the next main portion of information (EI) $U_{n+1}$ the value $q_n$ does not affect (in dependence from the features of the algorithm of training). In the result each trainee passes all portions of TI from the first to $N^{\text{th}}$, but the educational trajectory on each portion of EI is different for the different trainees. Formally LRKT in the given scheme is described by the vector $P = (q_1, q_2,..., q_n,..., q_N)$.

This vector allows to compare the various trainees from the common contingent.

The purpose of training (at distance) in the branched scheme (as and in the linear) is trivial – to go directly all portions (information fragments) of TI (EI) from $I$.

The branched externally regulated training programs function on the condition of fact, that the subjects of training (trainees) are divided by the academic-performance on $m$ groups. For each group of the subjects of training (trainees) there is the training program with its own way (level) of statement of the same learning material (EI). For example, at $m=3$: in the first training program the material can be presented in the great detailed and designed for the poorly trained subjects of training (trainees); in the second training program a certain learning material is more compressed and calculated directly on the medium trained subjects of training (trainees); in the third training program the learning material is stated in concisely (briefly) and is designed for epy highly trained diverse subjects of training (trainees). For the determination of the belonging of trainee to the subgroup on the $n+1^{\text{th}}$ step of training the relative number of valid answers to the questions of test is calculated on the $n^{\text{th}}$ portion of TI. If this value exceed the limits of some predetermined set interval, then the subject of training (trainee) is transferred directly to another subgroup – better or worse prepared in dependence from the received estimation of LRKT.

In the considerable case all sequence of EI is broken on the portions $U_1,...,U_N$. The studying by the subject of training (trainees) of all portions of TI (information fragments) corresponds to the training by the program with the most detailed level of statement of the material. The less detailed ways of statement will be differentiated by the absence of some portions of TI.

For each portion of TI (EI) a certain set of thresholds $a_1^n<...<a_i^n<...<a_m^n$ is set, with the using of which the subject of training (trainee) is corresponded directly to the group $k_n$ by the obvious decision rule (algorithm): $a_{i-1}^n \le q_n < a_i^n \Rightarrow k_n \in [1,m]$, where $k_n$ – the number of group, in which the subject of training (trainee) is transferred, performing the $q_n$ incorrect answers to the questions of test on the $n^{\text{th}}$ portion of TI (EI).

The block-scheme of the system of training on the branched externally regulated program does not differ from the shown in pic. 2.15 for the internally regulated program. The algorithm of training analyzes LRKT and IFPST, determining the numbers of the groups of trainees, in which they are transferred in the fact of studying of the next portion of TI, allowing to calculate directly the vector $P=(k_1^n,k_2^n,...,k_i^n,...,k_l^n)$, where $k_i^n \in \{\overline{1,m}\}$, $i \in \{\overline{1,l}\}$, which is formed in the process of training and allows to compare a row of trainees.

The purpose of training is to "bring" the trainee to the last portion of TI.

The training systems with the linear and branched algorithm in the basis of the training program are the private and degenerative case of the general scheme of training, and the purposes of training and the models of trainees are trivial.

The author of course (teacher) not only sets the parameters of the algorithm of training program, but and forms a sequence of displaying of the diverse of TI. The quality of such training program depends from the qualification of teacher.

The experience of constructing of the optimal sequence of presentation of the portions of TI requires the model of the subject of studying, wherein a sequence of presentation of the portions of TI is built before the beginning of training in ATS, and the training is carried out either by the linear, or the branched scheme or the algorithm (at the same time the accounting of IFPST and LRKT is possible).

The described training programs are compiled before the beginning of the process of training in ATS. However in last times the universal training programs are developed, forming directly in the process of their execution in IEE of ART system.

Under the generating training system is understood the program complex capable to form a sequence of presentation of EI and allowing to set the parameters of the algorithm of functioning of its components in the process of training.

### 2.6.2. The adaptation in the automated training system (at distance)

The main requirement to the modern ATS is consisted directly in the support of the maximal degree of individualization of the technological process of training (at distance), that is its adaptation to each certain subject of training (trainee), that not feasible practically at the traditional methods of mass training. The subject of training (trainee) acts the significantly difficult object of control and its exact (deterministic) a priori parametrical model does not exist, but, according to the classical and modern theory of automatic control, it is impossible to build the effective control of the specified object without adaptation. Under adaptation in the classical and modern theory of automatic control means the process of changing (of the nominal values) of the parameters and structure of the system, and it is possible, and the control influences based on the different current information with the purpose of achievement of a certain (optimal) condition of the control system at the initial uncertainty and the changing conditions of external environment (IEE). Applying this definition to the technological process of training (at distance), say, that directly the adaptation in a certain ATS (at distance) – the technological process of changing of the nominal values of diverse parameters and the existing structure of the parametrical model of the subject of training (trainee) and the means of training (generating the diverse information fragments as EI) based on the various current information, obtained in the course of training (at distance), with the purpose of achievement of an arbitrary optimal condition of the object of control at the initial uncertainty in the dynamical (stochastic) variable environment (IEE), which is linked with almost complete absence of the information about the trainee in the training system.

The adaptation has the several different hierarchical levels of realization, corresponding to the various stages of control by the difficult object of control: the parametrical adaptation of a given model, the structural adaptation of an existing model, the adaptation of the object of control (of the control system) and the adaptation of a purposes of control.

The parametrical adaptation is linked with the correction (of values) of the parameters of model. If in the process of evolution (functioning) of the object of control its structure changes, the parametrical adaptation does not always allows to build the parametrical model, adequate to a certain object of control (the subject of training or the means of training). Then the structural adaptation of the parametrical model of the object of control is realized. For example, it is used the procedure of selection on each step (iteration) of control from a limited set of alternative different parametrical models (in the sense of proximity to the object of control) of the best parametrical model. At the same time the identification of parameters of the alternative parametrical models directly by the defined methods of parametrical adaptation.

If and the structural adaptation of the parametrical model directly does not increase the efficiency of control of a certain object of control, then the adaptation of the existing object of control (the control system) is realized, that is the revision of boundary, separating the object of control and the environment (IEE) is carried out.

If and this does not have an effect, then the adaptation of the purposes of control is carried out. At the same time a new set of the purpose of control of the object of control is determined, the achievement of which is provided directly by the created control system.

Consider, how these levels of adaptation in the traditional ATS are realized.

In the linear training program any adaptation is completely absent. It is assumed, that the exact model of the subject of training and the means of training is known, and on the basis of this the sequence of statement of the learning material is build the optimal in the sense of some criterion (the time of studying of all TI). In the technological process of training (at distance) change EI only, and not on the basis of the current information, expressed in the data (there is no feedback), and by the hard (deterministic), determined previously scheme (algorithm) of training.

In the branched training programs the parametrical model of the trainee is characterized only by the answers of the trainee to the questions on any given portion of TI. An assumption is made, that if the trainee gave any more quantity of valid answers, then the portion of TI (information fragments) was learned by him and he can proceed to the next. However given model is simplified (this explains the low level of adaptation).

In the branched training programs directly with the several ways of statement of the learning material the parametrical model of the subject of training (trainee) is determined by one parameter – the rank of this subject of training (trainee). In the technological process of training (at distance) directly the parametrical adaptation of exactly this parameter (the one-parameter adaptation) is carried out. A very private case of the parametrical adaptation of a parametrical model is considered. Having determined the rank of the subject of training (trainee), he is trained by the optimal scheme for him, at the same time the psychological, physiological and linguistic features (parameters) of the technological process of the formation of knowledge (at distance) are ignored completely.

The elementary analysis of the existing training systems allows to make a row of conclusions:

- the training systems with the linear and branched schemes (algorithms) of control are a special case of the general scheme of control of the training system;
- the application of the basic provisions of the theory of automatic control in the training involves the taking into account of the specific regularities of process of the formation of knowledge;
- an overview of parametrical models in the technological process of the formation of knowledge shows, that there is not yet a universal parametrical model, and most from the considered existing parametrical models are built in the concrete situation for the solution of a certain applied task;
- in physiology, psychology and linguistics receive the quantitative expression some qualitative processes, occurring in the memory of trainee in the result of EI, and in the described training systems there are no such parametrical models in the technological process of the formation of knowledge (not provided);
- for the effective control of the technological processes of training (at distance) it is necessary to have the parametrical model of the subject of training (and the means of training), but the building of the exact parametrical model of the subject of training (and the means of training) is impossible, due to the difficulty of the existing object and the process of control, then it is necessary to build the approximate parametrical model and for the support of its adequacy to the real object in the process of control, to adapt its parameters and structure in the technological process of training;
- in the considered ATS due to the potential absence of the well formalized parametrical models of the object of control a low level of adaptation is provided;
- for the determination of the efficiency of the technological process of training (at distance) it is necessary the formalization of a certain purpose of training and the criterion of control, allowing to determine, whether the set purpose of control has been achieved.

All this requires to put in a new way the task of training (at distance) and the synthesis of ATS, relying on the difficult technological process of training (at distance) based on the parametrical model at the controlling of a difficult object of control.

The training system presents the system of control by the difficult object – a trainee with its model. The task of training is formulated and formalized more concrete:

- the purpose of training (at distance) $Z^*$ – determined by the methodical recommendations and the requirements to the professional (special) preparation of specialists;
- EI – TI, presented to the trainee and under the influence of which at he must form the certain diverse knowledge, abilities and skills, determined directly by the specified purpose of training (at distance);
- the parametrical model of the subject of training (trainee) – a set of parameters, characterizing the features of perception, processing and understanding of the content of a sequence of diverse information fragments (EI);
- the parametrical model of the means of training (ET and LW) – a set of parameters, characterizing the ways, methods and technologies of displaying of the content of a sequence of diverse information fragments (TI);
- the algorithm of training (at distance) – the rule of constructing of the next portion of TI directly in the technological process of training (at distance).

The process of training (at distance) is presented in the view of a sequence of sessions (lessons), starting in the moments of times $t_0, t_1, ..., t_n, ...$, in the general case are not equally spaced. In the initial moment of time the subject of training (trainee) is located in the condition $Y_0$. It is required to build a sequence of information fragments (EI) $\{U_n\}$, $n = 0,1,...$, which will transfer the subject of training (trainee) into the previously determined final condition $Y^*$. Moreover the process of transferring of the subject of training (trainee) from the condition $Y_0$ to $Y^*$ should be, in a certain sense, the optimal by a certain criterion. In the tasks of training (at distance) the best algorithm of training, that performs this translation in the shortest time (the optimum by time) should be considered.

For the system analysis of the efficiency of training introducing the function of quality of training Q, which depends from a certain condition of the subject of training (trainee) $Y$, and its nominal values in the discrete moments $t_0, t_1, ..., t_n, ...$ will be calculated:

$$Q_n = Q(Y_n),$$

where $Y_n$ – the condition of the subject of training in the moment of time of the beginning of the $n^{th}$ session of training $t_n$.

The criterion of the quality of training $Q_n$ characterizes the directly defined level of proficiency of the subject of training (trainee) in the moment of time $t_n$. Without the limiting of generality believe, that the criterion of quality of training $Q(Y^{**}) = Q^*$, where the nominal value of the level $Q^*$ will correspond to the absolute proficiency. The purpose of training (at distance) $Z^*$, thus, consists in the selecting of the optimal nominal value of the function of quality of training $Q$ by means of the minimal quantity of EI $U$:

$$Q(Y) = \min_{u \in U},$$

where $U$ – the set of EI, and $u$ – the set of permissible information fragments (EI), transferring the trainee from the condition $Y_0$ into the condition of absolute proficiency $Y^{**}$.

Due to the real properties of human memory the condition $Y^{**}$ and accordingly the level of absolute proficiency $Q^*$ practically not achievable. Therefore the training should be completed, when the criterion of the quality of training $Q_n$ reaches the specified threshold $\delta$:

$$Q_n \approx \delta, \text{ where } \delta \text{ – value, close to } Q^*.$$

The purpose of training (at distance) $Z^*$ consists in the reaching of the specified level $\delta$. At the same time believe, that the algorithm of training $A_1$ better the algorithm of training $A_2$, if it provides the achievement of the specified level $\delta$ for a shorter period of time or a smaller number of the sessions of training (at distance) by means of a set of EI (TI).

The purpose of training (at distance) $Z^*$ is formalized as follows:

$$Z^* = \begin{cases} Q(Y^*) \to \delta, \\ T(Y^*) \to \min, \end{cases},$$

where $T(Y^*)$ – the time or number of sessions of training, for which the trainee reaches the condition $Y^*$.

Formalize TI (a sequence of following of the information fragments). Let consider such technological processes of training (at distance), in which TI can be presented in the view of a finite set of renumbered elementary portions of EI (information fragments): $U = \{U_1, U_2, ..., U_N\}$. Their meaningful meaning is determined by the area of training (at distance). From this set of numbers on each $n^{\text{th}}$ session of training (at distance) with using of the algorithm of training the subset of EI is built. $U_n = \{u_1, u_2, ..., u_{M_n}\}$, $u_i \neq u_j$ at $i \neq j$, $u_i \in U$, containing the set $M_n$ of elementary portions of TI (a sequence of diverse information elements) with the numbers $1, ..., M_n$, which constitute the volume of learning material for the $n^{\text{th}}$ session of training $(1 \leq M_n \leq N)$.

Let consider the condition of trainee, whose condition on the $n^{\text{th}}$ session of training (at distance) will described by the vector of probabilities of ignorance of each from the information elements of TI:

$$Y_n \Leftrightarrow P_n = \{p_1^n, p_2^n, p_i^n, ..., p_N^n\},$$

where $p_i^n$ – the probability of ignorance of the $i^{\text{th}}$ element of TI in the $n^{\text{th}}$ moment of time $t_n (0 \leq p_i^n \leq 1)$. The absolute knowledge of all portions of TI is described directly by the null vector $p^{**} = 0$.

The condition of the $j^{\text{th}}$ subject of training (trainee) is changed by the means of using of the various portions of TI (the diverse information fragments) and described in the view:

$$P_n^j = F_n^j (P_{n-1}^j, U_n^j, C_{n-1}^j),$$

where $F^j$ – the operator of the parametrical model of the $j^{\text{th}}$ subject of training (trainee), $P_n^j$ – the condition of the subject of training (examinee) after the studying of portion of TI $U_n^j$; $C_{n-1}^j$ – the parameters of the subject of training (trainee) directly before, he passes the $n^{\text{th}}$ session of training (at distance) by means of the set of EI $U_n^j$.

The model represents the recurrent formula of transition from one condition $P_{n-1}$ to another condition of the subject of training $P_n$ under the influence of EI $U_n$ at the parameters $C_{n-1}$. Do not use the index of trainee $j$ for simplicity, since it only concretizes the task. All further reasoning takes place for any trainee, therefore $P_n = F(P_{n-1}, U_n, C_{n-1})$.

The kind of operator $F$ of the model of the subject of training (trainee) should be set adequately to the specificity of human memory at the training (at distance) to the learning material of a given structure and the semantics in the subject of studying (discipline). The kind of operator $F$ can change at the changing of the structure of TI and its semantics.

The condition $Y_n \Leftrightarrow P_n$ of the subject of training (trainee) directly is not observed, it is necessary to have the (automated) means of measurement for the estimation of this condition. Such (automated) means of measurement are the methods of research (tests), that is the questions, the answers on which carry the information about the condition of the subject of training.

Consider the simplest method of research (test) for the checking of LRKT directly in the result of studying of a certain portion of TI (EI) $U_n$. The reaction of the subject of training (trainee) has a certain view $R_n = F^0(P_n, U_n)$, where $F^0$ – the analytical operator of a certain subject of training (trainee), and the answers of examinee to the questions of the method of research (test) in TI $U_n$: $R_n = (r^n_{u_1}, ..., r^n_{u_{M_n}})$.

Here $r^n_{u_i} = \begin{cases} 0 \\ 1 \end{cases}$, if the subject of training (trainee) gave the incorrect or valid answer after the $n^{\text{th}}$ session of training (at distance) on the $u_i{}^{\text{th}}$ information element $U_n$.

This information is initial for the adaptation of the parameters of model: $C_n = \chi(C_{n-1}, R_n)$, where $\chi$ – the algorithm of adaptation allows to estimate the condition of trainee $P_n = \chi(P_{n-1}, U_n, R_n)$.

Here $\chi$ – the algorithm of estimation of the condition of the subject of training (trainee) on the results of the previous tact (iteration) of training (at distance) $<U_n, R_n>$ and a certain previous condition of the subject of training (trainee) $P_{n-1}$. The algorithm of training (at distance), allowing to determine the next portion $U_{n+1}$, consists in the minimization of the indicator of the quality of training (at distance) $Q$ on each step (stage) of the technological process of training (at distance). Then the task of optimization of the function of the quality of training is reduced to the next view:

$$Q(P_{n+1}) = Q(F(P_n, U_{n+1}, C_n)) \to \min_{U_{n+1} \in \Phi(R_{n+1})} \Rightarrow U^*_{n+1},$$

where $\Phi(R)$ – the set of portions of diverse TI (EI), satisfying to the resource $R$, $R_n$ – the certain resource, allocated on the $n^{\text{th}}$ session of training (at distance) (the expected duration of lesson $T$ or the machine time, available to the trainee and other), $U^*_{n+1}$ – the locally-optimal portion of TI, given to the trainee on the $n+1^{\text{th}}$ session of training.

The training (at distance) with using of the presented algorithm of training does not provide the solution of task of the achieving of the initial purpose of training $Z^*$, which was delivered by the expert (methodist, teacher or tutor). The case in fact, that the number of the sessions of training (at distance), obtained with using this algorithm, may not be minimal in time in the context of the function of the quality of training $Q(P_{n+1})$. But the minimization of the criterion of the quality of training $Q$ on each step of training (at distance), of course, gives the optimal nominal value of the solution, close to the minimal, as the value of criterion of the quality of training $Q$ with each session of training (at distance) decreases in an intensive manner and the moment of time $Q(Y^*) \approx \delta$ comes fast enough. At the same time a quasi-optimal solution, which in some cases coincides with the optimal one is received.

### 2.6.3. The specifics of the algorithm of training with the cognitive model of the trainee

The parametrical and structural adaptation of the model of the subject of training (trainee) is possible. In the last case the structure of the model changes in the process of training (at distance).

The condition of the subject of training (trainee) on the $n^{\text{th}}$ session of training (at distance) is described by the vector of probabilities of the ignorance of information elements of TI (EI). The information element of TI (EI) may be a concept, a rule, a definition, a task and other. In the task of training (at distance) to the understanding of texts in the national language of the information elements of TI (EI) are the various lexical units, that is the separate words or the phrases of sentences in the national language.

In the result of memorization by the trainee of the portion of TI on the $n^{\text{th}}$ session of training (at distance), he owns by the information elements of a given portion of EI with the probability equal to one:

$$p_i(t_n) = 0,\ i \in U_n,$$

that is the probabilities of ignorance of the inf. elements of EI from $U_n$ in the moment of time $t_n$ are equal to zero, however in the course of time directly occurs the interference back (forgetting). Using the scientific data of (cognitive) psychology in the area of research of memory, in the quality of model of the subject of training (trainee) $F_n$ choose the exponential dependency. Then the probabilities of ignorance of the information elements of TI change by the rule:

$$p_i^n = p_i(t_i^n) = 1 - e^{-\alpha_i^n t_i^n},\ i = 1,..., N;\ n = 1,2,...,$$

where $\alpha_i^n$ – the speed of forgetting of the $i^{\text{th}}$ information element of TI on the $n^{\text{th}}$ session of training, $t_i^n$ – the time since the moment of last approach to the studying of the $i^{\text{th}}$ information element of TI.

Naturally, the speed of forgetting of each information element of TI: decreases – if the information element of TI is output to the subject of training (trainee) for the memorization and does not change in the technological process of training (at distance), increases – if it is no longer studied by the subject of training (trainee):

$$\alpha_i^{n+1} = \begin{cases} \alpha_i^n, (i \notin U_n); \\ \gamma' \alpha_i^n, (i \in U_n, r_i^n = 0); \\ \gamma'' \alpha_i^n, (i \in U_n, r_i^n = 1, n = 1,2,...) \end{cases}$$

where $\gamma', \gamma'', \alpha_i^1 (i = 1,2,..., N)$ – the parameters, characterizing the features of memory of the trainee, $0 < \gamma' < \gamma'' < 1,\ \alpha_i^1 > 0$ – the initial speed of forgetting of the $i^{\text{th}}$ information element of TI.

Since on each session of training (at distance) the $i^{\text{th}}$ information element of TI: or it is output for the memorization $(i \in U_n)$, or not output for the memorization $(i \notin U_n)$.

In the model of the technological process of training (at distance) it is necessary to take into account the time of forgetting of the diverse information (EI) after its last studying $t_i^n$:

$$t_i^{n+1} = \begin{cases} \Delta t_i^n, (i \in U_n); \\ t_i^{n+1} + \Delta t_i^n, (i \notin U_n), n = 0,1,... \end{cases}$$

where $\Delta t_n = t_n - t_{n-1}$ – the interval of time between the two sessions of training (at distance), $(t_0, t_1,..., t_n)$ – the moments of time of the presentation of portions of TI in the limits of the sessions of training. The probabilities of ignorance of the $i^{\text{th}}$ information element of TI before the first studying directly on the $n^{\text{th}}$ session of training (at distance) is equal to one (that is before the beginning of training of the $i^{\text{th}}$ inf. element of TI unknown with the probability equal to one):

$$p_i(t_i^k) = \lim_{\tau \to 0} p_i(t_k - \tau) = 1$$

for $k = 0,1,..., n$, $i \in U_n \bigcap_{k=0}^{n-1} U_k$. At $n = 0$, $p_i(t_i^0) = 1$ for all $i = 1,2,..., N$ or $P_0 = 1$.

The changing of the probabilities of ignorance of the inf. elements of TI depends from the speeds of forgetting, which are determined by the individual properties of memory of the subject of training (trainee), and the time of ignorance of the various information elements of TI after their studying.

The procedure of correction (optimization) of values of the speeds of forgetting $\alpha_i^n (i = 1,2,..., N)$ is realized directly by the algorithm of adaptation on the basis of the innovative PCMB, containing the parameters $C_n$ (the physiological, psychological and linguistic IFPST). At the first level, the adaptation of the structure of the model of the subject of training (trainee) $F_n$ is carried out. The second level is linked with the parametrical adaptation of the model of the subject of training (trainee).

The criterion of the quality of training (at distance) $Q_n$ selecting one, which characterizes the level of training of the trainee as the subject of training. For the task of training of the understanding of text in the national language the given level is characterized by the probability of ignorance of the element of TI, randomly selected from this text:

$$Q_n = \sum_{i=1}^{N} p_i(t_i^n) q_i ,$$

where $p_i(t_i^n)$ – the probability of ignorance of the $i^{\text{th}}$ information element of TI $(0 < p_i(t_i^n) < 1)$; $q_i$ – the frequency of appearance of the $i^{\text{th}}$ information element of TI in the considered text (without repetitions of the various information elements of TI $q_i = 1$). The values (nominal values) $q_i (i = 1,2,..., N)$ are determined by the text, reflecting the content of the subject of studying (discipline) before the beginning of training.

At $n = 0$, $Q_0 = \sum_{i=1}^{N} q_i = 0$, $P_0 = \sum_{i=1}^{N} p_i(t_i^0) = 1$ it is expected directly, that the certain subject of training (trainee) does not know. For the other tasks of training $q_i$ can characterize the importance of the $i^{\text{th}}$ concept and so on. The purpose of training $Z^*$, for the achievement of which it is proposed to solve the local task on each step of training, which for the criterion $Q_n$ can be rewritten in the view

$$Q_n = \sum_{i=1}^{N} p_i(t_i^n) q_i \to \min_{U_n \in \Phi(L_n)} \Rightarrow U_n^* .$$

The result of solving of the given task is the locally-optimal portion of TI $U_n^*$, which is output to the subject of training (trainee) on $n^{\text{th}}$ session of training. The criterion $Q_n$ is calculated to the moment of time $t_n$ of the beginning of the $n^{\text{th}}$ session of training. At the same time the task of optimization of training (at distance) can have the several solutions. For example, can include in the set $U_n^*$ only those EI, the memorization of whose on $n^{\text{th}}$ session of training provides the greatest reduction $Q_n$ to the end of the session of training. Let call this procedure (the task of the optimization of training) zero-step.

The another solution of the task may be the inclusion into the set $U_n^*$ only those EI, the memorization of which on the $n^{\text{th}}$ session of training will provide the greatest reduction $Q_{n+1}$, that is the value of the criterion of the quality of training to the beginning of the next $n+1^{\text{th}}$ session of training. This procedure is called one-step. Similarly can build the $k$-step procedure, on which it is built $U_n^*$ with the purpose of minimization $Q_{n+k}$ to the beginning $n+k^{\text{th}}$ session of training. For the solving of the task of training (at distance) will build the zero-step procedure as the simplest and not requiring time-consuming (analytical) calculations.

For the selection of the optimal value (minimal) $Q_n$ to the end of the session of training, having the smallest value of multiplication $p_i(t_i^n)q_i$ are naturally included of EI in $U_n^*$, since as in the result of their memorization this multiplication tends to zero and thereby significantly affects on the decreasing of the nominal value of the criterion $Q_n$.

For the support of the optimal value $Q_n$ to the end of the $n^{\text{th}}$ session of training, having the resource $L_n$, it is necessary to find $M_n$ of maximal members in the sum, the indices of which and will determine the next portion of TI, presented to the trainee for the studying. This algorithm of optimization is written directly in the view

$$\begin{cases} u_1 = \max\limits_{1\le i\le N} p_i(t_i^n)q_i \\ u_i = \max\limits_{1\le i\le N(i\ne u_1)} p_i(t_i^n)q_i \\ \dots \\ u_{M_n} = \max\limits_{1\le i\le N(i\ne u_j,\, j=1,2,\dots M_n)} p_i(t_i^n)q_i \end{cases}$$

where $i$ – the index $U^*\in U$ of maximal nominal value $a_i$, that is $a_i^* = \max\limits_{1\le i\le N} a_i$, and $\{u_1,u_2,\dots,u_{M_n}\} = U_n^*$ – the directly defined portion of TI, which is output for the studying on the $n^{\text{th}}$ session. The volume of portion $M_n$ depends from the resource $L_n$.

Let $L_n = T_n$ – the duration of the $n^{\text{th}}$ session of training (at distance), or the time (the interval of time), allotted on the studying of a certain portion of TI $U_n$, and the time of studying of the $i^{\text{th}}$ inf. element of TI is inversely proportional to the probability of its ignorance. This assumption is based directly on the natural basis: the less likely the probability of ignorance of a certain information element, then the less time it is needed on its studying in the process of training. Then the volume $M_n$ of the next portion $U_n$ is determined from the following ratio:

$$M_n = \max_{1\le M\le N}\{M : T_n \ge k \sum_{i\in\{u_1,\dots u_M\}} p_i(t_i^n)\},$$

where $T_n$ – the average time of memorization of the element of TI at its first presentation to the trainee; $u_1,u_2,\dots,u_M$ – the numbers of information elements of TI, determined by the rule. The parameter $k$ is a priori unknown and therefore must be estimated adaptively in the process of training in dependence from the time, spent by the trainee on the performing of portion of TI:

$$k_{n+1} = k_n + v(T_n^{'} - T_n),$$

where $v$ – the dimensionless coefficient of the speed of adaptation at the memorization of TI, and $T_n^{'}$ – the time, spent by the subject of training (trainee) on the memorization of the portion of TI $U_n$.

The training ends, when $Q_n$ reaches the required level of proficiency $\delta$. The number of sessions $n$, for which is achieved $Q_n \to \delta$, determines the duration of the training.

Thus, the algorithm of training (at distance) consists in the following:

- the checking of knowledge of the subject of training (trainee) of the portion $U_n$ is carried out, in the result of which set of resulting values $R_n$ is formed;
- the adaptation of parameters of the subject of training (trainee) $C_n$ is carried out;
- the vector of probabilities of ignorance of the elements of TI is corrected, that is $P_n$ is formed;
- the criterion of the quality of training (at distance) $Q_n$ is calculated directly;
- if the value of criterion $Q_n \approx \delta$, then the training (at distance) ends.

At $Q_{n+1} > \delta$ the next portion of TI $U_{n+1}$ is determined, which is output for the studying. Then, at the next cycle of training (at distance) the item 1 – item 5 and so on are repeated again.

### 2.6.4. The specifics of the estimation of parameters of the cognitive model of the trainee

At the studying of the model of trainee the task of estimation of its unknown parameters arises. These parameters of model are $\gamma'$ and $\gamma''$ the corrections of the speeds of forgetting, and also the initial nominal values of these speeds $\alpha^1 = (\alpha_1^1, \alpha_2^1, ..., \alpha_N^1)$.

The parameters $\gamma'$, $\gamma''$, $\alpha^1$ reflect the individual features of the memory of trainee.

The initial values of the speeds of forgetting $\alpha^1$ can be estimated in the process of training by the results of the first examination by the method of maximal likelihood.

Let on the $n^{\text{th}}$ session to the trainee is given the first time information elements of TI, forming directly the mathematical set $U_n = \{u_1, u_2, ..., u_{K_n}\} \subset U$. For the data of certain information elements of TI $\alpha_i^n = \alpha_i^{n-1} = ... = \alpha_i^1 = \alpha (i \in U_n)$. The subject of training (trainee) studies directly the certain portion of EI $U_n$. The result of checking of the knowledge of portion $U_n$ through the time $t$ after the learning is presented in the view of the vector $R_n$ (for $i \in U_n$ the probabilities of ignorance: $p_i(t) = 1 - e^{-\alpha t} = p, (i \in U_n)$ are calculated).

Let's write the function of likelihood: $P = p^x (1-p)^{K_n - x}$, the minimizing of which by $p$ enables the possibility directly to estimate $P$, and therefore, and $\alpha$.

Here $x = \sum_{i \in U_n} r_i^n$ – the number of nonmemorable elements of TI from $K_n$ the firstly studied.

For the ease of calculation replace $P$ on $\ln P$, then for the finding of the value $\alpha$, at which the function $P$ takes the highest nominal value, calculating the derivative of $\ln P$ on $\alpha$ and equating to zero:

$$\frac{\partial \ln P}{\partial \alpha} = \frac{x e^{-\alpha t} t}{1 - e^{-\alpha t}} + (x - K_n) t = 0.$$

From here get directly the estimation of the parameter $\alpha$: $\hat{\alpha} = -\frac{1}{t} \ln \frac{K_n - x}{K_n}$.

The estimation of parameters $\gamma'$ and $\gamma''$ in the process of training seems quite difficult.

Therefore for their estimation it is proposed to conduct directly the corrective experiment (research) before the beginning of training (at distance).

For the task of training to the foreign vocabulary the given experiment has features. The trainee receives $N$ unknown words in the foreign language and must remember their translation. The studying is carried out daily in the course of a certain fixed time, the same for each certain subject of training (trainee). Before the studying the (automated) examination (testing) is carried out, the results of which are presented in the view of the vector $R_n = \{r_1^n, r_2^n, ..., r_N^n\}$, where $r_i^n = \begin{cases} 0 \\ 1 \end{cases}$, if the subject of training (trainee) has given the correct translation of the $i^{\text{th}}$ words in the $n^{\text{th}}$ examination and incorrect translation respectively.

Then the nonmemorable words are taught by the subject of training (trainee), and on the other day the (automated) examination (testing) on all words is carried out. This is repeated until the trainee remembers all the words, that is after the (automated) examination (testing) all $r_i^n = 0, i = 1,2,..., N$.

A posteriori data are the derived from the considered model. In the given case directly $M_n \Leftrightarrow N$ and $\Delta t_n = 1$ for all $n = 0,1,..., K$, where $K$ – the number of examinations until all $N$ words are fully remembered, that is

$$K = \min\{n : \sum_{i=1}^{N} r_i^n = 0\}.$$

The speeds of forgetting vary in this case: $\alpha_i^{n+1} = \begin{cases} \gamma' \alpha_i^n, (r_i^n = 0) \\ \gamma' \alpha_i^n, (r_i^n = 1) \end{cases}$, where $0 < \gamma' < \gamma'' < 1, (i = 1,2,..., N; n = 1,2,..., K)$, and the probabilities of information elements of EI take a certain view directly $p_i^n = 1 - e^{-\alpha_i^n}, (i = 1,2,..., N; n = 1,2,..., K)$. Every day ($\Delta t_n = 1$) all words $M_n \Leftrightarrow N$ are studied and remembered.

Since the words unfamiliar to the trainee are given for memorization, then $p_i^0 = 1$ for all $i = 1,2,..., N$. The initial speed of forgetting $\alpha$ can be estimated by the results of examination, carried out on the other day after the initial memorization of the words:

$$\hat{\alpha} = -\ln \frac{N - \sum_{i=1}^{N} r_i^0}{N}.$$

The parameters $\gamma'$ and $\gamma''$ are estimated by the method of maximal likelihood.

For the analysis of estimation $\gamma''$ let's enter $A_n$ – the set of numbers of words, which the trainee did not remember before the $n^{\text{th}}$ examination; $S_n$ – the number of words at $|A_n| = S_n$. Then for everyone $i \in A_n$ have

$$\alpha_i^n = (\gamma'')^{n-1}\alpha,$$

$$p_i^n = 1 - e^{-\alpha_i^n} = 1 - e^{-(\gamma'')^{n-1}\alpha} = p_n, (n = 1,2,...)$$

The experimental data is represented by the set $R_n$ of realizations $r_i^n$ random variables $\xi_i^n$, having the following distribution directly:

$$P\{\xi_i^n = 1\} = p_i^n,$$

$$P\{\xi_i^n = 0\} = 1 - p_i^n, (i = 1,2,..., N)$$

The value (nominal value) $x_n$ is defined as the sum $x_n = \sum_{i \in A_n} (1 - r_i^n)$, expressing the quantity of words from $S_n$ remembered in the $n^{\text{th}}$ examination. The mathematical function of likelihood in the view of the probability of obtaining of the all possible set of data $R_n$ of experiment is build. It depends from the parameter $\gamma''$:

$$P = \prod_{n=1}^{K} p_n^{S_n - x_n} (1 - p_n)^{x_n} = \prod_{n=1}^{K} [1 - e^{-(\gamma'')^{n-1}\alpha}]^{S_n - x_n} [e^{-(\gamma'')^{n-1}\alpha}]^{x_n}.$$

The calculating of the nominal value of the parameter $\gamma''$, at which $\ln P$ reaches the maximum. By the logarithmizing of the mathematical expression, it is obtained directly

$$\ln P = \sum_{n=1}^{K} \{(S_n - x_n) \ln[1 - e^{-(\gamma'')^{n-1}\alpha}] - x_n (\gamma'')^{n-1}\alpha\}$$

For the finding of maximum $\ln P$ it is taken the partial derivative by $\gamma''$ and equate it to zero:

$$\frac{\partial \ln P}{\partial \gamma''} = \sum_{n=2}^{K} [\frac{S_n - x_n}{1 - e^{-(\gamma'')^{n-1}\alpha}} e^{-(\gamma'')^{n-1}\alpha} (n-1)(\gamma'')^{n-2}\alpha - x_n (n-1)(\gamma'')^{n-2}\alpha] = 0.$$

From here for $\gamma''$ the mathematical equation is obtained directly

$$\sum_{n=2}^{K} \frac{S_n - x_n}{1 - e^{-(\gamma'')^{n-1}\alpha}} e^{-(\gamma'')^{n-1}\alpha} (n-1)(\gamma'')^{n-2} = \sum_{n=2}^{K} x_n (n-1)(\gamma'')^{n-2}$$

It is obvious, that to obtain the exact solution of this transcendent equation relatively to $\gamma''$ is not possible already at $K \geq 6$. Therefore simplify it.

From the estimation of the initial speed of forgetting $\hat{\alpha}$ follows, that $\hat{\alpha} \geq 1$ $\frac{\sum_{i=1}^{N} r_i^0}{N} \geq 1 - \frac{1}{e}$, that is than, when the share of unrecognized information elements of TI on the other day after the studying is greater by about 2/3. As the experiments on the memorization of foreign vocabulary have shown, this is extremely rare. Therefore in the future is advisable to carry out all the analysis for $\alpha < 1$. Besides, with the growth of $n$ the value $\alpha_i^n$ does not increase, that is $0 < \alpha_i^n < 1, (i = 1,2,..., N)$.

As $0 < \gamma'' < 1$ $0 < (\gamma'')^n \alpha < 1$, then directly: $e^{-(\gamma'')^n \alpha} \approx 1 - (\gamma'')^n \alpha$.

The mathematical expression $\sum_{n=2}^{K} (S_n - x_n)(n-1) = \alpha \sum_{n=2}^{K} S_n (n-1)(\gamma'')^{n-1}$ is obtained.

Let's build the approximate solution of given algebraic equation. For this consider at first the case, when the value $\gamma''$ close to one. The value $(\gamma'')^n$ into the algebraic row of Taylor is decomposed in the vicinity of one:

$$(\gamma'')^n = [1-(1-\gamma'')]^n = 1-n(1-\gamma'')+...$$

Substituting this into the previous expression, it is obtained directly

$$\sum_{n=2}^{K}(S_n - x_n)(n-1) \approx \alpha \sum_{n=2}^{K} S_n(n-1)[1-(n-1)(1-\gamma'')],$$

From where can estimate directly the nominal value $\gamma''$:

$$\hat{\gamma}'' = 1 - \frac{\sum_{n=2}^{K}[S_n(\alpha-1)+x_n](n-1)}{\alpha\sum_{n=2}^{K} S_n(n-1)^2}.$$

If the nominal value $\gamma''$ directly very different from one, then the obtained formula can used for the first approximation to $\hat{\gamma}''$.

For the estimation of the parameter $\gamma'$ it is necessary to find the average (for all examinations) number of non-memorizations of words (it is denoted through $\Theta$) and its mathematical expectation $M\Theta$.

By the experimental data can be calculated directly $\Theta$:

$$\overline{\Theta} = \frac{1}{N}\sum_{n=1}^{K}\sum_{i=1}^{N} r_i^n$$

The mathematical expectation of the average number of non-memorizations of words has the view

$$\overline{\Theta} = \frac{1}{N}\sum_{n=1}^{K}\sum_{i=1}^{N} M\xi_i^n = \frac{1}{N}\sum_{n=1}^{K}\sum_{i=1}^{N} Mp_i^n .$$

As the probability of ignorance $p_i^n = 1-e^{-\alpha_i^n} \approx \alpha_i^n$, then directly

$$M\Theta \approx \frac{1}{N}\sum_{n=1}^{K}\sum_{i=1}^{N} M\alpha_i^n$$

Find directly the mathematical expectation of the speed of forgetting $M\alpha_i^n$. The representation of the mathematical expectation of the random variable is used in the view

$$M\xi = M\{M(\xi \mid B)\}$$

where $M(\xi \mid B)$ – the conditional mathematical expectation of the random variable $\xi$ directly relative to the certain event $B$.

As $\alpha_i^{n+1} = \begin{cases}\gamma'\alpha_i^n \\ \gamma''\alpha_i^n\end{cases}$ with the probabilities $e^{-\alpha_i^n}$ and $1-e^{-\alpha_i^n}$ accordingly, then $M\alpha_i^{n+1} = M\{M(\alpha_i^{n+1} \mid \alpha_i^n)\} = M\{\gamma'\alpha_i^n e^{-\alpha_i^n} + \gamma''\alpha_i^n(1-e^{-\alpha_i^n})\} \approx \gamma' M\alpha_i^n + (\gamma''-\gamma')M(\alpha_i^n)^2$.

From here you can see, that $M\alpha_i^{n+1}$ depends from the second moment. Find $M(\alpha_i^n)^2$.

By the method of mathematical induction can directly show, that the $k^{\text{th}}$ moment of the speed of forgetting has the certain view

$$M(\alpha_i^n)^k = (\gamma')^k M(\alpha_i^{n-1})^k + [(\gamma'')^k - (\gamma')^k]M(\alpha_i^{n-1})^{k+1}$$

The estimation of parameter $\gamma'$ is obtained directly from the equality

$$M\Theta \approx \overline{\Theta}.$$

At the same time the successive approximations are build. As $M\alpha_i^1 = \alpha_i^1, (i = 1,2,..., N)$, then the expression $M\alpha_i^2$ is obtained, $M\Theta$ is determined directly for $K=2$ and the obtained result is equated to $\overline{\Theta}$, also calculated at $K=2$.

The first approximation $\hat{\gamma}_1'$ is obtained, which is used for the calculation $M(\alpha_i^2)^2$, after then repeat the described procedure. In the result the approximation $\hat{\gamma}_2'$ is obtained. This is repeated to $n=K$, in the result of which the nominal value $\hat{\gamma}_{K-1}'$ is obtained, which is obtained directly for the estimation of the nominal value of parameter $\hat{\gamma}'$.

Thus, by the results of preliminary experiment it is possible to build directly the estimations of the nominal values of parameters $\gamma'$ and $\gamma''$, and then to use in the process of training for the adaptation of the speeds of forgetting.

## 2.7. The principles of realization of the adaptive information environment based on the individual characteristics of the trainee

The algorithm of training program is the model of activity of the teacher on the control of the process of training and the various means of IEE of ART (the model of ART – MRT). At the developing of MRT it is required to take into account IFPST, and also the abilities of trainees to the self-control and self-regulation of cognitive activity of the subject of training. A row of the principles of building of the model of adaptive training program (MADTP) with the flexible structure of the control of cognitive activity is distinguished [13, 15, 16, 17, 72, 73, 94, 100]:

- the control of cognitive activity should be based on IFPST, characterizing the formed level of mental activity, diagnosed with help of the specialized methods of research;
- MADTP should provide the potential capability of the purposeful development of insufficiently formed IFPST, which at the same time become the separate objects of research;
- if the kind of activity requires the higher mental level, then the difficult form of activity should be decomposed on the simpler kinds, forming them through the system of simple operations and exercises;
- if the content of the learning-cognitive activity is based on the certain convergent and divergent abilities [47], which are formed at the insufficiently high level, then for their initial development a row of developmental and corrective methods should be applied, in particular by the means of training;
- the development of LMC for IEE of ART system with the properties of adaptation based on the parametrical CM is carried out with taking into account of the features of learning-cognitive activity of the subject of training (trainee), and LMC are designed on the basis of IFPST and its abilities to IW, and also the motivational-purpose installations of the technological process of ART.

In accordance with the listed theoretical principles in MRT it is possible to realize the two contours of adaption directly:

- the primary (main) – the adaptation of the means of IEE to the initial level of knowledge and the level of development of IFPST (the mental processes), the formed abilities to control their cognitive activity;
- the secondary (current) – the adaptation to the changing condition of trainee (the current nominal values of parameters of IFPST and the level of knowledge of trainee).

As at the introduction of the technologies of personally-oriented and adaptive training in the automated IEE based on IFPST requires taking into account a large quantity of parameters, than it is reasonable to develop and use PCMB.

The building of the contour of adaptation initiates the diagnostics of IFPST, which allows to differentiate trainees on the basis of a posteriori results according to the used models, methods and technologies of training in the automated IEE.

IFPST are measured by means of the various methods of research and are differentiated on the slightly changing and the conditionally-constant in the time in relation to the period of life of a person (examinee).

At the realization of the technologies of individually-oriented training in the automated IEE the practical interest presents the conditional-constant IFPST, the diagnostics of which is realized at the initial steps (stages) of training, and a posteriori data acts the nominal values of parameters, which are supposed to entered directly into CM of the subject of training and to use throughout of the (automated) educational trajectory.

The adaptation to the slightly changing IFPST is recommended for the approbation of the innovative methods, algorithms, technologies and the means of training, therefore it acts a more difficult and resource-intensive problem, which is realized by means of the quasi-dynamic diagnostics – the systematic testing (BC) in course of the process of ART.

The proposed structure of IEE of ART system with the properties of adaptation based on CM provides the taking into account of IFPST of two types (in the presence of the physiological, psychological and linguistic anomalies): the trainee – for the increasing of efficiency of the formation of his knowledge at the working with the various means of training; the teacher – at the formation and entering of MRK by means of the components of ART system, and also the working with the various SW, providing the support of educational cycle in IEE.

At the same time it becomes possible to trace the dynamics of IFPST, to carry out the diagnostics of the reasons of emergence of the difficulties and errors of trainee from the point of view of the various scientific aspects (the physiological, psychological, linguistic and others), which allows to solve the complex of tasks at the research of IEE of ART system.

It is not always possible to carry out the reliable diagnostics of the individual differences of trainees (IFPST), as the results of their activity are mobile and changing. The problem of comparability of a posteriori data in time is actualized. The creation of MADTP is divided on a row of stages, which are based on the defined principles and theoretical bases, considered at the realization of the process of ART.

The regularities of the educational process, the content, the logic of organization, the technology and didactic purposes acts as the bases for the creation of the organizational, methodical and technical support for the support of functioning of IEE.

The all process of the activity of teacher is divided on a row of stages.

At the first stage MRK is created, and also the algorithm of representation of information with the hard structure of control is developed in the basis of the automated means of training – the basic program of training, designed for the average-statistical trainee, which is build from the assumption, that the trainee owns knowledge, abilities, skills and the level of mental development according to the requirements of the chosen specialty or the present sphere of activity.

The theoretical basis of modeling of the educational process can serve the theory of the step-by-step formation of mental actions.

All tasks and exercises are presented with the possibility of choose of the answer or the way of random constructing of test is used, including the frames with the clarification of errors, allowing to obtain the necessary reference material.

At the second stage the teacher improves MRK for the subsequent presentation of the content of discipline to the trainee with taking into account of IFPST, considering the restrictions on the required LRKT: the low, medium and high. In MRT enters the certain elements of adaptation to LRKT and IFPST, includes a sets of relevant tests (tasks, theoretical questions and other). In dependence from the quality of performance of the tasks of test and the character of errors of the algorithm of program sets to the trainees the various trajectories, corresponding to the various educational programs.

At the next stage the teacher "refuses" from the assumption, that the trainee does not allow the errors, and the elements of the current and final adaptation are entered into MRT. The first adaptation is carried out in the form of clarification of the various errors, allowed at the performance of actions or operations by the subject of training. The second adaptation is built with taking into account of the accumulated errors and their character at the performing of the different tasks by the subject of training, including and generalizing. The task of final adaptation – the fixing and classification of errors, the diagnostics of LRKT and the correction of a sequence of training due to the including of AT, CC and the resources of EL. The final and current adaptation allow to realize the branching of the program of training and to provide the increasing of efficiency of the formation of knowledge of the trainees. The transfer from one program to another is carried out by the teacher on the results of automated diagnostics of LRKT in the form of testing. The control of training is realized by the disconnect (the linear algorithm) or the closed (the branched and adaptive algorithm) principles.

The trainee in the process of IW has the possibility to carry out the self-control by means of the checking of correctness of the carrying out of separate operations or a set of tasks in IEE.

The control system will become more flexible, if the teacher at the next stage of his design activity will work, proceeding from the assumption, that the trainee is able to estimate the level of residual knowledge, skills and experience.

The developer of MRT and the structure of the automated IEE needs to create the means of training and the auxiliary SW of the different degrees of difficulty, providing the possibility to the trainee to select the subprogram based on LRKT and IFPST.

At the next stage the another limitation is removed – the abilities and conditions for the providing of IW of trainee are taken into account, that is achieved by the introducing the personnel into MRT with the setting of problems and clarifications, the including of orienteers for the solving them.

The theoretical basis of modeling of the activity of teacher at this stage is the theory of algorithmization and problem training (at distance). MRT gives to the trainee the possibility to work by the ready-made algorithm, containing in the training program, or open it himself, that is to solve the problem. The trainee can create some algorithms, and to take some in the ready-made view.

Further one more significant limitation of the technological process of ART is removed. The subjects of training (at distance) are not always in condition to estimate accurately the compliance of the level of development of mental functions to the requirements of upcoming activity. This circumstance directly determines the inclusion in MRT of the corresponding psychological diagnostic methods of research (tests). After the analysis of the results of diagnostics to the trainee is recommended a certain model, technique or the technology of training in dependence from the results of diagnostics.

At the last stage it is necessary to analyze MRT from the point of view of the compliance of its structure to the components of the dynamic model of training.

At the same time the developed MRT should provide directly:

- the familiarization of trainee with the volume of upcoming work before the training;
- the realization of division of EI on a set of logically related portions;
- the taking into account of the potential possibility of planning of the work of trainee and the tracking of the estimated time of studying of each portion;
- the computer program contains the elements, helping to the trainee to form the system of criteria for the estimation of the results of activity.

In general the realization of MRT should take place in the conditions of psychological comfort, taking into account the various ways of work, which each trainee owns and to form the optimal individual structure of the process of training.

## 2.8. The specifics of the channel of information interaction of the subjects and means of training in the educational environment

For the traditional (classical) process of training the lecture can considered as the main way, providing the representation of a certain volume of information, but the training in IEE of ART has a row of specific features.

At the same time the channel of information interaction (communication) can be:

- the verbal – the typical for the disciplines of humanitarian profile;
- the verbal with the elements of multimedia – the demonstration of video-streams and (or) audio streams by means of the automated means of training;
- the verbal with the synchronous accompanying of multimedia elements – the greatest interest presents for the disciplines of technical profile.

The bandwidth of the channel of information exchange is determined by the pace of statement (representation) of the verbal component of lecture and the speed of the graphical accompanying of lecture by the teacher and the making-of-abstract of the lecture by the trainees.

At the first stage: the rate of passing (transmission) of information by the channel of communication, which is the typical for the disciplines of technical profile at the training (at distance). The information (expressed in the data) is first stated verbally and the pace is dictated (identified by the tutor and / or the automated means of training) from the one side by the possibility and the speed of making-of-abstract (familiarization) of the trainees, which impossible to increase radically without the use of special technical means (recorders, the special devices of video- and photo-registration of information), and from another – the difficulty of stated material, that is actually and at the stage of subsequent familiarization. If the higher the difficulty and informativity of material, than the faster its statement will be due to repetitions, the statement of additional reference details.

At the second stage: the formation of a certain graphical image, which is the practically mandatory attribute of lecture in the technical disciplines. There is a time delay, in the course of which the new incoming information is absent.

At the third stage the receiving of new information at the comments of graphical image. As it is necessary to transfer simultaneously the graphics on a carrier and comments, the partially duplicating of specifical graphical information (schemes), then the rate of reception of information decreases in relation to the verbal form of statement.

The aggregative summary volume of information (expressed in data), obtained by the trainee in the time of lecture, is calculated by the means of testing of his LRKT and the subsequent analysis of a posteriori data by the experts.

The organization of lecture classes in IEE of ART system is characterized by the fact, that the trainee is plunged into the specific virtual educational environment, in which the narrowest links of the channel of communication are relieved, linked with the necessity to make-of-abstract and redraw quickly the presented information (data). This allows to increase significantly the efficiency of delivery of the information to the trainees. Besides, it should to take into account, that at the presence of difficulties in the stated materials, to the trainee the possibility of practically instantly access to any information fragment at the help of the navigation system of ET for the replenishment of knowledge is provided.

The use of the distributed automated IEE of a new generation, covering the several EE or the learning (scientific) centres will allow to provide the integration of educational resources in a wide set of the subjects of studying (disciplines), and also to expand the complex of provided information services to the contingent of trainees.

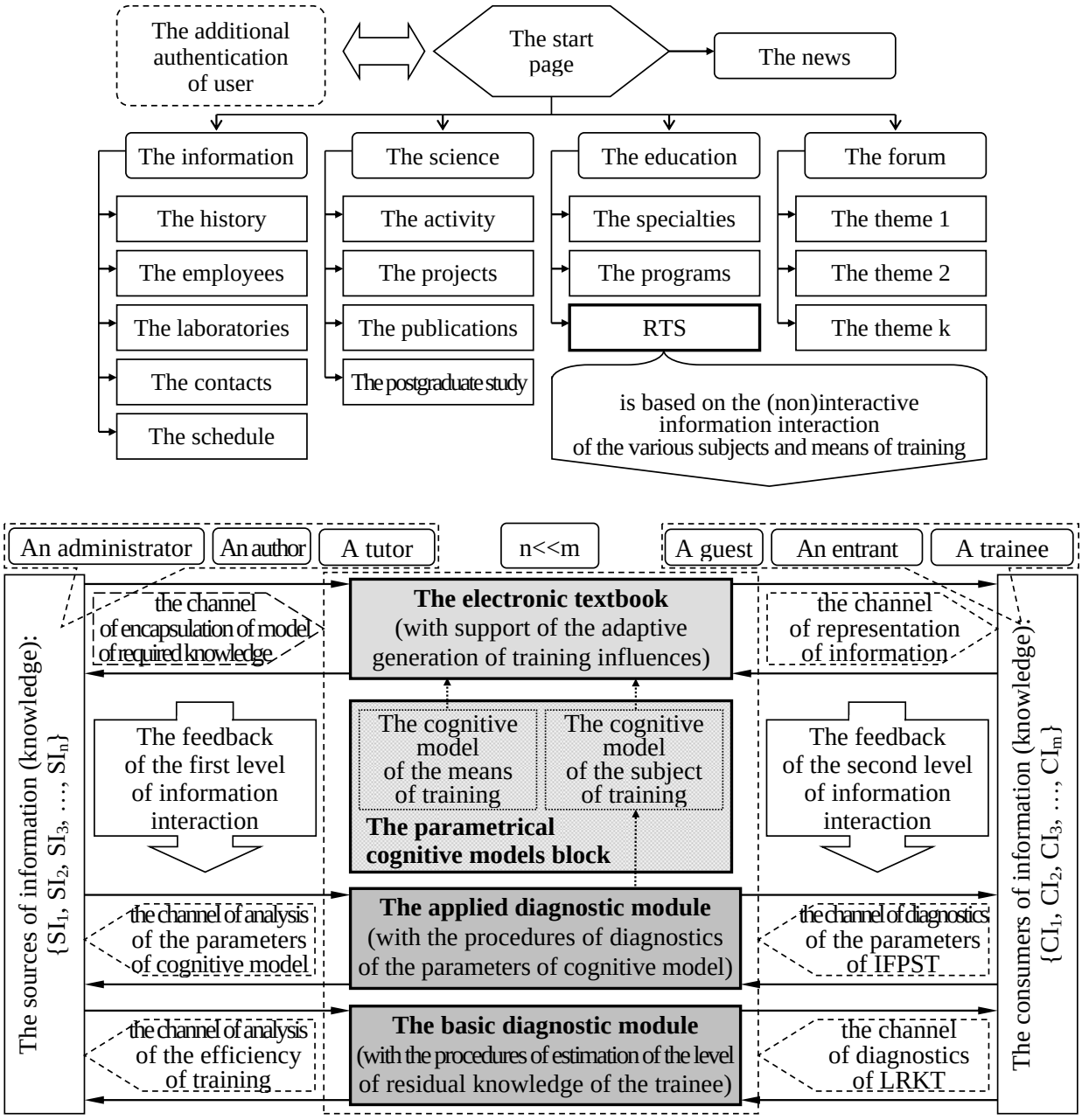
## 2.9. The structure of the automated training system (at distance) with the properties of adaptation based on the parametrical cognitive models block

The modern ART systems are developed on the basis of the innovative technologically-enhanced information-educational portals, which classically include a row of information sections (modules), related to EE (the general information, history, the educational and scientific activity, forum and other). As a rule, the access to RTS of IC of EE is possible directly from the portal.

The developed structure of the information-educational portal of the chair "Automatics and control processes" ("ACP") of "SPbSETU "LETI"" provides the development of the specific Web-application, segmented on a set of dynamically filled templates, at the same time ART system acts as the integral part of the chair IEE.

In the basis of the created automated IEE the information (computer) ART system is located, realized by the modular principle (classically), but, along with ET and DM, structurally including the module of adaptation based on the innovative PCMB (allows to take into account IFPST and the technical capabilities of the means of training), and also to realize the individually-oriented model of training.

The general structure of the developed ART system (pic. 2.16) includes the 4 channels and the 2 levels of information interaction (the direct and feedback of the first and second levels are researched): the first level – the channel of the encapsulation of knowledge and the channel of the analysis of condition, the second level – the channel of the representation of knowledge and the channel of the identification of condition.




Picture 2.16. The structural scheme of the remote training system with the properties of adaptation based on the cognitive models in the basis of the information-educational portal

The channel of the encapsulation of knowledge is intended for the filling of content of the elements of ART system by the data necessary and sufficient for the support of the educational cycle (the data about the subjects of training, the parameters of the means of training, LMM and others).

The channel of the analysis of condition allows to get the access to a posteriori results of training (the results of testing, the data of ERB and other).

The channel of representation provides the direct displaying of portions of EI (the information fragments) to the final user (trainee or examinee).

The channel of identification is intended for the diagnostics of LRKT and the parameters of CM of the subject.

All four information channels form the closed contour in ART system between the two categories of users, acting as the subjects of IEE.

The subjects of ART system are differentiated by the rights of access and act in the various roles: the group of the sources (carriers) of information (knowledge) [an administrator, an author and a tutor]; the group of the consumers of information [a guest, an entrant and a trainee (pupil and student)].

The limitation of communicative duplexity of the "virtual" dialogue between the groups of proficit and deficit units (participants) is caused directly by the mediation of information interaction (the subjects of training interact only through ET and DM), that is a significant drawback of any ART system, which needs to be qualitatively researched and technologically eliminated.

The information interaction between the subjects and means of training takes place in the specific IEE close to the virtual reality [65, 83, 87, 106], that allows to apply a new methods, principles and technologies of training, and also to realize the possibilities of using of the innovative PCMB.

In the adaptive means of training (ET) the material in each discipline is stratified on the parts, sections, chapters, modules, blocks, paragraphs and subparagraphs, to each certain stratum the block of control questions is associated, intended directly for the using in DM of ART system, that allows to organize effectively the current, intermediate and final control of the level of awareness of the subject (LRKT) in a row of the subjects of studying (disciplines) with the application of a whole row of the specialized models of "pseudo"-adaptation. These models of adaptation do not cover in full measure the both levels of communication interaction (information exchange) of ART system, and are carry only the experimental character (for the purposes of scientific researches), because allow sometimes to reduce the individual time of the cycle of testing due to the adjusting of a sequence questions to be displayed (from the general sample of questions, which are ranked in advance by the complexity by the tutor) based on the analysis of the answers of a certain examinee in the scale of time, approximating directly to the real scale of time (for the minimization of time costs and the maximization of the effect of synchronization of the virtual dialogue at the interactive interaction of the subjects and means of training).

## *2.10. The conclusions on the second chapter*

The conclusions on the second chapter of dissertation are formulated by the author:

- the modifications in the organization and technology of training at the realization of IEE of ART system with taking into account of IFPST based on ICT in EE are presented: the main technological stages and SW of ART are considered;
- the specifics of the automated individually-oriented training as the controlled process of the formation of knowledge of the trainee is described: the features of the structure of the process of training and the levels of the representation of knowledge in IEE, and also the semantic models of the representation of knowledge are distinguished;
- the structure of training as the controlled technological process is considered: the features of functioning of the components of ART system, the essence of the adaptive representation of information fragments processor, the bases of technology of the extraction of knowledge of the teacher for the purposes of building of TRM and the specifics of usage of the means of multimedia at the creation of ET;
- the theoretical bases of the adaptive training systems with the model of trainee are presented: the algorithms of training (at distance) in ATS, the adaptation in ATS, the specifics of the algorithm of training with the model of trainee and the estimation of parameters of CM;
- the features of the structure of the adaptive IEE based on IFPST are formulated;
- the specifics of the channel of information interaction (exchange) of the subjects of training and the means of training of IEE of ART system is reflected;
- the features and the structure of the open information-educational portal of the chair with the properties of adaptation based on PCMB are considered.

Thus, from the scientific provisions, obtained by the author in the second chapter are submitted on the defence: the structure of IEE and the principles (algorithms) of functioning of the components of ART system with the properties of adaptation based on the innovative PCMB.

The obtained results allow to realize the additional contour of adaptation based on IFPST and the technical capabilities of the means of training, allowing to provide the increasing in the efficiency (resultativity) of functioning of IEE of ART system.

# 3. The cognitive modeling technology and the structure of the parametrical cognitive models for the adaptive automated training systems

There are a set of problems, linked with the information interaction between the subjects of training and the means of training in the automated IEE. In the light of the personally-oriented training the interest of scientific community is accented on the various fundamental and applied areas of scientific knowledge, related to the problematics of the adaptation of information interaction of the subject of training with the means of training in the automated IEE [8, 14, 16, 36]:

- psychology of perception [51, 64, 69, 139] – Sazonov V.F., Izmailov C.A., Krol V.M., Kornienko A.F., Leushin L.I., Baru A.V., Gershuni G.V., Krylova A.L., Feldstein D.I., Smrnova V.M. and others;
- cognitive psychology [47, 60, 68, 120] – Arshinov V.I., Rakitov A.I., Labunskaya V.A., Potapova R.K., Druzhinin V.N., Kholodnaya M.A. and others;
- cognitive linguistics [34, 112, 113, 115] – Gik M.L., Kobrina N.A., Petrov V.V., Potapova R.K., Zinchenko T.P., Koverin A.A., Nelyubin L.L. and others.

Arises the necessity of research of the features of the realization of training in the automated IEE, and also the mutual influence of the subjects and means of training. In the appendix 5 considers some aspects of influence of the means of training on the health of the subjects of IEE of ART system in the process of training (at distance).

By the important condition of the increasing of efficiency of training (at distance) acts the psychological, the theoretical and practical readiness of trainees to IW. In the appendix 6 the psychological aspects of the individual readiness of trainees (examinees) to IW in IEE of ART system are leaded directly.

As practice shows, there is no the proper order in the planning of IW both by volume, and by time, about the low CUA of this kind of learning process in IEE of ART. The organization of IW of the trainee begins in a certain time, necessary for the studying of each discipline in the course of year, taking into account the quantity of scheduled hours for its studying and the necessary level of assimilation of the material.

The organization of IW can go simultaneously in the several directions:

- the development of the various private algorithms of solving of the typical tasks;
- the development of the algorithms of training programs and the special methods of training;
- the specialization of IW with taking into account of the practical tasks at the training in the specialty;
- the providing of the subjects of training by the special and reference information and literature in the area of practical use of the innovative means of training in IEE.

Such approach to the organization of IW requires the accurate control, that assumes:

- the formalization of purpose, tasks and the setting of requirements to IEE of ART system;
- the organization of educational process in the automated IEE;
- the preparation of methodical support of the technological process of training;
- the control of performance on all stages of the technological process of training;
- the estimation of the efficiency of functioning of IEE and the resultativity of training;
- the formulation of recommendations and the possible ways of improving of IEE.

The formalization should carry out in the several independent stages (gaps): the working-off of the list of actions in the course of IW of the trainee, the distribution of time between the disciplines in the semester (in the context of each discipline) and the scheduled planning. The homogeneous load of trainees in the course of all period of training is needed.

The success of organization and control of IW is impossible without the accurate system of control over it. At the same time the control in the view of the acceptance of completed works in the end of studying of the discipline is ineffective, as it does not organize the planned work of trainee in the course of all semester, and the teacher does not provide the constant feedback (based on ICT).

The means of control of IW of the trainee serve the adaptive training programs, including the elements of theory in the discipline, the algorithms of solving of the typical tasks, the demonstration examples and tests, allowing to diagnose and take into account IFPST. It is especially effective to use the means of training by the trainees of the evening department, where in comparison with the day department the necessary volume of studied material in the certain disciplines is saved, and the quantity of learning hours is reduced.

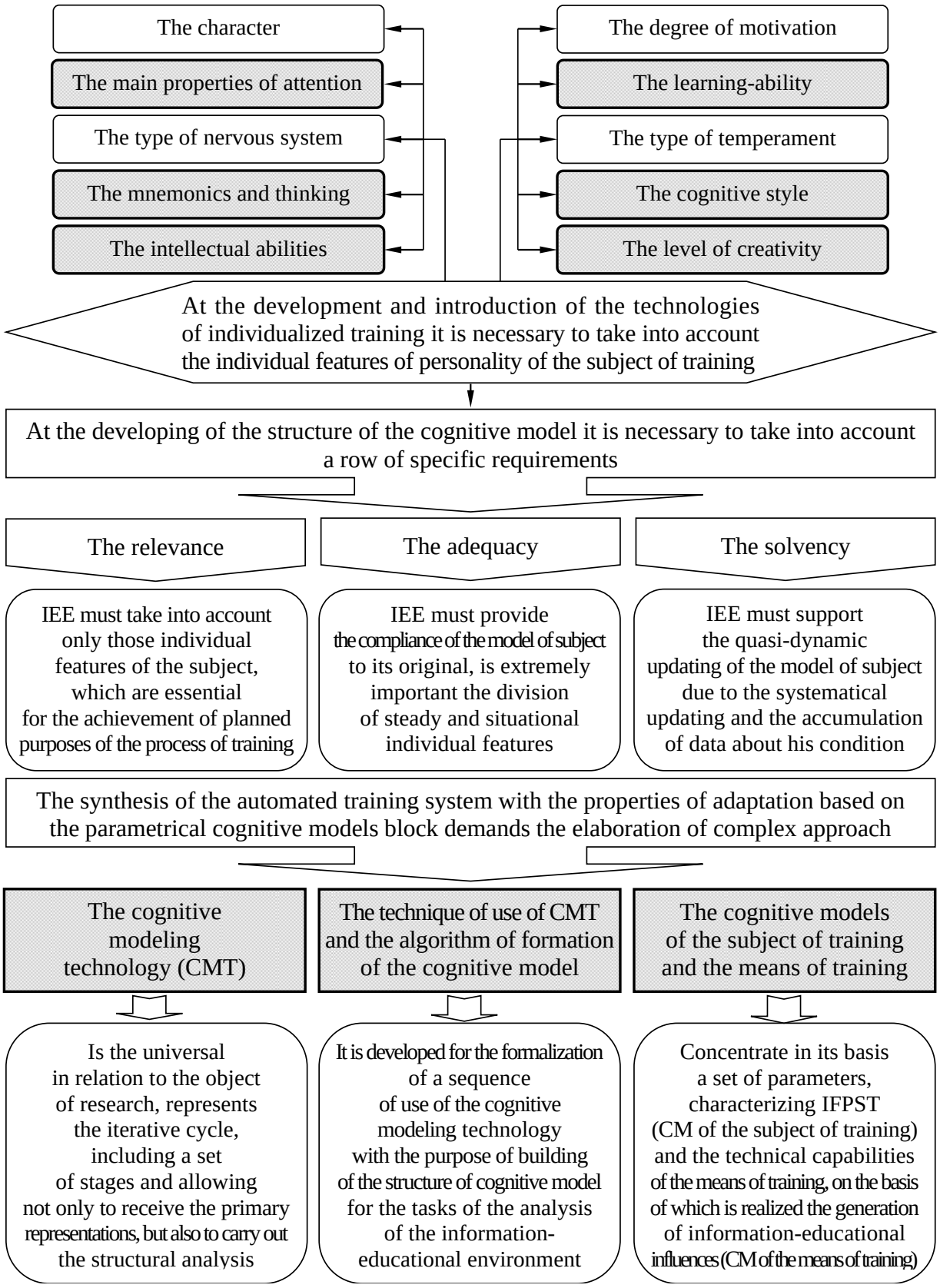
One from the actual problems of The high school is the justification of organization of the individually-oriented training in IEE of ART system based on ICT with the point of view of the scientific bases of physiology, psychology and linguistics. This problem is linked with a whole row of private psychological-pedagogical tasks. In the present time practically absent the fundamental researches, deeply and comprehensively reveal the psychological conditions of organization of ART. The itself concept of IEE based on ICT has not yet been the consideration with these positions. The psychological models and professiograms of specialists have not yet been developed, which need to prepare in the context of this system of the fundamental scientific approaches. It is not clear, to which specialties can train in IEE of ART system based on ICT, which impossible to train or possibly partially (especially at distance). The didactical and methodical questions of ART do not have a proper justification.

Obviously, the tasks of identification of IFPST are actualized and the need of improving of the methods of conducting of the control testing is arisen.

The most import directions of researches of IEE of ART system are:

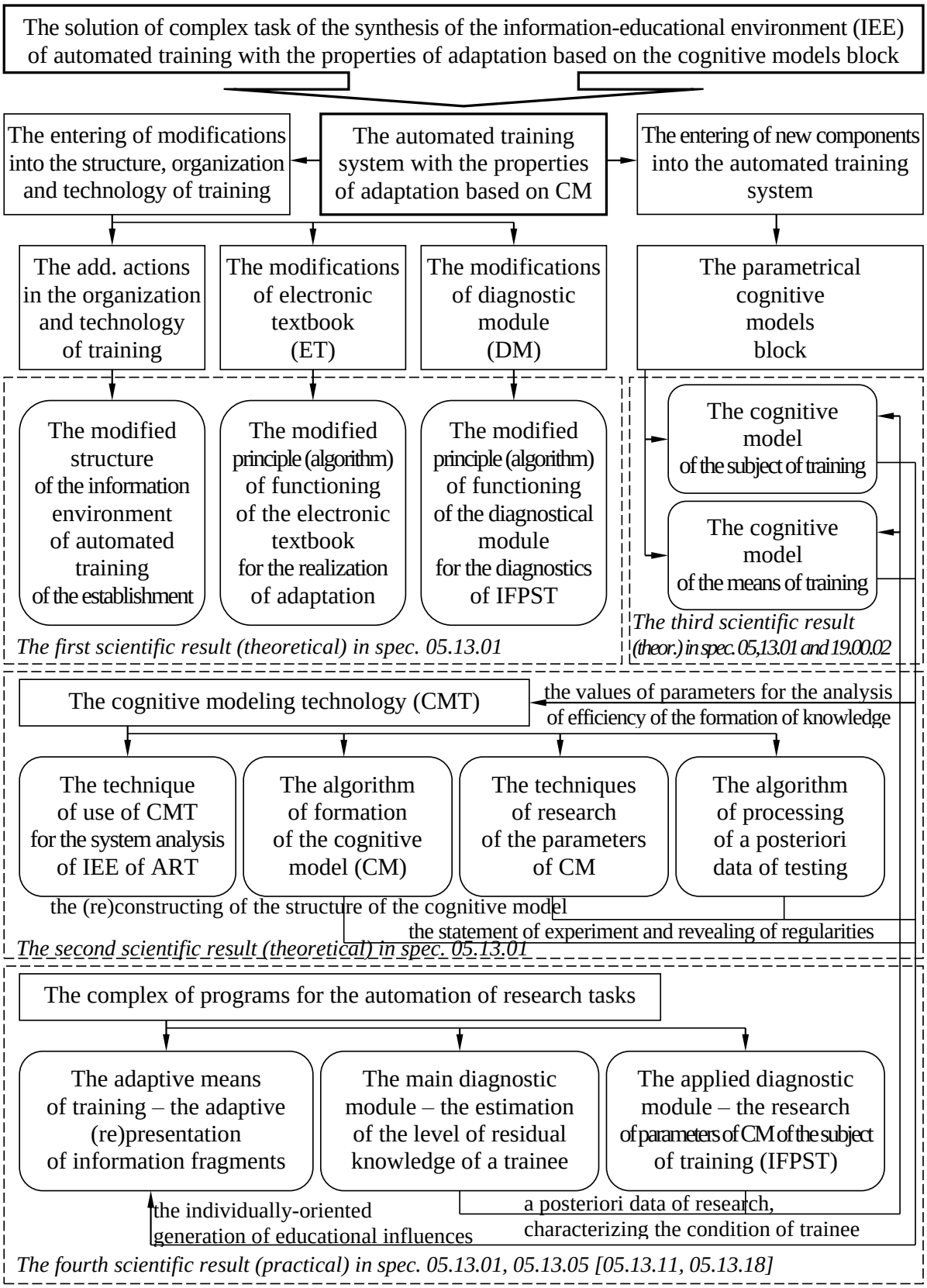
- the development of the skills of using of the modern means of IEE based on ICT;
- the studying of whole complex of conditions, necessary for the successful working in ART system (the individual features, properties and the qualities of personality sufficient for the realization of the effective automated training at distance);
- the research of IFPST, the revealing of the physiological, psychological and linguistic features of perception, processing and understanding of information by the subjects of training is the extremely important for the realization of the adaptive training in IEE based on the different modern (innovative) achievements in the area of ICT;
- the development of the methods of automated diagnostics of the entrants, wishing to train in IEE of ART system, the creation of the blocks of psychological methods for the diagnostics of IFPST, also their translation into the electronic (computer) view;
- the formation of the system of necessary requirements, which should satisfy the methodical means, used in ART system;
- the analysis, having in the present time LMC is used for the training in ART system regarding the adequacy of the declared purposes and tasks with taking into account of IFPST;
- the selection of the scientifically-based applied methods of research of IFPST, providing the high accuracy and the minimal time and transaction costs in the period of exploitation and support (of the practical use);
- the development and selection of the methods of statistical analysis, allowing quickly to reveal the tendences and dependencies in the heterogeneous samples of a posteriori data;
- the creation of the methods and applied programs for the solution of the scientific problem of automation of the technological process of identification of IFPST (trainees);
- the research of information interaction of the subjects with the means in IEE and the expansion of a set of various parameters, characterizing IFPST;
- the analysis of the different modern achievements and innovations in the area of ICT and the enhancing of technological capabilities of the means of training in IEE;
- the finding of highly-technological means and environments of programming for the realization of the components of IEE and the expanding of functional capabilities of the means of training;
- the development of the methods and models of representation of the different data for the realization the effective storage, searching and processing of data and the delimitation of the rights of access.

The priority task of research of IEE of ART is the increasing of efficiency of information interaction of the subjects of training with the means of training, that causes the potential necessity of development of CM and CMT for their building, allowing to carry out directly the system analysis of IEE (pic. 3.1).




Picture 3.1. The basic requirements to the structure of the cognitive model

The structure of the complex scientific approach to the synthesis and system analysis of IEE with the properties of adaptation based on the innovative PCMB is presented in pic. 3.2.




Picture 3.2. The complex approach to the synthesis and system analysis of the information-educational environment of the automated (remote) training system with the elements of adaptation based on the parametrical cognitive models block

### 3.1. The iterative cycle of the cognitive modeling technology for the formation of the parametrical cognitive models

CMT can applied in relation to a wide spectrum of the objects of research in the different subject areas, although it was developed for the system analysis of IEE of ART.

The active development of new technologies of mass communication in the last years initiates the need of a deeper research of the information interaction of the subjects of research in the communication environment of a new generation.

The given difficult problem requires the interdisciplinary scientific approach (private physiology of sensory systems, cognitive psychology and applied linguistics) and with this purpose it is supposed to develop CM and CMT for the system analysis of IEE.

Formally IW of trainees as the object of control in ART system and the possibility of its modeling represent the complex multi-parametrical system. The current condition of the subjects of training (trainees) is characterized by a certain learning-professional and social-psychological status of personality.

The control and EI are the various factors of the learning process, mutually-related with the program-technical (the means and technologies), the learning-methodical support (LMC), the social-psychological status of the subject of training (trainee) (IFPST) and the professional status of tutor (the qualification, competence and IFPST), and also the resource support of educational centre (the learning base) and other.

For the realization of the effective educational process it is supposed to introduce PCMB into the contour of ART, including CM of the subject of training and the means of training.

CM of the subject of training includes a set of parameters, reflecting the individual dynamics of the condition of the trainee at the transferring from the initial to the final condition, and the application of CM for the system analysis of IEE will allow to solve the following tasks:

- to determine and justify a minimal necessary set of the most significant direct and indirect criteria of quality of the (adaptive) training (at distance), providing the comparability of measurements and the set statistical properties;
- to provide the monitoring of quality of the different educational services and to create DB, based on the quasi-dynamic analysis of the information from which: from the one side,- it becomes possible to create the professiograms of the subjects of IEE, to reveal the dependencies between the social-psychological status of trainees and the various factors of the technological process of training (at distance); from the other side,- their learning and professional achievements, to provide the solution of the tasks of predicting of the learning and professional achievements, and also the tasks on the supporting of the making of decisions in the control of the technological process of training and the quality of the (adaptive) training (at distance).

The contour of control by ART system is the closed contour directly, providing the feedback for the collection and accumulation of information, the generation of EI, the diagnostics of LRKT and IFPST, and also the analysis of dependencies. The monitoring and control of the process of training consists in the purposeful accumulation of information with its subsequent classification, ordering and structuring. The structured information about the condition of the subject of training allows to create and modify the schemes and sequences of generation of EI (the information fragments) in the process of the controlled formation of knowledge, abilities and skills, taking into account IFPST at the working with LMC, to modernize the educational programs, to adapt the program-technical complex, to include into the educational process of new techniques of studying of the disciplines and other. The development of CMT is expedient and justified for the conducting of qualitative researches of IEE of ART system.

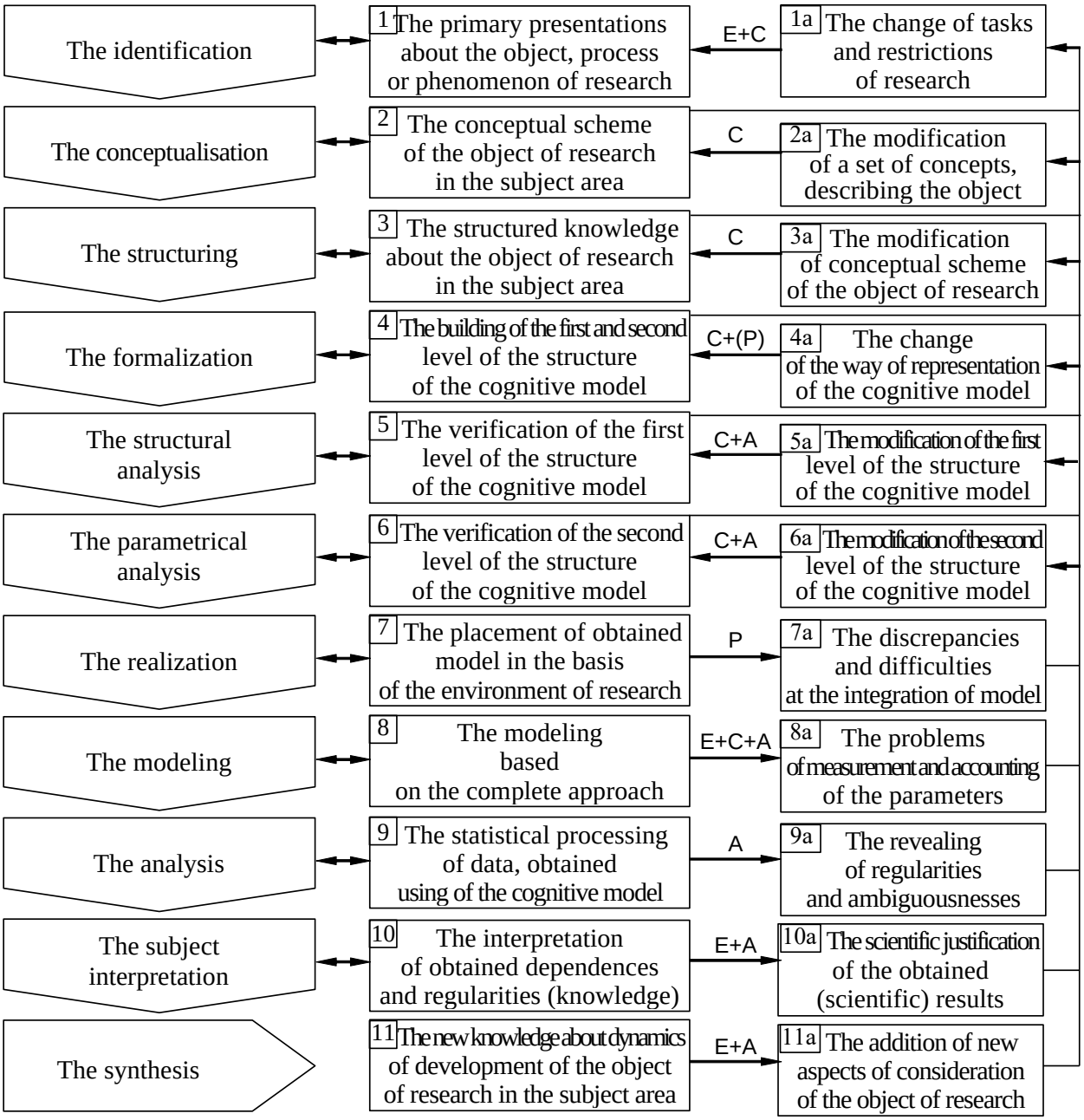
CMT is intended not only for the building of the structure of CM the object of research, but and its a subsequent parametrical filling and analysis.

The developed technology includes the iterative sequence of stages, providing a series of scientific-research actions directly for:

- the collecting of the primary presentations about the researched object, process or phenomenon in a certain (selected) subject area (a problem sphere);
- the selecting of a set of scientific aspects, revealing the different properties and the dynamics of functioning of the object, process or phenomenon of research;
- the (re)constructing of the structure of CM of the researched object, process or phenomenon;
- the carrying out of the structural and parametrical analysis of the obtained CM;
- the using of the obtained CM of the researched object, process or phenomenon in a certain environment (a problem sphere) of its functioning;
- the modelling, directed on the revealing of the nominal values of parameters in the basis of the structure of CM of object, process or phenomenon of research;
- the analysis of a posteriori data by the statistical methods with the purpose of revealing of the regularities of functioning of the object, process or phenomenon of research;
- the subject interpretation of the revealed regularities with the purpose of formalization of the merits and demerits of the object, process or phenomenon of research in a certain environment (a problem sphere) of its functioning;
- the accumulation of new knowledge about the researched object, process or phenomenon.

In case of the revealing of errors and inconsistencies CMT provides the return at the previous stages of research (analysis) with the purpose of carrying out of correction.

The iterative cycle of CMT is presented directly in pic. 3.3.




Picture 3.3. The iterative cycle of the cognitive modeling technology

For the difficult IEE of ART CMT provides the involvement of a row of consultants, which are designated directly by the certain letters: the methodist (E) – an expert in the area of pedagogics (IEE of ART system); the cognitologist (K) – a specialist in the area of the structuring of data and knowledge engineering, providing the correctness of the obtained structure of the parametrical CM; the system analyst (A) – a specialist in the area of the system analysis and modeling of IEE; the programmer (P) – a qualified specialist, knowledgeable the modern methods and approaches to the realization of the high-technological IEE by means of the environments of programming.

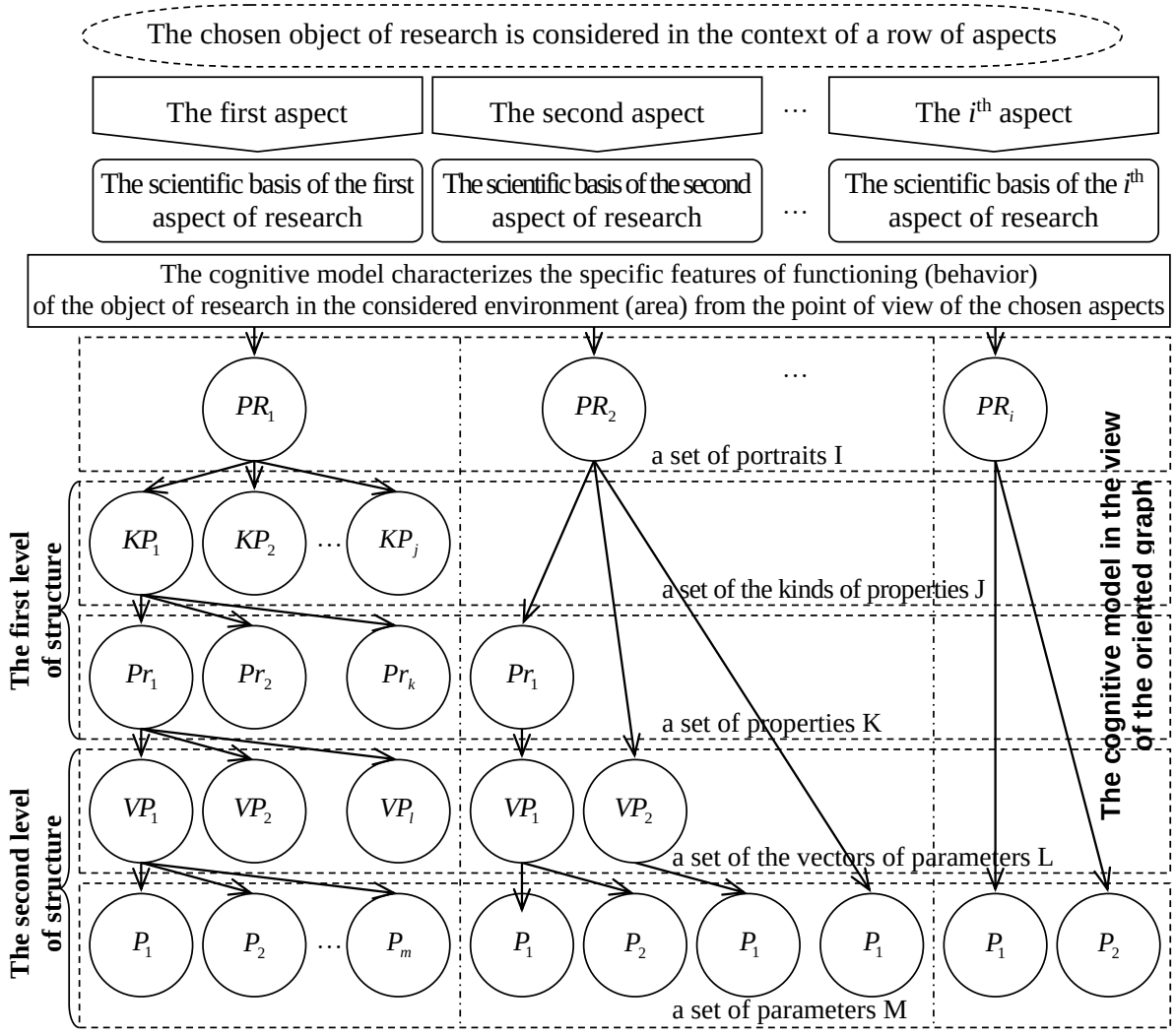
## 3.2. The features of presentation and formal description of the structure of the parametrical cognitive model

CM is oriented on the research of the difficult objects, processes and phenomena in the various subject areas, therefore it can have the different presentation and description.

The structure of CM presents the construct, echeloned on a set of portraits, each from which is stratified on a set of the kinds of properties, properties, the vectors of parameters and parameters, characterizing the object of research.

CM can be represented by the formal (the theory of sets and the theory of graphs) and the nonformal methods and models of knowledge representation (the structural scheme, the conceptual scheme and the ontology of the object of research in the subject area).

Using the apparatus of the theory of graphs, CM represents the oriented graph, in the vertices of which are concentrated (from up to down): the portraits, the kinds of properties, properties, the vectors of parameters and the parameters, which form the corresponding sets, characterizing the object, process or phenomenon of research in the subject area (pic. 3.4).

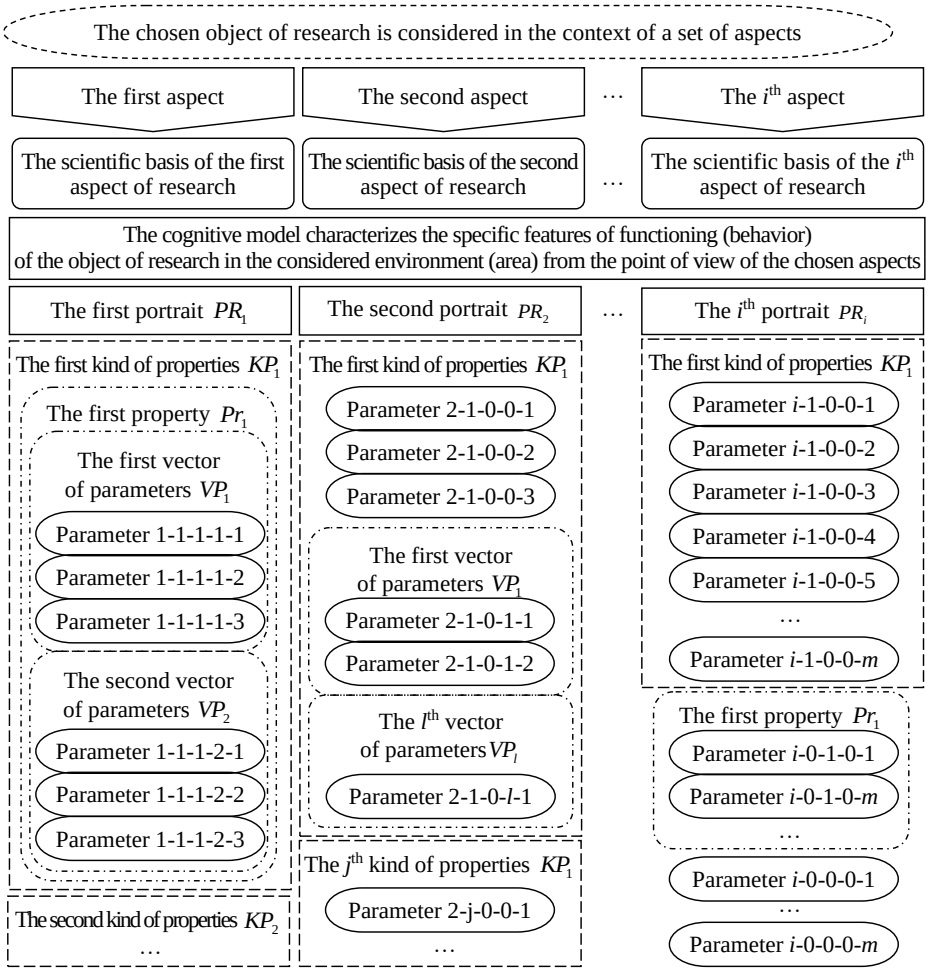



Picture 3.4. The recommended basis for the formation of the structure of the cognitive model (the formal representation)

In pic. 3.4 the following designations for the sets and countable indexes are introduced and used: the set of portraits (PR) I and the index of portrait *i*, the set of the kinds of properties (KP) J and the index of the kind of properties *j*, the set of properties (Pr) K and the index of property *k*, the set of the vectors of parameter (VP) L and the index of the vector parameters *l*, the set of parameters (P) M and the index of parameter *m*.

The specifics of the selected object of research allows to talk about the possibility of absence of some components in the basis of the structure of CM, thus, that the presented graph reduces and it does not have some vertices (the information elements of the corresponding mathematical sets). If the object is characterized by only one kind of properties, then it is needed to go to the one level down on the hierarchy of CM – to fill the elementary properties and parameters at once. If the object of research includes one kind of properties and one elementary property, then it is advisable to form the vectors of parameters and to fill them by the parameters. If the object of research contains one kind of properties, one elementary property and one vector of parameters, than it is advisable to add into the portrait a set of parameters at once, ignoring the remaining components (the information elements) of the hierarchy.

CM can represented by the classical way – by means of the structural scheme (pic. 3.5), which can used for the research of the structurally simple object.




Picture 3.5. The recommended basis for the formation of the structure of the cognitive model (the nonformal presentation)

### 3.3. The technique of use of the cognitive modeling technology for the system analysis of the object, process and phenomenon of research

The technique allows to form the structure of CM based on CMT (pic. 3.6).

For the use of CMT in relation to the object of research in the subject area is necessary to fulfill a row of certain conditions in the context of each stage (step).

*At the stage of identification* it is necessary to provide the collection of details (the purposes, tasks and limitations to IEE) necessary and sufficient for the formation of the structure of CM (for the difficult IEE CMT assumes the involvement of experts, see pic. 3.3).

it is required to determine which factors and aspects of the object of research in the subject area will be reflect the created structure of CM, taking into account, that their set can modified in the process of using of CMT.

*At the stage of conceptualization* the key concepts (properties and parameters), related to the features of the object of research in the subject area are allocated. The classes of concepts (the portraits and the kinds of properties) and the subgroups of parameters (the vectors of parameters) of research are determined, and also the areas of admissible values of parameters (the limits of variation of values) are specified.

*At the stage of structuring* the relationships and links between the selected key concepts (properties and parameters) and their classes (portraits and the kinds of properties) are determined, and also the subgroups of parameters (the vectors of parameters), characterizing the object of research in the subject area. At the given stage a peculiar field of knowledge (the ontology of the subject area), characterizing the object of research, which is necessary for the building of the structure of CM is formed.

*At the stage of formalization* the building (addition) of the structure of CM by the means of using of the one from the formal (nonformal) models of representation of data and knowledge from the area of artificial intelligence is provided.

The complete structure of CM, including all portraits with parameters, can be described by means of the theory of graphs and be the graph model.

*At the stages of the structural and parametrical analysis* it is necessary to carry out the analysis of correlation relationships and dependencies between the selected concepts (parameters). At the using of CMT each portrait in the structure of the parametrical CM must include directly a set of the vectors of parameters. A sets of parameters in the context of the various portraits should not intersect and be contradictory, and the obtained structure of CM should satisfy to the purposes, requirements and restrictions, developed in relation to the object of research.

From the point of view of the classical and modern mathematical statistics the use of the correlation-regression analysis is justified directly, which will allow to exclude the insignificant parameters in the basis of the portraits of the obtained CM.

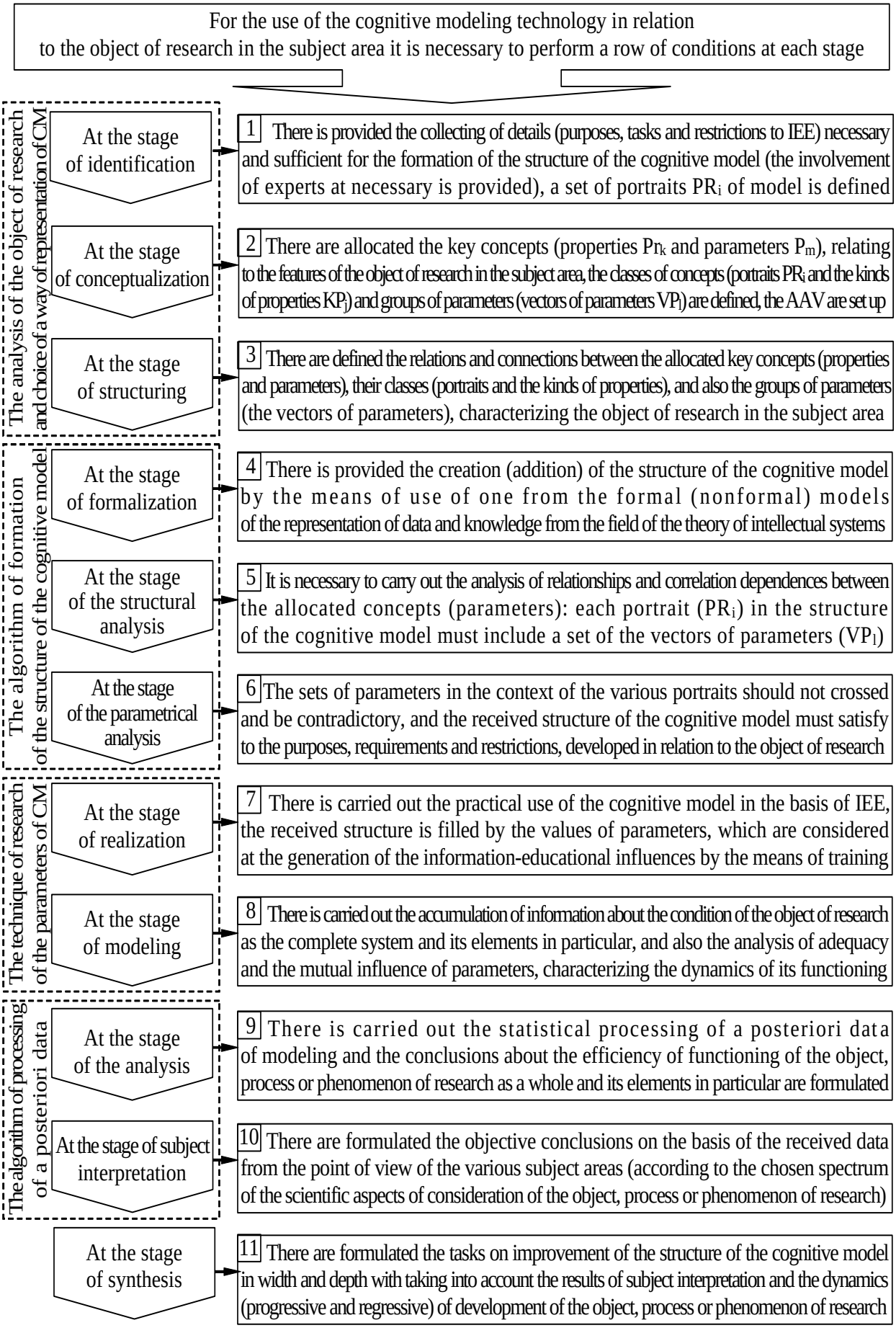
*At the stage of realization* the practical use of CM in the basis of IEE is carried out. For this the obtained structure of CM is filled by the values of parameters of the subjects of training, which further taken into account directly at the generation of various EI (information fragments) by the different means of training in IEE of ART system.

*At the stage of modeling* the accumulation of information about the condition of the object, process or phenomenon of research as an integral system and its elements in particular, and also the analysis of the adequacy and mutual influence of the nominal values of parameters, characterizing the dynamics of its functioning in a certain problem sphere is carried out.

*At the stage of analysis* the processing of a posteriori statistical data of modeling is carried out and the conclusions about the efficiency of functioning of the object, process or phenomenon of research as a whole and its elements in particular is carried out.

*At the stage of subject interpretation* the objective conclusion based on the obtained data from the point of view of the various subject areas is made (according to the selected spectrum of the scientific aspects of consideration of the object of research).

*At the stage of synthesis* with taking into account the results of subject interpretation and the dynamics (progressive or regressive) of the development of situation in the process of research the tasks on the improvement of the structure of the parametrical CM are formulated (if the parameters do not cover some aspects of research or be redundant).



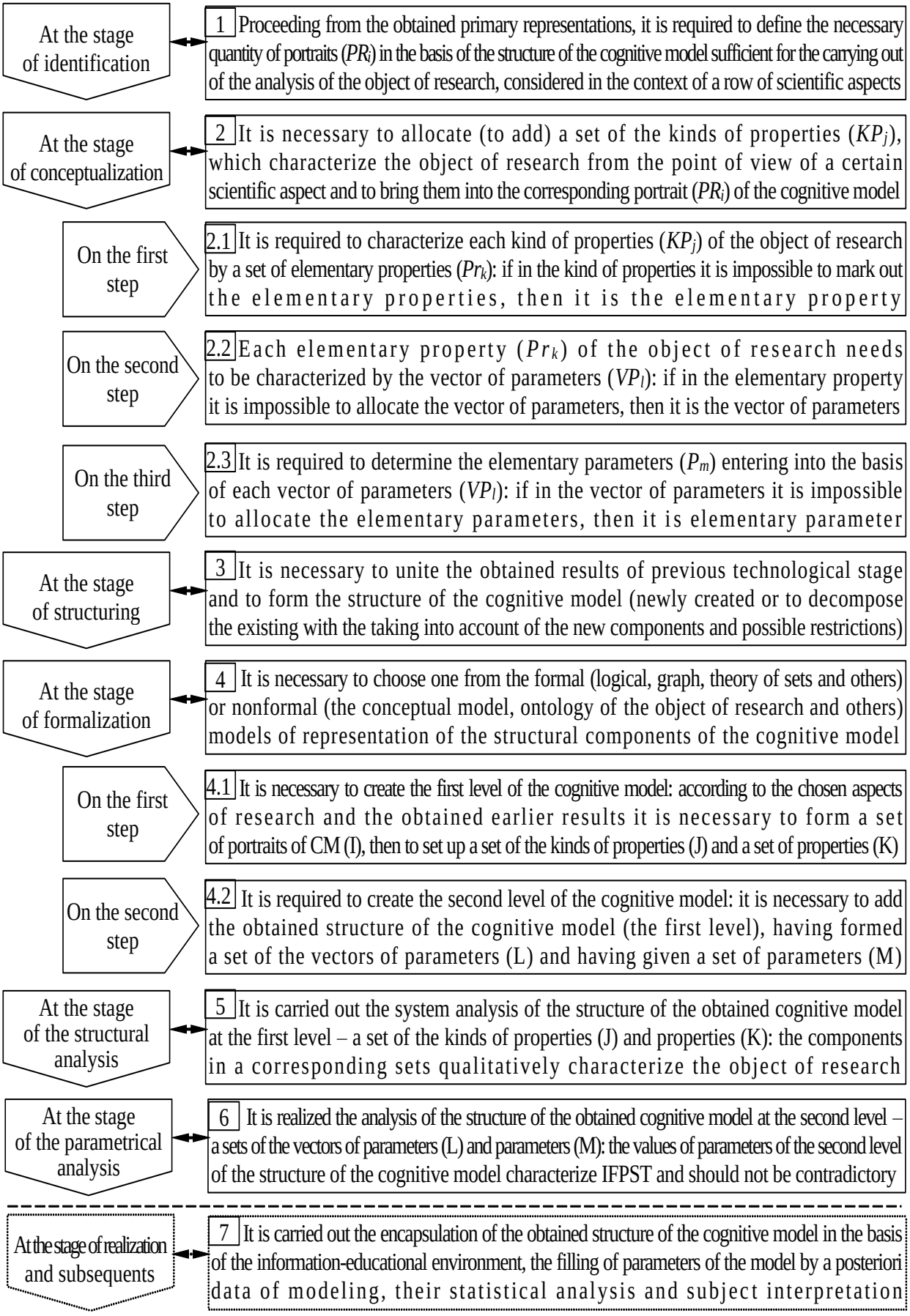

Picture 3.6. The technique of use of the cognitive modeling technology

### *3.4. The algorithm of formation of the structure of the cognitive model for the tasks of the system analysis of the information-educational environment*

A row of conditions needs to perform for each stage (step) of the system analysis for the usage of the developed CMT in the basis of IEE of ART system.

CMT is the closed cycle and in the process of its use for the formation of the structure of the parametrical CM it is necessary to adhere to the recommended structure (hierarchy) of the parametrical CM (pic. 3.4 and pic. 3.5), otherwise the errors in the process of the system analysis and modeling are possible. The presented technology allows a return to the previous stages of research with the purpose of potential support of correction of the revealed inconsistencies and the introduction of novations on any from the stages of the process of research, which entail the modification of the structure of the parametrical CM. The proposed algorithm of formation of the structure of CM is oriented on the building of the structure of the parametrical CM, presented in the view of the oriented graph (pic. 3.7).

The information interaction of the subjects of training and the means of training in IEE of ART system is the difficult (science-intensive) object of research. The solution of the task of adaption of the various EI (the information fragments), generated by the different means of training (ET, LW, EL and others), according to the identified IFPST, is come down to the development of two CM: the parametrical CM of the subject of training and the parametrical CM of the means of training (otherwise the scientific principle of consistency in the process of functioning of the dual contour of adaptation based on the developed innovative PCMB is not performed). The measurement (diagnostics) of IFPST, introduced into CM of the subject of training is performed in the beginning of the technological process of training (at distance), and the parametrical CM of the means of training is filled by the developers of the components of IEE of ART system in the course of life cycle of their program realization.




Picture 3.7. The algorithm of formation of the structure of the cognitive model

### 3.4.1. The building of the structure of the cognitive model of the subject of training for the tasks of the system analysis of the information-educational environment

The formation of the structure of the parametrical CM should be carried out according to the technique of use of CMT based on the algorithm of forming of the structure of CM, wherein the entire process of development includes a sequence of stages of CMT, each from which allows directly the existence of several steps.

*At the first stage (the identification)* proceedings from the obtained primary presentations it is required to determine the necessary quantity (set) of portraits ($PR_i$) in the basis of the structure of CM sufficient for the carrying out of the analysis of the object of research, which can be considered in the context of the several aspects, having the various scientific basis. At the same time for each aspect it is advisable to enter the separate portrait into the structure of CM, which is convenient for the subsequent analysis of a posteriori results of research.

For the analysis of the information interaction between the subjects and means of training and as a consequence of the efficiency of functioning of IEE the most significant scientific aspects of research are the physiological, psychological and linguistic. Therefore the three portraits are introduced ($PR_1$ – physiological, $PR_2$ – psychological and $PR_3$ – linguistic) in the basis of CM, but at the same time the structure of CM provides the further expansion in width – the addition of a new portrait ($PR_i$) and in depth – the addition of a new kinds of properties ($KP_j$), properties ($\mathrm{Pr}_k$), the vectors of parameter ($VP_l$) and parameters ($P_m$) as necessary.

*At the second stage (the conceptualization)* it is needed to allocate a set of the kinds of properties ($KP_j$), which characterize the object, process or phenomenon of research from the point of view of a certain scientific aspect and to enter them into the corresponding portrait ($PR_i$) of CM.

In the further the formation of the structure of CM of the subject of training, including directly the various three portraits ($PR_i$) is considered. The physiological, psychological and linguistic portraits contain by one main kind of properties ($KP_j$) respectively the sensory perception ($KP_1$), the intellectual abilities ($KP_2$) and the language communication ($KP_3$).

*On the first step of the second stage* each kind of properties ($KP_j$) of the object of research to characterize by a set of elementary properties ($\mathrm{Pr}_k$) is required.

The physiological portrait ($PR_1$) includes one basic kind of properties "sensory perception" ($KP_1$) and the several elementary properties derived from it ($Pr_k$): the properties of visual sensory system ($Pr_1$) and the properties of auditory sensory system ($Pr_2$).

In the psychological portrait ($PR_2$) contains one basic kind of properties "intellectual ability" ($KP_2$) and the several elementary properties derived from it ($Pr_k$): the converged ($Pr_3$) and divergent ($Pr_4$) abilities, the cognitive styles ($Pr_5$) and learning-ability ($Pr_6$).

The linguistic portrait ($PR_3$) contains the basic kind of properties "the language communication" ($KP_3$) and the only derivative property – the proficiency in the language of statement of the material ($Pr_7$).

*On the second step of the second stage* each elementary property ($Pr_k$) of the object of research is needed to characterize by the vectors of parameters ($VP_l$).

In the basis of the physiological portrait ($PR_1$) the properties of the visual sensory system ($Pr_1$) are revealed by the three vectors of parameters ($VP_l$): the anomalies of refraction of eye ($VP_1$), the anomalies of perception of space ($VP_2$) and the anomalies of color vision ($VP_3$), and the features of the auditory sensory system ($Pr_2$) – the functions of the external, middle and internal ear ($VP_4$).

In the basis of the psychological portrait ($PR_2$): the convergent abilities ($Pr_3$) are characterized by the level properties of intellect of the subject of training ($VP_5$); the divergent abilities ($Pr_4$) include the verbal ($VP_6$) and figurative ($VP_7$) creativity; the cognitive styles ($Pr_5$) include a set of the vectors of parameters ($VP_8 – VP_{13}$); learning-ability ($Pr_6$) is characterized by the vector of parameters ($VP_{14}$).

In the basis of the linguistic portrait ($PR_3$): the proficiency in the language of statement of the material ($Pr_7$) is characterized by the vector of parameters of the level of proficiency in the language statement ($VP_{15}$).

*On the third step of the second stage* it is required to define the elementary parameters ($P_m$), including directly in the basis of each vector of parameters ($VP_j$).

In the basis of the physiological portrait ($PR_1$) the vectors of parameters ($VP_j$) accordingly include the elementary parameters ($P_m$): the anomalies of refraction of eye ($VP_1$) – astigmatism ($P_1$), myopia ($P_2$) and hypermetropia ($P_3$); the anomalies of perception of space ($VP_2$) – acuity of vision ($P_4$), field of vision ($P_5$) and estimation of distance ($P_6$); anomalies of color vision ($VP_3$) – achromasia ($P_7$), protanopia ($P_8$), deuteranopia ($P_9$) and tritanopia ($P_{10}$), and the features of the auditory sensory system of the subject of training ($C_2$) at the level of functions of the external, middle and internal ear ($VP_4$) – the absolute sensitivity ($P_{11}$), the thresholds of sensitivity ($P_{12}$) and the maximal sensitivity ($P_{13}$).

In the basis of the psychological portrait ($PR_2$) the vectors of parameters ($VP_j$) accordingly include the elementary parameters ($P_m$): the convergent abilities ($VP_5$) – verbal intellect ($P_{14}$), deductive thinking ($P_{15}$), combinatorial abilities ($P_{16}$), the ability to reasoning ($P_{17}$), analytical thinking ($P_{18}$), inductive thinking ($P_{19}$), mnemonics and memory ($P_{20}$), planar thinking ($P_{21}$) and volumetric thinking ($P_{22}$); the verbal creativity ($VP_6$) – associativity ($P_{23}$), originality ($P_{24}$), uniqueness ($P_{25}$) and selectivity ($P_{26}$); the figurative creativity ($VP_7$) – associativity ($P_{27}$), originality ($P_{28}$), uniqueness ($P_{29}$) and selectivity ($P_{30}$); the cognitive styles ($VP_8$–$VP_{13}$) – field-dependence ($P_{31}$) and field-independence ($P_{32}$), impulsivity ($P_{33}$) and reflexivity ($P_{34}$), rigidity ($P_{35}$) and flexibility ($P_{36}$), concretization ($P_{37}$) and abstraction ($P_{38}$), cognitive simplicity ($P_{39}$) and cognitive complexity ($P_{40}$), categorical narrowness ($P_{41}$) and categorical width ($P_{42}$); the vector of parameters of training ($VP_{14}$) – implicit ($P_{43}$) and expletive ($P_{44}$).

In the basis of the linguistic portrait ($PR_3$) the vector of parameters of the level of proficiency ($VP_{15}$) includes the elementary parameters: the level of proficiency in the language of statement ($P_{45}$), the level of proficiency in the dictionary of terms ($P_{46}$) and the elements of interface ($P_{47}$).

*At the third stage (the structuring)* it is necessary to unite the obtained results of the previous stage and to form the structure (to create a new or to decompose the existing early with taking into account of new restrictions).

According to the previously recommended structure CM includes the 5 hierarchical levels, which, as had been previously shown, are described from the point of view of the theory of sets: a set of portraits (I), a set of the kinds of properties (J), a set of properties (K), a set of the vectors of parameter (L) and a set of parameters (M) of the object of research. In this case the structure of CM of the subject of training is considered as newly created, with all its components obtained at the first two stages (identification-conceptualization).

*At the fourth stage (the formalization)* it is necessary to select one from the formal (the logical, the graph, the theory of sets and others) or nonformal (the conceptual model, the ontology of the object of research and others) models of representation of the structural components of CM.

In the purposes of optimal presentation of the selected components of the object of research fits the ontology of the subject area (convenient for the perception of human), but for the formalization with the purpose of automation the process of modeling and in the basis of program toolkit, realizing the elements of IEE it is necessary to use the frame network, the semantic network, the logical model, the graph model and others.

For the formalization of the structure of CM of the subject of training the hybrid model was selected, hierarchically representing directly the oriented graph, the components of which at the certain levels form a set of sets.

It is proposed to decompose the structure of the parametrical CM at the two levels and to provide the realization of each from them separately by the principle "from up to down".

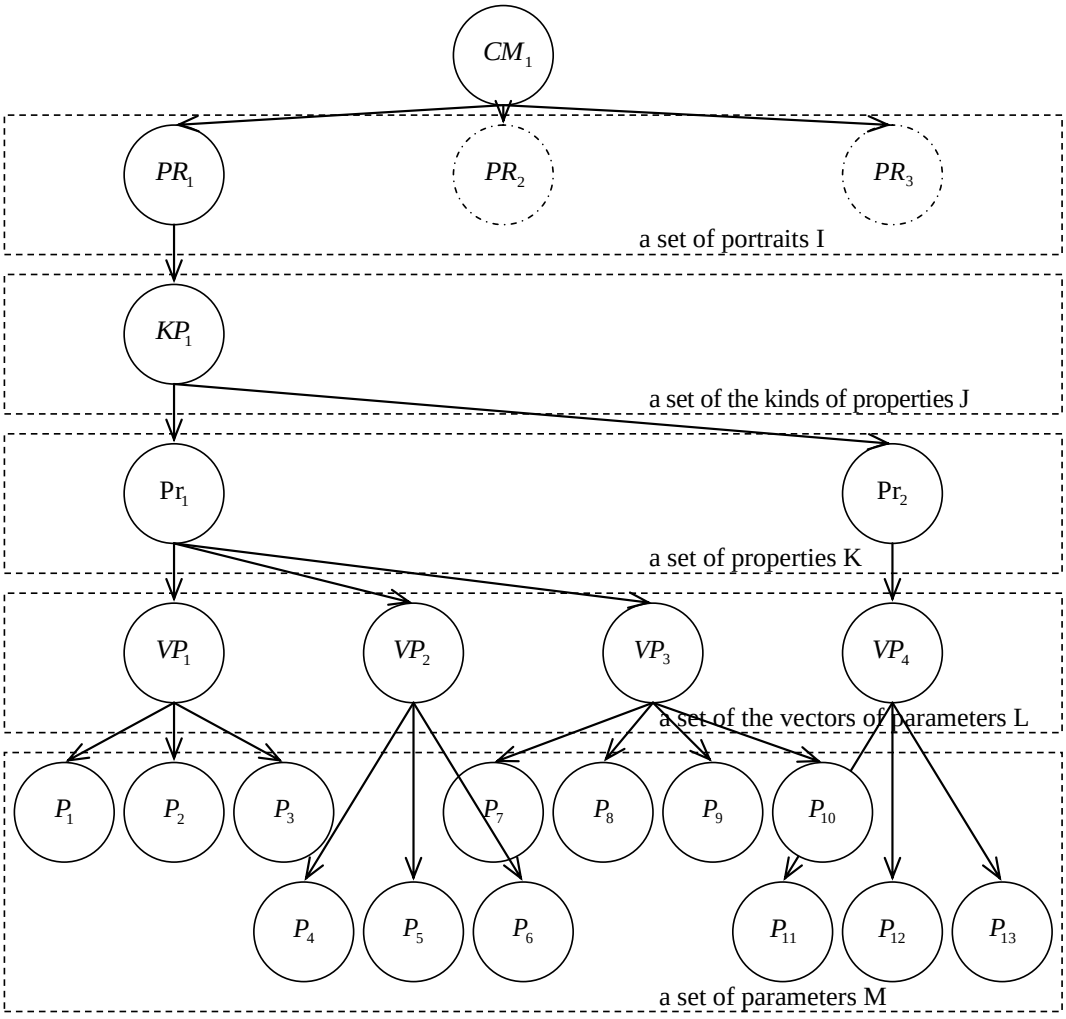
*On the first step of the fourth stage* it is needed to create the first level of CM.

According to the selected aspects of research and the previously obtained results it is necessary to form a set of portraits of CM (I), then in each from them to set a set of the kinds of properties (J) and a set of properties (K), acting as the vertices of graph. The arcs of the oriented graph express the relationships between the vertices of graph, located at the first level of CM in the corresponding sets.

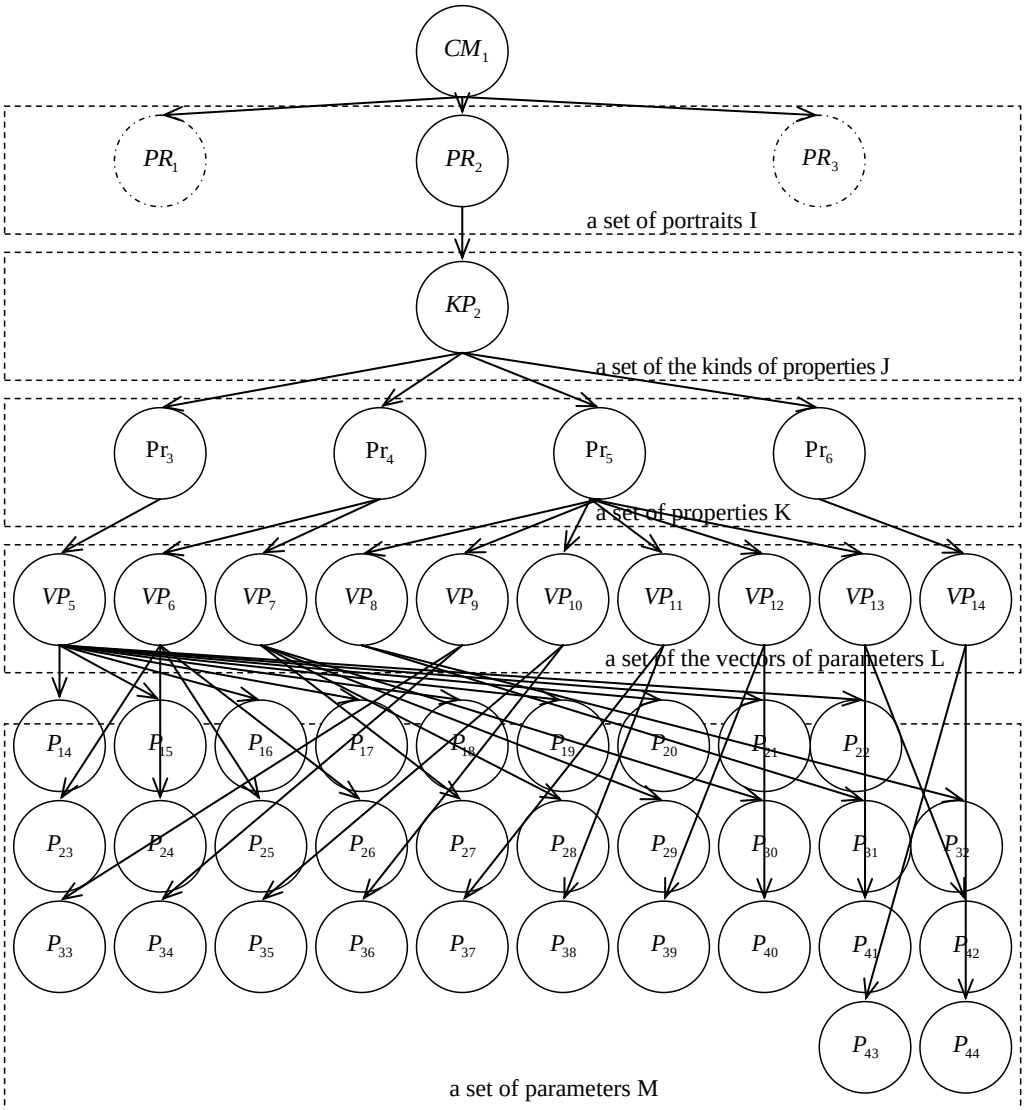
*On the second step of the fourth stage* it is necessary to create the second level of CM.

It is necessary to complement the obtained structure of CM (the first level), by the forming of a set of the vectors of parameters (L) and by the setting of a set of parameters (M).

The oriented graphs, reflecting the structure of the physiological, psychological and linguistic portraits of CM of the subject of training are presented respectively in pic. 3.8-3.10.




Picture 3.8. The graph, reflecting the structure of the physiological portrait of CM the subject of training



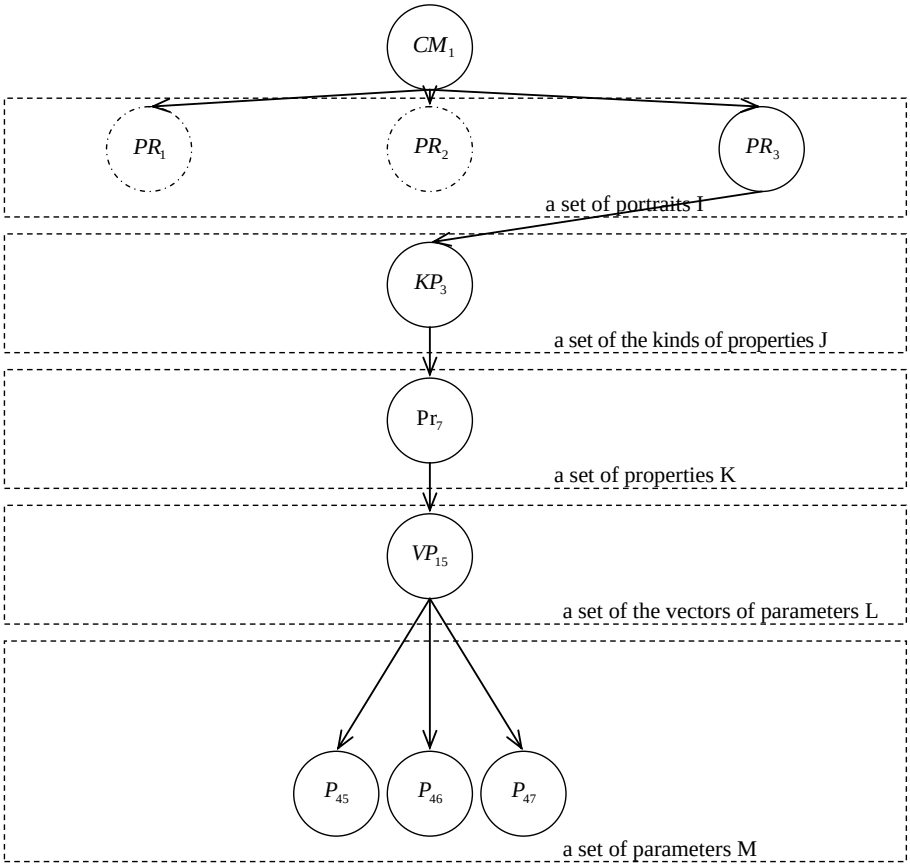

Picture 3.9. The graph, reflecting the structure of the psychological portrait of CM of the subject of training

The next two stages provide the analysis of the correspondence of the first and second levels the structure of the parametrical CM for the purposes of using in the basis of IEE of ART system.

*At the fifth stage (the structural analysis)* the analysis of the structure of the obtained CM is carried out at the first level – a set of the kinds of properties (J) and properties (K).

The set of considered components of a corresponding sets characterizes IFPST in the process of the formation of knowledge by means of EI (the information fragments), generated by the means of training, but is neither optimal, nor exhaustive, as it has a subjective basis (based on the experience of a certain expert).

*At the sixth stage (the parametrical analysis)* the analysis of the structure of the obtained CM is realized at the second level – the sets of the vectors of parameters (L) and parameters (M). The values of parameters of the second level of the structure of CM characterize IFPST, and their set covers all three scientific aspects of research of the subject of training and is not contradictory theoretically and practically (statistically).




Picture 3.10. The graph, reflecting the structure of the linguistic portrait of CM of the subject of training

The next three stages provide the support of the technological process of research of IEE of ART system based on the innovative PCMB, that allows to build the additional contour of adaptation with the taking into account of IFPST.

*At the seventh stage (the realization)* the encapsulation of the obtained structure of the parametrical CM into the basis of the automated IEE of ART system is carried out. At the same time takes into account the features of information flows, the methodical, technical and program components (depending from the concrete IEE of EE), and CM of the subject of training contains IFPST and is located in PCMB directly, which functions in concert with the basic DM and applied DM and the adaptive representation of information fragments processor of ET (pic. 2.9).

*At the eighth stage (the modeling)* the modeling, based on a holistic scientific approach is carried out directly. CM in the basis of the adaptive contour is filled by the actual (a priori) and current data. According to the general scheme of training as the controlled technological process the parametrical CM of the subject of training is formed at the initial stage by means of the automated testing based on the block of tests of IFPST (pic. 2.6).

The parameters of CM of the subject of training are characterized directly IFPST, which are taking into account further by the adaptive representation of a sequence of information fragments processor (pic. 2.8) of ET at the generating of EI (the information fragments), oriented on a concrete trainee (pic. 2.9).

In fact of the completion of studying of a certain information fragment (part, section, chapter, module, block, paragraph and subparagraph) or the discipline as a whole, the current, intermediate and final control of LRKT is carried out accordingly, the results of which are an aggregate of the model of current knowledge and are placed in ERB (pic. 2.3).

*At the ninth stage (the analysis)* the statistical analysis of the obtained a posteriori data in relation to the object of research is realized.

The relationship between the indicators of the resultativity of training and the nominal values of parameters of CM of the subject of training is revealed. Based on the revealed statistical regularities the reasons of difficulties of the subject of training in the process of the formation of knowledge are proved.

*At the tenth stage (the subject interpretation)* the revealed statistical regularities at the previous stage are interpreted in relation to the object of research from the point of view of the scientific aspects of consideration. The recommendations are formulated to the diverse subjects of training (trainees) and the ways of improvement of the various means of training due to means of the expanding of spectrum of the developed EI (the improvement of LMC) and the vector of parameters in the basis of the structure of CM.

*At the concluding stage (the synthesis)* the synthesized new knowledge about the dynamics of the object, process or phenomenon of research are applied directly for the development of a new and the modifying of existing purposes, tasks and restrictions, allowing to correct the structure of the parametrical CM in width and depth. CMT envisages directly return to the previous stages and steps, that allows operatively to carry out the updating of the structure of the parametrical CM.

### 3.4.2. The building of the structure of the cognitive model of the means of training for the tasks of the system analysis of the information-educational environment

*At the first stage (the identification)* the primary presentations about the specifics of the object of research were obtained and the important scientific assumption was accepted, that for the providing of consistency of the production of EI (the information fragments) the parametrical CM of the means of training is needed, in the basis of the structure of which (similar to the parametrical CM of the subject of training) the three different portraits are entered ($PR_1$ – physiological, $PR_2$ – psychological and $PR_3$ – linguistic).

*At the second stage (the conceptualization of situation)* it is necessary to allocate directly the mathematical set of the kinds of properties ($KP_j$), which characterize the selected object of research from the point of view of a certain scientific aspect and to include them into the corresponding portrait ($PR_i$) of CM.

Similar to CM of the subject of training CM of the means of training includes three portraits.

The physiological, psychological and linguistic portraits contain one each main kind of properties ($KP_j$) respectively the sensory perception ($KP_1$), intellectual abilities ($KP_2$) and language communication ($KP_3$).

*On the first step of the second stage* it is required each kind of properties ($KP_j$) of the object of research to be characterized by a set of elementary properties ($\mathrm{Pr}_k$).

The physiological portrait ($PR_1$) includes one basic kind of properties "the visual representation" ($KP_1$) and the several elementary properties ($\mathrm{Pr}_k$) derived from it: the properties of visual representation ($\mathrm{Pr}_1$) and the properties of sound representation ($\mathrm{Pr}_2$).

In the psychological portrait ($PR_2$) contains one basic kind of properties of "the way of representation" ($KP_2$) and the several elementary properties ($\mathrm{Pr}_k$) derived from it: the kind of information ($\mathrm{Pr}_3$), the additional capabilities of the displaying of information ($\mathrm{Pr}_4$), the style of presentation of information ($\mathrm{Pr}_5$) and the speed of representation of information ($\mathrm{Pr}_6$).

The linguistic portrait ($PR_3$) in the base contains one basic kind of properties "the language of communication" ($KP_3$) and the only derived property "the language of statement of material" ($\mathrm{Pr}_7$).

*On the second step of the second stage* each elementary property ($\mathrm{Pr}_k$) of the object of studying is needed to characterize by the vectors of parameter ($VP_l$).

In the basis of the physiological portrait ($PR_1$) the property of visual representation ($\mathrm{Pr}_1$) are revealed by the three vectors of parameters ($VP_l$): the parameters of background ($VP_1$), the parameters of font ($VP_2$) and color schemes ($VP_3$), and the properties of sound representation ($\mathrm{Pr}_2$) – the vector of parameters of the playback of audio stream as the information fragment ($VP_4$).

In the basis of the psychological portrait ($PR_2$): the kind of information ($\mathrm{Pr}_3$) is characterized by the vector of parameters ($VP_5$); the additional capabilities ($\mathrm{Pr}_4$) include the vector of parameters ($VP_6$); the style of presentation ($\mathrm{Pr}_5$) includes a set of the vectors of parameters ($VP_7 - VP_{12}$); the speed of representation ($\mathrm{Pr}_6$) is characterized by the vector of parameters ($VP_{13}$).

In the basis of the linguistic portrait ($PR_3$): the language of statement of the material ($\mathrm{Pr}_7$) is characterized by the vector of parameters "the level of statement of the material" ($VP_{14}$).

*On the third step of the second stage* it is required to define the elementary parameters ($P_m$), including directly into the basis of each vector of parameters ($VP_j$).

In the basis of the physiological portrait ($PR_1$) the vectors of parameters ($VP_j$) accordingly include the different elementary parameters ($P_m$): the vector of parameters of background ($VP_1$) – type of pattern ($P_1$), color of background ($P_2$) and combination of color ($P_3$); the parameters of font ($VP_2$) – set of font ($P_4$), size of point-size of symbol ($P_5$) and color of symbol ($P_6$); the color schemes ($VP_3$) – at achromasia ($P_7$), at protanopia ($P_8$), at deuteranopia ($P_9$) and at tritanopia ($P_{10}$), and the features of sound representation ($Pr_2$) are characterized by the parameters of playback of sound stream ($VP_4$) – volume ($P_{11}$), timbre ($P_{12}$), the type of flow ($P_{13}$) and sound scheme ($P_{14}$).

In the basis of the psychological portrait ($PR_2$) the vectors of parameters ($VP_j$) accordingly include the elementary parameters ($P_m$): the kind of information ($VP_5$) – textual ($P_{14}$), tabular ($P_{15}$), schematic plane ($P_{16}$), schematic volumetric ($P_{17}$), the sound as the main ($P_{18}$), the sound as accompaniment ($P_{19}$), combined ($P_{20}$), special scheme ($P_{21}$); the additional capabilities ($VP_6$) – the correction of sequence ($P_{22}$), the navigation on the course ($P_{23}$), the adding of modules ($P_{24}$), the selection of the kind of information ($P_{25}$), the selection of the style of presentation ($P_{26}$), the selection of speed of presentation ($P_{27}$), creative tasks ($P_{28}$), additional modules ($P_{29}$), additional literature ($P_{30}$); the style of presentation ($VP_7$-$VP_{12}$) – the holistic presentation ($P_{31}$) and detailed presentation ($P_{32}$), the automatic ($P_{33}$) and manual ($P_{34}$) switching, the constant ($P_{35}$) and variable type ($P_{36}$) of information, the deep concretization ($P_{37}$) and abstract statement ($P_{38}$), the simplicity of statement ($P_{39}$) and complexity of statement ($P_{40}$), the wide ($P_{41}$) and narrow ($P_{42}$) set of terms and definitions; the speed of representation of information ($VP_{13}$) – fast ($P_{43}$) and slow ($P_{44}$).

In the basis of the linguistic portrait ($PR_3$) the vector of parameters "the level of statement" ($VP_{14}$) includes the elementary parameters: the level of statement of material ($P_{45}$); a set of keywords and definitions ($P_{46}$); a set of elements in the basis of the interface of interaction ($P_{47}$).

*At the third stage (the structuring)* it is necessary to unite the obtained results of the previous stage and to form the structure of CM.

The structure of CM of the means of training includes the five hierarchical levels, which, as was presented early, are described from the point of view of the theory of sets: a set of portraits (I), a set of the kinds of properties (J), a set of properties (K), a set of the vectors of parameters (L), a set of parameters (M) of the object of studying. In given case the structure of CM of the means of training is considered as the newly created, and all its components are obtained on the previous two stages (identification-conceptualization).

*At the fourth stage (the formalization)* it is needed to select one from the formal or nonformal models of representation of the structural components of CM.

In the purposes of the optimal representation of the selected components of researched object the ontology of the subject area is suitable for the perception by the human, but for the formalization with the purpose of automation of the process of modeling and in the basis of the program toolkit, realizing the elements of IEE it is recommended to use the frame network, the semantic network, the logical model, the graph model and others.

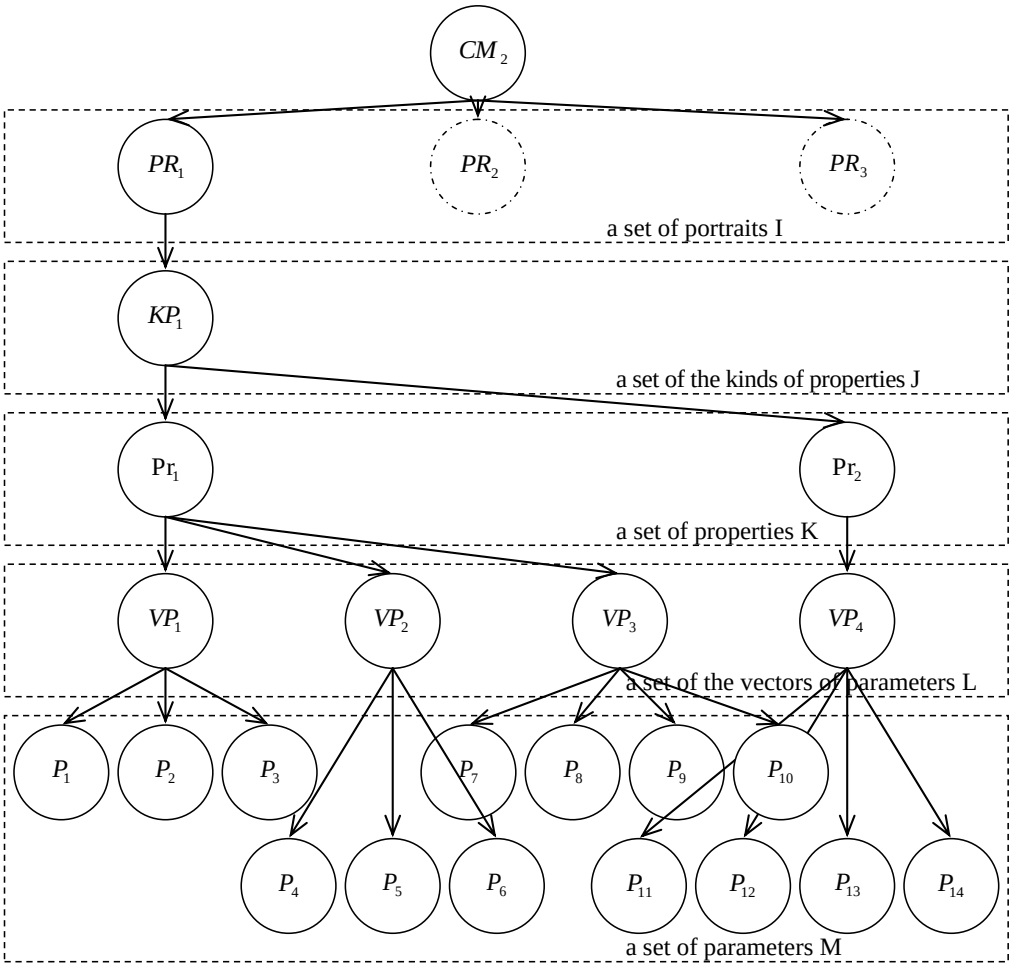
For the formalization of the structure of CM of the means of training the hybrid model was chosen, hierarchically representing directly the oriented graph, the vertices of which at the certain levels form a set of sets (pic. 3.4).

It is recommended to decompose the structure of the parametrical CM on the two levels and to provide the realization of each from them separately by the principle "from up to down".

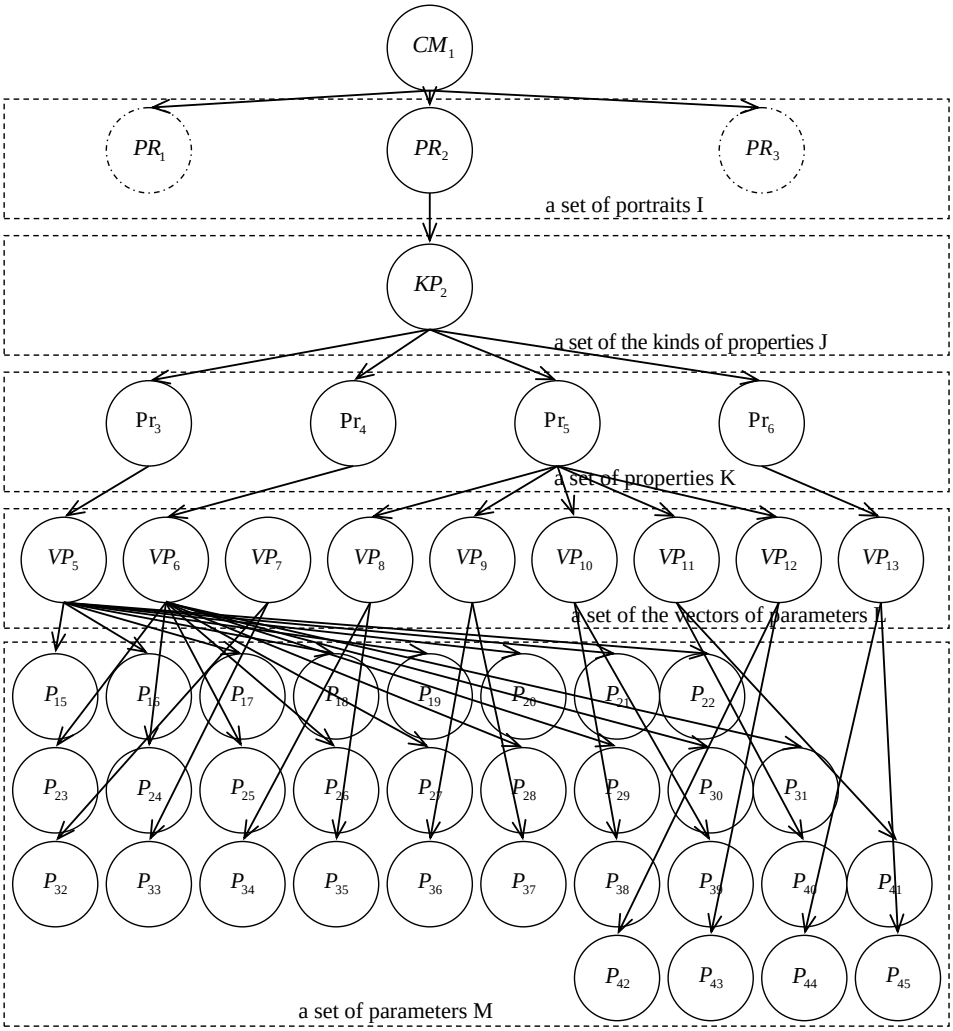
*On the first step of the fourth stage* the first level of CM of the means of training is created. According to the selected aspects of research and the previously obtained results a set of portraits of CM (I) is formed, then in each from them a set of the kinds of properties (J) and a set of properties (K) is set, acting as the vertices of graph. The arcs of graph express the relationships (by the principle of inclusion) between the vertices of graph, located at the first level of the parametrical CM in the corresponding sets.

*On the second step of the fourth stage* the second level of CM of the means of training is created. In essence, the obtained first level of the structure of the parametrical CM by the means of formation of the sets of the vectors of parameters (L) and parameters (M) is added.

The oriented graphs, reflecting the structure of the physiological, psychological and linguistic portraits of CM of the means of training are presented respectively in pic. 3.11-3.13.




Picture 3.11. The graph, reflecting the structure of the physiological portrait of CM of the means of training



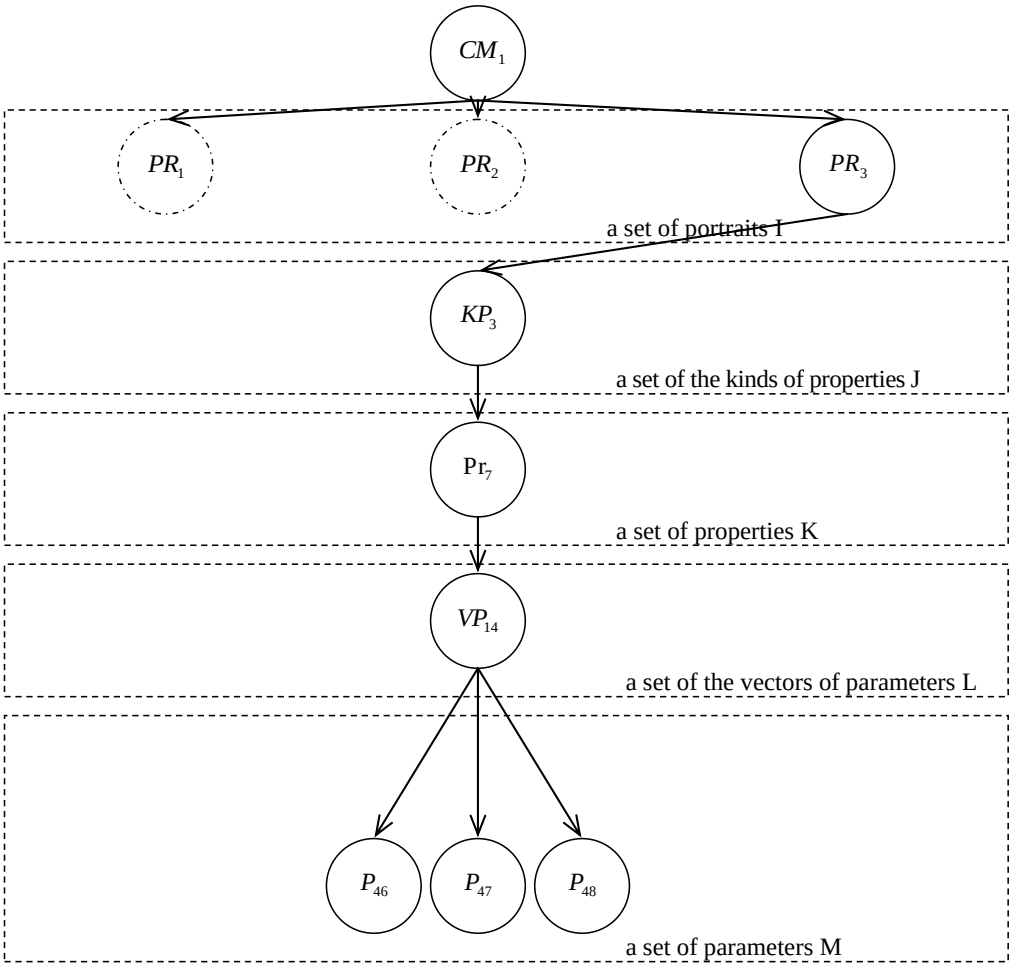

Picture 3.12. The graph, reflecting the structure of the psychological portrait of CM of the means of training

*At the fifth stage (the structural analysis)* the analysis of the obtained structure of CM at the first level is provided – the sets of the kinds of properties (J) and properties (K).

The set of considered components of the corresponding sets characterizes the features of functioning of the means of training in the process of the formation of knowledge of the trainee by means of the generation of EI (the information fragments) of the various kind, but is not neither optimal, nor exhaustive, because it has the subjective basis (based on the experience and qualification of expert in the certain subject area).

*At the sixth stage (the parametrical analysis)* the analysis of the obtained structure of the parametrical CM of the means of training at the second level is carried out – a set of the vectors of parameters (L) and a set of the elementary parameters (M).

The nominal values of parameters of the second level of the structure of CM of the means of training characterize the features of the generated EI (the information fragments), and their set covers all three scientific aspects of research of the means of training and should not be contradictory (from the point of view of the mathematical statistics).




Picture 3.13. The graph, reflecting the structure of the linguistic portrait of CM of the means of training

*At the seventh stage (the realization)* the encapsulation of the obtained structure of the parametrical CM into the basis of the automated IEE of ART system is carried out. It is necessary to take into account the features of information flows, the methodical, technical and program components, which depend from the concrete IEE of EE. The parametrical CM of the means of training includes the key parameters of representation of the information fragments of the adaptive means of training (ET) and is located, along with CM of the subject of training, in the innovative PCMB. The adaptive representation of a sequence of information fragments processor of ET functions directly on the basis of the data of the innovative PCMB, that causes the generation of EI (the information fragments) adequately to IFPST (pic. 2.8).

*At the eighth stage (the modeling)* directly the (cognitive) modeling of the object of research is realized, based on a holistic approach. The parametrical CM in the basis of the developed contour of adaptation in IEE of ADO system are filled by the various actual (a priori) and current data. According to the general scheme of training as the controlled technological process (pic. 2.6) CM of the means of training is formed on the stage of the design of components of IEE (ET and DM) and a set of its parameters corresponds to the technical capabilities of the program means.

The parameters of CM of the means of training characterize directly the potentially possible typology (kinds and features) of the various EI (the various ways of representation of the information fragments of different kind), which are subsequently generated in accordance with the measured IFPST, contained in the parametrical CM of the subject of training (the nominal values).

*At the ninth stage (the analysis)* the procedure of the statistical analysis of the obtained a posteriori data in relation to the object of research. The relationship between the indicators of the resultativity of training (at distance) is revealed, and also the values of parameters of CM of the means of training and CM of the subject of training. In the context of the spectrum of disciplines the ways of increasing of the efficiency of training are proved by the means of using of the various ways of generation of EI (CM of the means of training), taking into account the features of personality of the contingent of trainees in IEE (CM of the subject of training).

*At the tenth stage (the subject interpretation)* the revealed statistical tendences and regularities at the previous stage are interpreted in relation to the object of research from the point of view of the selected scientific aspects of consideration. The recommendations of specialists (experts) in the subject area are formulated: methodists (for the improvement of the existing and the introduction of a new methods of training), teachers and tutors (for the expand of content of the existing LMC), designers (for the improvement in the efficiency of functioning of the components of IEE), programmers (for the introduction of the highly-technological environments of programming, in full measure realizing the capabilities of the modern IEE of ART system), physiologists (for the revealing of the anomalies of sensory perception of the various information and the development of special schemes of the visual representation of information fragments), psychologists (foe the selection of the methods of research of the parameters of personality of the trainee, for the selection of a certain kind and style of presentation of the various information, increasing the efficiency of its processing at the level of psychodynamic construct) and linguists (for the revealing of the language problems of virtual communication in IEE of ART system and the development of the ways of their solution by means of the system analysis).

*At the last stage (the synthesis)* the obtained knowledge about the dynamics of the objects of research is applied for the development of a new and the modification of the existing purposes, tasks and restrictions, allowing to correct the structure of the parametrical CM in width and depth.

The developed CMT provides a return to the previous stages and steps, that allows to carry out operatively the updating of the structure of the parametrical CM and to eliminate the revealed inconsistencies and errors in a cyclic continuous mode.

### *3.5. The description of the structure of the parametrical cognitive model*

CM reflects the most important aspects of information interaction between the subjects of training and the means of training in IEE of ART system, allows to explain qualitatively the causes of difficulties in the process of the formation of knowledge. The consistency of generation of the information influences and IFPST is achieved by means of CM of the subject of training and CM of the means of training in IEE of ART.

CM of the subject of training (pic. 3.14) represents the parameterized repertoire, echeloned on a set of various portraits: the physiological (the features of sensory perception of information by the visual and auditory analyzers), the psychological (the convergent and divergent intellectual abilities, the learning-ability and the cognitive styles of the subject of training), the linguistic (the natural-language scientific aspects of virtual communication of the examinee), as a whole allows to analyze the efficiency of the process of the formation of knowledge, coming from the streams of information, generated by the means of IEE of ART and adsorbed at the level of psychophysiological construct of the head brain of the subject of training.

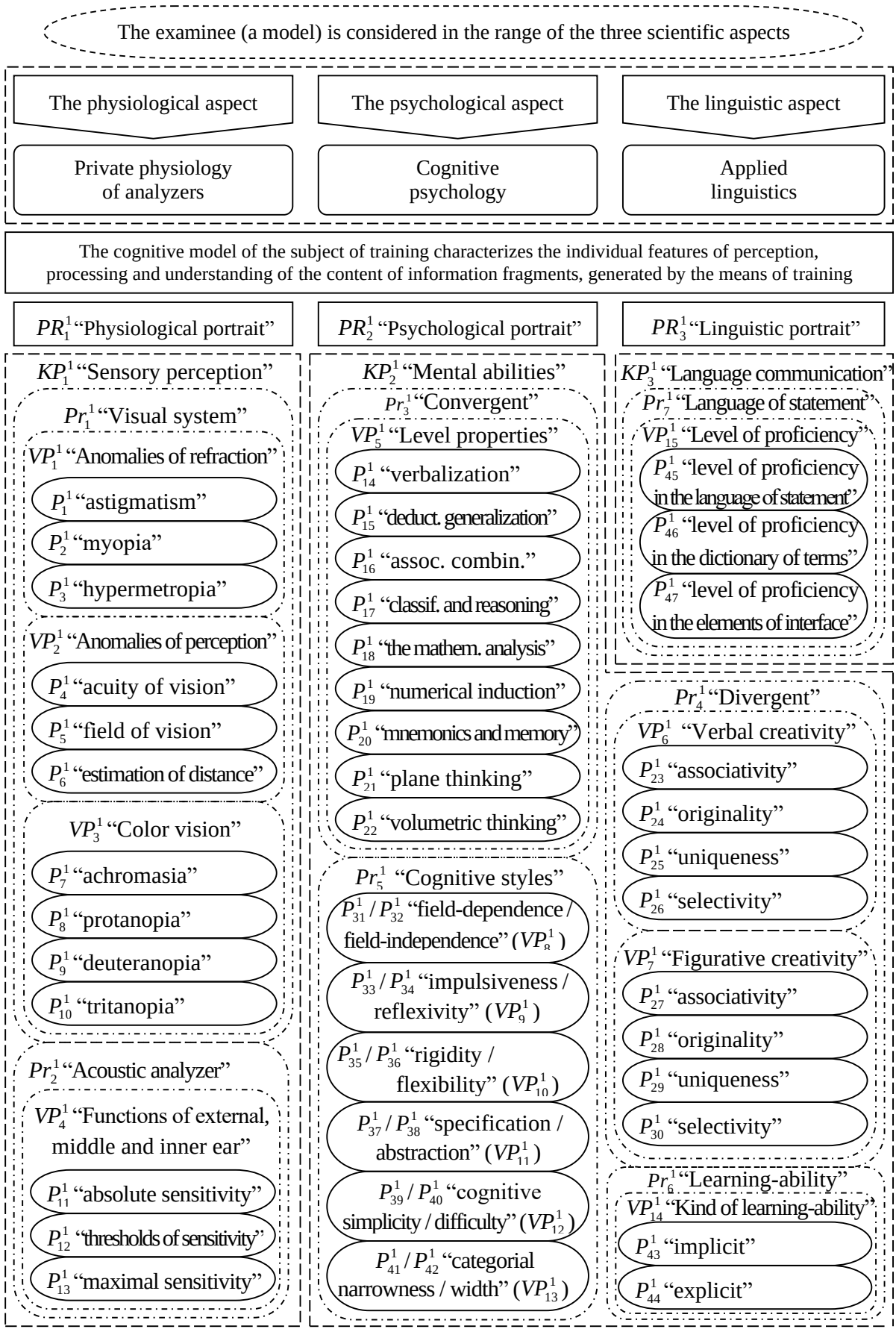
CM of the subject of training is technologically applicable in the contour of IEE of ART system, if the certain means of training are able to generate directly EI (the information fragments) in coordination with the parametrical CM of the means of training.

CM of the means of training (pic. 3.15) is differentiated on a row of different portraits: the physiological (the features of visual representation of the information fragments: the parameters of background, font and the color schemes of displaying of content by the means of training), the psychological (the way of representation of a sequence of information fragments: the kind of displayed information and the style of presentation of the information fragments) and the linguistic (the language aspects of virtual communication in IEE of ART system).

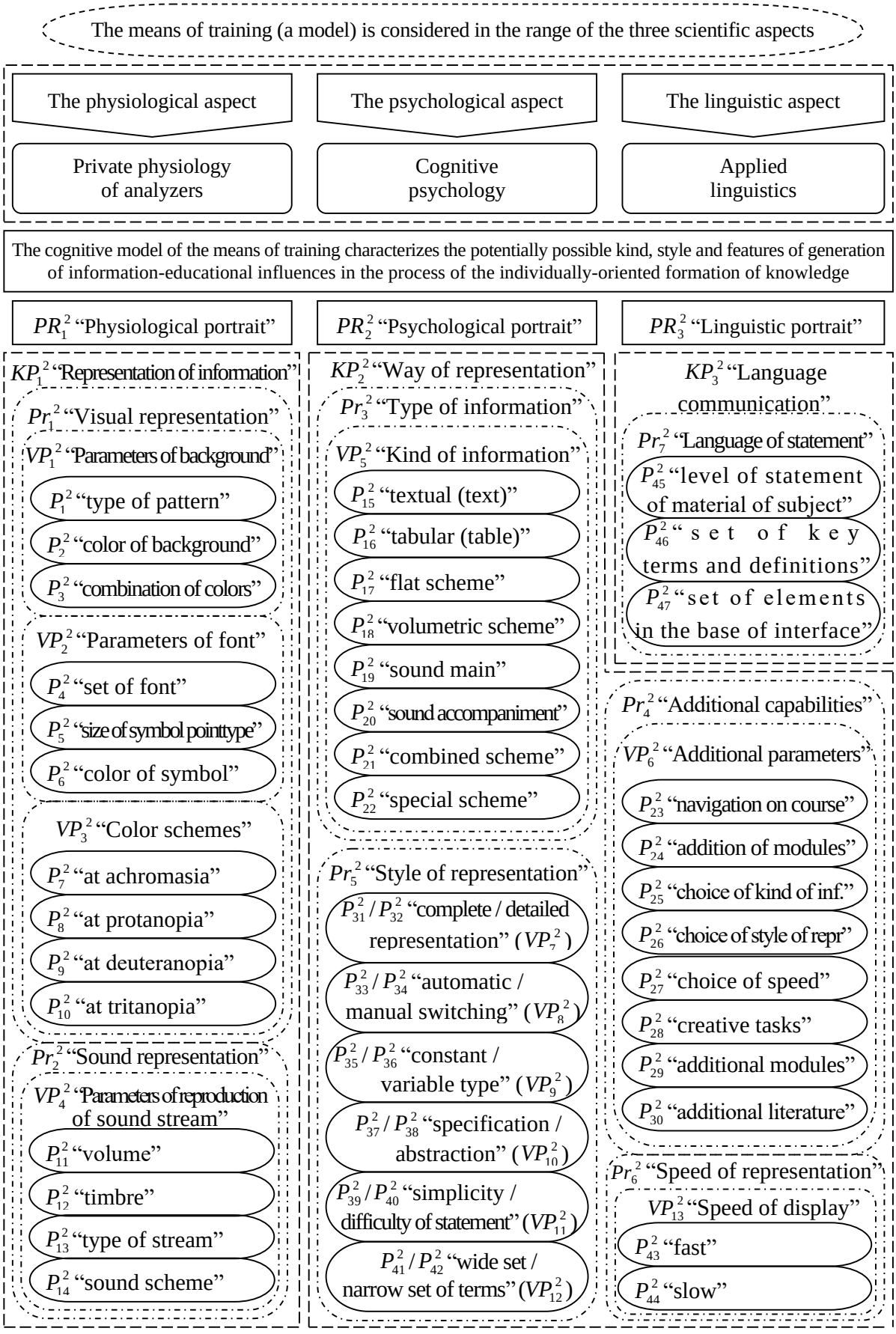
The parameters of CM of the subject of training are diagnosed with using of a set of the special methods of research from a row of the applied scientific areas: physiology of sensory systems (the physiological portrait), cognitive psychology (the psychological portrait) and applied linguistics (the linguistic portrait).

The nominal values of parameters of CM of the means of training are set by the results of analysis of the technical capabilities of the automated means of training and are modified in parallel to the life cycle of the program product, realizing directly the certain means of training (for example ET).

For the realization of the contour of adaptation based on PCMB it is necessary to carry out the modernization of program realization of the corresponding means of training.



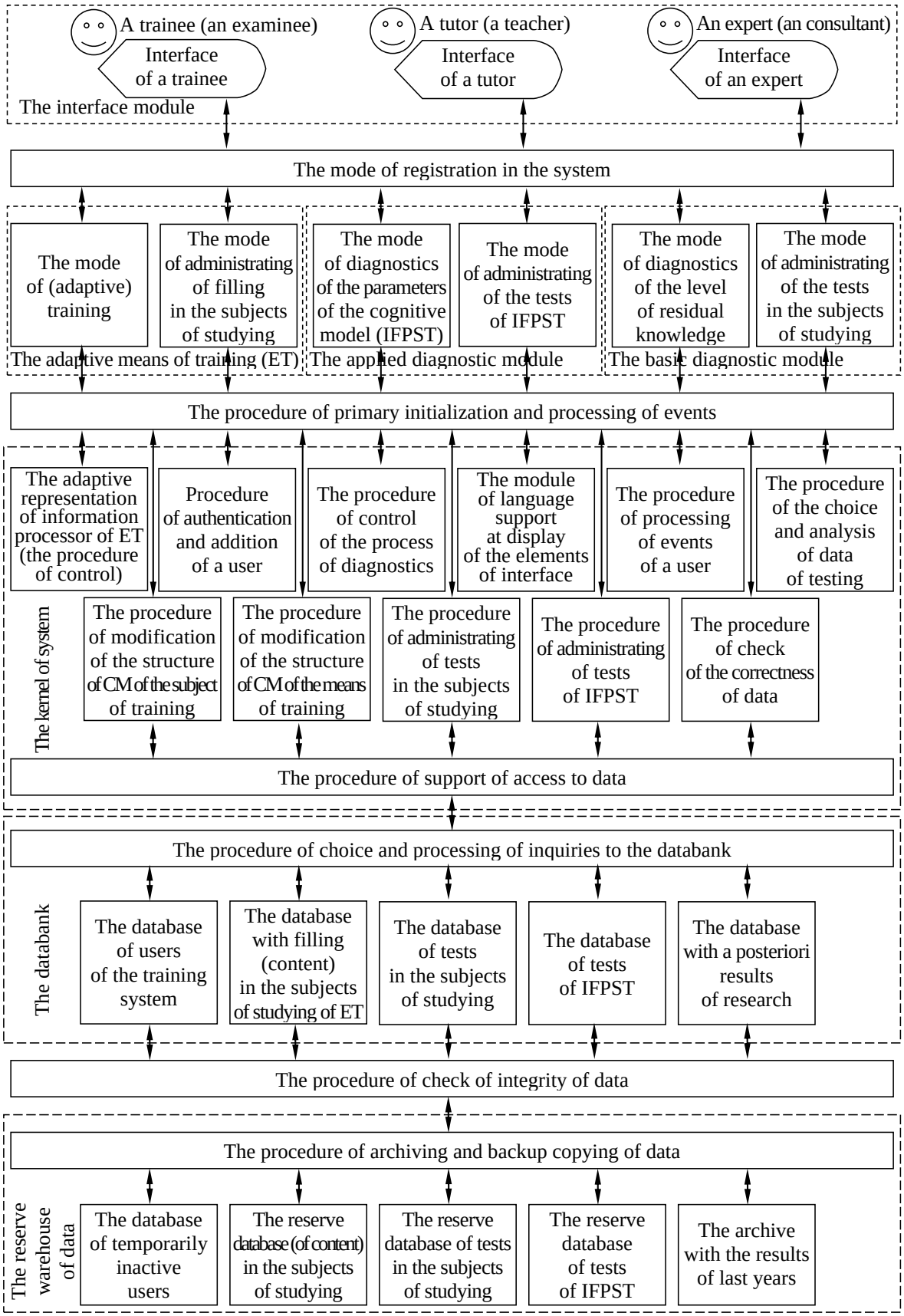

Picture 3.14. The structure of the parametrical cognitive model of the subject of training (the analytical-numerical representation)




Picture 3.15. The structure of the parametrical cognitive model of the means of training (the analytical-numerical representation)

## 3.6. The structural-functional scheme of the complex of programs for the automation of the tasks of research of the environment of training

In pic. 3.16 the structure of the complex of programs for the automation of the tasks of research is presented.




Picture 3.16. The structural-functional scheme of the complex of programs

## 3.7. The physiological portrait of the parametrical cognitive model

From the scientific point of view the subject of training in IEE of ART system is the unique in relation to the perception, processing and understanding of information [5, 51, 122, 130].

The process of perception of a sequence of information messages by the visual sensory system of the subject of training has the hierarchical structure. As the essential feature of this process is the presence of the mechanisms of identification and the classification of the various objects and images by their most common signs. In particular without the ability to group the objects and to distinguish them by the elements, it is impossible to classify each new phenomenon based on the cognitive associations.

The question about the fact, how the visual sensory system of a certain subject of training extracts and measures the signs of the visual signal, has not been studied deeply enough. There is a row of scientific data, evidence about the fact, that on the retina of eye, which performs the function of a visual analyzer, occurs directly the determination of the contours of image, the allocating of discrete elements and their identification. Then the input message is encoded, transmitted to the brain, where the other mechanisms come into action and the actual recognition of the visual image is taken place. This is consistent with the scientific fact, that the complete blindness occurs not only from the damage of the surface of retina or the nerve pathways directly, but and from the violations of functions of a certain areas of the cortex of the head brain. The damage of the separate areas of the cortex of the head brain of the subject of training leads to the violation of the process of processing of the visual information messages and is linked with a disorder of the process of visual perception (the visual dignosia). From the other side, the visual message can be perceived at the many distortions and even at the absence of some of its constituents information elements. The data of experimental researches suggest about the fact, that at the perception of incomplete or distorted message the conceptual information is involved, which is recorded and stored in the corresponding areas of the cortex of the head brain. In the process of perception of the graphical information message the analysis of the structure and optical-graphical characteristics of its constituent information elements is taken place. To the solution of given question today occupies the special attention of all scientists and specialists.

The another range of problems arises at the modeling of the process of visual perception and consists in a consecutive solution of the complex of tasks, related with the interpretation and understanding by the subject of training of the messages of natural language in the graphical form.

At the realization of interactive interaction of the subjects and means of training in IEE of ART system the practical and applied scientific tasks are solved, related directly with the automation of input and saving of the text, graphical and multimedia data, presented in a certain language in the basis of DB. Arises the necessity of taking into account of the difficulty, kind, type and volume of information, processed by the components of IEE of ART system and displayed to the final user.

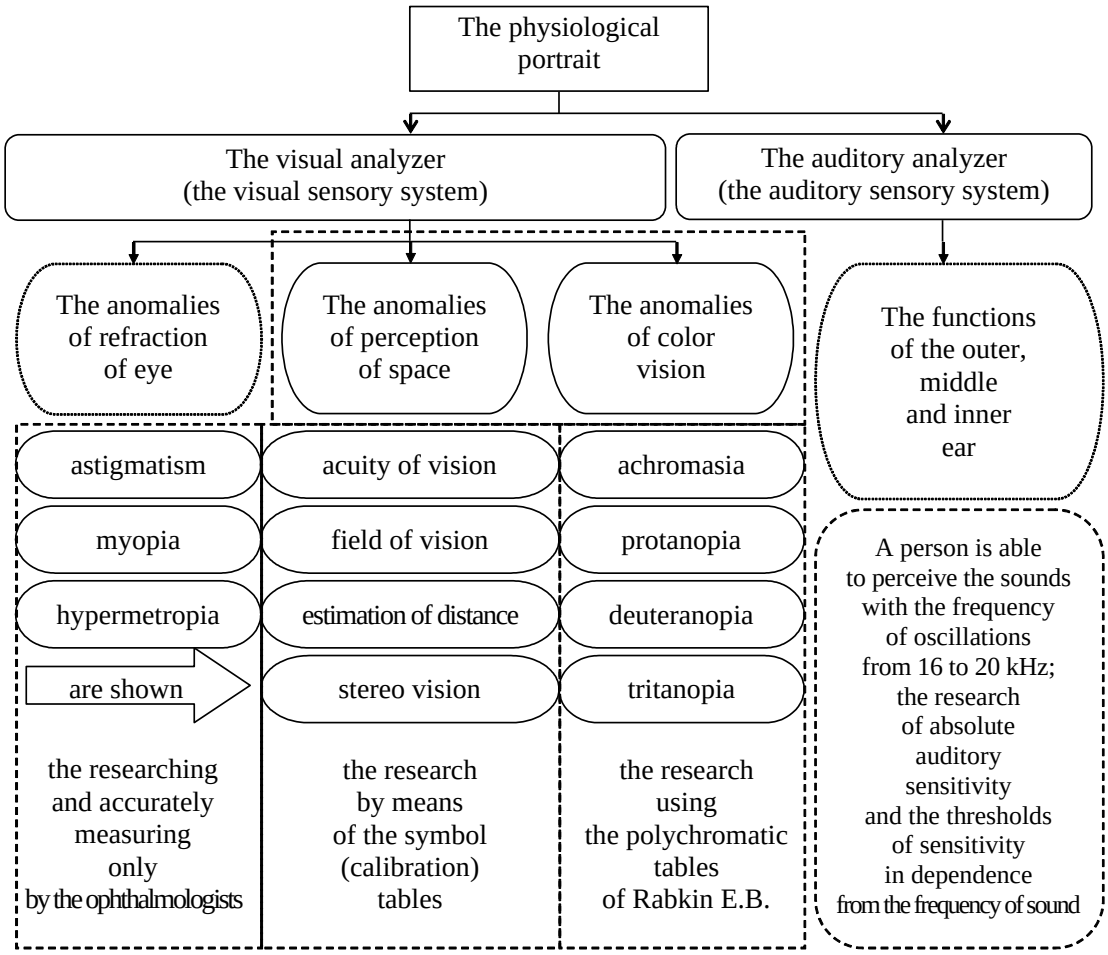
The fragment of text in the natural language or the structure of graphical image is considered as a set of hierarchically related elementary levels, which are considered as the information fragments (the portions of information).

The information is differentiated by the form of presentation, accessibility and perception. One from the characteristic properties of its consistent perception is the apperception as a dependence of the process of perception of the subject of training from its mental properties. Therefore in the course of organization of the technological process of training (at distance), it is necessary to take into account the features of the process of sensory perception of the subjects of training.

In the present time there are the several main ways of representation of the formed sequence of the various EI (the information fragments): the practical use of the printed or electronic carrier of information, the direct communication of the subjects of training in the real scale of time (the active form) and the mediated communication of the subjects of training in the arbitrary time (the passive form).

The psychophysiological aspect of the perception of information by the visual sensory system assumes the consideration of the model of the reduced eye with the taking into account of the tasks of classification and identification of any given information message.

At the research of IEE of ART system was obtained the physiological portrait of CM, which is formed on the scientific basis of the private physiology of analyzers and concentrates the individual features of visual and auditory sensory systems.




Picture 3.17. The structure of the physiological portrait of the cognitive model of the subject of training

From the point of view of the ophthalmology as a science the deviations in the structure and refraction of eye as the biological construct (the optical device) can have a complex genesis: the congenital and acquired defects (anomalies) of the structure (the internal structure), which cause the anomalies of the perception of space and color vision. The vector of the anomalies of refraction of the visual sensory system is not considered in given work. The anomalies of color vision at the perception of polychromatic spectrum of the photon radiation by the visual sensory system of the subject of training (examinee) are researched by means of the sequential presentation of the various polychromatic tables of Rabkin E.B.

### 3.7.1. The specifics of research of the anomalies of refraction of the eye

The visual analyzer (the visual sensory system) is the most important among all analyzers, as it gives up to 90% of the actual information, which is continuously arrives into the head brain from all receptors of the subject of training, including by the means of use of the peripheral nervous system.

The essence of the optical system of eye consists directly in the fact, that on the way to the photosensitive membrane of eye (retina) the rays of light penetrate through the anterior and posterior surfaces of cornea, crystalline lens and vitreous. For the convenience of building of the image on the retina the model of "reduced eye" are used, that is an eye, in which all refractive environments have the same coefficient of prelection. For the building of a graphical image on the surface of the retina it is need to know the size of a certain object and its distance from the surface of the cornea of the eye.

For the accurate visual perception (vision) of each object it is necessary, that the rays from all its points were focused on the surface of the retina of the eye. In order for the subject of training to distinguish accurately far located objects, their images must be exactly focused on the surface of the retina, at the same time the images of near objects on the retina are focused non-exactly, so they are perceived directly (visible by the examinee) indistinctly. Therefore, it is impossible to see simultaneously equally accurately the various objects, distant from the eye (as an optical device) on the different mileage (distance). The adaptation of eye (as a biological construct and an optical device) to the sensory perception of different-removed objects is called accommodation. At the accommodation the changing of curvature of the crystalline lens and its refractive capacity is occurred.

The mechanism of accommodation consists in the fact, that the contraction of the ciliary muscles leads directly to the changing of bulge of the crystalline lens of the eye of the subject of training. At the contraction of the ocular-muscular fibers of the ciliary body, the traction of the zinn ligaments, located on the edges of the capsule of crystalline lens, is relaxed, the pressure on the crystalline lens decreases, and it directly takes on a more convex form due to its elasticity. Consequently, the ciliary muscles are the accommodation muscles of eye. They are innervated by the parasympathetic fibers of the oculomotor nerve.

For the normal eye the far point of clear vision lies in the infinity, so such an eye considers the far objects without a mechanism of accommodation (without the significant contraction of the ciliary muscles of the visual sensory system). The objects, located closer, than 10 cm, are not clearly visible by a person with the normal vision, even at the maximal contraction of the ciliary muscles of the visual sensory system (at the maximal accommodation effort of the visual analyzer of the subject of training).

The anomalies of the refraction of eye

The anomalies of the refraction of eye are caused by the fact, that with the age the crystalline lens becomes less elastic and at the easing of the zinn ligaments its bulge increases only slightly (insignificantly) or does not change at all. Therefore the nearest point of clear vision moves away from the eyes (the visual analyzer). This condition is called the senile farsightedness or presbyopia. It is corrected directly with using of the biconvex lenses in the glasses.

The cornea sheath of eye is not strictly spherical surface, it has the different radius of curvature in the various directions (in the space), therefore there is a unequal refraction of rays in the different directions, that is called astigmatism (the unevenness of convergence of the rays of photon radiation). The astigmatism refers to the anomalies of the refraction of eye of the subject of training and is caused by the imperfection of the structure of the eye as an optical device. The astigmatism is corrected by the special cylindrical lenses in the glasses.

To the anomalies of refraction of the rays of photon radiation refer directly the short-sightedness (myopia) and far-sightedness (hypermetropia), which are not caused by the insufficient of the properties of refractive environments, and by the anomalous length of eyeball of the subjects of training (examinee).

At the short-sightedness the longitudinal axis of eye is too long, and its main focus is located in front of the retina – the circles of light-scattering appear on the retina instead of point. At the myopia the far point of clear vision is located on a very close distance. The myopia is corrected by the concave lenses in the glasses, which directly reduce the refractive force of the crystalline lens and shift the focus of image to the retina of eye.

At the far-sightedness the longitudinal axis of eye is short and the rays, coming from the far objects, focus behind the retina, and the blurred unclear image appears on the retina. At the far-sightedness the nearest point of clear vision is placed further away, that at the normal eye. The farsightedness is corrected by the biconvex lenses in the glasses of the subject of training.

The pupillary reflex

The hole in the center of the iridescent sheath – the pupil – passes only the central rays, without missing the peripheral rays of photon radiation (of the polychromatic spectrum), thereby contributing to the clarity of the graphical image of object on the retina. The size of pupil changes due to the contraction of muscles of the iridescent sheath of eye. At the changing of diameter of the pupil the light flow can change in 17 times. The reaction of the pupil of visual analyzer on the illumination is burden the adaptive character for the stabilization of the level of illumination of the retina of visual sensory system. In the dark the diameter of pupil increases significantly (the widening of pupil), and in the light its diameter decreases significantly (the narrowing of pupil is observed). These changes of the diameter of pupil occur reflexively and are called the pupillary reflex.

The muscles, surrounding the pupil of eye, are divided on the annular, innervated by the parasympathetic fibers, and the radial, innervated by the sympathetic nerves. The contraction of ring muscles causes the narrowing of pupil, and the contraction of the radial – its widening. Therefore the acetylcholine directly causes the narrowing of pupil, the adrenaline – widening. At the condition of excitement of the sympathetic nervous system (fear and rage), at the pain and hypoxia (discomfort) – the pupils of visual analyzer widen. The widening of the pupils of visual sensory system is an important symptom of a row of the important pathological conditions (pain shock, deep anesthesia and others).

The receptor section of the visual analyzer (eye) is represented directly by the various certain photo-receptors of retina: rods and cones. Each photo-receptor consists from the external segment sensitive to the action of light, containing a visual pigment, and the internal segment, containing a nucleus and mitochondrions, providing the energetical processes in the photo-receptor cell of eye of the subject of training.

At an ordinary human in the retina has 6-7 million cones and 110-125 million rods. The central fossa of the retina of visual sensory system contains only cones. By the direction to the periphery of retina the quantity of cones (the photopic vision) decreases, and the quantity of rods (the scotopic vision) increases significantly on the periphery. The periphery of the retina of visual analyzer contains almost exclusively rods. The cones function in the conditions of bright illumination and perceive colors, rods are the difficult scoto-receptors of the visual sensory system, which perceive light rays in the conditions of twilight (black-and-white) vision.

The place of exit of the visual nerve from the eyeball does not contain the photo-receptors and therefore is insensitive to the photon radiation. It is named as the blind spot.

Inside from the photo-receptor cells is located the layer of bipolar neurons, to which the layer of the ganglionic nerve cells of retina adjoins from the inside. The impulses from many photo-receptors converge to one ganglionic cell. One bipolar neuron is linked with many rods and several cones, and one ganglionic cell, in its turn, is linked with many bipolar cells. The interaction of the neurons of retina is provided by the horizontal and amacrine cells, the sprouts of which connect in horizontal the bipolar and ganglion cells of retina.

The photo-chemical processes, occurring in the receptors, represent the initial link in the chain of the transformation of light energy into the nerve excitation. After this the electrical potentials are generated in receptors, and then in the neurons of retina, which reflect the parameters of acting light (the flow of photon radiation).

The excitation of ganglionic cells leads to the fact, that the excitation by their axons, constituting the visual nerve of retina, enters into the head brain of the subject of training. The ganglionic cell is the primary neuron of visual analyzer (eye). The fibers of the visual nerve of visual sensory system form a crosshair, and the retina of one eye has the contra- and ipsilateral projection. The most part of the fibers of visual nerve enter into the external elbow bodies. The axons of their cells go directly to the occipital area of the cortex of head brain, where the primary projection zone of visual analyzer (eye) is located. The part of visual fibers are directed into the anterior tubercles of the quatrain and into the thalamus, from which the excitation enters immediately into the cortex of head brain of the subject of training.

### 3.7.2. The specifics of research of the anomalies of color-perception

The genesis of the anomalies of color vision of the subject of training is consisted in the fact, that the perception of color is caused by the functioning of two mechanisms (deviations are possible). By the primary mechanism is the photo-receptor mechanism of visual analyzer, which allows to estimate the spectral characteristics of photon radiation (light). The differentiation of perception by the color is carried out with the help of the color-receiving photo-receptors, reacting selectively on the different areas of polychromatic spectrum. The secondary mechanism is the nerve mechanism, which uses the information about the color from the color-receiving photo-receptors and recodes it in a certain way.

The theories of color-perception

There are a row of the different scientific theories of color-sensation (color-perception), but the three-component theory of color-perception is most recognized. According to this scientific theory, in the basis of the retina of visual sensory system there are three different types of light-sensitive photo-receptors – the cones. In the cones of the retina of eye the various light-sensitive substances are located, moreover, one cones contain the substance, sensitive to the red color, other cones – to the green color, the third cones – to the violet (blue) color. Each color acts the influence on the three color-sensitive elements, but in the different degree. These excitations are summed up by the visual neurons and, reaching to the cortex of head brain, give the integral sensation of one or another color (based on the red, green and blue).

The three-component scientific theory of the color vision of human has confirmed directly by the electrical-physiological researches. The impulses were removed from the single ganglionic cells of the retina of eye with the help of micro-electrodes at the illumination of it by the different monochromatic rays. It turned out, that the electrical activity in the most neurons arose under the influence of photon radiation of any wavelength in the visible part of spectrum. Such neurons are named directly the dominators (dominant). In other ganglionic cells, named the modulators, the impulses occurred only at the illumination by the flow of photon radiation with a certain wavelength only. In the retina of eye and the visual centers of head brain many neurons have researched, which are named the opponent neurons, and differ actually in the fact, that the action on the eye of the photon radiation in some part of spectrum excites them, and in the other parts of spectrum – it inhibits the physiological process of neural excitation. It is believed, that such neurons the most actively encode the information about the color.

The anomalies of color vision

The three-component scientific theory of color vision of the subject of training directly explains some forms of the pathology of color-perception. The various forms of the violation of color-perception of the subjects of training are occurred. The complete color blindness – achromasia is occur rare and is characterized by the fact, that a person sees all different objects only in the various shades of gray color (like the various graphical images on the colorless photographies). More often meets the partial color blindness at the subjects of training (the examinees). The three kinds of partial color blindness (dichromacy) are distinguished directly: protanopia (daltonism) (the most frequent), deuteranopia and tritanopia (the rarest).

The protanops are not able to distinguish the red color and the shades of red color. The deuteranops cannot distinguish the green color and the halftones of green color. The tritanops do not distinguish the blue (violet) color, and also the shades of blue color, but this disorder of color-perception is met extremely rare at the subjects of training.

All kinds of partial color blindness are well explained from the scientific point of view in the context of the three-component scientific theory of color-sensation (color-perception). Each from these kinds of anomalous disorders is the result of absence of one from the three color-receiving substances of cones, and the color vision at these subjects of training is carried out due to the preserved two photo-receptor substances.

The research of color vision has the great importance, especially for the persons, which by the kind of profession need to be well oriented in all colors. This research is carried out with using of the polychromatic tables of Rabkin E.B., and also by the means of use of the threshold polychromatic tables of Yustova E.N.

The description of the program toolkit for the automation of the process of research and the revealing of the anomalies of color-perception is presented directly in the appendix 7.

### 3.7.3. The specifics of research of the anomalies of the perception of space

The acuity of vision

Under the acuity of vision refers the potential ability of eye to distinguish the two luminous points separately at the minimal distance between them. The normal eye distinguishes the two points separately at the angle of view in one minute. This is due to the fact, that for the separate accurate vision of two points it is not necessary, that to have at least one unfussed cone between the excited cones. As the diameter of cone is 3 mcm, than for the separate vision of two points it is necessary, that the distance between the images of these points on the retina is at least 4 mcm, and such value of image is obtained precisely at the angle of view in one angular minute. If the angle of view will be less than one minute, then two luminous points merge into one.

The measurement of the acuity of vision is carried out with using of the special tables of optotypes, which consist from a several rows of letters or non-closed circles of various value. A number is placed opposite each string, meaning the distance in meters, from which the normal eye must distinguish the digits or figures of this string. The acuity of vision is expressed directly in the relative values, moreover, the normal acuity of vision of the subject of training is taken as one.

The field of vision

The field of vision is named directly the visible contour or space, visible by the eye at the fixing of the look of the subject of training (examinee) in one point. If to fix the look of any object, then the image falls on the yellow spot, in this case the subject of training sees the object by the central vision of eye. The subjects (objects), images of which fall on the rest places of retina, are perceived (registrated) by the peripheral vision of visual analyzer. There is differentiated the color (chromatic) and colorless (achromatic) field of vision. The achromatic field of vision is larger than the chromatic field of vision, as it is caused by the functioning of rods, located mainly on the periphery of retina.

For the various colors of the polychromatic spectrum of photon radiation the field of vision is different, the most of all – for the blue color, and the narrowest – for the green color.

The field of vision of the green color is smaller, than the blue color in the direction downward and left for the left eye and the right for the right eye at the men and women.

The field of vision for the blue color is larger, than for the red color (at young-men and young-women).

The field of vision is diagnosed by the means of using of the perimeter of Forster K.F.R.

The estimation of distance

The perception of the depth of space and the estimation of distance to the object is possible both at the vision by one eye (the monocular vision), and by two eyes (the binocular vision). At the binocular vision the estimation of distance is acting significantly more accurate. Some value in the estimation of close distances at the monocular vision by the visual sensory system has the phenomenon of accommodation (adjustment). For the estimation of distance to the object (subject) it has the essential meaning, that the image of the subject (object) on the retina will be the larger, than the closer it is.

The vision by the both eyes

Under the vision by the both eyes is understood the stereoscopic vision itself.

At the consideration of the subject at the examinee does not experience the feeling of two subjects, though has two images on the two retinas of the visual sensory system. At the vision by the both eyes the images of all subjects are fall on the corresponding or identical areas of retina and in the perception of human these two images merge into one single image (picture). In this is easy to make sure practically, if to press slightly on one eye from the side, than it begins to double in the eyes, because the compliance of retinas is disturbed. If to look at the close subject, converging the look of each eye, then the image of a more distant point falls on the non-identical points of the surface of retina, which are otherwise named the dysparatic and the image will therefore appear bifurcated.

The estimation of the size of subject: the size of subject is estimated as the function of two variables – the size of image on the retina and the distance of the subject from the eye.

If the distance to the unfamiliar subject (object) due to the insufficient relief is difficult to estimate, then the errors in the determination of the size of subject are possible.

### 3.7.4. The program toolkit for the automation of research of the parameters of the physiological portrait of the cognitive model of the subject of training

The program toolkit provides the mode of administrating, in which the potential possibility of modification of DB (KB) is realized. In the mode of diagnostics the function of identification of the nominal values of parameters of the physiological portrait of CM of the subject of training (examinee) is realized.

The description of the program toolkit is presented in the appendix 7.

### *3.8. The psychological portrait of the parametrical cognitive model*

From the point of view of the scientific-practical and applied psychological researches of the mental construct of head brain and intellect as its latent property, the several main scientific approaches are highlighted, for each from which is characterized the conceptual line in the treatment of nature of the subject of research [18, 21, 47, 117, 120]:

- the social-cultural approach – the intellect is considered as the result of the process of socialization of the personality, and also the influence of public culture as a whole;
- the genetic approach – the intellect of examinee is interpreted as a consequence of the becoming complicated of adaptation of the person in relation to the conditions of external environment;
- the processual-activity approach – represents directly the intellect as a special form of activity of the social subject (the mental activity in the process of the intellectual activity of person);
- the educational approach – operates by the intellect as a specific product of purposeful training (the formation of knowledge of the subject of training);
- the information approach – decomposes the intellectual activity on a set of elementary processes of the processing of different information;
- the phenomenological approach – interprets directly the intellect as a special form of the content of consciousness of the knowing subject (examinee);
- the functional-level approach – the intellect as a system of cognitive processes, occurring on the different levels of the mental construct of head brain;
- the regulatory approach – represents directly the intellect as the factor of self-regulation of the mental activity of head brain of the subject of training.

It should be noted, that the essence of research of the psychological portrait of CM of the subject of training is reduced directly to the consideration of the specifics of manifestation of the highest nervous activity of head brain from the point of view of cognitive psychology – the individual features of the structural components of intellect as the latent property of the psychophysiological construct of head brain in the process of carrying out of the mental activity of the subject of training in IEE of ART system are considered.

The higher nervous activity of human and higher animals is characterized by the presence of the primary and secondary signaling systems, that determines the general ability to reasoning in the process of thinking as an intellectual activity.

The intellect causes the potential ability and predisposition of the subject of training to carry out a certain kind of productive activity.

The intellect is considered as an evolving transformator of information (inseparable from a biological organism), mediating in its interaction with the environment and urged to provide the existence and development of the subject of training.

The intellect has the specific structure, consisting from a row of various layers (by opinion of Druzhinin V.N. and Kholodnaya M.A., "The institute of psychology" of "RAS").

The intellect is interpreted as a repertoire of parameters, which develops due to the training procedures and is a specific form of organization of the individual mental experience, providing directly the potential possibility of effective primary perception, understanding and interpretation of processes in the external environment. The higher the level of intellectual development of the subject of training (the examinee), the more difficulty the individual mental experience in composition and organization, and by the criteria of intellectual maturity directly are: the breadth of horizon, the flexibility of thinking and the multifactoriness of the estimations of events, the ability to process the heuristically difficult information and to predict.

The presented information should be technologically taken into account directly: the psychological features of personality (group), to create the conditions for the formation of the intellectual properties of personality, to activate the meta-cognitive awareness, to meet to the requirements of ergonomics and to exclude the pragmatism of education. The main feature of the cognitive scientific direction in the modern psychology – the orientation on the research of the latent mechanisms of information processing and the formation of knowledge at the level of the psychophysiological construct of head brain of the subject of training from the point of view of the information and educational approaches.

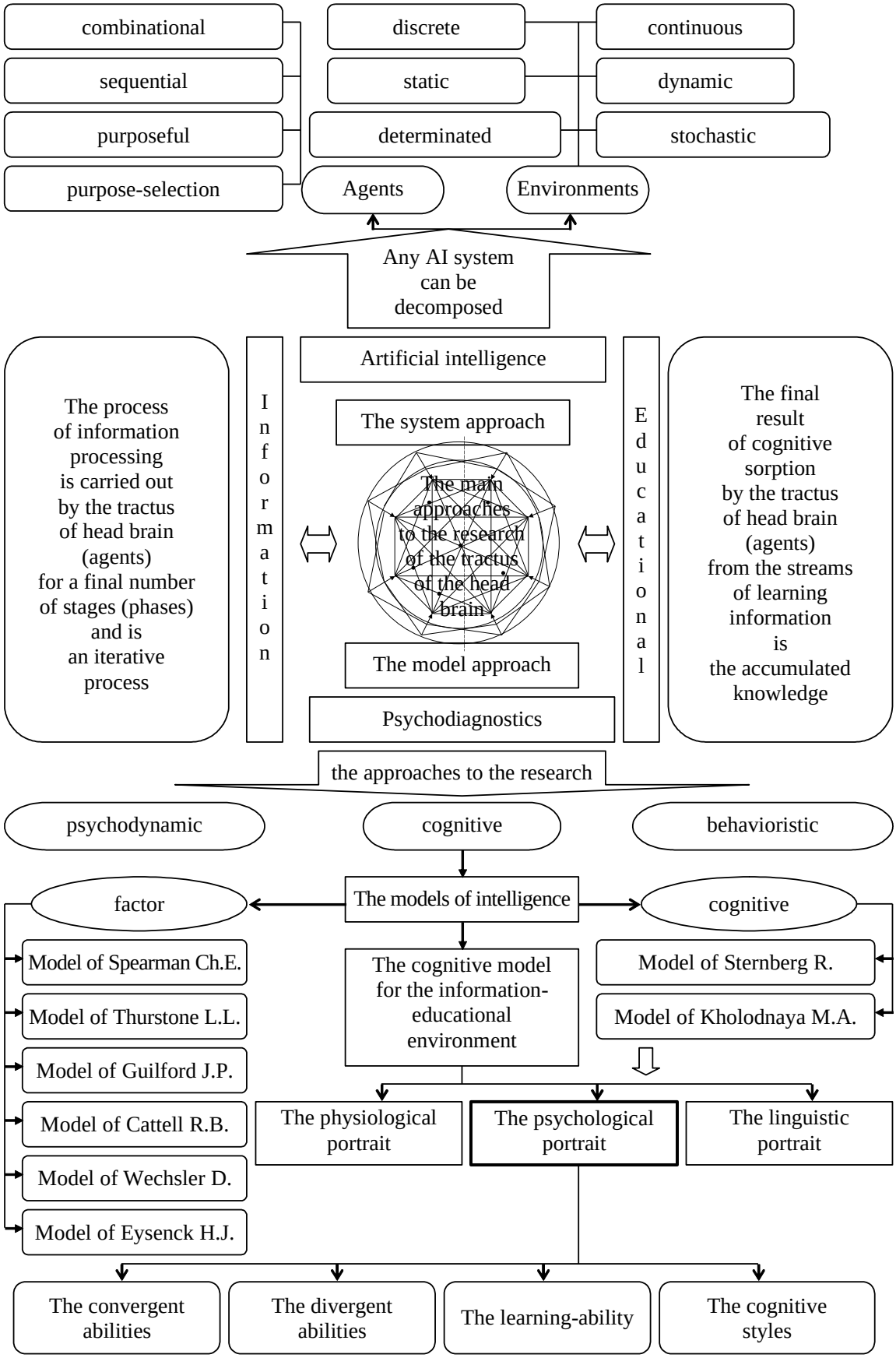
The intellect can be considered as a set of interacting information subsystems with a certain organization and the specifics of the interface of interaction. Each information subsystem is positioned in a certain layer of intellect as the manifestation of the psychophysiological construct of head brain.

The information model allows to consider the motivational-emotional regulation of thinking as a process of the expedient transformation of information.

There are many scientific approaches and theories to the research of intellect, the essence of which is presented by the author directly in the appendix 9. For the tasks of the system analysis of IEE of ART system it is advisable to consider the information, educational, system and model scientific approaches.

The researches in the area of the psychophysiology of functioning of the mental construct of head brain has influenced on the becoming and development of the theory of intellectual systems.

At the researching of the intelligent information systems operate by the classical scientific conception of acad. of "RAS" Pospelov D.A., who claims, that any artificial intelligence system can be structurally decomposed on a set of agents (the carriers of intelligence), functioning in the different environments (pic. 3.18).




Picture 3.18. The main directions of the research of intellect and the structure of the psychological portrait of the cognitive model

The information scientific approach allows to consider the training (at distance) as an iterative process of processing information and the formation of knowledge of the trainee by the tractus of head brain of the subject of training (agents) for a final number of stages (phases).

The educational scientific approach allows to say, that the final result of information interaction of the subject and the means of training are the accumulated knowledge.

At the consideration of psychodiagnostics a row of private scientific approaches are distinguished, the most interest from which is the cognitive scientific approach. From the point of view of psychology and psychodiagnostics a row of models of intellect can be distinguished, but for the purposes of research of IEE of ART system the structure of the model of Kholodnaya M.A. is suitable. In the modern scientific literature the psychologists describe the various types of the cognitive structures, acting (in essence) in the quality of varieties of "the schemes of understanding":

- "the prototypes" – the combination of the most typical sensory-visual signs, stored in the memory and allowing to make decision about the degree of compliance of a certain object (subject) of any given category (Rosh E., 1978 y.);
- "the perceptual schemes" – the various spatial representations, which, being formed under the influence of past experience, are responsible for the reception (perception), collection (processing) and organization of information, found on the sensory surfaces (carriers) (Neisser U.G., 1981 y.);
- "the hierarchical perceptual schemes" – the multilevel cognitive structure, organized by the type of hierarchical network and including the spatial images of objects, including their global (symmetry, closeness, compactness and others) and detailed (the red, two angles and others) properties (Palmer J., Palmer L., 1977 y.);
- "the complex of schemes" – includes the various spatial configurations (the sign perceptive configurations), the operational structures (the rules of the transformation of information) and the cognitive schemes (the level of "mental experience" available for the given subject of training), reflecting the strategies of reasoning of the expert in the subject area and aggregating his knowledge and life experience (Pascual-Leone A., 1970 y.);
- "the frames" – the schematized presentations about any given stereotypical situation, consisting from the generalized "framework" (the structure of the subject area), reproducing the stable characteristics of this situation, and "nodes", which are sensitive directly to its probabilistic characteristics (can be filled by a new structured data) (Minsky M.L., 1978 y.);
- "the scenarios" – the cognitive structures, contribute to the reproduction of diverse sequence of events in time, expected by the observer (Schenk R.K., 1980 y.);
- "the cognitive maps" – the certain orientative cognitive schemes, related with the movement in the (external) environment (Tolmen R.Ch., 1932 y.);
- "the deep semantic and syntactic universals" – the basic language structures, describing the different difficult objects, processes and phenomena of research, predetermining the character of their use and understanding by the means of use of the lexical units of natural language (Osgud Ch.E., 1980 y., Chomsky A.N., 1972 y.).

The efficiency of activity of the subject of training in a certain area is related with the possibility of use of the accumulated skills in the process of achievement of the result. The formation of knowledge, abilities and skills of the subject of training is provided in the process of training (at distance) of a certain kind of activity (profession). The probability of successful training (at distance) of a certain kind of activity causes the presence of genetically caused inclinations and abilities.

In the domestic (cognitive) psychology an attempt to systematize and analyze the cognitive abilities was undertaken firstly by Druzhinin V.N. In the context of the developed by him theory of general abilities, among the latter the following are considered: the intellect – the ability to solve the tasks based on the application of existing knowledge, the learning-ability – the potential ability to acquire (form) a new knowledge and the creativity – the ability to transform knowledge with the participation of imagination and fantasy [47].

Any informative (cognitive) ability is operationally described through the indicators of efficiency of the intellectual (professional) kinds of activity. In the quality of the latest (kinds of activity) can act directly the content-resultative characteristics of intellectual activity (the correctness of answer, the originality of ideas, the success of assimilation of knowledge and skills, the accuracy and completeness of displaying of the situation in the cognitive image of the subject of training) and its processual-dynamic characteristics of intellectual activity (the speed of answer, the fluency of ideas, the pace of training and the measure of regulation of the building of cognitive image).

With taking into account these indicators (parameters) the proposed classification (by Druzhinin V.N.) can be expanded and refined for the purposes of the system analysis of IEE. In particular, the four main aspects of the functioning of intellect are distinguished [132, 112], characterizing the four types of intellectual abilities of the subject of training (examinee): the convergent (the level properties of intellect of a certain subject of training) and the divergent (the verbal and figurative creativity) intellectual abilities, the learning-ability (the implicit and explicit) and the cognitive styles of the subject of training.

At the modern stage of the development of psychology the methods of research of learning-ability, the attempts of revealing (testing) of a new, the systematization and diagnostics of various cognitive styles of the subject of training are located in the stage of origin.

### 3.8.1. The specifics of research of the convergent intellectual abilities

The vector of convergent intellectual abilities is the structural component of the psychological portrait of the developed CM of the subject of training, acting as one from the manifestations of the psychophysiological construct of head brain of the subject of training, determining the individual productivity of deductive thinking, which is linked with the speed of searching of the normative-single valid variant of answer in accordance with the regulation of situation (in a certain subject area), the requirements of tasks or the time restrictions on the production of decisions.

The convergent intellectual abilities characterize the level of development of the structural components (properties) of intellect and determine the success of individual productive activity of the subject of training in the regulated conditions.

The research is scientifically justified, and Kholodnaya M.A. and Druzhinin V.N. consistently differentiate the given vector of abilities on a row of the properties of intellect:

- the level – the achieved level of the development of intellectual abilities and mental functions (the verbal and non-verbal properties) of the subject of training, affecting the influence on the speed of the perception of various information, the volume of short-term and long-term memory, the concentration of attention, the awareness in the context of a certain subject area (a problem sphere), the vocabulary, the analytical abilities and other properties of the subject of training;
- the combinatorial – the potential abilities to the revealing of diverse relationships, the ratios and regularities in the process of thinking (the intellectual activity);
- the procedural – the elementary processes of the processing of various information.

The level properties of intellect were studied mainly in the context of the testological approach. The degree of their severity allows to estimate the level of the development of intellectual abilities. It these properties of intellect Thurstone L.L. was called “the basic intellectual abilities”, and Cattell R.B. divided them on the “fluid” and “crystallized” intellect. The typical example of the level properties of intellect of the subject of training (the examinee) is the features of intellectual activity in the process of activity, which are diagnosed and analyzed with help of the testological scale of Wechsler D.

The area of research of the combinatorial properties of intellect is reflected in the works of Bruner J.S. and his scientific colleagues, where give the assumptions about the different forms of intellectual activity, in the basis of which are lied the processes of categorization, acting as the basis of associative memory and figurative thinking (Bruner J.S., 1977 y.).

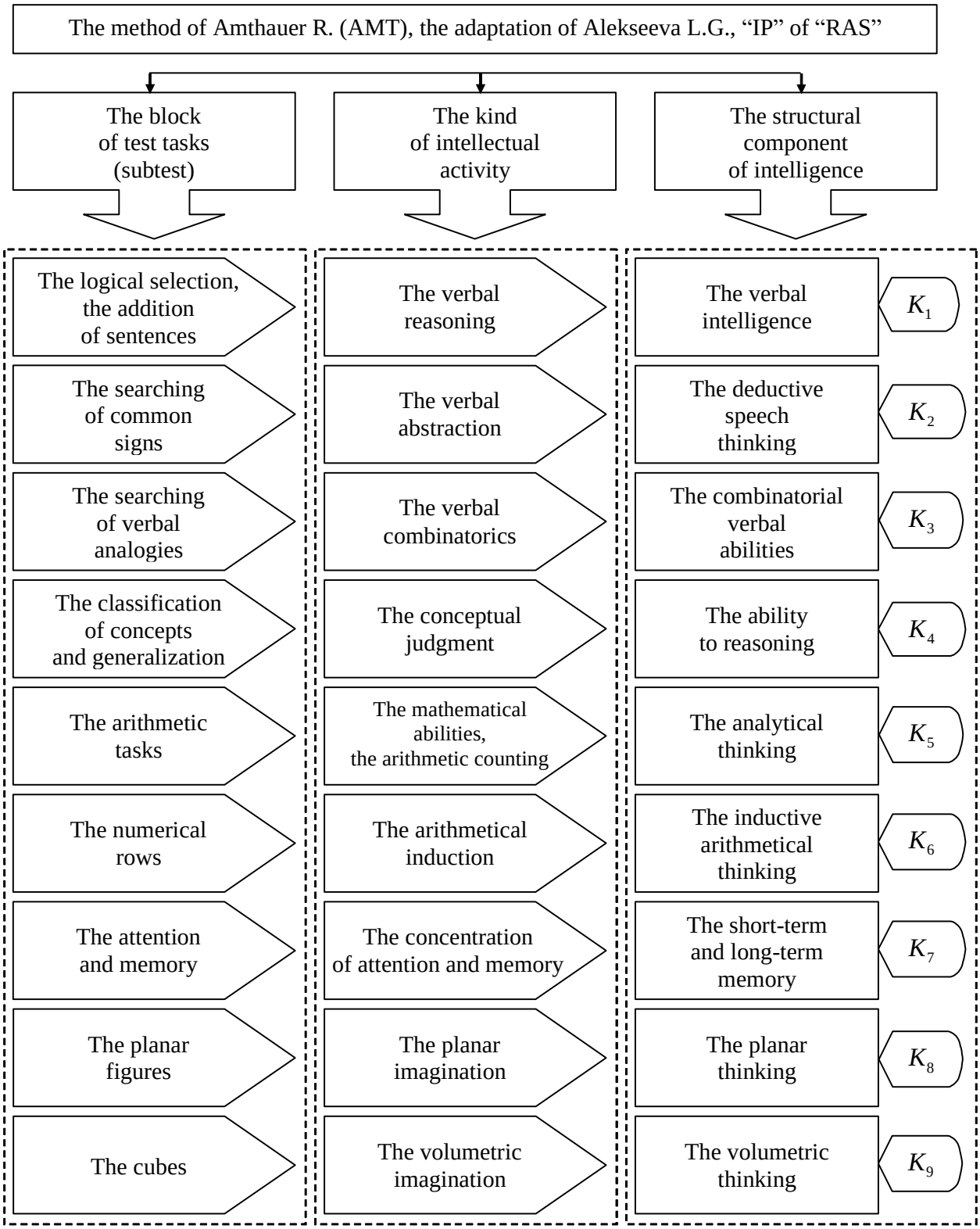
In particular the tasks of classification require from the subject of training (examinee) the ability to reveal the common signs of objects, processes and phenomena of research. The combinatorial properties of intellect are manifested at the performing of tasks, in which the examinee must establish independently the valid, from his point of view, relationships (answers) in the presented stimulus material. An example is the tests on the understanding of the content of text and the generalizing of concepts.

In the testological approaches of research of the intellect the processual properties not taken into account at all, as the test diagnostics is oriented exclusively on the estimation of the resultative side of intellectual activity. The experimental-psychological researches have formed the presentation about the fact, that the intellect of the subject of training (examinee) is not a static trait, but rather acts as a dynamic system of information processing. The (automated) diagnostics of intellect accents the attention on the estimation of the fact, how a person performs any given task, how he solves any given task. Nevertheless, the look has been preserved on the intellect as a convergent ability, although the researchers were interested in the reasons of individual differences in the success of intellectual activity, but they were studied on the material of normative tasks, initiating the various actions and answers of the subjects of training (examinees).

In cognitive psychology as a science the elementary information processes were underwent studied, standing behind the concrete indicators of performance of the certain psychometric tests by the subject of studying (Hunt E.B., Eisenk G.Y.).

In Russia the scientific community ("RAS") is recognized the method of research of Amthauer R. (AIST – Amthauer intelligence structure test): it has many modifications and adaptations (including copyright), and its validity is checked on a wide professionally-differentiated sample of examinees from 13 to 60 years old.

The essence of the method of research consists in the sequential presentation of a continuum of question-answers structures of the tasks of test to the examinee, grouped by the subtests (blocks): "The logical selection, the addition of sentences", "The searching of common signs, the exclusion of word", "The searching of verbal analogies", "The classification of concepts, generalization", "The arithmetic tasks", "The numerical rows", "The attention and memory", "The flat figures" and "The cubes", which activate the certain kinds of intellectual activity (thinking) (the verbal reasoning, the verbal abstraction, the verbal combinatorics, the conceptual judgment, the arithmetic counting, the arithmetic inductive inference, the concentration of attention and mnemonics, the planar imagination and the volumetric thinking), and the measuring of the level of development of the structural components of intellect is dynamically carried out (the verbal intellect, the inductive speech thinking, the verbal combinatorial abilities, the ability to reasoning, the analytical thinking, the inductive arithmetic thinking, the short-term and long-term memory, planar thinking and volumetric thinking).




Picture 3.19. The structure of the method of research
of the vector of the convergent intellectual abilities of Amthauer R.

In pic. 3.19 the nominal values of coefficients are calculated by the computer program by way of the usual automatic incrementation on one in case of the valid answer of the subject of training (examinee) to each question, including directly into the corresponding block of questions (the subtest).

### 3.8.2. The specifics of research of the divergent intellectual abilities

The vector of divergent intellectual abilities is the structural component of the psychological portrait of the formed CM of the subject of training, acting as one from the manifestations of the psychophysiological construct of head brain of the subject of training, determines the individual productivity of inductive thinking, characterizes the creative potential of personality (creativity) of the examinee.

In opinion of Druzhinin V.N. and Kholodnaya M.A. the divergent abilities cause the possibility of generation of a set of original and non-obvious ideas, in the nonregulated conditions of activity of the subject of training (the examinee). The creativity in the narrow sense of word – the divergent thinking, the distinctive feature of which is the diversity and variability of searching of the different, equally valid decisions regarding the same situation. The creativity in the wide sense of word – the creative intellectual abilities, including the potential ability to bring something new into the experience (Barron F X.), the potential ability to breed the various original ideas directly in the conditions of resolving or statement of new actual problems (Ouallah M.), the potential ability to grasp the certain gaps and contradictions, and also to formulate the hypotheses regarding the missing elements of situation (Torrens E.P.) and the ability to refuse from the stereotypical ways of thinking (Guilford J.P.).

In the quality of the criteria of creativity it is advisable to consider the complex of certain properties of intellectual activity:

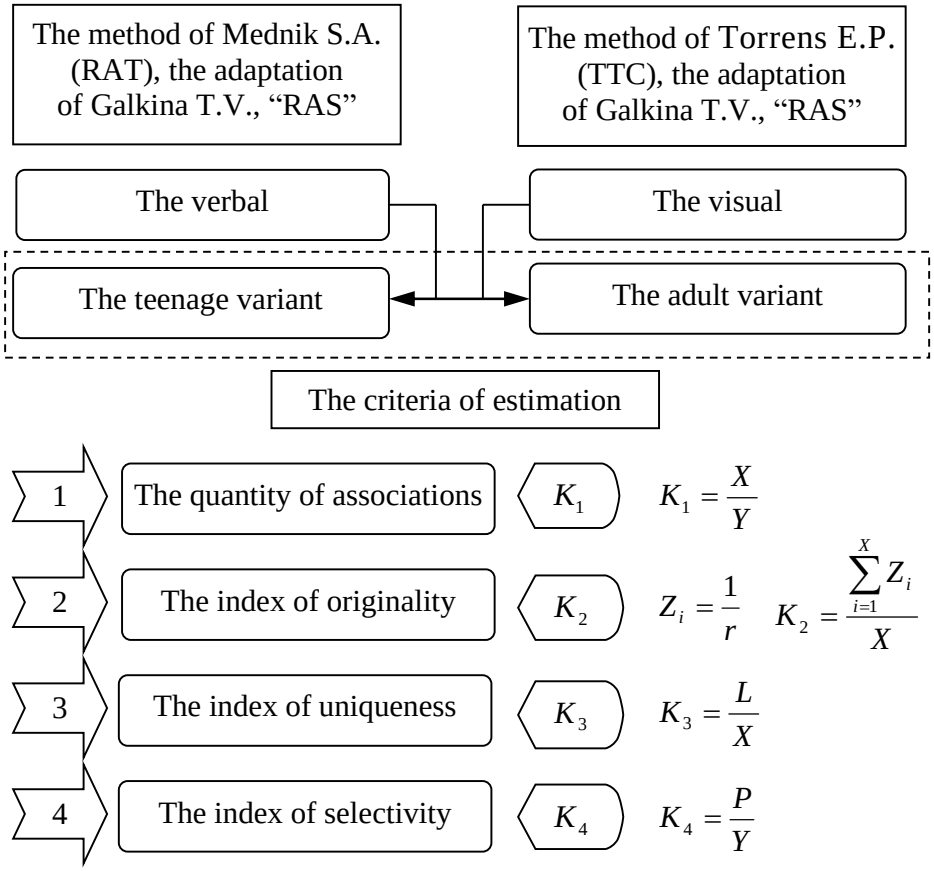
- the fluency – the quantity of various ideas, arising per unit of time;
- the originality – the potential ability to produce "the rare" ideas, differentiating from the generally-accepted and typical answers of examinee and expert;
- the susceptibility – the sensitivity to the unusual details, contradictions and uncertainties, and also the flexible and fast switching between the different ideas of examinee;
- the metaphoricity – the readiness to work in a fantastic, "impossible" context, a propensity to use the various symbolic and associative means for the expression of thoughts and the ability in simply to see the difficult and contrary.

The typical for the diagnostics of creativity are the tasks of the following plan: to name all possible ways of using of a familiar subject; to name all subjects, which may belong to a certain class; to continue the metaphor; to make a finished image based on a simple graphical form (for example a circle) and so on (Anastasi A., 1982 y.; Druzhinin V.N., 1995 y.).

In the most researches at the estimation of creativity, as a rule, the first two indicators are taken into account: the quantity of formulated ideas by the examinee and the degree of the rarity of answers (ideas) of the examinee compared with the answers of other examinees. Over time, however, it turned out, that the specified indicators of divergent thinking are not means the unambiguous evidence of the presence of creativity as the creative intellectual ability of the subject of training (the examinee). The originality and uniqueness of associations were put into consideration.

Finally, the situation in the area of the research of creativity has worsened and the fact, that the indicators of creativity (even in their full set) very poorly predict the real creative achievements of a person in his ordinary and professional activity.

In the quality of the methodical basis of research the several author's methods were used for the various age groups of examinees (the adolescent and adult variants): the verbal creativity – the method of research of Mednik S.A. (RAT – Remote associations test or the research of remote associations of the subject of training as the examinee); the figurative creativity – the method of research in the form of testing of Torrens E.P. The adaptations of the employees of "RAS" Alekseeva L.G. and Galkina T.V. ("The laboratory of psychology of general abilities", "The institute of psychology" of "RAS") were used.




Picture 3.20. The structure of the method of research the vector of divergent intellectual abilities of the subject of training

In pic. 3.20 the following designations of parameters in the coefficients are used: $X$ – the total quantity of answers (associations) of user; $Y$ – total quantity of tasks; $r$ – the frequency of occurrence of a concrete answer at a certain examinee relative to a given homogeneous sample of all answers of all examinees; $Z_i$ – the originality of the $i^{\text{th}}$ answer regarding to the given homogeneous sample of answers; $L$ – the quantity of unique answers at $Z_i = 1$; $P$ – the number of the matches of selections.

### 3.8.3. The specifics of research of the kind of learning-ability of the subject of training

The presentation about the learning-ability as a manifestation of the level of intellectual (mental) development arose in the context of the concept "zone of near development" (Vygotsky L.S.). The formation of new intellectual mechanisms in the zone of near development depends both from the character of training, and from the creative independence of the subject himself.

At a wide interpretation learning-ability is considered as a general ability to the assimilation of new knowledge (the structured data) and the ways of activity. From the point of view of Kalmykova Z.I., the learning-ability is synonymous with the productive thinking (the ability to acquire the principally new knowledge in the process of training). Directly "the core" of individual intellect, in her opinion, is the possibilities of the subject of training to the independent discover of new knowledge. Accordingly, the main criterion of learning-ability – the "profitability" of thinking: the brevity of path in the independent revealing and formulating of some regularities in the new material in course of its studying (Kalmykova Z.I., 1981 y.).

In the more narrower sense of the word "learning-ability" – the value and pace of the growth of efficiency of the intellectual activity under the influence of any given EI.

At that in the quality of the criteria of learning-ability of the subject of training are:

- the quantity of dosed (previously structured) assistance, in which the trainee needs from the side of the teacher (tutor);
- the possibility of the transferring of learned knowledge (the previously structured data) or the different ways of action on the performance of a similar task.

The development of the tests of learning-ability is just beginning in the scientific community. In the quality of the example can cite the modern method of research "The diagnostic program", prepared by Gutke Yu. and Volrab U. "The diagnostic program" – the express test of learning-ability (it takes 45 minutes), in which the child is offered a series of tasks with the increasing level of difficulty, acting in the quality of the means of training in the conditions of constant feedback with the examinee (the subject of training is directly provided with necessary assistance, the samples of solution are offered, the explanations are given, his errors are analyzed and other). The material is the geometrical figures, on which the examinee must master the action of classification by the analogy (to find the regularity in the variance of form, color, size and contour of the presented figures) (Gutke Yu., Volrab U., 1986 y.).

The following characteristics of intellectual activity of the examinee are taken into account in the quality of the indicators of learning-ability of the subject of training:

- the need in a prompt (taking into account the content and the way of presentation of the assistance, and also the measure of its use);
- the consumption of time (the interval of time) on finding of the principle of analogy of figures;
- the kinds of errors of the subject of training (the examinee) with the analysis of their sources;
- the quantity of displayed exercises to the subject of training (the examinee).

Some researchers consider it possible to talk about two types of learning-ability, which are based on the different neurophysiological mechanisms of thinking of the examinee and which are linked with the different ways of the acquiring of knowledge of the subject of training:

- the explicit learning-ability – the training is carried out very quickly with using of the innovative methods, at the same time the arbitrary conscious control of the processes of processing of the information by the subject of training is activated;
- the implicit learning-ability – the training is carried out slowly by the previously established algorithm, in the conditions of gradual accumulation of the information and the formation of knowledge and different skills not understood by a person.

For the automated IEE the practical interest has the revealing of the contingent of trainees, having the characteristic signs of the explicit learning-ability.

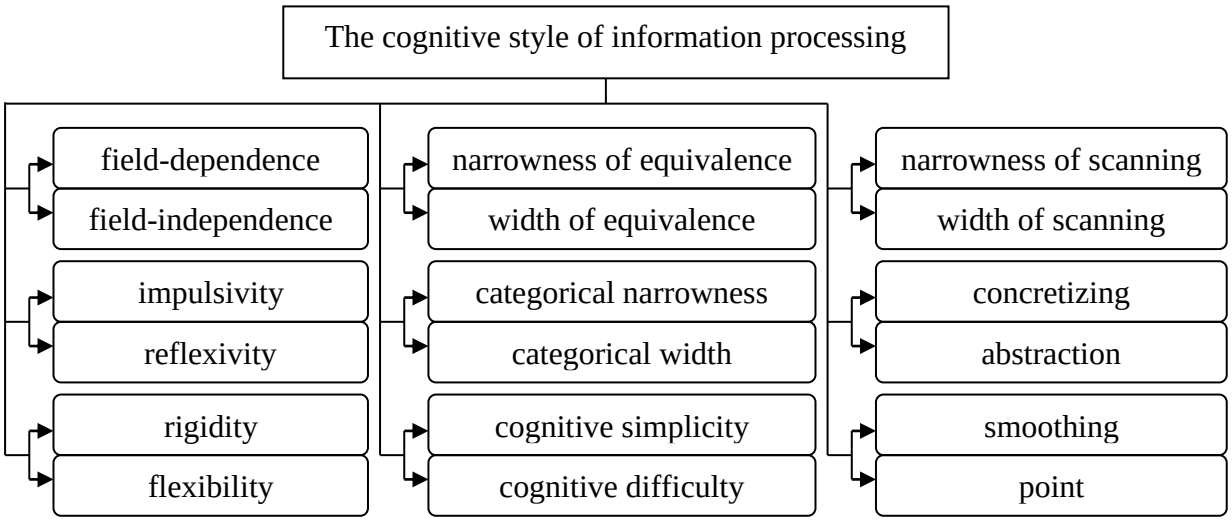
### 3.8.4. The specifics of research of the individual cognitive styles

The cognitive style is established in cognitive psychology and covers about two dozen concrete empirically distinguished properties, describing the individual features in the bipolar (dipole) scales, which are interpreted as the "personal" features of the cognitive sphere of the subject of training. In contrast from the personal inclinations or traits, measured by the means of use of the verbal questionnaires or the projective tests, the empirical diagnostics of the cognitive styles is built mainly by way of the quantitative analysis of the performance of instrumental samples, where the subject of training solves a certain cognitive task: finds a "noisy" figure, selects a stimulus from the several alternatives, similar with a reference image, classifies words or images and other.

The construct "the cognitive styles" at all the difference in its many definitions can be covered by the following main criteria (characteristics):

- these are the changing in ontogenesis, but relatively stable (in relation to the age group) individual features of the cognitive sphere of the subject of training;
- they characterize the ways of posture used by the subject of training, often named the cognitive strategies of thought activity;
- they are relatively independent from the motivational sphere and purpose aspirations and are the features of personality of the subject of training in the following scientific aspects: demonstrate the general approach of the subject of training to resolving situations of uncertainty, reflect the connection of cognition with affect (as a wide designation of the emotional sphere) and the dependence of individual differences from the cognitive control as a kind of self-regulation.

The modern reviews of researches increasingly link the style features with the resolution of situations of uncertainty mainly in certain conditions, in relation to which the subject of training does not have the skills of orientation and execution. It is the indicator of time of answer (the average on the several samples) or its modifications serve as operational correlates of such styles, which are represented by the oppositions "field-dependence – field-independence", "impulsivity – reflexivity", "flexibility – rigidity". From the many other styles in relation to our topic the specified are most interesting because in one way or another they claim to be criteria for the classification of the ways of the cognitive actions, relying mainly on the direct use of the external stimulus factors or the cognitive efforts in the internal plan (in comparison with signs, submission to conscious forms of control of the ways of choosing of the answer and another). The researchers of the cognitive styles assumed, that the longer time, required for the answer to the examinee in the tasks-samples, including the visual orientation, means directly the greater expression of parameters and "reflexivity" (in opposed to "impulsivity" by Kagan J.), and "field-dependence" (by Witkin). A more thorough visual search for the certain orienteers in both cases is linked directly with the dynamics of preparation of the answer by the subject of training (the examinee). In the test of Strup J.R. as the way of measurement of "flexibility-rigidity" the increase of time of delay of the answer is the indicator of greater dependence from the external stimulus factors. The developed long before the emergence of the concept "the cognitive style" the method of Strup J.R. became later one from the means of measurement of the cognitive control of the subject of training. At rather contradictory results in relation to the different external criteria and correlation of the cognitive styles between themselves these specificities have proven to be precisely the names of reliable differences in the individual characteristics of the strategies of the subject of training in the conditions of uncertainty and relative difficulty of tasks, that require the internal self-regulation of the cognitive efforts of the subject of training.




Picture 3.21. A set of bipolar properties, included into the cognitive style

In particular at the conducting of scientific researches the greatest interest the following parameters of the cognitive styles are presented directly:

- the "impulsivity", presented in the view of the personal disposition – the questionnaire of Azarov V.N. was used, allowing the ranking of examinees from more "impulsive" to "reflexive" by "raw estimations", the character of questions in the method of research (test) allows to rate it as the variant of questionnaire on "the personal risk" of the subject of training (the examinee);
- "impulsivity – reflexivity", presented directly by the dichotomy of the cognitive style by the method of Kagan J. (Matching family figures test – MFFT).

### 3.8.5. The specifics of research of the level of meta-cognitive awareness of the subject of training in the subject of studying (the discipline)

The research of the level of meta-cognitive awareness (from the point of view of psychology) is reduced to the diagnostics of LRKT by the cycle of the subjects of studying (from the point of view of pedagogics).

Druzhinin V.N. believes, that there is a correlation dependence between the success of training in the subjects of basic level (Russian language, literature, history, foreign language, geography, physics, algebra, geometry, chemistry, zoology and drawing) and the structural components of intellect (the verbal, mathematical and spatial).

For the purpose of automation of research of LRKT the basic DM on the basis of the architecture of the expert system was used, containing at the basis of KB question-answers structures in the relevant discipline (the technical description is presented in the appendix 10).

### 3.8.6. The program toolkit for the automation of research of the parameters of the psychological portrait of the cognitive model of the subject of training

The program product provides directly the mode of administrating, in which the potential possibility of modifying of KB and DB is realized. The mode of diagnostics the program toolkit realizes the identification of the nominal values of parameters of the psychological portrait of CM of the subject of training.

The description of the program toolkit is provided in the appendix 11.

### 3.9. The linguistic portrait of the parametrical cognitive model

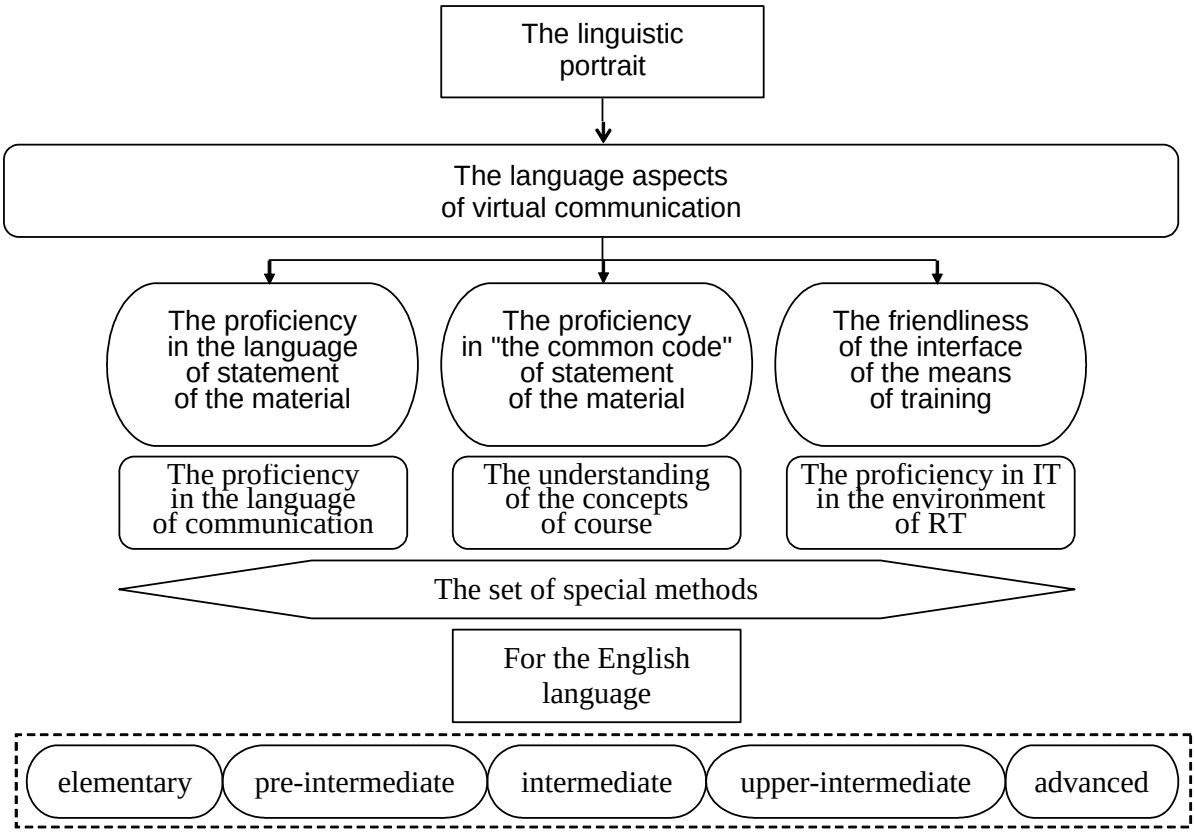
The scientific researches in the area of artificial intelligence (AI) has put forward in the quality of the actual task of the linguistic modeling of language mechanisms of the understanding of text in the natural language [7, 35, 53, 54, 71, 87, 141, 142, 149]. The basis of understanding is the knowledge of language, inextricably linked with the thinking of person, his thesaurus and accumulated life experience, his combined knowledge about the world. For the work in the area of AI is characterized the special importance, attached to the latter. At one time Schenck R., outlining his extremely interesting and perspective theory of conceptual dependence, at the creation of which the authors, as noted, "found themselves involved in the attempts of modeling almost all aspects of intellectual activity, which are related with the language", note, that for the elimination of possible ambiguity (inaccuracies) of sentences "may require the knowledge of almost everything, that exists in the world", and sees a way out from the impossibility of taking into account such volume of knowledge in the real system in the building of analyzer, which will work in a very limited area, and in which accordingly can be described "all knowledge about this area". Similarly in the another scientific work Schenk R. and Abelson R.P. write directly: "the researchers of understanding of the natural language in the course of some time feel, that the difficult scientific problem can be solved by us to the extent, in which we are able to characterize our knowledge about the world".

The modeling of the process of understanding dictates the different extended requirements in the area of the analysis of language, at the same time the limitation of linguistic material, taken into accounts in the scientific works on AI, many scientists and researchers note. The leading role is assigned directly to the following scientific principle: "A separate sentence and the related with it presentation provide an possibility to predict, that will follow further proceeding from the assumptions or reasonings. This prediction is based on the current knowledge about the given situation".

The specifics of the difficult process of understanding of the text in the natural language from the point of view of cognitive linguistics are presented in the appendix 8.

In the course of our researches of the linguistic portrait of CM the function of speech in the communication is not limited by the categorization, understanding and description, equal as and understanding not limited by the differentiation of the course of reasoning in the process of thinking and the reconstruction of virtual dialogue between the subjects of training.

The linguistic portrait of the parametrical CM of the subject of training (pic. 3.22) is based on a row of the special methods of research (tests) of applied linguistics, allowing to reveal the individual level of proficiency in the language and "common code" (the knowledge of keywords and definitions of the subject area) in the course of statement of the material, and also to determine directly the friendliness of the elements of interface of the developed program product at the working of the final user.




Picture 3.22. The linguistic portrait of the cognitive model of the subject of training

### 3.9.1. The specifics of research of the level of proficiency in the language of statement of the material

At the research of the difficulties of communicative interaction of the subjects and means of training the level of proficiency in the language of statement of the material plays a role. If the level of proficiency in the language of the subject of training is lower than the level, used in the electronic methodical manual, then the perception of information deteriorates (the subject of training not linguistically perceive and not understand the material). Therefore it is important value has the research of the level of proficiency in the language of the subject of training with the purpose of adequately presentation of information in IEE of ART.

For the identification of the level of proficiency in the language of statement of the material of the subject of training a row of the author's methods of research (tests) are used directly.

In the given scientific work (dissertation) the method of research (test) of "The Colchester educational center" (Great Britain) is taken as a basis, which includes 80 questions and allows to research the level of proficiency in the English language.

### 3.9.2. The specifics of research of the level of proficiency in the dictionary of terms

The dictionary of terms is presented a set of key concepts, used in the electronic version of methodical manuals in a certain subject of studying. For the successful formation of knowledge of the trainee it is necessary and sufficient condition is the knowledge of the essence of used concepts in LMM at the working with ET.

In given case it is advisable to research the proficiency in the dictionary of key terms, which are used in the methodical manual in a certain subject of studying.

The research practically does not differ from the diagnostics of LRKT in the discipline. The difference is that case, that the given research is carried out before the beginning of the studying of the discipline and allows: to determine the level of preparation of the subject of training and the proficiency in the key concepts, used at the statement of the given discipline; to predict the success of the technological process of training (at distance). If the level of preparation of the subject of training is low for the mastering of the given discipline, then to recommend the additional reference materials and informational resources to him.

### 3.9.3. The specifics of research of the linguistic friendliness of interface

For the increasing of the efficiency (resultativity) of information interaction in the communication environment of ART with using of the program means it is necessary, that the subject of training knows the appointment of the elements of interface and has the skills of operating by them. In this case it is purposeful to research the friendliness of interface of the program means in relation to the subject of the technological process of training.

The research is carried out in the form of a usual automated testing, which allows to reveal the level of proficiency in the program means of training, used directly in the basis of the innovative IEE of ART system: starting from the research of appointment of a certain program means of training and finishing by the features of using of its various elements of interface. At the compiling of tests (the methods of research) you should take into account the manual of user and the technical description of the program means, used for the support of IEE.

### 3.9.4. The program toolkit for the automation of research of the parameters of the linguistic portrait of the cognitive model of the subject of training

The program product provides directly the mode of administrating, in which the potential possibility of modification of KB and DB is realized. For the research of the nominal values of parameters of the linguistic portrait of CM of the subject of training the special method of research (test) of “The Colchester educational center” (Great Britain) for the English language is used. The mode of diagnostics the identification (testing) of the nominal values of parameters of the linguistic portrait of CM of the subject of training is realizes directly.

The description of the developed program toolkit, allowing to conduct the research of the nominal values of parameters of the linguistic portrait of CM of the subject of training is presented directly in the appendix 10.

## *3.10. The conclusions on the third chapter*

The conclusions on the third section of dissertation are formulated by the author:

- the innovative technology of building of the structure of the parametrical CM for the carrying out of the system analysis of the different objects, processes and phenomena of research in the various subject areas (the problem spheres) is developed;
- the formal description of the structure of the parametrical CM from the point of view of the theory of graphs and the theory of sets (the analytical representation) is presented;
- the essence of the technique of use of CMT for the system analysis of the object, process or phenomenon of research (the basic technique of use of CMT) is opened;
- the algorithm of formation of the structure of the parametrical CM for the tasks of IEE is developed and the sequence of creation of the structures of CM of the subject and means of training is reflected;
- the description of the physiological, psychological and linguistic portraits of the parametrical CM of the subject of training and the means of training from the point of view of private physiology of sensory systems (analyzers), cognitive psychology and applied linguistics respectively is presented;
- the specifics of the process of research of the values of parameters of CM is described;
- the innovative program complex for the automation the process of research (diagnostics) of the nominal values of parameters of CM is developed.

Thus, from the scientific provisions, received by the author in the third chapter are submitted for defence: CMT, the technique of its use and the algorithm of formation of CM based on the two ways of representation, CM of the subject of training and CM of the means of training.

These scientific results allow to carry out the complex system analysis of the efficiency (resultativity) of the formation of knowledge of the trainee in ART system from the point of view of a series of the previously selected scientific aspects of research (the physiological, psychological and linguistic portraits of the parametrical CM), and also to form the structures of the parametrical CM of the subject and means of training, accumulating respectively the nominal values of parameters, characterizing IFPST and the potential possible kinds (types) of EI.

# 4. The experimental checking of the cognitive models for the system analysis and the increase in the efficiency of information interaction of the subjects and means of training

The technology of adaptive training contributes to the creation of optimal conditions for the providing of increasing of the efficiency of information interaction between the subjects of training and the means of training with taking into account of the individual features and abilities (the physiological, psychological, linguistic and others), in particular it will allow to the trainee to increase the resultativity of training (LRKT), and to the teacher to provide the monitoring and control by the technological process of training.

The proposed CMT allows to conduct the primary analysis of IEE, to build CM, providing the realization of the adaptive model of training, and also to estimate the efficiency of the individually-oriented formation of knowledge of the trainees.

In given chapter it is supposed to provide the statement and conducting of a series of experiments, directed on the justification of the efficiency of use of CMT in IEE and the reliability of scientific results, obtained in the course of the dissertation research.

The results of experiment allow to make the qualitative conclusion about the structure of LMC, which is formed in accordance with the adopted organizational model of training, and also to estimate the efficiency of functioning of the computer means of training in the basis of the automated IEE, realized with the using of any given technology.

MRK, formed by the teacher (the subject of pedagogics), causes the necessity of structuring of all learning material in the discipline on a set of linked information fragments (modules) with the purpose of subsequently filling of the database of the automated means of training (ET). Each module of the electronic learning manual additionally contains a structured sequence of reference question-answers structures for the possibility of realization of the intermediate and final testing of LRKT.

The analysis of the results of experiment will allow to allocate the ways of further improving of the technologies of training and the methods of estimation of LRKT. Moreover, that in the basis of the modern technologies of automated training and testing is supposed the splitting of material and the tasks of test in the theme (module) by the principle of gradually increasing of the level of difficulty of information fragments. This allows each trainee to realize effectively the gradual studying of a sequences of diverse information fragments of the discipline and then objectively to estimate LRKT in the subject of studying (discipline). Such structure of organization of the learning process allows directly to form and carry out the individual strategy of training for each trainee. The emergence of objective and subjective difficulties in the process of the formation of knowledge of the trainee, as a rule, leads to the decreasing of efficiency and the increasing in the time of training.

At the consideration of question of the improving of quality and estimation of the efficiency of functioning of IEE of ART system directly use the various criteria of estimation, based on a large quantity of various indicators, among which:

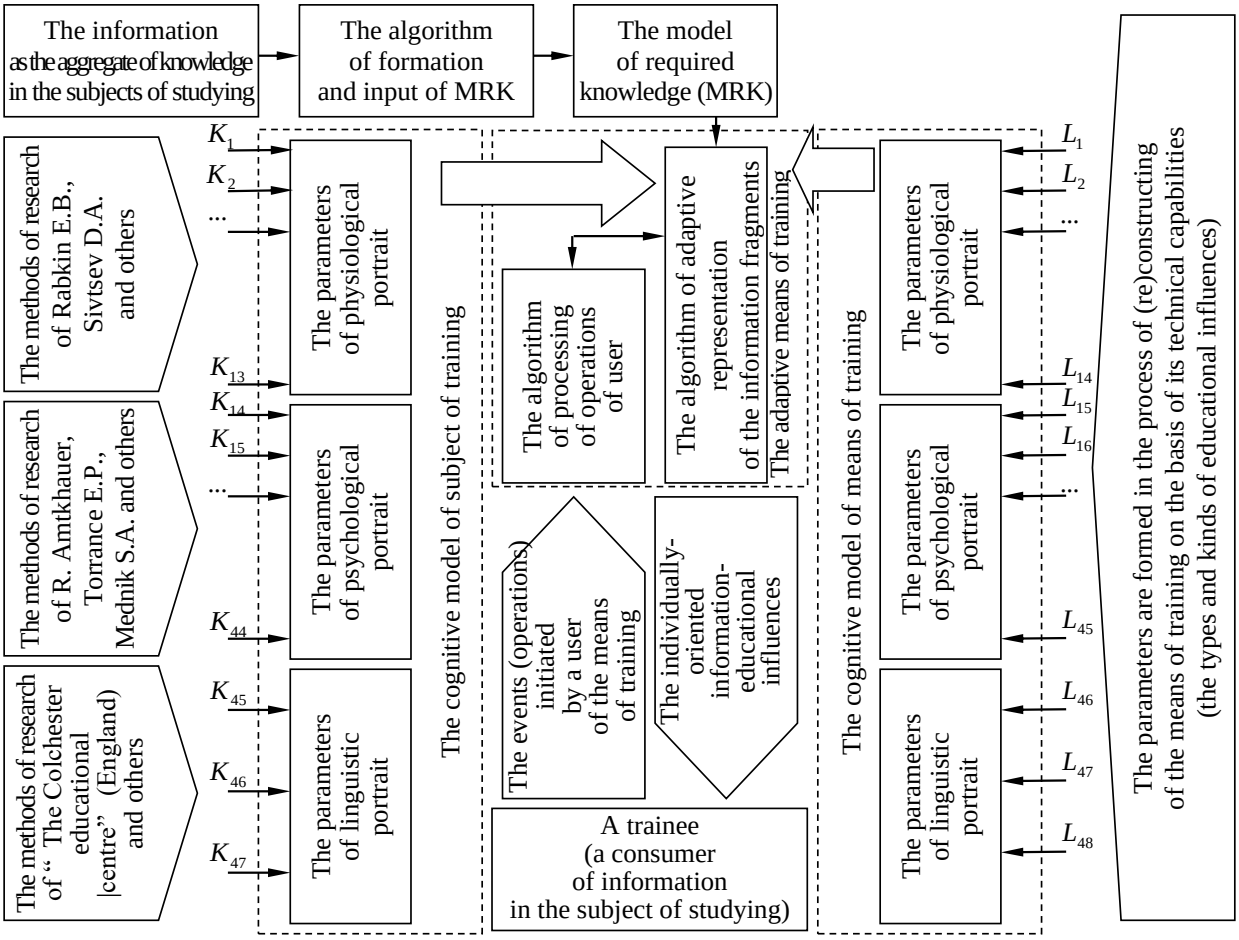
- the potential multivariability of passing of the educational trajectory by the trainee is caused by the potential possibilities of correction of a sequence of the displaying of information and the elements of navigation;
- the informativity of EI – the quantity of various information, contained in the sequence of information fragments and the level of its difficulty;
- the possibility of adjusting of the parameters of the visual representation of information fragments (background, font and the scheme of displaying), and also the realization of taking into account of the anomalies of sensory perception by the visual analyzer (the visual sensory system);
- the possibility of adjusting of the parameters of the audio representation of information (volume, timbre and the scheme of reproduction of the sound flow) by the means of training;
- the selection of the kind of displaying of a sequence of information fragments (text, table, the flat scheme, the volumetric scheme and sound stream);
- the style and features of the representation of information by the means of training (the holistic or detailed representation, the automatic or manual switching, the constant or variable type of EI, the deep concretization or abstract statement, the cognitive simplicity or difficulty of statement of the content of material, the wide or narrow set of keywords and definitions);
- the setting of the speed of the presentation of information (high and low);
- the selection of the method of carrying out of testing and the technology of diagnostics of LRKT;
- the providing of friendliness of the virtual dialogue and the language of communication (the algorithm of the presentation of material, the set of the elements of interface of the automated means of training and the level of statement of the material);
- the flexibility of virtual dialogue of the subject of training in IEE of ART system (the degree of compliance to the natural dialogue, the way of input and output of the information, and also the indication of errors and the features of giving of the explanations and clarifications).

## *4.1. The features of organization and conducting of the experiment*

The organization and carrying out of a series of experiments of based on CMT comes down to:

- the studying of the iterative cycle of CMT and the techniques of its use for the analysis of IEE of ART;
- the selection of a certain way of representation of the parametrical CM: the oriented graph, the structural scheme or other models of representation;
- the formation of CM of the subject of training and CM of the means of training by the means of using the algorithm of formation of CM of the subject of training in the basis of IEE;
- the analysis of the initial (theoretical) CM of the subject of training and the means of training, the selection of a certain sets of parameters, which should be researched and diagnosed directly in the course of the upcoming experiment;
- the application of the method of research of the nominal values of parameters of CM and setting up of the applied DM for the carrying out of the automated diagnostics of the nominal values of the various parameters of CM of the subject of training;
- the primary examination of the contingent of trainees (the examinees), the revealing by the means of use of the automated diagnostics of the physiological, psychological and linguistic parameters of perception, processing and understanding of the information (the information fragments), and then their entry into the parametrical CM of the subject of training;
- the formation of the parametrical CM of the means of training based on the analysis of technological capabilities of the automated means of training, its ability to generate the various sets of EI (the information fragments);
- the use of the formed CM in the basis of the automated IEE;
- the individually-oriented presentation of the learning material to the contingent of trainees in the view of a set of information fragments by means of the adaptive means of training (ET), operating based on PCMB;
- the automated diagnostics of LRKT with using of the basic DM and the application of the algorithm of processing of a posteriori data of testing;
- the application of the mathematical methods for the deep statistical analysis of a posteriori data and the revealing of dependencies and regularities, and also the degree of influence of the nominal values of various parameters.

In the course of the primary examination of the contingent of trainees (the subjects of training) it is necessary to take into account the specifics of carrying out of a series of experimental researches, which can be characterized directly by the following scheme (pic. 4.1).




Picture 4.1. The specifics of carrying out of research for the improving of efficiency of the formation of knowledge of the trainee based on the cognitive models

After the analysis of the initial (theoretical) CM of the subject of training and the choosing of the actual (practical) set of various parameters it is necessary to select a set of methods for the carrying out of research, providing the potential possibility of the automated diagnostics. For the research of the nominal values of new parameters of CM the new procedures of diagnostics (tests) in the basis of the applied DM are created.

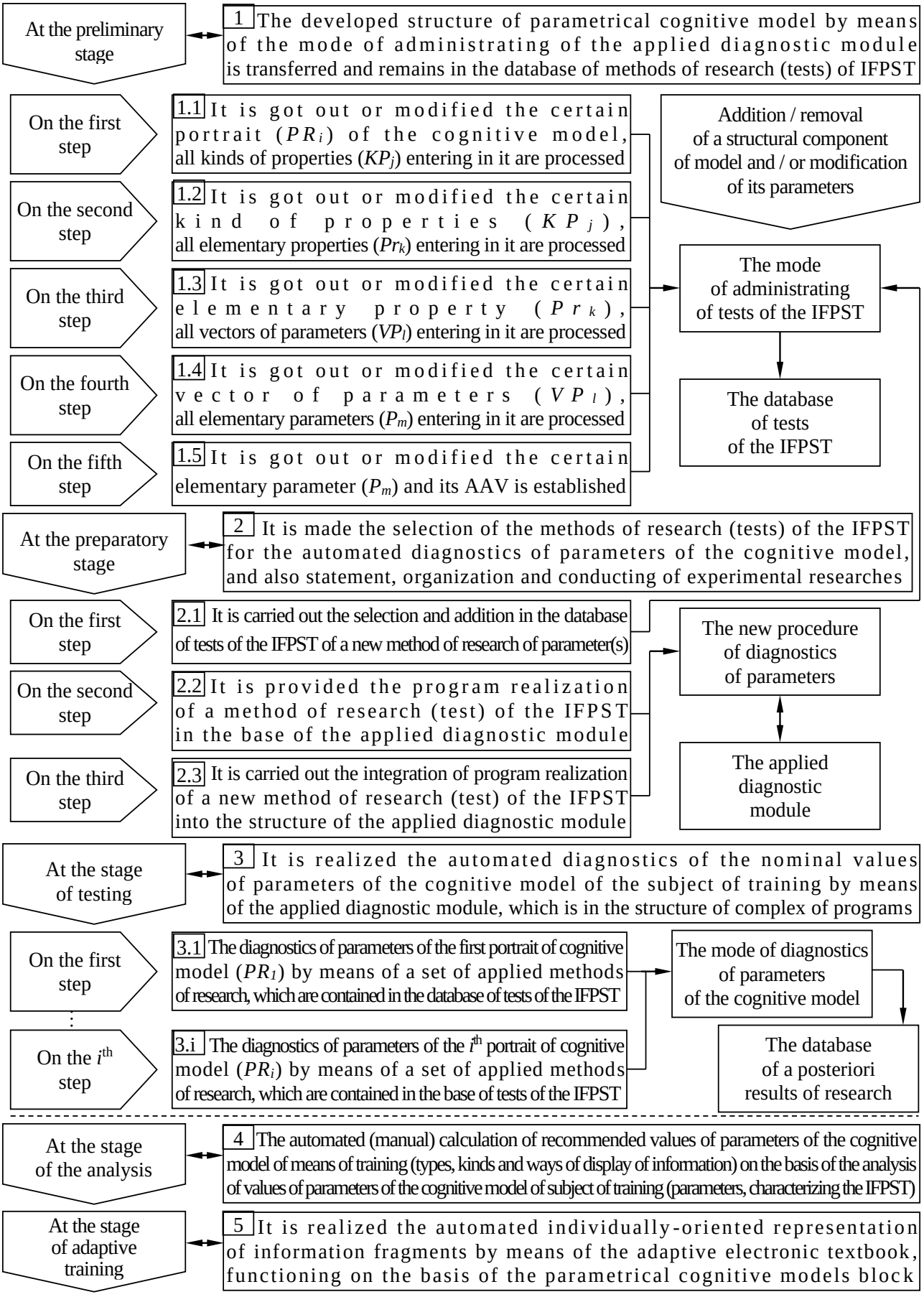
## *4.2. The techniques of research of the parameters of the cognitive models of the subject of training and the means of training in the environment of training*

The specialized methods of research are proposed (pic. 4.2 and pic. 4.3) for the formalization of the process of organization and carrying out of research of the nominal values of parameters of CM of the subject of training and CM of the means of training.

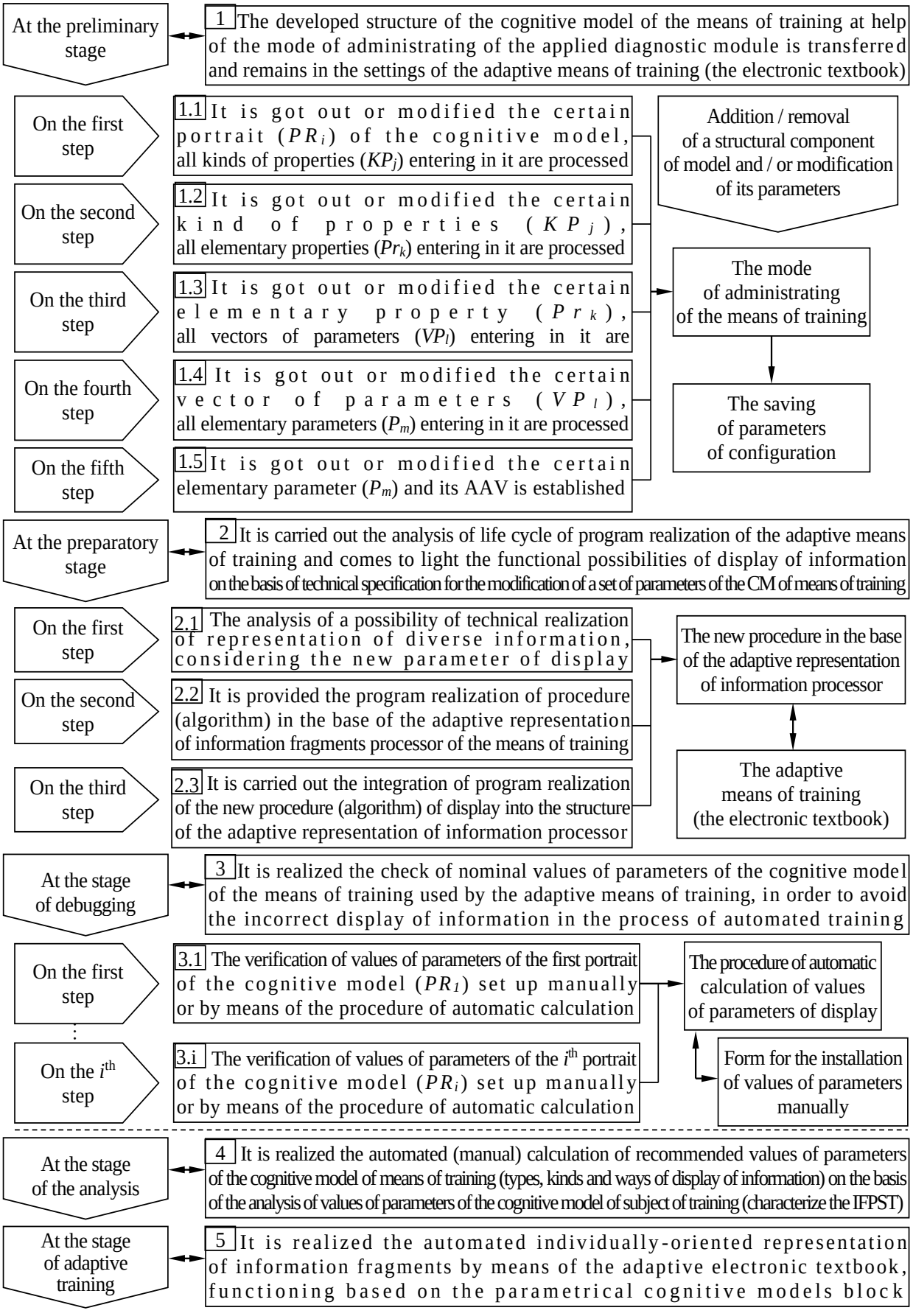
The use of the given methods will allow to concretize the sequence and content of actions, directed at the preparation of the applied DM, the statement and carrying out of a series of the (automated) experiments, providing the automated diagnostics of the nominal values of parameters of the parametrical CM of the subject of training and CM of the means of training. Based on a posteriori values of parameters of CM of the subject of training the automated (manual) calculation (selection) of the recommended nominal values of parameters of the parametrical CM of the means of training is carried out, on the basis of which the adaptive representation of information processor directly realizes the generation of a sequence of EI adequately IFPST.

The tasks of experiment are came down to the estimation of influence of the values of parameters of CM on the resultativity (efficiency) of the formation of knowledge of the trainee in IEE of ART, and also directly the confirmation of truth and working-capacity of the principles, methods and algorithms, developed by the author in the dissertation.

The interest presents the estimation of mutual and separate influence of the factors on the resultativity (efficiency) of the process of the formation of knowledge of the trainee.




Picture 4.2. The technique of research of the parameters of the cognitive model of the subject of training




Picture 4.3. The technique of research of the parameters of the cognitive model of the means of training

At the using of CMT in IEE the estimation of LRKT ($Y_i$) can be considered as a criterion of the resultativity (efficiency) of training and is the result of the complex influence of various factors, which can be differentiated in relation to the subject and means of training:

1. The group of factors (parameters), caused by IFPST at the perception, processing and understanding of information fragments:
   - the physiological factors (the influence of features of the perception of information by the visual and auditory sensory system): the presence / absence of anomalies of refraction (astigmatism – $K_1$, myopia – $K_2$ and hypermetropy – $K_3$); the presence / absence of anomalies of perception (the acuity of vision – $K_4$, the field of vision – $K_5$ and the estimation of distance – $K_6$); the presence / absence of anomalies of color-perception (achromasia – $K_7$, protanopia – $K_8$, deuteranopia – $K_9$ and tritanopia – $K_{10}$); the disorders of functions of the external, middle or internal ear (not considered);
   - the psychological factors (the influence of features of information processing): *of the level of development of the convergent intellectual abilities* (the verbal intellect – $K_{14}$, the deductive thinking – $K_{15}$, the combinatorial abilities – $K_{16}$, the ability to reasoning – $K_{17}$, the analytical thinking – $K_{18}$, the inductive thinking – $K_{19}$, the mnemonics and memory – $K_{20}$, the planar thinking – $K_{21}$ and the volumetric thinking – $K_{22}$); *the level of development of the verbal creativity* (the index of associativity – $K_{23}$, the index of originality – $K_{24}$, the index of uniqueness – $K_{25}$ and the index of selectivity – $K_{26}$); *the level of development of the figurative creativity* (the index of associativity – $K_{27}$, the index of originality – $K_{28}$, the index of uniqueness – $K_{29}$ and the index of selectivity – $K_{30}$); *the bipolar cognitive styles* (field-dependence – $K_{31}$ or field-inpendence – $K_{32}$, impulsivity – $K_{33}$ or reflexivity – $K_{34}$, rigidity – $K_{35}$ or flexibility – $K_{36}$, concretization – $K_{37}$ or abstraction – $K_{38}$, cognitive simplicity – $K_{39}$ or cognitive difficulty – $K_{40}$ categorical narrowness – $K_{41}$ or categorical width – $K_{42}$); *the learning-ability* (implicit – $K_{43}$ and explicit – $K_{44}$);
   - the linguistic factors (the influence of the features of understanding of the content of information fragments): *the presence* / absence *of language problems* (the level of proficiency in the language of statement of the material – $K_{45}$, the level of proficiency in the dictionary of terms – $K_{46}$ and the level of proficiency in the elements of interface – $K_{47}$);

2. The group of factors, caused by the technical capabilities of the means of training at the generation of a sequence of EI (the information fragments):
   - the physiological factors (the influence of the features of representation of the visual and sound information by the means of training): *the parameters of background* (the type of pattern – $L_1$, the color of background – $L_2$ and the combination of colors – $L_3$); *the parameters of font* (the typeface of font – $L_4$, the size of point-size of symbol – $L_5$ and the color of symbol – $L_6$); *the color schemes* (at achromasia – $L_7$, at protanopia – $L_8$, at deuteranopia – $L_9$ and at tritanopia – $L_{10}$); *the parameters of playback of audio stream* (volume – $L_{11}$, timbre – $L_{12}$, the type of stream – $L_{13}$ and the sound scheme – $L_{14}$);
   - the psychological factors (the influence of features of the way and style of representation of the information fragments): *the kind of information* (textual – $L_{14}$, tabular – $L_{15}$, the schematic plane – $L_{16}$, the schematic volumetric – $L_{17}$, the sound as main – $L_{18}$, the sound as accompaniment – $L_{19}$, combined – $L_{20}$ and the special scheme – $L_{21}$); *the inclusion of additional capabilities* (the correction of a sequence of statement – $L_{22}$, the navigation on course – $L_{23}$, the adding of modules – $L_{24}$, the selection of the kind of information – $L_{25}$, the selection of style of presentation – $L_{26}$, the selection of the speed of presentation – $L_{27}$, the creative tasks – $L_{28}$, the additional modules – $L_{29}$ and the additional literature – $L_{30}$); *the style of presentation* (the holistic presentation – $L_{31}$ or detailed presentation – $L_{32}$, the automatic – $L_{33}$ or manual switching – $L_{34}$, the constant – $L_{35}$ or variable type of information – $L_{36}$, the deep concretization – $L_{37}$ or abstract statement – $L_{38}$, the simplicity of statement – $L_{39}$ or difficulty of statement – $L_{40}$ and the wide – $L_{41}$ or narrow set of terms – $L_{42}$); *the speed of representation of information fragments* (high – $L_{43}$ and low - $L_{44}$);
   - the linguistic factors (the influence of the features of statement of the material): the level of statement of the material – $L_{45}$; a set of keywords and definitions – $L_{46}$ and a set of elements in the basis of the interface of interaction – $L_{47}$;
3. The factors of unknown and random origin (the stochastic influences), impact of which on the resultativity of training is supposed to be insignificant, so they are not taken into account in the course of the automated experiment.

The practical use of CMT in “IBI” and “SPbSETU "LETI"” consisted in the carrying out of a series of experiments in the eight learning groups in a row of disciplines: “Banking”, “Accounting and audit”, “Informatics”, “Artificial intelligence”, “Taxes and taxation”, “Management accounting”, “Insurance” and others.

The comparative analysis and the estimation of efficiency (resultativity) of training between the several learning groups of trainees was carried out with using of the generally-accepted criteria (indicators) of the efficiency of training, where the coefficients $K = \{k_1; k_2; k_3\} = \left\{ Y_i - Y_{i-1}; \frac{Y_i}{Y_{i-1}}; \frac{Y_i - Y_{i-1}}{Y_{i-1}} 100\% \right\}$ respectively designate the absolute, comparative and relative indicators of efficiency.

### 4.3. The algorithm of processing of a posteriori data of testing

A posteriori data, obtained in the result of preliminary research of the nominal values of parameters of CM of the automated diagnostics of LRKT, characterize respectively IFPST and the resultativity of training in the complex of disciplines.

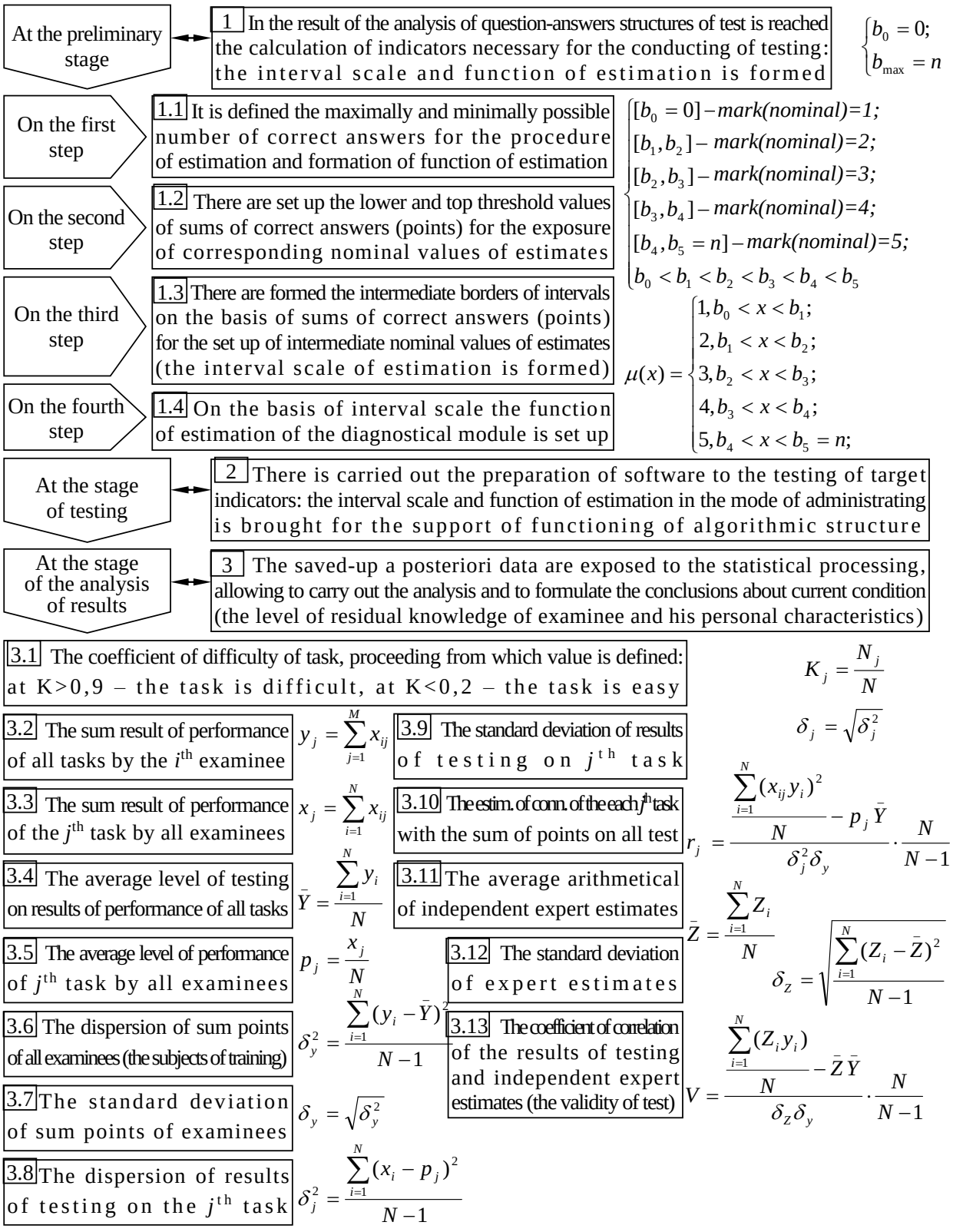
The analysis of the efficiency (resultativity) of ART of the contingent of trainees with taking into account of the values of parameters of CM of the subject of training and the means of training allows to reveal not only the tendency to the increase or decrease of efficiency (resultativity) of the formation of knowledge in IEE of ART system, but also the mutual dependencies and the degree of influence of a set of parameters on LRKT.

The revealed dependencies will allow to realize the prediction of estimations of LRKT based on the combinations of the values of parameters of CM and to differentiate the contingent of trainees in relation to the various variants of passing of the educational trajectory, adequately to the difficulty of statement and the ways of presentation of the material of discipline.

The degree of influence of the nominal values of parameters of CM on the estimation of LRKT will allow directly to reveal the sensitivity to their change, to exclude from the consideration less significant parameters of CM and subsequently to add new and actual for the further researches of IEE.

For the optimization of time costs and the automation of carrying out of the deep statistical analysis of the obtained data in the course of research of the parameters of CM is proposed to use the statistical package “SPSS”.

For the carrying out of the analysis of the efficiency of functioning of IEE the algorithm of processing of a posteriori results of testing of LRKT and the diagnostics of IFPST is proposed, allowing to form preliminary of a sample of control questions, the interval scale and the function of estimation for the providing of testing (pic. 4.4).




Picture 4.4. The algorithm of processing of a posteriori results of testing

## 4.4. The results of statistical processing of a posteriori data

The collection of results of the automated testing of LRKT and diagnostics of IFPST was carried out respectively by means of the basic DM and the applied DM, providing the registration of a posteriori data into the specialized DB.

The results of statistical processing of a posteriori data are presented in tabl. 4.1.

Table 4.1

**The results of statistical processing of data of the experiment**

| The name of indicators | The number of experimental group of the examinees | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| The quantity of examinees | 26 | 28 | 22 | 25 | 27 | 23 | 21 | 24 |
| 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 |
| ASD of average point | 0,867 | 0,178 | 1,958 | 0,879 | 0,577 | 0,783 | 1,679 | 1,047 |
| The experiment №2 (with the use of CMT) | | | | | | | | |
| The average point $Y_2$ | 4,041 | 3,674 | 3,357 | 3,786 | 4,157 | 3,853 | 3,821 | 3,743 |
| ASD of average 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 |
| $k_3$, % | 4,96 | 7,62 | 4,13 | 2,94 | 3,0 | 5,77 | 0,82 | 2,69 |
| The change of ASD | -0,144 | -0,051 | -0,215 | -0,136 | -0,131 | -0,129 | -0,141 | -0,061 |

The values of the indicators in tabl. 4.1 indicate about the increasing of the average point on 0.82-7.62% and the decreasing of ASD of the average point after the use of CMT.

For the elimination of the factor of randomness there was the need of additional researches, including the analysis of the dynamics of change of the indicator of resultativity of training for the several years, and also the setting up and conducting of a series of experiments with the purpose of estimation of the influence of the various factors (parameters) on the efficiency of the formation of knowledge of the trainee. The various information fragments were presented to the contingent of trainees by the means of use of the innovative adaptive means of training.

The analysis of the dynamics of change of the nominal values of the indicator of efficiency (resultativity) of training (LRKT) for the past three years previously was carried out and the efficiency of use of CMT in the educational process (2006 y., groups 1,2,3) was estimated, the results (a posteriori data) of which are presented directly in tabl. 4.2.

Table 4.2

**The results of preliminary statistical analysis of the resultativity of training**

| The name of indicators | The number of the group of trainees | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| The indicators of the resultativity of training for 2004 y. | | | | | | | | |
| The quantity of trainees | 20 | 21 | 25 | 18 | 18 | 15 | 0 | 0 |
| The average point $Y_1$ | 4,05 | 4,286 | 4,24 | 4,611 | 4,056 | 4,4 | - | - |
| ASD of average point | 0,686 | 0,845 | 0,779 | 0,502 | 0,802 | 0,507 | - | - |
| The indicators of the resultativity of training for 2005 y. | | | | | | | | |
| The quantity of trainees | 24 | 22 | 24 | 25 | 24 | 22 | 23 | 21 |
| The average point $Y_2$ | 4,333 | 4,046 | 4,375 | 4,16 | 4,042 | 4,091 | 4,696 | 4 |
| ASD of average point | 0,817 | 0,785 | 0,824 | 0,8 | 0,859 | 0,811 | 0,559 | 0,894 |
| The indicators of the resultativity of training for 2006 y. (with the use of CMT in the three groups) | | | | | | | | |
| The quantity of trainees | 26 | 23 | 29 | 24 | 25 | 22 | 22 | 22 |
| The average point $Y_3$ | 4,5 | 4,609 | 4,379 | 3,708 | 3,92 | 3,773 | 4,455 | 3,818 |
| ASD of average point | 0,707 | 0,656 | 0,775 | 0,751 | 0,572 | 0,612 | 0,858 | 0,853 |
| The results of statistical analysis | | | | | | | | |
| The indicators, reflecting the change of efficiency of training for 2004-2005 year | | | | | | | | |
| $k_1$ | 0,283 | -0,240 | 0,135 | -0,451 | -0,014 | -0,309 | - | - |
| $k_2$ | 1,07 | 0,944 | 1,032 | 0,902 | 0,997 | 0,93 | - | - |
| $k_3$, % | 6,996 | -5,606 | 3,184 | -9,783 | -0,343 | -7,025 | - | - |
| The change of ASD | 0,13 | -0,06 | 0,045 | 0,298 | 0,056 | 0,304 | | |
| The indicators, reflecting the change of efficiency of training for 2005-2006 year | | | | | | | | |
| $k_1$ | 0,167 | 0,563 | 0,004 | -0,452 | -0,122 | -0,318 | -0,241 | -0,182 |
| $k_2$ | 1,039 | 1,1392 | 1,001 | 0,891 | 0,97 | 0,922 | 0,949 | 0,955 |
| $k_3$, % | 3,846 | 13,923 | 0,099 | -10,857 | -3,01 | -7,778 | -5,135 | -4,546 |
| The change of AQD | -0,109 | -0,129 | -0,049 | -0,0494 | -0,287 | -0,199 | 0,299 | -0,042 |

In tabl. 4.2 reflects the resultativity of training for 2004, 2005, 2006 years, characterized by LRKT of the day (the groups 1-6) and evening department (the groups 7 and 8). The nominal values of indicators for 2004-2005 y. in the table show both the increase on 3-7% (the groups 1 and 3) and the decrease on 5-10% (the groups 2, 4, 5 and 6) in the efficiency (resultativity) of training without the use of CMT in IEE.

In 2005-2006 y. at the statement of the content of the discipline "Informatics" CMT was used, on the basis of which a series of experiments and also the statistical processing of a posteriori data (the results of the experiment) were staged and conducted.

The experimental researches were carried out in the context of the separate sections of discipline, the information fragments on which were presented to the contingent of trainees by the means of use of the adaptive means of training (ET).

For the increasing of visibility of the change in the indicators of efficiency of training at the practical use of CMT in 2006 year (the groups 1, 2 and 3) the increasing of the level of difficulty at the statement of the studied material was provided. The obtained data (2005-2006 y.) indicate about the sharp decrease of the resultativity of training on 3-10% (the groups 4-8) and its significant increasing on 3-14% (the groups 1-3).

According to the proposed method of research of the parameters of CM of the subject of training (pic. 4.2) on the stage of testing of IFPST the vectors of parameters of the physiological (the acuity of vision, the field of vision and color-perception), the psychological (the convergent and divergent intellectual abilities of trainee) and the linguistic portraits (the level of proficiency in language) were diagnosed by the means of use of the applied DM with use of the applied methods, presented in pic. 4.1.

At the stage of the analysis of parameters of the physiological portrait of CM no subjects with the different anomalies of the perception of information of the visual sensory system were revealed among the subjects of training (the contingent of trainees). The research of the linguistic portrait of CM is directed directly on the revealing of compliance between the level of statement of the material by the means of training and the level of proficiency in the national or foreign language of statement of the subject of training. The statement of material was carried out in the English language to the native speakers of the Russian language.

The results of research are presented directly in the appendix 12.

At the stage of the adaptive training the automated representation of information fragments was carried out by means of the adaptive means of training (ET), taking into account the parameters of IFPST, contained in CM of the subject of training. At the representation of the learning material EI (the information fragments) of the several main kinds were used as the main: the verbal, tabular and schematic (flat).

At the final stage the automated diagnostics of parameters of LRKT were carried out with using of the basic DM, containing in their basis the two scales of estimation (standard and point).

As practice has shown, the point scale of estimation increases the accuracy of diagnosis of LRKT, which increases with the increasing of the quantity of questions with many valid variants. At the same time the choice of the invalid variant of answer by the examinee is practically taken into account (the sum of penalty points is automatically calculated directly).

The results of the automated experiment are presented in the appendix 12, and the acts about the practical use of the results of the dissertation in the appendix 13.

### *4.5. The conclusions on the fourth section*

The conclusions on the fourth section of dissertation are formulated by the author:

Based on the analysis of the results (data) of practical use of the parametrical CM in IEE of ART system the following conclusions were made:

- the effective use of CM is impossible without the solving of the tasks of designing of the adaptive means of training and the modernization of LMC;
- the character and degree of influence of the nominal values of parameters in the portraits of CM have the individual character and depends from the contingent of trainees;
- actually the efficiency of training with the using of CMT is determined by the capabilities of the means of IEE, the content of electronic content and the purposes of training, varying in accordance with the program of studying of the discipline.

Thus, from the scientific provisions, obtained by the author in the fourth chapter are submitted for defence: the technique of research of the parameters of CM and the algorithm of processing of a posteriori results of testing.

The obtained results (a posteriori data) allow to form and to prepare the organizational, methodical, hardware and SW, and also to provide the statement and conducting of a series of experimental researches, allowing directly with sufficient statistical certainty to estimate the degree of influence of the parameters of CM on the resultativity (efficiency) of training and to reveal the statistical regularities in a posteriori data of testing.

# The conclusion

In the result of carried out research the following conclusions can be made.

At-first. At the turn of the XX$^{th}$ and XXI$^{st}$ centuries the new ICT were widespread. On their basis the formation of information society (the information subsociety) is carried out, operating in the high-technological information environment of a new generation ("infosphere"). The social subjects in the environment cannot exist and develop dynamically without the adequate system of education, especially the higher education. The modern realities dictate the increase of the importance of DE-based on the new ICT, acting the significant influence on the qualitative level of realization of ART systems of EE. But the solving of these difficult problems is impossible without the analysis and reformation of the methodological principles of applying of the traditional and new IT in the system of education. It is for this reason in the dissertation research also considers a row of significant methodological problems (the area and sphere of pedagogics), related to the role of educational IT in the light of the interaction of "the subject-the means of training" of IEE, and also their potential possibilities in the process of the formation of knowledge. Among the most important and actual scientific priorities on the modern stage are distinguished the building of the global system of open education, that is confirmed by the researches of "The institute of informatization of education", which highlights a broad row of the national priorities of reformation of the modern and existing system of education in Russia, among which:

- the improving of quality by means of the fundamentalization and application of the innovative approaches, based on the application of a new ICT;
- the orientation on the leading character of the synthesis and development of IEE with taking into account of the scientific problems of the post-industrial (information) society;
- the expanding of the sphere of use and the accessibility for the consumers of education by the means of use of the technologies of ART and the automation of traditional IEE;
- the orientation on the modern creative aspects of building of IEE and the personal orientation of the used means and environments of training (at distance).

At-second. In the present time the systems of higher education of many countries, including The Russian Federation (Russia), are beginning to test on yourself the influence of the key technological tendences and achievements. The virtual information environment of training is becoming increasingly important, as the expanding of the sphere of use of the modern ICT is carried out.

Along with the organizational-methodical basis (classically) the virtual environment of ART includes the technological – it is oriented not only on the kind of used ICT, but and the potential possibility of using of any given technologies in the basis of IEE.

The use of the modern ICT in the educational activity allows:

- to increase the profitability of the educational centre and the efficiency of performing of the various kinds of work, accompanying to the educational activity;
- to provide a wide nomenclature of educational services to the various categories of consumers due to the building of IEE with using of the technologies of ART;
- to unite a set of territorially distributed educational centres due to the use of communication environments of a new generation, in particular the global computational network "Internet".

At-third. In the quality of the explanatory methodological principle in the research of the various characteristics of the professional development of personality "the principle of creative amateur-performance" of the subject of training is chosen, proposed and substantiated in the scientific works of Rubinstein S.L. This given scientific principle means, that IT of ART system significantly contributes to the increasing of personal potential of the individual. The task of the importance of tele-communication and computer technologies was solved, used in the certain ART system of the educational establishment (HEI), in the formation and development of the professional potential of personality of the subject of training.

It was noted, that new ICT allow to realize a row of classical didactical principles of the classical of IEE on the qualitatively new level – they allow:

- to study the phenomena in the difficult technical, biological, economic, systems at the macro- and micro-level of consideration by the means of use of the automated IEE and the technologies of computer modeling;
- to present in a convenient scale for studying the difficult processes, the really proceed with a high or low speed in the environment of functioning.

At-fourth. In the present time DE has two kinds, and namely: the traditional (classical) extramural training (at distance), related with the paper form, and the open training (education), based on the use of electronic mail and virtual environment. ART combines the traditional and computer IT – the paper and electronic. ART represents the unity of information and educational processes, functioning with taking into account of the achieved level of information culture of the social subjects on the given stage of development of the modern civilization.

This new communication system has made the significant changes into the modern culture, turning it into the info-culture of post-industrial society. The latter represents the unity of traditional culture and the electronic means of communication (the innovative means of automation). The changing modern sociocultural reality of the public formation, the emerging information culture have a significant impact on the sphere of the (distance) education in general, especially on RT system. Quite naturally, in education, including and DO, IT is used, the strategy of organization of which depends from the type of culture of the given society. In the scientific work the importance of information culture in the development and functioning of DE system and the open education was established.

ICT in the sphere of education are differentiated on the two basic categories:

- the non-interactive – the printed and video-materials on the carriers of various kind;
- the interactive – the computer, multimedia and tele-communication: the tele-bridges and conferences by the digital dedicated channel of communication.

In the course of historical development a row of stages in the development of the paradigm of ATS are monitored:

- the emergence of the automated training programs and environments (60$^{th}$ years);
- the development of producing ATS and the development of models, oriented on the scientific basis of modern cognitive psychology (70$^{th}$ years);
- the synthesis of the tool means and environments based on knowledge engineering (80$^{th}$ years);
- the emergence and widespread use of the means of automation in the sphere of multimedia and hypermedia educational ICT and ART systems, the possibility of the obtaining of access to the professional data and knowledge banks (90$^{th}$ years).

At-fifth. The coming era – the informatization of society requires an adequate it model of informatization and the corresponding paradigm of education in accordance with the belonging to any given modern civilization. As the system of education is one from the components of culture, then the forming modern information culture (the "network" culture and the culture of electronic-digital society) with the need leads to the increasing of the specific gravity of ART in the system of education.

In the dissertation considers a row of theories (the theory of autonomy and independence of training, the theory of industrialization and the theory of interaction and communication), underlying in the basis of the principle of automated training (at distance).

The form of DE has the significant importance value for the countries with large territories and the unevenly distributed scientific-educational centres, in particular for RF. The importance of the realization of DE in RF is confirmed by the introduction of The Federal program of The government of RF "The development of the unified educational information environment" (2001-2005 years).

At-sixth. In connection with the informatization of the various spheres of social activity there is the increase of importance of new ICT in the system of education, especially in the environment of ART.

IEE of ART systems of the scientific (educational) establishments at least include:

- the tool means of automation of the preparation of the electronic LMM;
- the innovative EL (the modern information resources and services);
- the means of administering of the learning course and control of the process of training;
- the means of automation of working in the tele-communication environment "Internet".

The main stages of becoming and development of the modern technologies of ART include:

- the planning of the process of automated training (at distance);
- the preparation of the modern LMC in disciplines (the subjects of studying);
- the computerized training of the contingent of trainees in the disciplines;
- the automated estimation of LRKT (the subjects of training) in IEE of ART system.

The technology of ART requires a more deeper studying and understanding of the features of information interaction of the subjects of training with the means of training, an adequate expression of which the author were synthesized parametrical CM, allowing to reveal the reasons of difficulties in the process of automated training.

In the basis of any automated IEE of the modern high-technological educational centre is based on the scientific principle of individual orientation of the developmental trajectory and the adaptation of EI (the information fragments), generated by the modern means of training in the process of representation of the content in concert with the various personal features of the subject of training. The algorithms of control by the automated training (at distance) are interpreted as the algorithms of development of the learning tasks and clarifications, which are determined by the objective regularities of IEE of ART system and the used information technologies and the methods of training (at distance).

From the one side, in accordance with the objective capabilities of human, the trainee at each moment of time works with a certain portion of information, at the same time being at a certain stage of automated training (as the difficult technological process of the formation of knowledge of the contingent of trainee). From the other side, the algorithm of control of automated training (at distance), which is formed on the basis of the representations of the teacher (the subject of training), can transfer the trainee to the previous stages of automatized training (in the case of emergence on the objective reasons of such a social need).

The training can be considered as the controlled process by the principle of feedback, consisting from a set of various operations (functions) and has dual character: in its course not only the knowledge of the trainee (the subject of training) is formed, but and the process of automated training (at distance) is realized, that is ultimately, determined by the requirements, presented to the knowledge of trainee, their initial condition and abilities of the subject of training (the examinee). For the take into account of IFPST, the parametrical CM of the subject of training and a set of the methods of research (the block of tests) for the identification of IFPST are introduced into consideration.

The formalized model of the process of automated training (at distance) allows to form reasonably the block structure of the modern adaptive ET, realized by the block-modular principle, where each module supports the corresponding stage of the process of training due to the necessary set of algorithms, realizing the operations of the processing of events and the filling of content by the content. The subject filling of the modules are the semantic models of the subject of studying, describing the purposes of the corresponding stages of automated training (at distance), the procedures and means of them achievement, and also the texts, contained in the semantic models.

The structural scheme of the adaptive representation of information processor of ET, functioning on the basis of the innovative PCMB, taking into account IFPST was developed. In the basis of the structural (semantic) model of the subject of studying of the adaptive ET is leaned the meta-model of the subject of studying (the universal structure, is necessary and sufficient for the encapsulation of information on a row of the subjects of studying). The meta-model of the subject of studying is presented the tree of purposes of training, each vertex of which – the purpose appointment of a certain information fragment (the electronic book, in particular: its part, section, chapter, module, block, paragraph, subparagraph, item and the terminal text on the screen page).

At-seventh. The main requirement to the modern ATS is in the providing of the maximal degree of individualization of the process of training, that is the ability of adaptation to each concrete trainee, that is not feasible at the traditional methods of mass training.

The training program is the model of activity of the teacher on the control of automated training (at distance) and the components of IEE, that is reflected in the principles of realization of ART with the flexible structure of control:

- LPA should be based directly on the formed level of mental activity, diagnosed by the corresponding ways;
- the insufficiently formed kinds of mental activity should develop in a purposeful with the taking into account of IFPST (PCMB);
- if the kind of activity requires a more higher level of assimilation, then the more difficult form of activity should be decomposed into simpler kinds, and the formation of knowledge should be carried out through a set of simple operations and exercises;
- LPA of the subject of training (the examinee) should be designed with the taking into account of its ability to the self-diagnostics and independent training.

For the taking into account of IFPST it is advisable to introduce the two contours of adaption:

- the first – reflects the adaptability of the different computer programs to the initial level of training and the development of the mental processes of trainees, formed abilities and skills of the trainee to control their LPA;
- the second – provides the adaptation to the changing IFPST in the process of training.

At-eighth. The parametrical CM concentrates the most important parameters, which are echeloned on a row of portraits and characterize the different IFPST, and also allow to analyze the efficiency of information interaction of the subjects of training with the means of training and to reveal the causes of difficulties in the technological process of the formation of knowledge due to the perceived EI.

CMT is intended for the synthesis of the structure of CM and the filling it by the parameters.

The structure of the parametrical CM includes a row of various of portraits: the physiological (formed on the scientific basis of the private physiology of sensory systems), the psychological (formed on the scientific basis of cognitive psychology) and the linguistic (formed on the scientific basis of applied linguistics).

The physiological portrait characterizes the individual features of the visual and auditory sensory systems of the subject of training, including: the anomalies of the refraction of eye as the biological construct (the optical device) and the anomalies of the perception of space and the polychromatic spectrum.

The visual sensory system (the physiological portrait) is located directly in the contour of the peripheral nervous system of human as the biological kind, oriented on the primary perception of visual and auditory influences in the process of encoding and decoding of information, perceived by the organs of hearing and vision.

The psychological features of personality (the psychological portrait) effect on the individual specifics of the processing of information fragments by the psychophysiological construct of head brain of the human (the subject of training), taking into account the convergent and divergent intellectual abilities, and also the learning-ability of the subject of training (the examinee) and his cognitive style.

The linguistic portrait of CM characterizes the linguistic features in the process of information interaction of the subject with the means of training: the individual level of proficiency in a certain language of statement of material, "the common code" as a combination of key concepts and definitions, used in the modern innovative electronic LMM, the friendliness of interface – the knowledge by the subject of training of the appointment and proficiency of a set of the elements of interface, used in program means of ART.

The set of portraits of CM and the parameters, included in each of them, can be modified as needed to deploy the research "in width" and "in depth".

The methodological significance of CM consists in the fact, that it gives the opportunity to build the contour of adaptation, allowing to provide the generation of a sequence of information fragments (EI) by the means of training, which adequately to IFPST, and also to estimate the efficiency (resultativity) of the information interaction of a certain subject of training with the means of training in IEE of ART system, taking into account the capabilities of the high-technological means of training and IFPST.

In the course of the dissertation research the program complex was developed, which allows to carry out the diagnosing of the nominal values of parameters of CM.

# The bibliographic chapter

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**II. The list of publications on the theme of dissertation research of the author**

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236. Vetrov A.N. The topology and conception of organization of the integration environment of "SIO "ACNS"": the collection of scientific reports and multimedia-presentations (slides) in the form of scientific monography on the rights of manuscript (philosophical sciences (natural, technical, economic, humanitarian, social, medical, sports and military sciences)) (spec. 01.02.01, 05.13.01, 05.13.10, 19.00.02 (19.00.03), 08.00.10) / A.N. Vetrov; "SIO "ACNS"". – SPb.: "SIO "ACNS"", "SPbSETU "LETI"", 2013. – 8 p. (+ 78 slides).
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238. Vetrov A.N. “The scientific research institute "System and financial analysis based on cognitive modeling technology" of "RA(N)S" named after Veniaminov V.N.”, their divisions of fundamental and applied scientific researches (at the microscopic level), and also their local and international scientific newspapers and journals: the collection of scientific reports and multimedia-presentations (slides) in the form of scientific monography on the rights of manuscript (philosophical sciences (natural, technical, economic, humanitarian, social, medical, sports and military sciences)) (spec. 01.02.01, 05.13.01, 05.13.10, 19.00.02 (19.00.03), 08.00.10) / A.N. Vetrov; “SIO "ACNS"”. – SPb.: “SIO "ACNS"”, “IBI”, 2013. – 14 p. (+ 87 slides).
239. Vetrov A.N. “The scientific fund "System and financial analysis based on cognitive modeling technology" named after Prokopenko N.A.”, their financing divisions of fundamental and applied scientific researches (at the microscopic level), and also their local and international scientific newspapers and journals: the collection of scientific reports and multimedia-presentations (slides) in the form of scientific monography on the rights of manuscript (philosophical sciences (natural, technical, economic, humanitarian, social, medical, sports and military sciences)) (spec. 01.02.01, 05.13.01, 05.13.10, 19.00.02 (19.00.03), 08.00.10) / A.N. Vetrov; “SIO "ACNS"”. – SPb.: “SIO "ACNS"”, “IBI”, 2013. – 16 p. (+ 84 slides).
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D. The reports on the scientific-research work

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260. Vetrov A.N. Appendix to the report on the individual initiative SRW "The research of the environment of automated training with the properties of adaptation based on the cognitive models" for 2003-2005 y., carried out during writing of my dissertations: the appendix to the report on SRW (physical-mathematical, technical, humanitarian, social and medical sciences) (spec. 01.02.01, 05.13.01, 05.13.10, 19.00.02 (19.00.03)), SPb.: "SPbSETU "LETI"", "IBI", "SPbSUEF "FINEC"", M.: ""VNTIC" of "RAS"", 2005 (2006). – 654 p.
261. Vetrov A.N. The report on the individual initiative SRW "The research of the information environment of automated training with the properties of adaptation based on the cognitive models and the financial analysis of the organization by means of the cognitive modeling technology" for 2006-2008 y., carried out during writing of my dissertations: the report on SRW (physical-mathematical, technical, economic, humanitarian, social and medical sciences) (spec. 01.02.01, 05.13.01, 05.13.10, 19.00.02 (19.00.03), 08.00.10), SPb.: "SPbSETU "LETI"", "IBI", "SPbSUEF "FINEC"", M.: ""VNTIC" of "RAS"", 2008 (2009). – 716 p.

E. The scientific articles

(in the scientific journals, recommended by "HAC of RF")

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263. Vetrov A.N. 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 / A.N. Vetrov, E.E. Kotova, N.N. Kuzmin // "Proceedings of "The Volgograd state technical university"", №8, 2006. – SPb.: "SPbSETU "LETI"", 2005, Volgograd: "VSTU", 2006. – 9 p. (P.194-196).
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265. Vetrov A.N. The adaptive information-educational environment of the automated (remote) training based on the parametrical cognitive models / A.N. Vetrov, E.E. Kotova, N.N. Kuzmin // "Proceedings of "SPbSETU "LETI"", №1, 2006. – SPb.: "SPbSETU "LETI"", 2006. – 14 p. (P.101-111).

266. Vetrov A.N. The realization of the adaptive training in the automated educational environment based on the cognitive models / A.N. Vetrov // "Proceedings of "SPbSETU "LETI"", №1, 2007.– SPb.: "SPbSETU "LETI"", 2007. – 8 p. (P.10-16).
267. Vetrov A.N. The cognitive modeling technology in the automated educational environment / A.N. Vetrov // "Proceedings of "RUPF (RUDN)"", №4, 2008. – SPb.: "SPbSETU "LETI"", 2006, M.: "RUPF", 2008 (Bibliogr. 13 nom. – Rus. – Dep. in ""VINITI" of "RAS"", 2008). – 18 p. (P.26-42).
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330. Vetrov A.N. “The scientific fund "System and financial analysis based on cognitive modeling technology" named after Prokopenko N.A.” / A.N. Vetrov // “Quality management in modern High school (HEI)”, the section “Educational politics and new technologies of teaching”: the materials of “The XI$^{th}$ international scientific-methodical conference” (“IHEAS”), RF, Saint-Petersburg city, the 30$^{th}$ of October 2013 y. – SPb.: “IBI”, 2013. – 3 p. (+ 51 slides).
331. Vetrov A.N. The fundamental scientific researches financing divisions (at the microscopic level) of “SF "SFA CMT" n. a. Prokopenko N.A.” / A.N. Vetrov // “Quality management in modern High school (HEI)”, the section “Educational politics and new technologies of teaching”: the materials of “The XI$^{th}$ international scientific-methodical conference” (“IHEAS”), RF, Saint-Petersburg city, the 30$^{th}$ of October 2013 y. – SPb.: “IBI”, 2013. – 3 p. (+ 15 slides).
332. Vetrov A.N. The applied scientific researches financing divisions (at the microscopic level) of “SF "SFA CMT" n. a. Prokopenko N.A.” / A.N. Vetrov // “Quality management in modern High school (HEI)”, the section “Educational politics and new technologies of teaching”: the materials of “The XI$^{th}$ international scientific-methodical conference” (“IHEAS”), RF, Saint-Petersburg city, the 30$^{th}$ of October 2013 y. – SPb.: “IBI”, 2013. – 3 p. (+ 15 slides).
333. Vetrov A.N. The local and international scientific newspapers and journals of “SF "SFA CMT" n. a. Prokopenko N.A.” / A.N. Vetrov // “Quality management in modern High school (HEI)”, the section “Educational politics and new technologies of teaching”: the materials of “The XI$^{th}$ international scientific-methodical conference” (“IHEAS”), RF, Saint-Petersburg city, the 30$^{th}$ of October 2013 y. – SPb.: “IBI”, 2013. – 3 p. (+ 18 slides).
334. Vetrov A.N. ““Saint-Petersburg exhibition centre named after Brezhnev L.I." at "Exhibition of achievements of science and technology named after Sobchak A.A."” / A.N. Vetrov // “Actual problems of economics and new technologies of teaching (Smirnov readings)”, the section “Educational politics and new technologies of teaching”: the materials of “The XIII$^{th}$ international scientific-practical conference” (“IHEAS”), RF, Saint-Petersburg city, the 22$^{nd}$ of March 2014 y. – SPb.: “IBI”, 2014. – 3 p. (+ 51 slides).
335. Vetrov A.N. The fundamental scientific researches (financing) exhibitions divisions (at the microscopic level) of ““SPbEC n. a. Brezhnev L.I." at "EAST n. a. Sobchak A.A."” / A.N. Vetrov // “Actual problems of economics and new technologies of teaching (Smirnov readings)”, the section “Educational politics and new technologies of teaching”: the materials of “The XIII$^{th}$ international scientific-practical conference” (“IHEAS”), RF, Saint-Petersburg city, the 22$^{nd}$ of March 2014 y. – SPb.: “IBI”, 2014. – 3 p. (+ 15 slides).
336. Vetrov A.N. The applied scientific researches (financing) exhibitions divisions (at the microscopic level) of ““SPbEC n. a. Brezhnev L.I. " at "EAST n. a. Sobchak A.A."” / A.N. Vetrov // “Actual problems of economics and new technologies of teaching (Smirnov readings)”, the section “Educational politics and new technologies of teaching”: the materials of “The XIII$^{th}$ international scientific-practical conference” (“IHEAS”), RF, Saint-Petersburg city, the 22$^{nd}$ of March 2014 y. – SPb.: “IBI”, 2014. – 3 p. (+ 15 slides).
337. Vetrov A.N. The local and international scientific newspapers and journals of ““SPbEC n. a. Brezhnev L.I." at "EAST n. a. Sobchak A.A."” / A.N. Vetrov // “Actual problems of economics and new technologies of teaching (Smirnov readings)”, the section “Educational politics and new technologies of teaching”: the materials of “The XIII$^{th}$ international scientific-practical conference” (“IHEAS”), RF, Saint-Petersburg city, the 22$^{nd}$ of March 2014 y. – SPb.: “IBI”, 2014. – 3 p. (+ 18 slides).

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339. Vetrov A.N. The features of realization of the innovative integration environment of “SIO "ACNS"”, “SRI "SFA CMT" of "RA(N)S" n. a. Veniaminov V.N.”, “SF "SFA CMT" n. a. Prokopenko N.A.” and “"SPbEC n. a. Brezhnev L.I." at "EAST n. a. Sobchak A.A."” / A.N. Vetrov // “Modern education: contents, technologies, quality”, the section “Perspective technologies of training: distance education”: the materials of “The XX$^{th}$ international scientific-methodical conference” (“IHEAS”), RF, Saint-Petersburg city, the 23$^{rd}$ of April 2014 y. – SPb.: “SPbSETU "LETI"”, 2014. – 2 p. (+ 75 slides).
340. Vetrov A.N. The conception and strategy of informatization of the integration environment of “SIO "ACNS"” and entering its organizations: the national and international programs of transition to the information society / A.N. Vetrov // “Quality management in modern High school (HEI)”, the section “Educational politics and new technologies of teaching”: the materials of “The XII$^{th}$ international scientific-methodical conference” (“IHEAS”), RF, Saint-Petersburg city, the 23$^{rd}$ of October 2014 y. – SPb.: “IBI”, 2014. – 3 p. (+ 65 slides).
341. Vetrov A.N. The fundamental and applied areas of activity of “SIO "ACNS"”, “SRI "SFA CMT" of "RA(N)S" n. a. Veniaminov V.N.”, “SF "SFA CMT" n. a. Prokopenko N.A.” and “"SPbEC n. a. Brezhnev L.I." at "EAST n. a. Sobchak A.A."” / A.N. Vetrov // “Quality management in modern High school (HEI)”, the section “Educational politics and new technologies of teaching”: the materials of “The XII$^{th}$ international scientific-methodical conference” (“IHEAS”), RF, Saint-Petersburg city, the 23$^{rd}$ of October 2014 y. – SPb.: “IBI”, 2014. – 3 p. (+ 10 slides).
342. Vetrov A.N. The information resources, products and services of post-industrial society: the scientific newspapers and journals of “SIO "ACNS"” and included its organizations / A.N. Vetrov // “Quality management in modern High school (HEI)”, the section “Educational politics and new technologies of teaching”: the materials of “The XII$^{th}$ international scientific-methodical conference” (“IHEAS”), RF, Saint-Petersburg city, the 23$^{rd}$ of October 2014 y. – SPb.: “IBI”, 2014. – 3 p. (+ 58 slides).

343. Vetrov A.N. The fundamental scientific researches branch "Cognitive modeling in the mathematical sciences" ("OMN") of "SIO "Academy of cognitive natural sciences"" / A.N. Vetrov // "Actual problems of modern science and technology: cognitive approach", the section "Theory of mathematics and the complex system analysis based on the cognitive modeling technology", the section "Theory of cybernetics and (cognitive) informatics": the materials of "The I st international scientific conference on fundamental sciences" ("SIO "ACNS""), RF, Saint-Petersburg city, the 01st-31st of March 2015 y. – SPb.: "SIO "ACNS"", 2015. – 3 p.
344. Vetrov A.N. The fundamental scientific researches branch "Cognitive modeling in the physical sciences" ("OFN") of "SIO "Academy of cognitive natural sciences"" / A.N. Vetrov // "Actual problems of modern science and technology: cognitive approach", the section "Theory of physics, astronomy and space researches", the section "Theory of nuclear physics and physics of atomic nucleus": the materials of "The I st international scientific conference on fundamental sciences" ("SIO "ACNS""), RF, Saint-Petersburg city, the 01st-31st of March 2015 y. – SPb.: "SIO "ACNS"", 2015. – 2 p.
345. Vetrov A.N. The fundamental scientific researches branch "Cognitive modeling in the nano-technologies and information technologies" ("ONIT") of "SIO "Academy of cognitive natural sciences"" / A.N. Vetrov // "Actual problems of modern science and technology: cognitive approach", the section "Theory of electronics, radio-engineering and connection", the section "Theory of automatics, computer engineering and the system analysis based on the cognitive modeling technology", the section "Theory of nano-technologies for the mechanical-engineering, instrument-making, polygraphy, reprography and photo-cinema-technics, the light and food-processing industry, transport, architecture and construction": the materials of "The I st international scientific conference on fundamental sciences" ("SIO "ACNS""), RF, Saint-Petersburg city, the 01st-31st of March 2015 y. – SPb.: "SIO "ACNS"", 2015. – 6 p.
346. Vetrov A.N. The fundamental scientific researches branch "Cognitive modeling in the exact sciences" ("OEMMPU") of "SIO "Academy of cognitive natural sciences"" / A.N. Vetrov // "Actual problems of modern science and technology: cognitive approach", the section "Theory of (theoretical) mechanics and gyroscopes", the section "Theory of mechanical-engineering, instrument-making and metrology", the section "Theory of power-engineering and electric-engineering": the materials of "The I st international scientific conference on fundamental sciences" ("SIO "ACNS""), RF, Saint-Petersburg city, the 01st-31st of March 2015 y. – SPb.: "SIO "ACNS"", 2015. – 3 p.
347. Vetrov A.N. The fundamental scientific researches branch "Cognitive modeling in the industry and chemical sciences" ("OHNM") of "SIO "Academy of cognitive natural sciences"" / A.N. Vetrov // "Actual problems of modern science and technology: cognitive approach", the section "Theory of the light, food, forest and wood-processing industry, the architecture and construction, the agricultural, wood, water and fish economy and aqua-culture", the section "Theory of chemistry, chemical technology and chemical industry": the materials of "The I st international scientific conference on fundamental sciences" ("SIO "ACNS""), RF, Saint-Petersburg city, the 01st-31st of March 2015 y. – SPb.: "SIO "ACNS"", 2015. – 3 p.

348. Vetrov A.N. The fundamental scientific researches branch "Cognitive modeling in the biological sciences" ("OBN") of "SIO "Academy of cognitive natural sciences"" / A.N. Vetrov // "Actual problems of modern science and technology: cognitive approach", the section "Theory of biology and pharmacology", the section "Theory of physical-chemical bio-technology": the materials of "The I$^{st}$ international scientific conference on fundamental sciences" ("SIO "ACNS""), RF, Saint-Petersburg city, the 01$^{st}$-31$^{st}$ of March 2015 y. – SPb.: "SIO "ACNS"", 2015. – 2 p.
349. Vetrov A.N. The fundamental scientific researches branch "Cognitive modeling in the physiology, fundamental medicine and public-health-services" ("OFFM") of "SIO "Academy of cognitive natural sciences"" / A.N. Vetrov // "Actual problems of modern science and technology: cognitive approach", the section "Theory of physiology, bio-physiology and private physiology", the section "Theory of medicine, public-health-services, labor safety, environment preservation and ecology of person": the materials of "The I$^{st}$ international scientific conference on fundamental sciences" ("SIO "ACNS""), RF, Saint-Petersburg city, the 01$^{st}$-31$^{st}$ of March 2015 y. – SPb.: "SIO "ACNS"", 2015. – 3 p.
350. Vetrov A.N. The fundamental scientific researches branch "Cognitive modeling in the sciences about The Earth" ("ONZ") of "SIO "Academy of cognitive natural sciences"" / A.N. Vetrov // "Actual problems of modern science and technology: cognitive approach", the section "Theory of geo-physics, geology, mining and metallurgy", the section "Theory of oceanology, structure and physics of atmosphere, geodesy, cartography and geography of The Earth and planets": the materials of "The I$^{st}$ international scientific conference on fundamental sciences" ("SIO "ACNS""), RF, Saint-Petersburg city, the 01$^{st}$-31$^{st}$ of March 2015 y. – SPb.: "SIO "ACNS"", 2015. – 3 p.
351. Vetrov A.N. The fundamental scientific researches branch "Cognitive modeling in the social sciences" ("OON") of "SIO "Academy of cognitive natural sciences"" / A.N. Vetrov // "Actual problems of modern science and technology: cognitive approach", the section "Theory of social sciences, philosophy, science-study, politics and political sciences, sociology, (cognitive) psychology, state, law and jurisprudential sciences, patenting business, invention and rationalization-work", the section "Theory of economics and economic sciences, organization, management, statistics and the financial analysis based on the cognitive modeling technology": the materials of "The I$^{st}$ international scientific conference on fundamental sciences" ("SIO "ACNS""), RF, Saint-Petersburg city, the 01$^{st}$-31$^{st}$ of March 2015 y. – SPb.: "SIO "ACNS"", 2015. – 6 p.

352. Vetrov A.N. The fundamental scientific researches branch "Cognitive modeling in the global problems and international relations" ("OGPMO") of "SIO "Academy of cognitive natural sciences"" / A.N. Vetrov // "Actual problems of modern science and technology: cognitive approach", the section "Theory of demography, pedagogics and national education, standardization, the complex studying of separate countries and regions, the general and complex problems of natural, exact, technical, public and applied sciences and manufacture branches", the section "Theory of culture and cultural-science, art and art-science, mass communication, journalism and mass media means, religion, internal trade and tourist-excursion service, external trade, transport, housing-communal economy, housekeeping and consumer services at the international level": the materials of "The I$^{st}$ international scientific conference on fundamental sciences" ("SIO "ACNS""), RF, Saint-Petersburg city, the 01$^{st}$-31$^{st}$ of March 2015 y. – SPb.: "SIO "ACNS"", 2015. – 4 p.
353. Vetrov A.N. The fundamental scientific researches branch "Cognitive modeling in the historical-philological sciences" ("OIFN") of "SIO "Academy of cognitive natural sciences"" / A.N. Vetrov // "Actual problems of modern science and technology: cognitive approach", the section "Theory of history and historical sciences", the section "Theory of science of language, (cognitive) linguistics, literature, study of literature and oral national creativity": the materials of "The I$^{st}$ international scientific conference on fundamental sciences" ("SIO "ACNS""), RF, Saint-Petersburg city, the 01$^{st}$-31$^{st}$ of March 2015 y. – SPb.: "SIO "ACNS"", 2015. – 2 p.
354. Vetrov A.N. The fundamental scientific researches branch "Cognitive modeling in the sports sciences" ("OSN") of "SIO "Academy of cognitive natural sciences"" / A.N. Vetrov // "Actual problems of modern science and technology: cognitive approach", the section "Theory of competitions, sport and sports sciences": the materials of "The I$^{st}$ international scientific conference on fundamental sciences" ("SIO "ACNS""), RF, Saint-Petersburg city, the 01$^{st}$-31$^{st}$ of March 2015 y. – SPb.: "SIO "ACNS"", 2015. – 1 p.
355. Vetrov A.N. The fundamental scientific researches branch "Cognitive modeling in the military sciences" ("OVN") of "SIO "Academy of cognitive natural sciences"" / A.N. Vetrov // "Actual problems of modern science and technology: cognitive approach", the section "Theory of architecture, construction, technics, history, education, politics and economics in the armed forces": the materials of "The I$^{st}$ international scientific conference on fundamental sciences" ("SIO "ACNS""), RF, Saint-Petersburg city, the 01$^{st}$-31$^{st}$ of March 2015 y. – SPb.: "SIO "ACNS"", 2015. – 1 p.
356. Vetrov A.N. The environment of automated training with the properties of adaptation based on the cognitive models / A.N. Vetrov // "Informatics (computer science) and computer technologies", the section "The theoretical bases of informatics (computer science) and informatization of society", the section "Information systems and technologies", the section "Modeling of system", the section "The processing and analysis of big data": the materials of "The city seminar at "The scientific council on informatization of Saint-Petersburg city" at "The Government of Saint-Petersburg city"" ("RAS"), RF, Saint-Petersburg city, the 26$^{th}$ of June 2015 y. – SPb.: ""SPII" of "RAS"", 2015. – 3 p. (+ 28 slides).

357. Vetrov A.N. The applied scientific researches direction "Cognitive modeling in the natural sciences" ("NEN") of "SIO "Academy of cognitive natural sciences"" (part 1) / A.N. Vetrov // "Improvement of quality of researches and developments in the modern organization: cognitive approach", the section "Applications of (cognitive) informatics, cybernetics, automatics, computer engineering, data transmission and connection", the section "Applications of mathematics, mathematical physics, mechanics, metrology, astronomy, space researches, the complex system analysis based on the cognitive modeling technology and the complex problems of natural sciences": the materials of "The I$^{st}$ international scientific conference on applied sciences" ("SIO "ACNS""), RF, Saint-Petersburg city, the 01$^{st}$-31$^{st}$ of October 2015 y. – SPb.: "SIO "ACNS"", 2015. – 6 p.
358. Vetrov A.N. The applied scientific researches direction "Cognitive modeling in the natural sciences" ("NEN") of "SIO "Academy of cognitive natural sciences"" (part 2) / A.N. Vetrov // "Improvement of quality of researches and developments in the modern organization: cognitive approach", the section "Applications of geo-chemical ecology and preservation of environment", the section "Applications of models of The Earth and The Solar system planets in geography, geology, geodesy and cartography, astronomy and other sciences": the materials of "The I$^{st}$ international scientific conference on applied sciences" ("SIO "ACNS""), RF, Saint-Petersburg city, the 01$^{st}$-31$^{st}$ of October 2015 y. – SPb.: "SIO "ACNS"", 2015. – 2 p.
359. Vetrov A.N. The applied scientific researches direction "Cognitive modeling in the natural sciences" ("NEN") of "SIO "Academy of cognitive natural sciences"" (part 3) / A.N. Vetrov // "Improvement of quality of researches and developments in the modern organization: cognitive approach", the section "Applications of models, methods and technologies of geology of oil and gas and the oil and gas industry", the section "Applications of the system analysis based on the cognitive modeling technology, prediction, standardization, unification and the complex problems of exact technical sciences": the materials of "The I$^{st}$ international scientific conference on applied sciences" ("SIO "ACNS""), RF, Saint-Petersburg city, the 01$^{st}$-31$^{st}$ of October 2015 y. – SPb.: "SIO "ACNS"", 2015. – 3 p.
360. Vetrov A.N. The applied scientific researches direction "Cognitive modeling in the natural sciences" ("NEN") of "SIO "Academy of cognitive natural sciences"" (part 4) / A.N. Vetrov // "Improvement of quality of researches and developments in the modern organization: cognitive approach", the section "Applications of theoretical and experimental physics, geo-physics, power-engineering, electric-engineering, electronics and radio-engineering, nuclear physics, technics and instrument-making", the section "Applications of (non)organic chemistry, crystallography, mineralogy and chemical industry": the materials of "The I$^{st}$ international scientific conference on applied sciences" ("SIO "ACNS""), RF, Saint-Petersburg city, the 01$^{st}$-31$^{st}$ of October 2015 y. – SPb.: "SIO "ACNS"", 2015. – 3 p.
361. Vetrov A.N. The applied scientific researches direction "Cognitive modeling in the applied technical sciences and technologies" ("NNT") of "SIO "Academy of cognitive natural sciences"" (part 1) / A.N. Vetrov // "Improvement of quality of researches and developments in the modern organization: cognitive approach", the section "Applications of mining and metallurgy", the section "Applications of sciences about wood and wood processing": the materials of "The I$^{st}$ international scientific conference on applied sciences" ("SIO "ACNS""), RF, Saint-Petersburg city, the 01$^{st}$-31$^{st}$ of October 2015 y. – SPb.: "SIO "ACNS"", 2015. – 2 p.

362. Vetrov A.N. The applied scientific researches direction "Cognitive modeling in the applied technical sciences and technologies" ("NNT") of "SIO "Academy of cognitive natural sciences"" (part 2) / A.N. Vetrov // "Improvement of quality of researches and developments in the modern organization: cognitive approach", the section "Applications of noo-sphere knowledge and technologies: the (heavy) mechanical-engineering, instrument-making, polygraphy, reprography and photo-cinema-technics, the light and food-processing industry, transport, architecture, construction and other branches", the section "Applications of scientific problems of agro-industrial complex": the materials of "The I$^{st}$ international scientific conference on applied sciences" ("SIO "ACNS""), RF, Saint-Petersburg city, the 01$^{st}$-31$^{st}$ of October 2015 y. – SPb.: "SIO "ACNS"", 2015. – 4 p.
363. Vetrov A.N. The applied scientific researches direction "Cognitive modeling in the geo-political sciences and researches" ("NSGI") of "SIO "Academy of cognitive natural sciences"" / A.N. Vetrov // "Improvement of quality of researches and developments in the modern organization: cognitive approach", the section "Applications of geo-politics and safety", the section "Applications of classical and military history": the materials of "The I$^{st}$ international scientific conference on applied sciences" ("SIO "ACNS""), RF, Saint-Petersburg city, the 01$^{st}$-31$^{st}$ of October 2015 y. – SPb.: "SIO "ACNS"", 2015. – 3 p.
364. Vetrov A.N. The applied scientific researches direction "Cognitive modeling in the society steady development of post-industrial country" ("NURS") of "SIO "Academy of cognitive natural sciences"" / A.N. Vetrov // "Improvement of quality of researches and developments in the modern organization: cognitive approach", the section "Applications of complex problems of country development": the materials of "The I$^{st}$ international scientific conference on applied sciences" ("SIO "ACNS""), RF, Saint-Petersburg city, the 01$^{st}$-31$^{st}$ of October 2015 y. – SPb.: "SIO "ACNS"", 2015. – 4 p.
365. Vetrov A.N. The applied scientific researches direction "Cognitive modeling in the social-economic and jurisprudential sciences" ("NSEPP") of "SIO "Academy of cognitive natural sciences"" (part 1) / A.N. Vetrov // "Improvement of quality of researches and developments in the modern organization: cognitive approach", the section "Applications of inter-branch jurisprudential and economic system researches of society and country", the section "Applications of complex problems of micro-(macro-)economics, social sphere and market economy of country": the materials of "The I$^{st}$ international scientific conference on applied sciences" ("SIO "ACNS""), RF, Saint-Petersburg city, the 01$^{st}$-31$^{st}$ of October 2015 y. – SPb.: "SIO "ACNS"", 2015. – 3 p.
366. Vetrov A.N. The applied scientific researches direction "Cognitive modeling in the social-economic and jurisprudential sciences" ("NSEPP") of "SIO "Academy of cognitive natural sciences"" (part 2) / A.N. Vetrov // "Improvement of quality of researches and developments in the modern organization: cognitive approach", the section "Applications of economics, management, sociology, statistics and their other branches", the section "Applications of the financial analysis, accounting and audit of the (credit) organization based on the cognitive modeling technology": the materials of "The I$^{st}$ international scientific conference on applied sciences" ("SIO "ACNS""), RF, Saint-Petersburg city, the 01$^{st}$-31$^{st}$ of October 2015 y. – SPb.: "SIO "ACNS"", 2015. – 4 p.

367. Vetrov A.N. The applied scientific researches direction “Cognitive modeling in the biological and medical sciences” (“NBME”) of “SIO "Academy of cognitive natural sciences"” / A.N. Vetrov // “Improvement of quality of researches and developments in the modern organization: cognitive approach”, the section “Applications of biology, ecology and physiology of plants”, the section “Applications of bio-technology, bio-medicine, ergonomics and labor safety of organic individuals”: the materials of “The I$^{st}$ international scientific conference on applied sciences” (“SIO "ACNS"”), RF, Saint-Petersburg city, the 01$^{st}$-31$^{st}$ of October 2015 y. – SPb.: “SIO "ACNS"”, 2015. – 3 p.
368. Vetrov A.N. The applied scientific researches direction “Cognitive modeling in the humanitarian sciences, art and creativity” (“NGNOT”) of “SIO "Academy of cognitive natural sciences"” (part 1) / A.N. Vetrov // “Improvement of quality of researches and developments in the modern organization: cognitive approach”, the section “Applications of (cognitive) linguistics, (national) creativity, culture, art and religion”, the section “Applications of literature, science-study, philosophy, journalism and mass communication means”: the materials of “The I$^{st}$ international scientific conference on applied sciences” (“SIO "ACNS"”), RF, Saint-Petersburg city, the 01$^{st}$-31$^{st}$ of October 2015 y. – SPb.: “SIO "ACNS"”, 2015. – 3 p.
369. Vetrov A.N. The applied scientific researches direction “Cognitive modeling in the humanitarian sciences, art and creativity” (“NGNOT”) of “SIO "Academy of cognitive natural sciences"” (part 2) / A.N. Vetrov // “Improvement of quality of researches and developments in the modern organization: cognitive approach”, the section “Applications of problems of (cognitive) psychology, education, science and support of young scientists (the programs of grants and others)”, the section “Applications of innovations of project "The Russian encyclopedias", philosophy of science, technics and technology on the branches of knowledge”: the materials of “The I$^{st}$ international scientific conference on applied sciences” (“SIO "ACNS"”), RF, Saint-Petersburg city, the 01$^{st}$-31$^{st}$ of October 2015 y. – SPb.: “SIO "ACNS"”, 2015. – 3 p.
370. Vetrov A.N. The applied scientific researches direction “Cognitive modeling in the physical training and sport” (“NFS”) of “SIO "Academy of cognitive natural sciences"” / A.N. Vetrov // “Improvement of quality of researches and developments in the modern organization: cognitive approach”, the section “Applications of sport, sports sciences and actions”: the materials of “The I$^{st}$ international scientific conference on applied sciences” (“SIO "ACNS"”), RF, Saint-Petersburg city, the 01$^{st}$-31$^{st}$ of October 2015 y. – SPb.: “SIO "ACNS"”, 2015. – 1 p.
371. Vetrov A.N. The applied scientific researches direction “Cognitive modeling in the military sciences” (“NVN”) of “SIO "Academy of cognitive natural sciences"” / A.N. Vetrov // “Improvement of quality of researches and developments in the modern organization: cognitive approach”, the section “Applications of architecture, construction, technics, history, education, politics and economics in the armed forces”: the materials of “The I$^{st}$ international scientific conference on applied sciences” (“SIO "ACNS"”), RF, Saint-Petersburg city, the 01$^{st}$-31$^{st}$ of October 2015 y. – SPb.: “SIO "ACNS"”, 2015. – 1 p.

372. Vetrov A.N. The fundamental developments branch "Cognitive modeling in the mathematical sciences" ("OMN") of "SRI "SFA CMT" of "RA(N)S" n. a. Veniaminov V.N." / A.N. Vetrov // "Actual problems of modern science and technology: cognitive approach", the section "Theory of mathematics and the complex system analysis based on the cognitive modeling technology", the section "Theory of cybernetics and (cognitive) informatics": the materials of "The II$^{nd}$ international scientific conference on fundamental sciences" ("SIO "ACNS""), RF, Saint-Petersburg city, the 01$^{st}$-31$^{st}$ of March 2016 y. – SPb.: "SIO "ACNS"", 2016. – 3 p.
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498. Vetrov A.N. The features of the electronic card for the automated training system with the properties of adaptation based on the cognitive models / A.N. Vetrov // “Advances in information, electronic and electrical engineering”, the section “Information systems”: the materials of “The 8th IEEE workshop” (“VTU n. a. Gediminas”), The republic of Lithuania, Vilnius city, the 22nd of April 2021 y. – M.: “VTU n. a. Gediminas”, 2021. – 4 p. (+ 11 slides).
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# The list of appendices

“The cognitive modeling technology
for the system analysis of the information-educational environments”
(“The environment of automated training with the properties of adaptation
based on the cognitive models” – the research and processing of data)

The specialty 05.13.01 – “The system analysis, control and information processing” (technical sciences) [the adaptive systems of automatic control with the determined entrance influences and the reference cognitive models of the subject of training and the means of training, the reconstructed models of the cognitive processes]

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