THE SAINT-PETERSBURG STATE UNIVERSITY

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THE ENVIRONMENT OF AUTOMATED TRAINING WITH THE PROPERTIES OF ADAPTATION BASED ON THE COGNITIVE MODELS

The specialty 05.13.01 – "The system analysis, control and information processing" (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)

THE DISSERTATION

on the competition of scientific degree
of the candidate of technical sciences

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Saint-Petersburg
2019

UDC 681.513.66+004.81
LBC 32.965-01(09)+22.18
V-39

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V-39 Vetrov A.N. The environment of automated training with the properties of adaptation based on the cognitive models: the dissertation (tech., phys.-math. and med. sciences) (spec. 05.13.01, 05.13.10, 19.00.02 (19.00.03)) / A.N. Vetrov; “The S.-Petersburg.st.un-ty”. – SPb.: “SPbSETU "LETI"”, 2005, M.: “RAS”, 2007, SPb: “SPbSU”, 2019. – 272 p.: 79 pic., 29 tabl. – Bibliogr. 35 (85) nom. – Rus. – Dep. in “RAS”, 2007.

In the dissertation there were reflected the problematics, relevance and theoretical bases of creation of the information-educational environments and operation of the systems of automated training at distance, containing the adaptive intellectual means of training of a new generation, the factors, significantly influencing to the increase in efficiency of the formation of knowledge of the contingent of trainees are revealed.

As the subject of research performs the structure of the system of automated (remote) training with the properties of adaptation based on the cognitive models, and also the principles and algorithms of functioning of its components.

There were presented the modifications in the organization and technology of the automated training for creation of the contour of adaptation based on the parametrical cognitive models block, which allows to realize the individually-oriented formation of knowledge of the contingent of trainees taking into account the level of their residual knowledge and physiological, psychological and linguistic features.

There was created the cognitive modeling technology, including the technique of its use, the ways (models) of representation of the structure of the cognitive model, the algorithm of formation of the structure of the cognitive model, the techniques of research of parameters of the cognitive models and the algorithm of processing of a posteriori data of testing.

There were formed the structures of the cognitive models of the subject of training and the means of training, which are in the basis of the parametrical cognitive models block.

There was developed the complex of programs for automation of the tasks of research, which includes the adaptive electronic textbook and the diagnostic modules.

It was intended for the scientists and the staff of SRI, the teachers of technical HEIs and the students of the specialties: 071900 – “Information systems in technics and technologies”, 210100 – “Control and computer science in technical systems”.

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The list of definitions

The remote education – the complex of educational services, provided to the differentiated contingent of consumers in the country and abroad by means of the specialized information-educational environment, which is based on the information and communication technologies of exchange of training information at distance (satellite, radio and cable networks of data transmission) providing the open access to the educational resources of various type and appointment.

The automated (remote) training – the operated process of formation of knowledge of the contingent trainees by means of use of a set of hardware and software means of the information-educational environment realizing the interactive remote dialogue of the teachers and trainees located on the specially equipped automated work places with the certain information centre of educational establishment according to the individual schedule of training (at distance), allowing to control the results of self-contained (independent) work, to change the training mode according to the individual features of the subjects of training.

The adaptive means of training (electronic textbook) – the automated work place, equipped with a set of hardware and software allowing to provide the representation of a set of information fragments on the concrete discipline on the basis of a set of models, algorithms and strategies of training in a convenient form to the contingent of trainees taking into account their level of residual knowledge and individual features (physiological, psychological, linguistic and others).

The information fragment – the portion of information represented in various ways within limits of displayed screen page, reflecting and retelling the semantic matter of unit (part), section, head, paragraph, module or block of information on the subject area, which decomposition is inexpedient or impossible.

The cognitive model – the (re)constructing in width and depth repertoire of parameters, echeloned on a set of portraits (according to the quantity of chosen certain scientific aspects) and stratified on a number of diverse mathematical sets (a sets of kinds of properties and properties, a sets of vectors of parameters and parameters).

The basic diagnostic module – the automated work place, equipped with a set of hardware and software allowing to realize the automated testing of the level of residual knowledge of the contingent of trainees by means of a set of question-answers structures (tests) which are contained in the database and shown for the subsequent decision.

The applied diagnostic module – the automated work place, equipped with a set of hardware and software allowing to provide the automated diagnostics of the individual features (characteristics) of the personality of the subject of training by means of a set of special methods of research.

The list of reductions and symbols

ATS	–	the automated training system (environment)
ART	–	the automated (remote) training
AWP	–	the automated work place
DB (KB)	–	the database (knowledge base)
PCMB	–	the parametrical cognitive models block
GOST	–	the state standard
AT	–	the additional task
DM	–	the diagnostic module
RE	–	the remote education (training at distance)
IT and ICT	–	the information and communication technologies
IFPST	–	the individual features (abilities) of the personality of the subjects of training (a trainee and a tutor)
IEE	–	the information-educational environment
IC	–	the information centre
CC	–	the computerized course
CM	–	the cognitive model
CW	–	the course work (term paper)
LAN	–	the local area network
MADTP	–	the model of adaptive training program
MDT	–	the model of distance training
MRK	–	the model of required knowledge
TI(I)	–	the training information (influence)
OT	–	the open training (education)
EEs	–	the educational establishment
SW	–	the software
TW	–	the test work
PECM(PC)	–	the personal electronic computing machine (computer)
BC	–	the boundary (intermediate) control
IW	–	the self-contained (independent) work
CMT	–	the cognitive modeling technology
TRM	–	the theoretical-reference (help) module
TMC(M)	–	the training-methodical complex (manual)
TMD	–	the training-methodical department
LRKT	–	the level of residual knowledge of trainees
ETB	–	the electronic test (record) book
ET	–	the electronic textbook
“IEEE”	–	“The institute of electric and electronics engineers leaning technology task force” (“The institute of engineers on electric-technics and radio-electronics” and “The commission in the field of educational technologies”)
IPX/SPX	–	“Intranet packet exchange” / “Sequence packet exchange” (the protocol for the gateway-network exchange of packages of data)
TCP/IP	–	“Transmission control protocol” / “Internet protocol” (the protocol of data transmission control for the networks “Intranet” / “Internet”)
“WWW”	–	“The World wide web” (“The World wide web” or “Internet”)

Introduction

The systems of education of the developed countries of the world use various groups of standards in the field of quality of IEE and apply in its basis two strategies of preparation of the contingent of trainees: fundamental – the logical sequence of statement of information on the connected disciplines from the various areas of scientific knowledge, providing the preparation of specialists of a wide profile; special – building of an educational trajectory with the reference point on the certain specialization of the contingent of trainees in the context of future profession.

In IEE of EEs of various level of the system of education are used the traditional and computer technologies of training, at the same time they operate in the context of the various admissible forms of the organization of educational process: internal (full-time) – with separation from a main activity in audiences (rooms) of basic educational institution or its representations, correspondence (extramural) – without separation from a main kind of prof. activity with division in time, intramural-extramural – combines both forms and it is often used for the increase of qualification (professional development) of the diploma (certified) specialists.

The informatization of establishments of the system of education acts as the difficult scientific problem initiating the consideration of a wide range of scientific areas, and also the creation of innovative approaches, methods, technologies and algorithms at realization of the automation means at the basis of IEE, which provide a possibility of the analysis and increase in efficiency of functioning of ART systems.

The scientists mark out a large quantity of the nodal aspects of informatization of EEs: political, social, regional, organizational, technical, program, implementation, technological, pedagogical, ergonomic, physiological, psychological, linguistic, economic and others.

Each from the considered aspects causes the genesis (emergence) of a set of the traditional approaches and directions of research of IEE: organizational, technical and methodical support (Krupoderov R.I., Tikhonov A.N. and others); the problematics of introduction and use of ICT in the sphere of education (Dovgyallo A.M., Kinelev V.G. and others); the development of the system of education of the certain country against background of the crisis of national factors (Kashitsin V. P., Sadovnichiy VA. and others); the theory of open systems, mathematical models and methods of the analysis (Haken G., Yzerman M.A. and others); the theory of artificial intelligence and brainware (Gurevich I.B., Pospelov D.A. and others); the modeling and algorithmization of training process (Bespalko V. P., Klarin M.V. and others); the theory of intellectual systems and languages of knowledge representation (Andreyev V. P., Pospelov D.A. and others).

Many specialists (experts) in the field of the theory of information and artificial intelligence actualize the development of the adaptive and intellectual means and environments of training, allowing significantly to increase the level of quality of the (re)preparation of specialists (experts) on a wide set of specialties by means of the accounting of IFPST, and also to approve the innovative models and algorithms at the basis of IEE of ART system.

1. The condition of the problem of creation of the adaptive intellectual environments of training

The globalization of information environment influences to the dynamically changing preferences of consumers of educational services, the requirements and standards from the side of country, which need to be considered when developing the infrastructure of IEE of establishments of the system of education and the realization of the components of ART systems.

IEE of the modern EEs is developing on the basis of traditional and IT, proceeding from the need of implementation of the admissible forms of conducting of educational activity: internal, intramural-extramural and correspondence (remote).

The remote form of education is of the greatest interest for the countries and regions with the uneven distribution of the scientific and educational centres.

The informatization of IEE and the supply of functioning of ART act as the actual tasks, that allows to pass from the traditional methods and technologies to ICT, but initiates the need of modernization of the existing organizational, methodical, technical and other types of supply.

As informatization understand the organizational social-economic and scientific-technical process of the creation of optimum conditions for the satisfaction of information needs of the professionally differentiated social subjects and various organizations (natural and legal entities and the country) in the certain subject areas by means of the introduction of the automation means, increasing the efficiency of creation, distribution and use of the information resources, works and services, demanded at the information market.

The process of informatization of the establishments of the system of education is directed to the increase of the level of organization of IEE and the efficiency of functioning of all its components due to introduction and practical use of the innovative achievements in the field of ICT allowing to automate the various technological operations, accompanying the process of training and to lower of the temporary and transaction expenses, arising in the course of educational process.

The informatization of the information environments of EEs initiates the introduction of the automation means, and also the creation and modification of different types of supply:

- organizational – the creation of the infrastructure of IEE, allocation of the key directions and the policy of introduction of the modern automation means: the purposes, the tasks and the directions of informatization of EEs or centre;
- technical – the development of hardware, software and brainware supply, allowing to automate a set of operations which are carrying out by the subjects of IEE: AWP, LAN and the equipment of data transmission;
- technological – the search of new approaches, the improvement of methods and technologies of the formation of knowledge of trainees at the traditional and ART;
- methodical – the transfer of TMC on the electronic carriers of information: information resources, banks and DB and KB with the information of different appointment.

1.1. The relevance of creation of the adaptive intellectual means and environments of automated training

The informatization of establishments of the system of education causes the accounting of the existing needs, modern requirements and restrictions at developing of the components of IEE, and also initiates the elaboration of approaches to the introduction of the automation means in the context of the various directions of educational activity.

According to the principles of automated training and open education, the training process of the modern EEs is based on the use of wide opportunities of the automated (open) IEE, for the formation of which requires the active work of specialists on preparation and support of the electronic educational resources, but the technologies of creation of such training-methodical materials of a new generation, considering the individual features of the subjects of training (IFPST and LRKT) are worked insufficiently out.

When developing the different kinds of supply of ART is implementing the complex of actions of various level: organizational – the development of requirements, duty regulations, tasks and functions to the employees and divisions of EEs; technical – the analysis and selection of technological novelty, the allocation of the directions of introduction of the hardware and equipment used in the basis of IEE; software – the program means, supplying the reduction of temporary and transaction expenses by means of the automation of the different operations accompanying the educational activity; methodical – the selection and formation of the information resources on different carriers and TMC on a set of disciplines (subjects of studying).

The modern condition in the market of educational services, the existing requirements and contradictions cause the need of development of the complex approach (technology) to the increase in the efficiency of functioning of IEE of ART systems and the creation of architectures of the intellectual adaptive means of training.

Development, support and service of the components of ART systems causes the involvement of professionally-differentiated specialists (experts), using in the process of their work the modern achievements in the field of information technologies, means and environments of programming, multimedia and computer graphics, technologies of artificial intelligence and representation of knowledge.

The main properties of the open information systems are inherent in ART systems, carry to some of them: the expansibility of functional purpose, the structure and applied software, the network mode of access to information resources and training courses, the scalability of characteristics on number of the served users and productivity of the server, the compatibility on a code and data between different architectures and platforms of modern computers and systems the causing of shipping of the hardware and software, the friendliness of the interface of the user, the flexibility of its control adequate to the requirements and the level of preparation of the final user.

1.2. The analysis of the condition of problem and the existing contradictions

The analysis of the modern condition of ICT in the sphere of education focuses attention to need of the solution of the number of problems arising when developing of the components of ART systems and the adaptive means of training of a new generation, which are used at the basis of IEE and allow to take into account not only LRKT, but also and IFPST (physiological, psychological, linguistic and others), that allows to allocate a number of contradictions initiating of the complex of various tasks:

- the level of development of IT and the available achievements of information industry cause a possibility of their practical use in the sphere education, but there are no adequate theories and conceptions of informatization of establishments of the system of education for creation of the automated IEE, as EEs at the various levels of the system of education have the characteristic specifics of introduction and use of the automation means;
- the modern requirements of the state and international bodies, regulating the policy of development of the system of education and the dynamically changing needs of the various categories of consumers of educational services actualize the need of introduction of innovations for the increase in the efficiency of functioning of the components of IEE of ART system;
- the existing approaches, methods and technologies to the creation of electronic TMC, and also the components of ART systems are almost not focused on the accounting of IFPST, though the automated IEE use in its basis the individually-oriented model of the organization of training process, which is potentially allowing to introduce the means of training of a new generation based on intellectual algorithms and adaptive models;
- the development of the architecture of the means of training of a new generation actualizes the need of carrying out of researches of the specifics of information exchange between the subjects and means of IEE of ART system;
- the increase in the efficiency of the formation of knowledge of the trainees based on the technologies of individually-oriented ART with use of adaptive models in the basis of the components of IEE focuses attention to the need of entering of the modifications in to the organization and technology of training;
- there is the need of improvement of the principles and algorithms at the basis of the means of monitoring of training process, allowing flexibly to react on the change of condition (LRKT and IFPST) of the contingent of trainees in the course of approbation of new techniques of training, and also on the modifications of IEE of ART systems, caused by the introduction of innovative components.

The modern level of development of ICT causes the possibility of use of the technologies of individual, personally-oriented and adaptive training when developing the means of training, which earlier were practically not used in view of complexity of their introduction and the impossibility of realization of the components of IEE.

The existing ICT of ART and distributed network training have a set of features:

- the information, acting as the aggregate of knowledge on a set of disciplines is transferring regardless from the condition of the means of telecommunications in the region and the degree of remoteness of the trainee relatively of the educational center;
- the availability, the efficiency of updating and the convenient way of representation for the trainee the content of educational resources, including the training-methodical complex and its materials on the printing and electronic carrier;
- the opportunity to the teacher remotely to carry out the consultations of the territorially distributed trainees in the minimum time.

The usage of technologies of the distributed network training provides to trainees the open access to the various information resources concentrated on the server of the information center of EEs on the communication channels of different type by means of the local or global network. Access to the educational resources with the dynamically updated information on a set of disciplines stored on the file-servers of the territorially distributed educational (scientific) centres is directly possible by means of the premises (rooms) equipped by AWP with use of diverse technologies of ART.

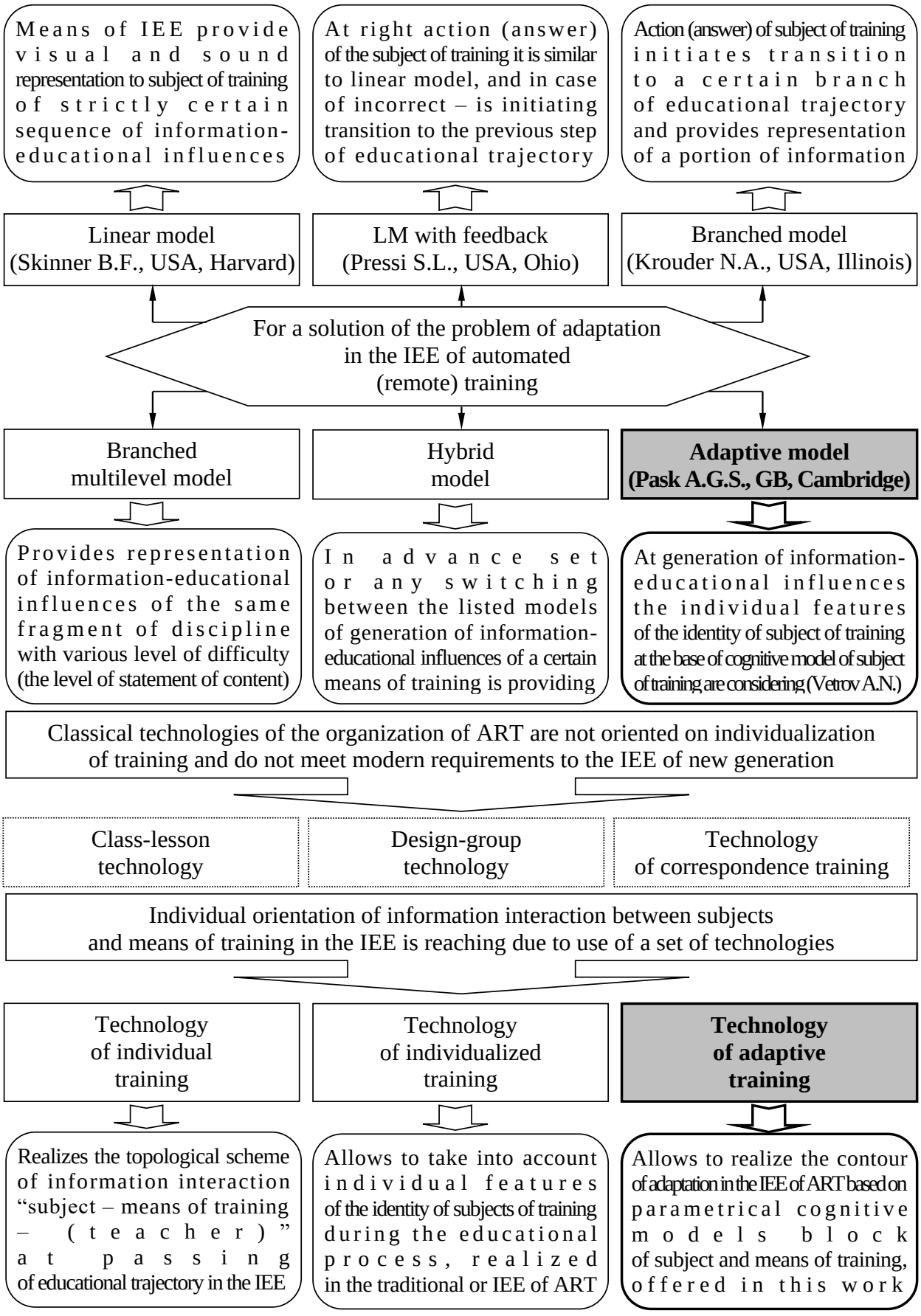
The introduction of technologies of the personally-oriented training and the adaptive models at realization of the means of training at the basis of IEE of ART actualize the consideration of a set of the innovative approaches: psychophysiology of perception (Baru A.V., Gershuni G.V., Izmaylov Ch.A., Croll V.M., Feldshtein D.I. and others), cognitive psychology (Arshinov V.I., Druzhinin V.N., Zinchenko T.P., Rakitov A.I., Haymen A., Holodnaya M.A. and others) and linguistics (Geek M.L., Kobrina N.A., Potapova R.K. and others).

The psychophysiology of perception allows to explain the regularities of primary perception of the polychromatic range of light radiation and sound signals when transfer of the content of information fragments on discipline by means of respectively the visual and acoustic sensory systems of the human.

The cognitive psychology allows to disclose the essence and the specifics of individual dynamics of the processes of secondary information processing by the psychological construct of the head brain of human, and also to provide the adequate representation of a set of information fragments for the increase in the efficiency of process of the formation of knowledge of the contingent of trainees on a set of subject areas.

The cognitive linguistics reflects the features of understanding of the content of information fragments presented to the contingent of trainees on the various levels of statement of the material of discipline with use of the certain language.

At realization of the means of training of a new generation at the basis of IEE of ART systems the classical models lose their relevance (pic. 1.1): linear model (Skinner B.F.), linear model with feedback (Pressi S.L.), branched model (Krouder N.A.), that causes the emergence of the branched multilevel and adaptive models, allowing to realize the maximum individualization of process of the formation of knowledge of trainees and adaptation to LRKT and IFPST.



Pic. 1.1. The organizational models and technologies of interaction of the subjects and means of training for the solution of the problem of adaptation in the information-educational environment

The advantages of the adaptive IEE of ART are: flexibility, openness, universality, polydegree of structure, expansibility, fine tuning under LRKT and IFPST.

In present time there are the several ways of the individualization of process of the formation of knowledge at the expense of means of the automated educational environment:

- the generative approach – oriented on the independent choice by the user of the certain information and the designing of educational trajectory proceeding from the actual needs of consumers at present moment;
- the generative-diagnostic approach – the generation of structure and sequence, the choice of parameters, and also the way of display of the content of information fragments is carrying out by the algorithms of the means of training based on the preliminary diagnostics of the parameters of IFPST and the revealed LRKT;
- the search (navigation) approach – consists in the suppling of search and navigation within the limits of information storages, databanks, DB based on the algorithms of data processing and the models of presentation of data and knowledge, performing the declarative and procedural function on the relation to information, that it is characteristic for the resources of electronic libraries;
- the heuristic approach – allows to realize the components of IEE of ART, operating on the basis of the individually-oriented and adaptive technology, using the methods of artificial intelligence and algorithms, allowing to realize the conclusion on incomplete data in the process of generation of information;
- the expert approach – the components of IEE of ART realize the current and total diagnostics of IFPST, the testing of LRKT during all process of the formation of knowledge of the contingent of trainees, that allows to reveal the negatively influencing factors, and also to characterize the reasons of difficulties of trainees during the information interaction between the subjects of training and the means of training from the point of view of the various subject areas;
- the combined approach – assumes the use of a combinatory combination of the listed approaches, which proceeding from the purposes, tasks, conditions, requirements and restrictions to the components of IEE, and also the features of organizational, methodical and technical supply.

At the same time it is possible the realization of the various modes of information interaction of the subjects of training and the means of training at their work in IEE of ART:

- the choice of the types and parameters of generation of TI is completely defined by the algorithms of the means of training operating in the automatic mode;
- the control of the process of training is implementing at the algorithmic level, and the navigation is carrying out by the trainee independently in the manual mode;
- the mixed control of the process of training: at the beginning the trainee carries out the navigation manually (panel), and in case of the gain of quantity of incorrect actions is implementing the transfer of control to the algorithm of training.

1.3. The degree of readiness of the problem of creation of the adaptive intellectual technologies and means of training

The problem of creation of the intellectual technologies based on expert knowledge and the adaptive means of training of a new generation is not essentially new, as its decision leans on the existing fundamental bases, which were to the certain extent developed earlier by teachers, physiologists, psychologists and linguists, but owing to the increasing requirements of society and the prompt rates of development of ICT appears the possibility of program realization of the components of ART systems and their practical use in the basis of IEE. The scientific-technical, organizational, technological, methodical and pedagogical bases of functioning of RE were developed only for the last decades, therefore by many specialists (experts) emphasize the special relevance of carrying out of researches at developing of the architectures and elements of the automated means and the environments of training by means of the modern approaches in programming.

In development of the theoretical and applied bases of creation and development of IEE of ART systems were engaged many Russian scientists and specialists (experts): Andreyev A.A., Apatova N.V., Geyn A.G., Gershunsky B.S., Yershov A.P., Lapchik M. P., Matros D.Sh., Mashbits E.I., Polat E.S., Robert I.V., Skibitsky E.G., Sovetov B.Ya. and others.

The works of domestic and foreign scientists were devoted to the questions of organization, technical and methodical support of RE in the sphere of higher education on the basis of ICT: Gryuntsev A.N., Domracheev V.G., Zhafyarov A.Zh., Ivannikov A.D., Kashitsin V.N., Krivosheyev A.O., Krupoderov R.I., Moiseyeva M.V., Pobedonostsev K.A., Polat E.S., Tikhonov A.N., Young D., Muchnis M., Knight P. and others.

The following scientists were engaged in the problems of use of ICT for the organization and automation of educational process: Foster J., Vilm R., Dovgyallo A.M., McLean K., Kleiman G., Uinfrey F., Kinelev V.G., Manushin E.A., Sadovnichiy V.A. and others.

The problems and prospects of development of education on the background of the existing crisis in the system of education and the existence of specific national factors: Colin K.K., Semyonov A.L., Voronina T.P., Kashitsin V.P., Molchanova O.P. and others.

The methodological bases of development of education in the era of a new IT: Gershunsky B.S., Kleiman G.M., Colin K.K., Krivosheyev A.O., Lyaudis V.A., Mashbits E.I., Robert I.V., Tikhomirova O.K. and others – authors represent the informatization as the main way of overcoming of the crisis of education by the development of technologies of ART, the usage of new methods and strategies of training, the improvement of the politics of development of the system of education and the production of the directions of automation of IEE.

In the context of the informatization of education on the basis of the achievements of ICT the important theoretical direction is the personally-oriented training: Bim-Bud B.M., Bondarevskaya E.V., Petrovsky A.V., Yakimanskaya I.S. and others. By authors have defined and disclosed the principles and technologies of the personally-oriented training, which were successfully used at developing of the means of training based on ICT.

A specific place at the application of ICT in training was held questions of the psychophysiology of perception of information at using of the automated means of training on the basis of ICT: Baumstein T.A., Belgorodsky L.S., Geltishcheva E.A., Kaysina O.V., Croll V.M., Izmaylov Ch.A., Matiukhin V.V., Sandomirsky M.E. and others.

The realization of ART and the development of methodical support for the carrying out of the classes with the use of ICT on different disciplines and the additional classes in the establishments of the general (average) education: computer science (Filimonenkov D.O., Yakovleva T.A. and others), mathematics (Kostina G.E., Matveeva T.A. and others), geometry (Lazdina N.G., Maier V.R. and others), physics (Misyura Ya.S., Kuprikhina A.I. and others), Russian language (Yasnitskaya I.A., Yasnitsky U.G. and others), foreign language (Chislova A.S., Skorodumova E.S., Ishkova G.M., Zvyagina I.I., Borovikova T. M. and others), history (Shtyrov A.V. and others), music (Gorbunova I.B. and others) and others.

The improvement of technological cycle of ART and the development of software (Semyonov V.V., Letova T.A., Luneva S.U., Mogilev A.V., Mukhina N.V. and others), multimedia applications (Maryasina T.D. and others) and telecommunication systems (Antonov S.V., Sovetov B.Ya. and others) at the basis of IEE.

The direct researches of the questions of application of ICT in education are carrying out in the following main directions: the psychological-pedagogical aspects of training with application of ICT (Gagne R., Jonassen D.H., McKnight C. and others), the programmed training and the development of training systems (Briggs L., Harrison N., Kearsley G. and others), the technologies of training at distance and distance training (Harasim L., Knowles M.S., Moore M.G. and others) and the perception of electronic information (Dillon A., Nielsen J., Norman D.A., Salomon G. and others).

Insufficiently there were worked out the principles of system integration of ICT into the information environment of EEs, under which is understood as the open system (for open ART), accumulating the intellectual, scientific-technical, social, cultural, hardware, software, organizational and methodical resources.

According to opinion of the academicians of "RAS" Yershov A.P. and Arsky U.M. the open IEE is the transitional stage on the way to the synthesis of "infosphere" – reaching due to the integration of the regional and international IEE, including a set of the information-educational resources, forming by the different educational centres.

Mathematical methods, models of the analysis and synthesis of the automatic control systems (Yzerman M.A., Besekersky V.A., Popov E.V. and others), the theory of open systems (Haken G., Uyemov A.I. and others), the theory of modeling of training process (Bespalko V. P., Klarin M.V., Mashbits E.I. and others), the theory of intellectual systems and languages of representation of knowledge (Andreyev V. P., Ivashchenko K.I., Pospelov G.S., Pospelov D.A. and others), the theory of algorithms (Gurevich I.B., Yefimova S.M., Zhuravlev U.I. and others), the object-oriented paradigm in the modern environments of programming (Zikhert K., Davies S.R., Stinson K. and others).

The requirement of development of the adaptive intellectual IEE is actualizing.

The problem of IT in the "adaptive" training was not rather widely solved, though its applied tasks, important owing to their fundamental nature, were developed by teachers, physiologists, psychologists, linguists and specialists (experts) in the field of IT: the problems of the theory of training systems and innovative processes in education (Galperin P.Ya., Zagvyazinsky V.I., Makhmutov M.I. and others), the personally-oriented education (Amonashvili Sh.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 psychological-pedagogical bases of the use of IT (Geyn A.G., Yershov A.P., Leontyev A.A. and others), the modeling of IEE and programmed training (Bespalko V. P., Gershunsky B.S., Talyzina N.F. and others), the psychophysiology of perception (Izmaylov Ch.A., Croll V.M., Smirnov V.M. and others), cognitive psychology (Druzhinin V.N., Zinchenko T.P., Holodnaya M.A. and others) and applied linguistics (Geek M.L., Kobrina N.A., Potapova R.K. and others).

By many authors it was emphasized, that at the modern stage of the development of science and IT was emphasized the technical capability of realization of the open educational systems, based on the principle of distributed architecture and realized with use of the modern achievements of IT and the technologies of Web programming, nonlinear video-tape-editing and line video, multimedia and flash presentations, allowing to provide the access of wide range of consumers to a set of information resources, containing the selected and previously structured information on a set of subject areas.

As the system of education of each separately considered country is unique, that moves forward the certain strategy of informatization, providing the development of the complex of purposes, actions and tasks allocated on the introduction of the automation means in the basis of IEE of EEs, considering the specific features of geographical arrangement of the cultural, scientific and educational centres, political, economic, social-demographic and professional factors of the country, population and organizations.

In the light of globalization of the information environment the intensification of growth of the diverse flows of scientific-technical, economic, political, medical and other information as the antiderivative of aggregate of knowledge causes the essential increase of cognitive load of the subjects of information exchange: as the sources, so and the consumers of information. The task of reduction of the temporary and transaction expenses in the process of the studying of the content of information resources, the creation of products of the information industry, providing the information services to the subjects of the information market with the purpose of increase of their awareness in various subject areas and the satisfaction of needs in the obtaining of actual information initiates the development of a package of measures directed on the improvement of the system of education due to introduction of the innovative approaches and technologies at creation of the means of training at the basis of IEE.

1.4. The purpose and the tasks of creation of the adaptive information-educational environment of the automated training system based on the cognitive models

In this dissertation are stated some results of my scientific research directed to development of the environment of automated training with the properties of adaptation based on the cognitive models and its components.

The object of research – the information-educational environment of the automated (remote) training system of educational establishment.

The subject of research – the automated (remote) training system with the properties of adaptation based on the parametrical cognitive models block.

The research is directed to the possibility of the analysis of the automated IEE and the realization of the means of training providing the individually-oriented process of formation of knowledge of the contingent of trainees taking into account LRKT and IFPST.

The hypothesis of research is based on assumptions about the continuity of development of new IT and the expansion of sphere of their use in education, providing the possibility of realization of the means of adaptive training in the automated IEE, taking into account physiological, psychological, linguistic and other features of the subjects of educational process, that, eventually, will allow to provide the formation of knowledge of the trainee with the minimum loadings, transaction and temporary expenses, and also to sustain the required level of preparation (professional competence) of the trainees.

The purpose of research is the increase in the efficiency of functioning of IEE of ART due to realization of the individually-oriented formation of knowledge of the trainee with use of the adaptive generation of educational influences on the basis of PCMB and the complex of programs for automation of the tasks of research.

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

1. The analysis of modern approaches, methods, technologies and algorithms to the creation of IEE of ART and the adaptive means of training causes the consideration of:
   - the modern aspects and the directions of informatization of the information environments of EEs and training centres due to the introduction of the means of automation;
   - the theoretical bases of creation of the automated IEE of the adaptive training with the model of the subject of training at the basis of the theory of automatic control, the approaches and principles at the basis of algorithms of their functioning;
   - the organizational models and the technologies of realization of the information interaction between the subjects and means of training in IEE of ART;
   - the main actions at the organization of the individually-oriented formation of knowledge of the contingent of trainees: the models and algorithms of representation of the information-educational influences in the environment of ART;
   - the specifics of realization of the automated research of IFPST, the monitoring of progress of the contingent of trainees and the estimation of LRKT.

2. The creation of the structure of IEE of ART system with the properties of adaptation based on PCMB initiates the carrying out of a set of researches:
   - the analysis of features and the development of modifications in the organization of IEE, the realization of the principles and algorithms of functioning of the components of ART system, and also the improvement of the main technological stages of the operated process of formation of knowledge of the contingent of trainees on the basis of the models of adaptive training for realization of the accounting of IFPST and LRKT;
   - the creation and the analysis of structure of the channel of information interaction of the subjects and means of training in IEE of ART system, including PCMB;
   - the search of possible ways of the increase in efficiency of the formation of knowledge of trainees with use of the individually-oriented technologies and the adaptive means of training, operating on the basis of IFPST and LRKT;
   - the allocation of physiological, psychological and linguistic factors, influencing on the increase in efficiency of the information interaction between the subjects and means of IEE, acting as the parameters of CM.
3. The development of CMT allowing to carry out the complex analysis of the efficiency of functioning of IEE of ART system with the properties of adaptation based on CM and to realize the making of decisions on the basis of the revealed regularities by means of the statistical processing of a posteriori data of experiments:
   - about the reasons of difficulties of the trainees in the process of their formation of knowledge by means of the adaptive electronic textbook, generating a set of the information fragments reflecting the content of subject based on PCMB;
   - about the need of reconstruction of the structure of CM in width and depth by means of the addition of new parameters and the removal of the existing parameters.
4. The development of PCMB at the basis of IEE of ART, including the repertoires of parameters:
   - CM of the subject of training – characterized a set of various IFPST;
   - CM of the means of training – reflects the features of presentation of information.
5. The development of the complex of programs for the automation of research tasks, including:
   - the adaptive means of training (ET) realizes the individually-oriented generation of educational influences by means of the adaptive representation of information fragments processor operating based on PCMB;
   - the basic DM provides the estimation of LRKT on studied disciplines with use of a set of tests and point scale based on weight coefficients;
   - the applied DM is intended for the research of the vectors of parameters of CM.

The main **methods of research** are:

- theoretical – the theory of systems, theory of control, the system analysis and modeling, the structuring and representation of knowledge, engineering psychology and pedagogics;
- experimental – the applied methods of the physiology of analyzers (sensory systems), cognitive psychology and applied linguistics.

1.5. The stages of creation and the analysis of the environment of automated training based on the cognitive models

During carrying out of my long scientific-research and methodical work it is possible to allocate a set of stages, each of which is characterizing by the certain scientific theoretical and practical results, received throughout the training in post-graduate study and conducting the teaching activity, which have formed into the basis of my dissertation, and also were used in the training process of "The Saint-Petersburg state electrotechnical university "LETI"" ("SPbSETU "LETI"") and "The international banking institute" ("IBI") (RF, Saint-Petersburg city).

At the first stage (2003 – 2004 year) there was carried out the analysis of literature sources, the patent researches with the purpose of search of possible analogs of the developed objects, and also there were came to light the existing problems, arising during the creation, supply and service of the components of IEE of ART systems.

According to the principle of open training, the training process of modern EEs is based on the use of ample opportunities of the open IEE, for formation of which requires the active work of diverse specialists on the preparation and support of electronic educational resources, but insufficiently were worked out the technologies of creation of such training-methodical materials of a new generation, taking into account IFPST along with LRKT.

The carried-out analysis of the theoretical bases of creation of the automated IEE of the adaptive training with the model of the subject of training has allowed to allocate a set of the organizational models and technologies of interaction of the subjects with the educational means, and also the main actions at the organization of the individually-oriented formation of knowledge of the contingent of trainees as the operated process: the models of representation of TI, the algorithms of training, the methods and means of diagnostics of IFPST, the specifics of realization of the monitoring of progress and the estimation of LRKT.

The received my scientific results were published in the form of performances and publications in the collections of materials of the next international conferences, held in "SPbSETU "LETI"" and "IBI" by "IHEAS" and "The interregional educational consortium of Russia":

1. The IXth international scientific-methodical conference "Modern technologies of training", which was held in "SPbSETU "LETI"", RF, Saint-Petersburg city, on the 23rd of April 2003 year:
   - mine publication and scientific report in the section "Technologies of training" on the theme "The application of the artificial intelligence systems in the problem training: on the example of the program-diagnosing module of the expert training system".

2. The II[nd] international scientific-practical conference "Actual problems of economics and new technologies of teaching", which was held in "IBI", RF, Saint-Petersburg city, on the 12[th]-13[th] of March 2003 year:
   - mine publication and scientific report in the section "Modern technologies of training" on the theme "The influence of development of information and communicational technologies on society and education";
   - mine publication and scientific report in the section "Educational politics and new technologies of teaching" on the theme "The conception of development of the intellectual training systems based on the fast prototyping technology";
   - mine publication and scientific report in the section "Educational politics and new technologies of teaching" on the theme "The working demonstration prototype of the expert system of training as the pedagogical program-diagnosing means".
3. The III[rd] international scientific-practical conference "Actual problems of economics and new technologies of teaching", which was held in "IBI", RF, Saint-Petersburg city, on the 11[th]-13[th] of March 2004 year:
   - mine publication and scientific report in the section "Educational politics and new technologies of teaching" on the theme "The cognitive model of the user as the means of communicative interaction with the remote training system";
   - mine publication and scientific report in the section "Educational politics and new technologies of teaching" on the theme "The bases of the technology of construction of the parametrical cognitive models for the tasks of the remote training environment;
   - mine publication and scientific report in the section "Mathematical methods and information technologies in economics" on the theme "The features of support of the information safety at the level of applications in the environment of WWW with the use of PHP";
   - mine publication and scientific report in the section "Humanitarian and social knowledge and their role in economics and education" on the theme "The features of professional activity of the personality in the conditions of globalization of the information environment".
4. The II[nd] international scientific-methodical conference "Quality management in modern High school (HEI)", which was held in "IBI", RF, Saint-Petersburg city, on the 17[th]-18[th] of June 2004 year:
   - mine publication and scientific report in the section "Quality management in High school (HEI)" on the theme "The applications of the expert training systems for the automation of control of a level of knowledge on the subject areas";
   - mine publication and scientific report in the section "Quality management in High school (HEI)" on the theme "The features of application of the expert training systems for the automated estimation of qualification of the professional participants of securities market".

There were prepared and published two my sections in the collective scientific monography "The factors of success in the educational activity of modern HEI" on the theme "The tendencies of development of the information environment of remote education" and "The cognitive model for the adaptive systems of remote training". There was developed my methodical support on the discipline "Computer science": theoretical course of lectures and laboratory practical work. The manuscript of my dissertation was made out.

There was developed CMT (the iterative cycle of CMT was created) and there was enabled the realization of components of IEE of ART system with the properties of adaptation based on CM: the basic DM, which was practically used by me on classes on the discipline "Artificial intelligence in the tasks of control" (a day department).

There was carried out the management of diploma design on the theme: "The development of the program toolkit of qualification estimation of the professional participants of securities market" (Zinovyeva N.N., group 8832, mark of "SAC" "perfectly").

At the second stage (2004 – 2005 year) there was carried out the development of structure of IEE of ART system with the properties of adaptation based on PCMB: there were researched the features of channels of information interaction of the subjects of training and the means of training, the specifics of organization, the main technological stages of training as operated process and the principles of functioning of the components of IEE of ART system.

My received scientific results were published in the form of speeches and publications of materials at the next international conferences, held in "SPbSETU "LETI"" and "IBI" by "IHEAS" and "The interregional educational consortium of Russia":

5. The IVth international scientific-practical conference "Actual problems of economics and new technologies of teaching", which was held in "IBI", RF, Saint-Petersburg city, on the 15th-16th of March 2005 year:
   - mine publication and scientific report in the section "Innovative technologies of education" on the theme "The features of the information environment structure of the adaptive RT systems";
   - mine publication and scientific report in the section "Innovative technologies of education" on the theme "The cognitive model structure for the support of the information environment of the adaptive training";
   - mine publication and scientific report in the section "Innovative technologies of education" on the theme "The research of the convergent and the divergent intellectual abilities of the cognitive model of the subject of training for the tasks of the inf. environment of the adaptive training".
6. The IIIrd international scientific-methodical conference "Quality management in modern High school (HEI)", which was held in "IBI", RF, Saint-Petersburg city, on the 21st-22nd of June 2005 year:
   - mine publication and scientific report in the section "Monitoring and support of the quality management system" on the theme "The application of the intellectual training systems (for the automated estimation of the level of residual knowledge in the subjects of training and the diagnostics of the convergent and the divergent intellectual abilities of the cognitive model of the subjects of the information environment of the adaptive automated training)".

There was carried out developing the techniques and algorithms in the basis of CMT, there were received the structures of CM of the subject of training and the means of training, there were realized the principles of functioning of the components of IEE of ART system with the properties of adaptation based on PCMB, there were carried out the statement and carrying out of the series of experimental researches.

There was developed the structure of the adaptive means of training, there were realized the main DM and the applied DM, which were subsequently practically used on a practical training on the disciplines "Computer science" (a day and evening departments) and "Intellectual technologies of representation of knowledge" (a day department).

There was created by me my methodical support of the discipline "Computer science": there was developed the course of lectures and methodical instructions for carrying out of laboratory practical work.

There was performed the management of diploma design on the themes:

- "The development of the diagnostic module of the open educational portal for the tasks of the information environment of the automated remote training" (Blinkov R.U., group 9832, estimation of "SAC" "perfectly");
- "The development of the program toolkit of diagnostics of the level of convergent intellectual abilities of the cognitive model of the examinee for the tasks of the information environment of the adaptive training" (Tasoyeva E.B., group 9832, estimation of "SAC" "perfectly");
- "The development of the program toolkit of diagnostics of the level of divergent intellectual abilities of the cognitive model of the examinee for the tasks of the information environment of the adaptive training" (Fedoseyeva N.A., group 9832, estimation of "SAC" "good").

At the third stage (2005 – 2006 year) there were improved the principles of functioning of the components of IEE of ART system, there were improved CM of the subject of training and CM of the means of training, and also there were developed the techniques and algorithms at the basis of CMT. There was enabled the development of architecture and realization of the adaptive representation of information fragments processor – the main component of the automated means of training (ET).

My received scientific results were published in the form of speeches and publications of materials at the next regional and international conferences, held in "SPbSETU "LETI"" and "IBI" by "IHEAS" and "The interregional educational consortium of Russia":

7. The 4th All-Russian scientific conference "Control and information technologies", which was held in "CSRI "Electric-device"" and "SPbSETU "LETI"", RF, Saint-Petersburg city, on the 10th-12th of October 2006 year:
   - mine publication and scientific report in the section "Information technologies of control and modelling" on the theme "The adaptive information environment of the automated training based on the cognitive models";
   - mine publication and scientific report in the section "Information technologies of control and modeling" on the theme "The cognitive modeling for the analysis of the information-educational environment".
8. The international conference "Problems of cybernetics and informatics (computer science)", which was held in "The Azerbaijan national academy of sciences", Baku city, on the 24th-26th of October 2006 year:
   - mine publication and scientific report in the section "Problems of control and the system analysis" on the theme "The information environment of the automated training with the properties of adaptation based on the cognitive models".

The methodical instructions to the laboratory works on the discipline of "Computer science" for the students of the first course were published:

- Vetrov A.N. The operating system "MS Windows 98/Me/2000": the methodical instructions to the laboratory works / O.U. Belash, A.N. Vetrov, E.E. Kotova; edited by the prof. N.N. Kuzmin. – SPb.: The publishing house of "SPbSETU "LETI"", 2005. – 72 p.;
- Vetrov A.N. The package of applied programs "MS Office 97/2000": the textual editor "Word": the methodical instructions to the laboratory works / O.U. Belash, A.N. Vetrov, E.E. Kotova; edited by the prof. N.N. Kuzmin. – SPb.: The publishing house of "SPbSETU "LETI"", 2005. – 64 p.;
- Vetrov A.N. The package of applied programs "MS Office 97/2000": the system of spreadsheets "Excel": the methodical instructions to the laboratory works / O.U. Belash, A.N. Vetrov, E.E. Kotova; edited by the prof. N.N. Kuzmin. – SPb.: The publishing house of "SPbSETU "LETI"", 2005. – 76 p.

My 3 scientific articles, containing the received scientific results were published:

- 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 // “Proceedings of "IHEAS"” (“The Ukrainian branch”), №1, 2005. – SPb.: “SPbSETU "LETI"”, 2005, Kiev: “IHEAS”, 2005. – 21 p. (P.102-121).
- 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);
- Vetrov A.N. The information environment of the automated training based on the cognitive models / A.N. Vetrov, E.E. Kotova, N.N. Kuzmin // “Proceedings of "IHEAS"” (“The Moscow branch”), №3 (37), 2006. – SPb.: “SPbSETU "LETI"”, 2006, M.: “IHEAS”, 2006. – 15 p. (P.100-112);
- Vetrov A.N. The adaptive information-educational environment of the automated (remote) training base 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).

There was carried out the completion of techniques and algorithms at the basis of CMT, there were specified the structures of CM, there were modernized the principles of functioning of the components of IEE of ART system with the properties of adaptation based on PCMB, there was programmatically realized the adaptive representation of information fragments processor at the basis of architecture of the adaptive means of training (ET considering IFPST).

There was modernized the program realization of the adaptive means of training, there was carried out the filling of DB of the basic diagnostic module and the applied diagnostic module by the new tests (the methods of research of LRKT and IFPST), which were subsequently practically used on a practical lessons on the discipline “Computer science” (a day and evening departments).

There were developed my methodical manual (textbook) and its electronic analog on the discipline “Computer science”.

Using techniques and algorithms at the basis of CMT on a practical lessons on the discipline “Computer science” there was carried out the experiment with use of the developed complex of programs: there were formed the structures of CM, including an actual set of parameters for the purpose of research; there was carried out the automated diagnostics of IFPST, acting as the values of parameters of CM of the subject of training due to use of the applied DM; there was realized the individually-oriented generation of information fragments to the contingent of trainees by means of the adaptive means of training; there was held the automated testing of LRKT by means of the basic DM; there was provided the analysis of received results with use of the algorithm of processing of a posteriori data of testing.

The statistical processing of experimental data was carried out.

At the fourth stage (2006 – 2007 year) there was the check of reliability of results, the statistical analysis and identification of regularities, the interpretation of dependences, the definition of directions and tasks of further researches of IEE of ART system.

The received scientific results were published in the form of speeches and publications of materials at the next international conferences held in "IBI" by "IHEAS" and "The interregional educational consortium of Russia":

9. The VIth international scientific-practical conference "Actual problems of economics and new technologies of teaching", which was held in "IBI", RF, Saint-Petersburg city, on the 13th-14th of March 2007 year:
   - mine publication and scientific report in the section "Educational politics and new technologies of teaching" on the theme "The analysis of the information environment of the automated training with the properties of adaptation based on the cognitive models";
   - mine publication and scientific report in the section "Educational politics and new technologies of teaching" on the theme "The software of the automated educational environment with the properties of adaptation based on the cognitive models".
10. The XIIIth international scientific-practical conference "Modern education: contents, technologies, quality", which was held in "SPbSETU "LETI"", RF, Saint-Petersburg city, on the 19th of April 2007 year:
    - mine publication and scientific report in the section "Perspective technologies of training" on the theme "The program complex for the research of the adaptive information-educational environment based on the cognitive models".
11. The Vth international scientific-methodical conference "Quality management in modern High school (HEI)", which was held in "IBI", RF, Saint-Petersburg city, on the 21st-22nd of June 2007 year:
    - mine publication and scientific report in the section "Creation of the quality management system" on the theme "The techniques and algorithms in the basis of the cognitive modeling technology";
    - mine publication and scientific report in the section "Improvement of the quality management system in HEI" on the theme "The adaptive means of training in the automated educational environment based on the parametrical cognitive models block".

The definition of directions and tasks of a further research and development of IEE of ART with the properties of adaptation based on CM, the improvement of techniques and algorithms at the basis of CMT, and also the received structures of CM of the subject of training and CM of the means of training.

1.6. The list of received scientific results

In the context of system and model approaches were defined the structure, characteristic and interrelation of the elements of IEE of ART system, including organizational-methodical and program-technical resources, which have formed in the basis of dissertation and were practically used in training process.

The basic scientific provisions, received by me as the author during scientific-research and methodical work for 4 years and **their novelty**:

1. There was created the structure of IEE of ART system with the properties of adaptation based on CM, assuming the additional contour of adaptation based on IFPST and the potential technical capabilities of the means of training, which provides the increase in the efficiency of functioning of IEE of ART system:
   - there were presented the modifications in organization and technology of ART, providing the realization of the adaptive model of training, allowing to provide the individually-oriented generation of educational influences based on PCMB;
   - there were developed the principles of functioning of the components of IEE of ART system with the properties of adaptation based on CM (the adaptive means of training, the basic and applied DM), and also the adaptive representation of information fragments processor at the basis of the adaptive electronic textbook.
2. There was developed CMT, which allows to provide the complex analysis of the efficiency of functioning of IEE of ART in the context of a series of the chosen scientific aspects and the increase in the efficiency of process of the formation of knowledge of the contingent of trainees in IEE of ART system with the properties of adaptation based on CM:
   - the iterative cycle of CMT, which includes the sequence of stages;
   - the technique of use of CMT for the analysis of IEE of ART system;
   - the algorithm of formation of the structure of CM;
   - the ways of representation of the structure of CM on the basis of the formal classical ways of presentation of structured data (logical model and productional model), the nonformal classical ways (frame model, semantic network and ontology) and offered innovative ways (the oriented graph combining the theory of sets and the multilevel structural scheme without any communications);
   - the techniques of research of the parameters of CM of the subject of training and CM of the means of training;
   - the algorithm of processing of a posteriori data of testing.
3. There was developed PCMB containing CM, which act as the basis of realization of the contour of adaptation and the implementation of the system analysis of IEE of ART system:
   - CM of the subject of training – accumulates the parameters characterizing of IFPST;
   - CM of the means of training – the repertoire of parameters reflecting of a potential set of kinds, types and ways of representation of information fragments.
4. There was developed the complex of programs for the automation of research of IEE of ART system, which includes several program components:
   - the adaptive means of training (the electronic textbook) – realizes the individually-oriented generation of educational influences by means of the adaptive representation of information fragments processor;
   - the basic diagnostic module – realizes the automated estimation of LRKT;
   - the applied diagnostic module – realizes the research of parameters of CM of the subject of training and the subsequent analysis of a posteriori data.

The theoretical importance of research consists of:

1. The bases of reorganization of IEE taking into account of the realization of adaptation to IFPST were offered:
   - the structure of ART system with the properties of adaptation based on PCMB;
   - the specifics of training as the operated process of the formation of knowledge;
   - the features of structure and realization of the components of ART system;
   - the bases of the extraction of subject knowledge for the purpose of creation of the theoretical-reference (help) modules (TRM) of the adaptive means of training, the architectures of the components of IEE of ART (ET and DM) of a new generation and the parameters of their estimation;
   - the specifics of use of multimedia in IEE of ART.
2. The features of modification of the organization of IEE and the technological process of the operated formation of knowledge, and also the principles of functioning of the components of ART system at realization of the contour of adaptation based on PCMB were marked out.
3. There was presented the structure of the channels of information interaction of the subjects and means of training in IEE of ART system with the properties of adaptation based on PCMB, there were allocated the key parameters, influencing on the efficiency of the formation of knowledge of a trainee in IEE of ART system.

The practical value of carried out research consists of:

1. CMT provides the complex analysis of IEE of ART system based on CM.
2. The received structures of CM of the subject of training and CM of the means of training by means of the algorithm of formation of the structure of CM allow to provide the generation of information fragments adequately of IFPST (were set previously).
3. The developed technique of research of the parameters of CM and the algorithm of processing of a posteriori data of testing formalize according to the sequences of the statement of experiment and the processing of a posteriori data.
4. The complex of programs provides the automation of the adaptive generation of information fragments on discipline on the basis of the previously diagnosed parameters of CM and the subsequent estimation of LRKT.

The reliability of scientific results was provided by the system approach to the description of the object of research, the correct use of the fundamental provisions of theory of information, physiology of sensory systems, cognitive psychology, applied linguistics and ergonomics, the adequacy of the received (cognitive) models to the real processes, the proved application of the approved methods of research, the strict logic of carrying out of the (automated) research, the results of statistical processing of a posteriori data obtained by means of the specially developed software (SW), the approbation of basic provisions of my dissertation at the seminars and conferences of various level, the introduction of the results of dissertation research in training process.

The practical use (introduction) of results of research was carried out in "SPbSETU "LETI"", "IBI" and other organizations, that was confirmed by the relevant protocols with a posteriori results of research and acts.

The research was carried out in parallel with the preparation of my dissertation, and the received scientific and practical results were approved in the training process of "SPbSETU "LETI"" on the disciplines "Intellectual technologies of representation of knowledge" (laboratory practical work, a day department) and "Computer science" (theoretical course of lectures and laboratory practical work, a day and evening departments).

On the discipline "Computer science" I have independently developed my methodical support: theoretical course of lectures and laboratory practical work.

Publications. On the theme of dissertation were publ. 43 on 2007 y. (80 on 2012 y.) scientific works: 01 textbook and 03 methodical instructions to the lab. works on the discipline "Computer science"; 02 sections in 01 coll. scientific monography of "IHEAS" (with forms. coauthors-teachers); 08 (16) learning manuals and scientific monographies (without coauthors); 01 (02) report(s) on the individual initiative SRW; 05 (12) scientific articles in the scientific journals, recommended by "HAC of RF", from them 00 (05) scientific articles were deposited in ""VINITI" of "RAS""; 22 (43) scientific reports in the materials of 11 (24) international scientific conferences, and also have been received 04 copyright certificates about deposition and registration of the works – the objects of intellectual property in "RAS" (RF, Moscow city).

In 2005-2007 y. (2012 y.) the norm for candidate (doctor) of technical sciences is executed (it was required 02 (10) scientific articles in scientific journals from the list of "HAC of RF").

During of carrying out of research the manuscript of my doctoral dissertation was prepared:

- volume 1 (main part) – the introduction, four chapters, the conclusion, the bibliographic section, including 281 names, stated on 180 p. of typewritten text, including 44 pictures and 2 tables was presented;
- volume 2 (appendixes) – contains 14 appendices on 246 p. of typewritten text, including 89 pictures and 154 tables;
- volume 3 (appendixes) – contains 1 appendix on 412 p. of typewritten text, including 177 pictures and 169 tables.

Considering the techniques and algorithms at the basis of CMT in relation to the various stages of ART it is expedient to allocate **the directions and tasks of further researches** with the purpose of improvement of the received results:

- at the stage of identification and conceptualization – it was recommended to pick up the software means for the visualization of the process of development of the conceptual and structural scheme of the researched object in the subject area (the subject of training and the means of training) and to create the method of its formalization;
- at the stage of formation of the structure of CM – the choice of the optimum model of representation (graph or scheme was offered) and the improvement of the created CM;
- at the stage of diagnostics of IFPST – the improvement of the technique of research of the parameters of CM of the subject of training and the selection of the modern methods for the realization of automated diagnostics of the values of parameters, entering in the basis of CM;
- at the stage of adaptive training – the modernization of algorithms and procedures in the basis of the structure of the adaptive representation of information fragments processor;
- at the stage of testing of LRKT – the modernization of the algorithm of processing of a posteriori data of testing, the choice of the kind of scale and function of estimation for the realization of automated testing by means of the basic DM, and also the selection of analytical coefficients for the estimation of condition of the examinee and the quality of used test.

On the basis of carried out research we'll form the conclusions on the first chapter:

1. The level of development of modern ICT causes the possibility of their practical use in the sphere of education for the realization of the principle of individually-oriented training in the automated IEE.
2. The priority directions of development of the system of education at the present stage according to the requirements of information society were allocated.
3. The informatization of establishments of the system of education and the introduction of the means of automation of the process of training initiates the consideration of a wide range of questions and the solution of tasks in the context of the various branches of scientific knowledge.
4. The social needs in the post-industrial society actualize the revision of some provisions and classical bases, which were used at creation of the automated IEE in the modern EEs.
5. The rates of development of ICT and the realized on their basis the means of automation advance the possibilities of their practical use at the basis of IEE, causing the need of carrying out of the additional researches.
6. At the modern stage of the development of science and technology was caused the technical capability of realization of the components of IEE and the means of ART with the architecture of a new generation, allowing to reach the maximum individual orientation and adaptation of the automated process of the formation of knowledge of the contingent of trainees due to the accounting of the various IFPST and LRKT.
7. The structure of IEE of ART and the essence of ICT in education was considered, and also the main components (technical, software, organizational and methodical), connected with the technological process of training were allocated.
8. The appointment, the potential opportunities of the automated means of training and the ways of increase in efficiency of IEE at introduction of ICT were proved.
9. The main stages of development of ATS on the basis of ICT, and also the kinds and tasks of the automated means of training, providing the increase of quality of the rendering of educational services to a wide range of consumers were allocated.
10. The essence and the basic principles of ART, and also new models and technologies of realization of the modern adaptive means of training were considered.
11. The automated IEE of a new generation are designing on the basis of the modern technologies of ART with use of the models and algorithms of the personally-oriented and adaptive training, providing the possibility of accounting of LRKT and IFPST at all stages of the formation of knowledge of trainees.
12. The analysis and estimation of the efficiency of functioning of the automated IEE of EEs initiate the need of carrying out of the complex researches, directed to the development of special approaches, methods and technologies, oriented to the modernization of organizational, technical, software, brainware and methodical support at the creation of the components of ART systems, carrying out the certain functions.

2. The analysis of information technologies and the theoretical bases of creation of the information-educational environments and the automated means of training

The intensification of growth of the diverse flows of information caused by the globalization of information environment initiates the elaboration of approaches, methods and technologies providing the increase in efficiency of creation, distribution and use of information resources, products and services in the various spheres of social activity. Many international organizations, regulating the policy and strategy of development for the system of education in the developed countries of the world, make new demands to the organizational, methodical, technical and other support of the existing and again created (new) information environments of EEs, initiating the emergence of innovative approaches, methods and technologies to the development of the automated means of training (of a new generation) and the increase of level of the quality of preparation of the specialists on different specialties.

There is appearing the communication environment of a new generation "WWW" ("The World wide web"), allowing to provide the open access to the various categories of territorially distributed consumers to the scientific, technical, medical, educational and other information as the aggregate of knowledge. In the establishments of the system of education of different level significantly increases the cognitive load on the subjects of educational process in view of the expansion of a range of fundamental and applied areas, and also the minimization of an object and subject of research.

The commission on educational technologies at the international organization "IEEE" ("The institute of electric and electronics engineers leaning technology task force") emphasizes the special relevance of development of IT of training, offering at the same time the following directions: the automated training systems (ATS), IEE based on virtual reality, the intellectual and adaptive models, methods and means of training, the structuring and representation of knowledge, the multimedia and hypermedia technologies, cognitive computer science and computer graphics, the object-oriented paradigm and the hi-technological environments of programming.

The existing problems of the system of education and the increasing needs of social subjects initiate the reorganization of the information environments of EEs, the improvement of the traditional (classical) technologies of training for the purpose of introduction of the means of automation of educational process, allowing to realize the accounting of the individual features of trainees and teachers due to the modern achievements in the field of new information technologies.

There are appearing the intellectual and adaptive means of training in the automated educational environments, operating on the basis of the branched heuristic algorithms, allowing to realize the flexible methods and strategies of representation of information fragments on discipline to the contingent of trainees taking into account of their level of preparation on basic disciplines, to diagnose LRKT and IFPST.

2.1. The modern standards in the field of quality of the information-educational environment

Today there is existing a large quality of different standards, which are grouping in relation to the certain sphere of their practical use.

The standardization of the components of IEE and the tool software means providing their realization on the basis of the modern achievements in the field of ICT acts as the complex problem and the relevant task of modern EEs, considering the dynamics of process of their development, improvement and modification.

The quality of the automated means of training on the market of education services and the software products on the information market is estimating by the check of compliance of each nomenclature unit to the requirements of various standards. During the whole life cycle of the certain software product the various groups of (industrial) standards are using, regulating the required level of quality in the process of its design, program realization, operation and support. The full technological cycle of creation and service of the automated means of training causes the need of use of a wide range of standards in the context of each from technological reserves (stages).

The consumer preferences and properties of the software means, put by the producer are significantly connected with the various standards of quality.

The regulatory base in the ensuring of quality of IEE of ART there are the international standards ISO of series 9000-14000, basic of which are:

- ISO 9001:1987 – The systems of quality. The model for the ensuring of quality at design and/or development, production, installation and service;
- ISO 9000-3:1991 – The general guide of quality, the standards on the ensuring of quality. The guideline instructions and standards on their application;
- ISO/IEC 9126:1991 – The information technologies. The estimation of production of software. The characteristic of the level of quality of the technological process of development and the guideline instructions on their application;
- ISO/IEC 9127:1988 – The systems of information processing. The documentation of user and information on the cover of the packages of software;
- ISO/IEC TR 9294:1990 – The information technology. The guideline instructions on the management of documentation on the software;
- ISO/IEC 12119:1994 – The information technologies. The packages of software. The requirements to quality and testing.

In present time on the territory of RF are using two standards ISO/IEC 9126-1993 and ISO/IEC 9127-1994 (and their newer modifications). The estimation of quality of the software means is regulating GOST 28195-89. To the basic indicators of quality of the software products, according to GOST 28195-89, ISO/IEC 9126 and GOST 28195-89 are: reliability, simplicity of service, productivity, convenience, efficiency, universality, accuracy, expandability, autonomy and integrability.

The standard ISO/IEC 9126 defines the six main characteristics for the estimation of quality of the components of IEE: functionality, reliability, convenience of support, usability, productivity and portability (relocating).

Considering the producers of software in the various countries and regions the variation of a set of used standards and criteria of estimation of the program products is observing. For the estimation of IEE and the components of ART systems it is necessary to take into account the features of organizational, technical and methodical support, and also the specifics of use of the various ICT.

The creation of IEE and its approbation in the process of real use by many educational institutions of various level and profile allow to develop a set of standards in practice: the structure of presentation of data, terminology, the technologies of preparation of TMC and support, the technology of organization of the training process, the electronic document circulation (management) system and the supply of the quality of training.

Such approach allows to take into account the opinions of a wide range of (specialists) experts, to develop the most acceptable requirements for use in practice and the corporate standards of quality in establishments of the system of education of RF. These standards will be more functional and viable, than the standards, developed by the highly-qualified specialists by the method of discussions during the meetings on working groups or other similar collective actions.

The analysis of literary sources has shown, that at the creation of IEE of ART systems the developers use the following basic principles and approaches:

- orientation on the methodology of the structural analysis and design;
- use of the means of modeling and the visual environments of programming on the basis of the high-level languages of programming for realization of the components of ART system based on the object-oriented approach;
- use of the modular principle at design, realization and support of the components of ART system, the unification of the separate modules for the purpose of their fast integration, subsequent modernization and replacement;
- the improvement of user interfaces and the development of the components of ART system with use of the principle of distributed architecture, the technologies of "WWW", the methods of development of the structures of data in the distributed DB, the infological schemes of difficult databanks and the models of representation of knowledge in KB;
- the increase of productivity of the information systems due to means of introduction of the modern technologies of parallel and distributed calculations, the architecture of "thin" client-server and "fat" client-server allowing to realize the (territorially distributed) information exchange in the different local and global communication networks "Ethernet" and "Internet";
- the improvement of brainware at the basis of the program realization of the components of ART system due to use of heuristics and the intellectualization of computing procedures of processing and exchange of data.

2.2. The priority aspects and the directions of informatization

Today the priority aspects of informatization of education are:

- the regional aspect – includes the accounting of territorial features of the functioning of EEs, the national-ethnic factors, the types of EEs and the levels of preparation of trainees in the system of education, the economic, technological and other support of a new generation;
- the social-economic aspect – was connected with the definition of a role and value of the means of computational technics for the intensification of production processes in the various spheres of social activity, including in education, the forecasting of possible social consequences of the informatization due to the introduction of the means of automation, the analysis of stereotypic situations, connected with use of the information and communicational technologies in the (non)production fields of activity of the (post-industrial) society;
- the organizational aspect – the creation of innovative infrastructure of IEE and the realization of approaches to the control of the process of training (at distance) in EEs;
- the technical aspect – includes inside the characteristic of technical capabilities of the modern perspective diverse means of computational technics in the purposes of automation of the various technological processes in EEs;
- the software aspect – the forecasting of emergence of new approaches, tools means and environments of programming, providing the possibility of development of the information educational technologies taking into account of technical capabilities and requirements imposed to IEE of ART systems;
- the implementation aspect – considers the possibilities and the ways of practical use of the hardware means of computational technics and software support in the educational process, and also provides the choice of criteria for the estimation of expediency and efficiency of their introduction;
- the pedagogical aspect – was caused by the detection of requirements and conditions promoting of the realization of the major purposes installations at using of the information technologies and the means of automation for the increase in the efficiency of processes accompanying to the educational activity;
- the physiological aspect – researches the regularities of the sensory perception of information by the visual and acoustic sensory systems of trainee, displayed by the means of training in the automated educational environment;
- the psychological aspect – reveals the features of processing of the polytypic educational influences by the psychological construct of the head brain;
- the linguistic aspect – focuses the attention on the specifics of understanding of the content of information fragments on a set of disciplines;
- the philosophical aspect – includes inside the consideration of the features of information interaction of the subjects of training and the means of training in the information-educational environment from the point of view of the system of scientific knowledge.

2.3. The basic principles of automated training

The results of theoretical and scientific-practical researches of many specialists (experts) emphasize the need of research of the information interaction between the subjects of training and the means of training in IEE, the search of ways of the increase in the efficiency of functioning of ART systems, and also the creation of optimum conditions for support of the formation of knowledge and the development of the identity of trainees.

The specifics of ART assumes the organization of information interaction of the subjects of training by means of the means of training in the automated IEE, the important value has the personal initiative of trainees, as the priority was given to IW on the individual programs with the possibility of modification of the educational trajectory, and also opens the possibility of approbation of the innovative algorithms, models, techniques and technologies of representation of the diverse information fragments on a set of the studied disciplines (the subjects of studying) in the certain EEs.

Distinguish from a set of organizational, methodical, technical, pedagogical and psychological principles allocating: adaptability, flexibility, controllability, personal orientation and complexity, which are characteristic not only for the traditional education, and also acquire the relevance in the context of ART.

A set of principles is ranging and subdividing into a set of blocks, each of which includes several levels according to the priority purposes, problems, tasks, the features of elaboration of the approaches, algorithms and mechanisms of decision.

The social-pedagogical principles – are regulating by the state policy in the field of the informatization of the sphere of education and include: systemacity, continuity, regionality, nationality, historicism, adaptability, availability, openness, unification, scientific character, standardization and fundamental nature.

The psychological principles – the development of personality in the process of ART, include: ergonomics, socialization, the development of personality, individualization and complexity.

The organizational-technological principles – reflect the features of organization of the innovative IEE and technology of the process of training (in distance) in EEs, include: purpose-directability, controllability, observability and feedback.

The greatest effect at developing of the means of training in the basis of the traditional and automated IEE is reaching when the principles work as the uniform system.

There is a set of private principles, characteristic only for ART, which are: openness, territorial distribution, expediency, personal initiative and the interactivity of interaction, the design of training-cognitive activity, the self-contained (independence) of assimilation of knowledge, adaptability, complexity and economic efficiency. On the basis of the system of principles is solving the complex of general and private tasks of the creation of IEE.

In this work it is offering the creation of the environment of automated training with the properties of adaptation based on PCMB and CMT for the its analysis, providing the increase in the efficiency of the formation of knowledge of trainee at the basis of IFPST.

The automated training allows to provide the remote access to a set of educational resources, assumes the use of the means of computational technics, considers as training at distance and constructs on the certain theoretical provisions, principles and the kinds of support (organizational, technological, technical, methodical and others).

The first level was formed by the social-pedagogical principles – regulating by the state policy in the field of the informatization of education:

- the principle of systemacity – the analysis and synthesis of the components of the system of education, providing the formation of the complex of scientific knowledge and the effective management of all its links for the achievement of the required level of quality;
- the principle of continuity – the ensuring of purposeful receiving and the improvement of knowledge, abilities and skills during all life of trainees, the creation of conditions for transition from one level of education to another;
- the principle of territoriality – the accounting of regional features, in which functioning the establishments of the system of education: arrangement, national-ethical factors, types and levels of EEs;
- the principle of nationality and historicism – orientation to originality and historicism in the process of evolution of the national system of education, its roots and traditions;
- the principle of democratization – granting to the consumers of educational services of a set of rights and freedoms at the choice of the form and the direction of training;
- the principle of availability – providing to the trainees the open, but individual on the content and volume access to the various resources of IEE;
- the principle of scientific character and standardization – the development of the content of educational programs adequately to the modern achievements of science and the requirements presented in "The state educational standards";
- the principle of unification – the realization of the universal and quickly developed components of IEE of ART system meeting to the modern requirements.

The second level was formed by the psychological principles – the complex development of personality in the process of training with the use of technologies of ART:

- the principle of ergonomics – to be orientated towards the level of development of abilities, IFPST and LRKT for the supporting of comfort and the protection of health;
- the principle of development of personality – to realize the complex of actions for the creation of conditions, providing the physical, mental and other development;
- the principle of socialization – to consider the requirements, interests and the properties of personality of trainee, to reveal the factors of IEE, exerting the negative impact on him;
- the principle of individualization – to be guided on a set of IFPST for the increase in the efficiency of the process of training during the work of trainee with the content of information resources by means of the traditional and IT;
- the principle of complexity – to provide the complexity of development of personality due to use of the achievements of the system of scientific knowledge from various branches.

The third level was formed by the organizational-technological principles:

- the principle of purpose-directability – to organize the process of the formation of knowledge proceeding from the features of activity of the subjects of training, to create the conditions of realization of their interests, ways and the strategies of achievement of the purposes of training;
- the principle of controllability – to realize the possibility of control under the process of training according with the certain law and algorithm of control, to provide the possibility of quasidynamic measurement and updating of the condition of trainee, including LRKT (the resultativity of training) and IFPST;
- the principle of observability – to develop the hardware and software means, providing the flexible and convenient monitoring under the educational process and the dynamics of change of the condition of trainee in the automated IEE;
- the principle of feedback – to provide the possibility of the analysis of executed operations on a set of stages of the educational process on the certain educational trajectory and the estimation of their influence on the increase of LRKT.

The following belongs to the private principles of distance training:

- the principle of openness – to realize the process of the formation of knowledge of trainees in IEE by means of use of the automated means of training, providing the open access to a set of information resources;
- the principle of territorial distribution – the modern ART systems represent inside the distributed information systems, containing the banks of knowledge on the subject areas, the components of which can be located in the various places of planet and perform the various functions and tasks;
- the principle of expediency – the expansion of the sphere of practical use of ART systems for the solution of various didactic tasks for the purpose of increase in the efficiency of the formation of knowledge and the development of personality of trainees;
- the principle of personal initiative and interactivity of interaction – the creation of interfaces of a new type and conditions for the manifestation of the constant cognitive interest of trainees, the formation of requirements to the obtaining of knowledge;
- the principle of design of training-cognitive activity – to the process of creation of the model of teaching and its application it is necessary to approach as to the means of conscious and vigorous activity of the participants of ART;
- the principle of self-contained (independence) of the assimilation of knowledge – the creation of optimum conditions for the self-contained (independent) formation of knowledge, abilities and skills by the trainee in the context of their use in the future professional activity;
- the principle of adaptability – the organization of process of the formation of knowledge of trainees with use of the adaptive models based on IFPST and LRKT;
- the principle of complexity and economic efficiency – the comprehensive accounting of specifics of all components of ART system and the requirements of consumers for the increase of profitability of the providing of educational services.

2.4. The stages of development of the automated means and environments of training

The world practice of use of the modern educational IT at the basis of the automated IEE allows to distinguish a set of stages during their evolution.

The 1st stage (60th years). *The specialized packages of training programs* – ATS, allowing to create the computer courses (CC) in IEE. In the systems of this kind the definition of technique, content and types of TI is delegating to the teacher, and the process of training and the estimation of progress is implementing by the means of IEE.

The 2nd stage (70th years). *The intellectual and branched ATS.* During this period the main efforts of theorists of ART are directing to the creation of the models of training at the basis of achievements of the engineering of knowledge. Actively are developing the approaches and methods of the representation of knowledge, developed in the field of artificial intelligence. Considerably are developing the models of the representation of knowledge, choice and creation of which connect with the problematics of collecting and structuring of a training material, and also the optimization of organization of the technological process of training. One of the main tasks of didactic programming – the synthesis of the purposeful system of optimum control of the training operations, when performing of which the condition of knowledge and abilities of trainee approaches to the demanded. At present time remains the relevance of solution of the listed problems by many specialists (experts).

The 3rd stage (80th years). *The development of engineering of knowledge and tool means of creation of ATS.* The deep scientific researches in a set of areas are carrying out: the modeling of reasonings and explanations for the realization of ATS, the development of the intellectual technologies of structuring and representation of knowledge on the subject areas, the creation of the strategies of training and the methods of estimation of LRKT. It is observing the tendency to the development and deployment of the integrated educational environments, allowing to use of the information resources with the polytypic information (texts, audio-recordings, schemes and images), including the analytical and imitating models of studied objects and processes, DB and expert knowledge, the systems of imitating modeling and support of making of decisions, allowing to carry out the different calculations: scientific, engineering-technical, economic, medical and others.

Works in the field of psychophysiology of perception, cognitive psychology and applied linguistics, cognitive computer graphics and representation of knowledge are developing. Computer animation in the training programs contributes to the development of the convergent and divergent intellectual abilities, as makes active the associative, plane and volumetric thinking, selectivity of process of cognitive activity of mentality, that allows to introduce the methods of correction.

The 4th stage (90th years). *The emergence of computers and ATS of a new generation, fiber-optical channels of communication, the introduction and development of multimedia, hypermedia and communicational technologies.* Changes in the modern architecture of information systems and technologies of the realization of hardware, software and brainware allow to realize ATS of a new generation.

2.5. The features of organization of the information-educational environment of the automated training at distance

The features of structure of IEE were closely connected with the level of EEs in the system of education, the compliance of its organizational, technical and methodical support to diverse international standards and various modern requirements of the bodies regulating the development of the system of education of the country or region.

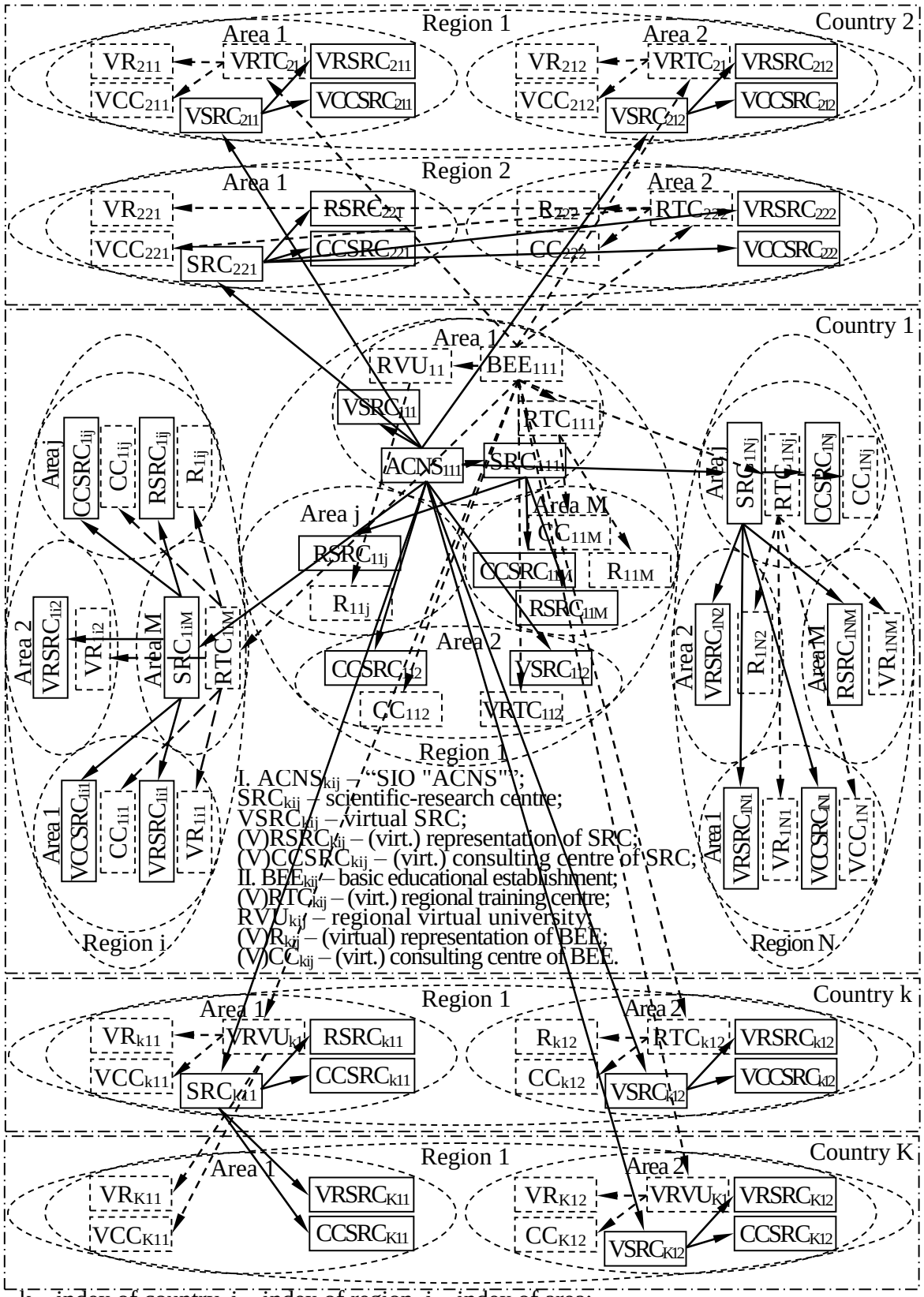
Today the processes of integration of the international and regional information environments of EEs directed to the creation of uniform educational space, which provides the access of users to a set of information resources and allows to render a differentiated set of educational services are observing.

The generalized topological structure of the uniform IEE of ART system (pic. 2.1) was connected with the features of organization and functioning of the certain EEs of various type irrespective from their location in the system of education (tab. 2.1).

Table 2.1

The kinds, forms of participation and characteristic signs of establishments

№	Name	Description
1.	Basic educational establishment or centre of training (BEE_{ij})	EEs, carrying out the process of training (at distance) on the own training plans and working programs or the separate training courses (programs) with issue of the document about education from its own name, having the potential possibility of creation of the certain virtual representation
2.	Regional representative office of BEE (RR_{ij}) or training centre (RTC_{ij})	EEs, having the certificate of RR or RTC of BEE and certified by its teachers-consultants (tutors), technical personnel, organizing the training process on its techniques, issuing the document about education from its name
3.	Territorial point of access to information resources (TPA_{ij})	The organization, having the certificate of TPA of BEE, providing to the consumers of educational services the possibility of training at distance by means of access to information resources through the network "Internet", but not carrying out any educational functions. The role of TPA can quite carry out the library or school with classes of PC and the possibility of access to the network "Internet"
4.	Consulting centre (CC_{ij})	The organization, providing the consulting services on the potential use of hardware and software of IEE of ART system. It is engaging in the introduction of new technologies, the realization and testing of software, the development and expansion of regional IEE, the (re)preparation of technical personnel, operating the distributed IEE
5.	Virtual representation (VR_{ij})	The program complex in IEE providing the cycle of training at distance, functioning for the realization of the possibility of access to the information resources and services of BEE or its representation by means of ICT

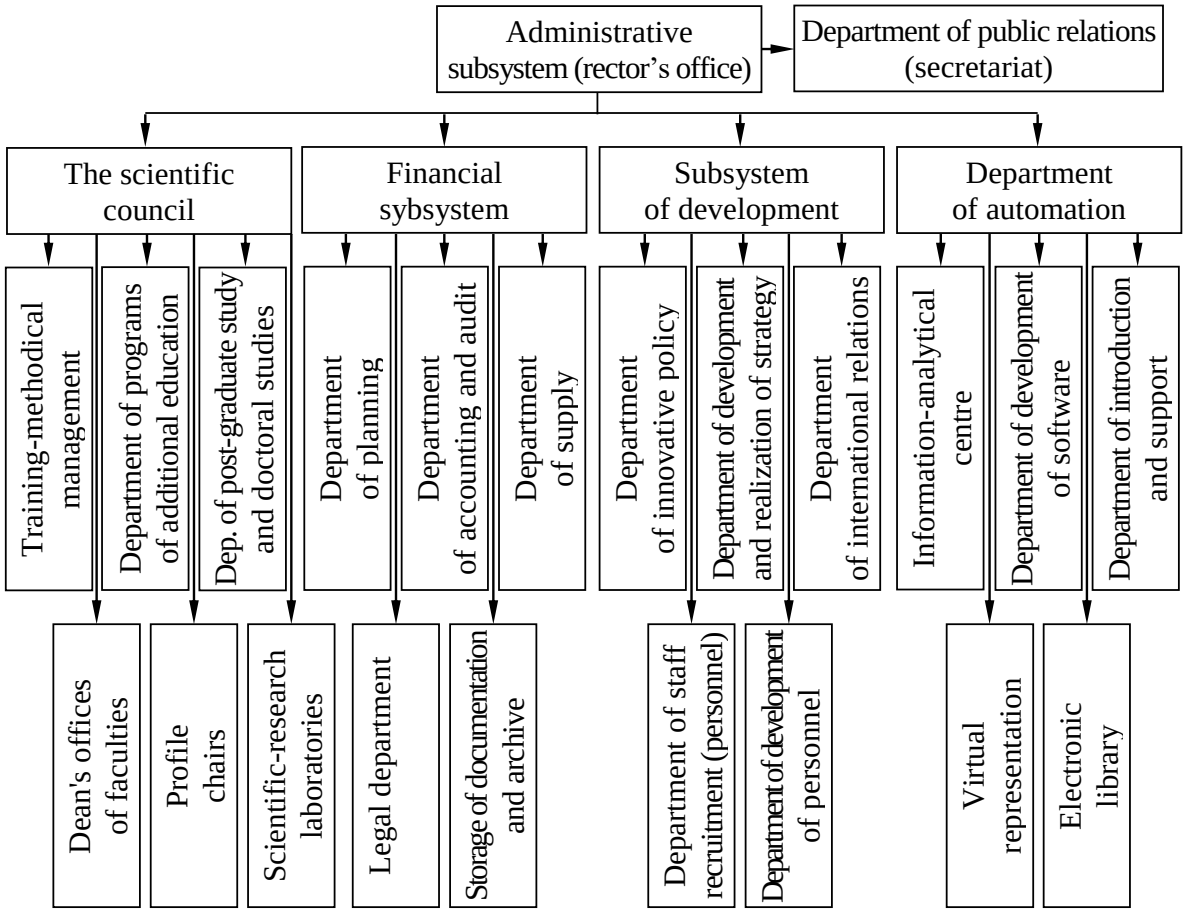


k – index of country, i – index of region, j – index of area;
K – quantity of countries, I – quantity of regions, J – quantity of areas.

Pic. 2.1. The topological scheme of the integrated international scientific cluster (the scientific-research centres and the information centres of automated training (at distance) in the several geographical regions): on example of the information-educational and scientific environment of "SIO "ACNS""

The features of organizational structure of the certain EEs depend on its level in the system of education, the profile of trained specialists (experts) and a set of provided educational services to the contingent of consumers.

The organizational structure of the certain basic EEs (its regional representative office) includes a set of divisions covariant to the directions of educational activity (pic. 2.2), which provide the support of the traditional forms of training (at distance), and also give to the differentiated diverse contingent of trainees the potential opportunity to use the various services of ART system.



Pic. 2.2. The structurally-functional scheme
of basic educational establishment or its virtual representation

The department of post-graduate study and doctoral studies – carries out the personal records of post-graduate students and applicants interested to receive the scientific degrees of candidate and doctor of sciences.

The information-analytical centre carries out the collecting of statistical data for the analysis of the efficiency of functioning of IEE, reveals the dependences and carries out the analysis of supply and demand in the market of educational services.

The department of development of software – develops the architecture and debugs the program realization of the components of IEE of ART system.

The department of introduction and support – provides the integration of program realization of the components of IEE of ART system and carries out their support in to the current life cycle of software product, realizing the component of IEE.

The electronic library – contains a set of information resources.

2.5.1. The distinctive features of the information-educational environment of the automated training system

The following acts as the distinctive features of IEE of ART system:

- the process of the formation of knowledge of trainees happens in IEE of ART system, the support of functioning of which is reached by means of the various means of training (components), realizing the certain functions;
- the communicative limitation owing to the indirectability of the duplex information interaction between the subjects of training and the means of training;
- the need of support of AWP of all subjects of IEE in an efficient condition (the technical support of hardware and software);
- the non-uniform contingent of users with the various level of proficiency in the software means of computational technics, used in IEE and realized with the use of the modern achievements of ICT;
- the wide nomenclature and appointment of hardware and software, providing the functioning of the diverse components of ART system;
- the essential increase of quantity of subjects of IEE causes the high load on the relevant AWP and local area network.

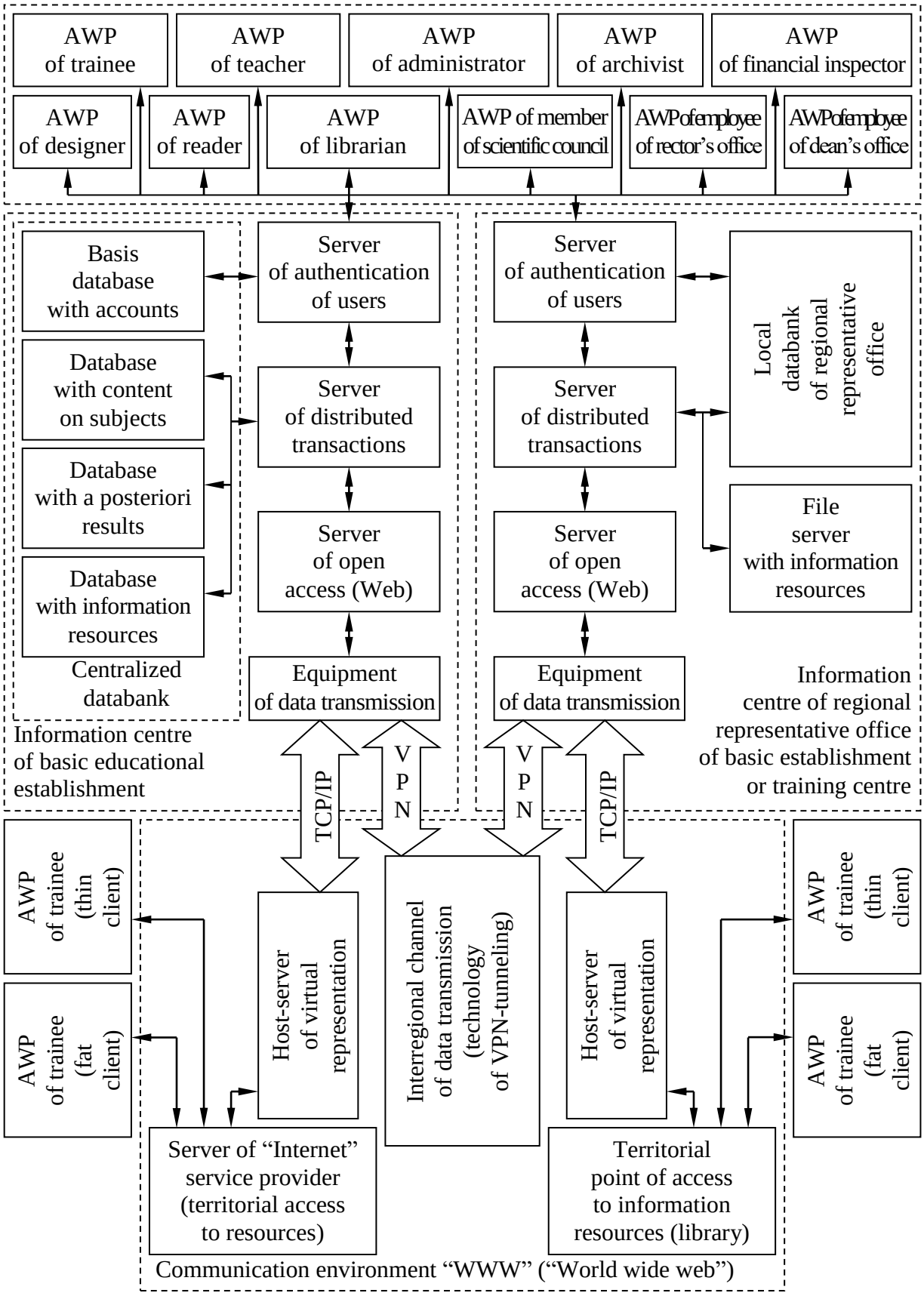
The modern condition of ICT shows new requirements to the educational technologies, the content of training courses and the means of automation of processes accompanying to the activity of diverse EEs of different level.

The question of preliminary preparation, repreparation and increase of qualification of the service personnel, in particular the curators of lessons in the training groups and computer classes demands the development of skills of possession of PC for the use of a minimum necessary set of software sufficient for the support of the certain educational process, and also the support of formation of the ethical standards necessary for normal work in the local and global computational networks adequately to the level of information culture.

The trainee requires to be prepared to the mastering of the modern means of information processing, the fast perception of large volumes of information adequately to the individual features of perception, processing and understanding of its content. This problematics imposes the certain restrictions to the organization and technology of the process of training in the audience equipped by the means of IT.

Innovative approaches are oriented on the organization of AWP on the basis of the technologies of individually-oriented training and assume the work of users of different categories adequately to the conditions, purposes and solved by them tasks.

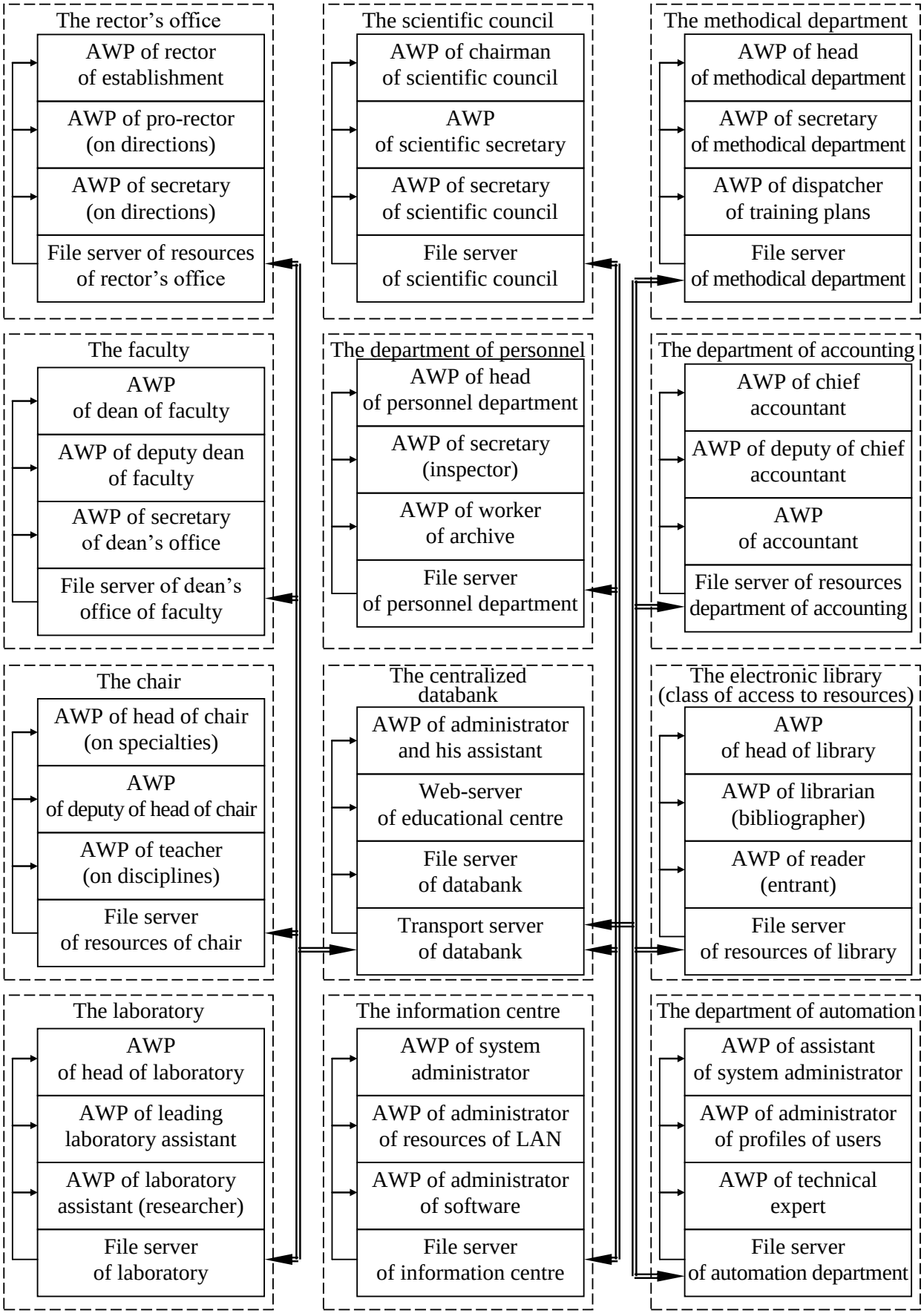
AWP of IEE of ART (fig. 2.3) ensure the work of users of various categories, acting as the administrative and service personnel, and also the consumers of educational services: the staff of rector’s office, dean's offices and chairs; the readers of electronic library; teachers; trainees and entrants. Each AWP contains PC and a set of software for work.



Pic. 2.3. The standard scheme of interaction of the information centre of educational establishment and the automated workplaces of the subjects of training

The territorially distributed AWP of the subjects of IEE of ART interact with the certain information centre of EEs by means of use the network "Internet".

The standard IEE of the certain EEs includes a set of AWP (pic. 2.4).



Pic. 2.4. The automated workplaces of the subjects of the information environment of educational establishment

The operation of AWP of the subjects of IEE using the various automated means of training initiates the emergence of a set of problems:

1. The existence of LAN causes the emergence of a set of advantages, shortcomings and restrictions at the transfer of audio-video information of various type:
   - allows to share the resources of LAN on the several AWP with the means of training for demonstration of a set of functions of any program;
   - realizes the remote possibility of rendering of personal help from a tutor, excludes the need of transition of a teacher to AWP of trainee and delivery of an explanation to a trainee directly on his AWP;
   - provides the transfer of image from the screen of teacher on the monitors of trainees, allowing to show the material with the use of the computer and to carry out the demonstration at work with the programs ("NetOp School");
   - the broadcast of the content of screen of AWP of trainee to the screen of computer of a teacher with the possibility of remote control by means of the keyboard and manipulators, allowing the teacher to work individually with each trainee, without leaving his AWP ("Remote Admnistrator").
2. The operating systems for the realization of the environment of program environment, providing the implementation of programs of the users of various categories:
   - the network operating systems ("Microsoft Windows 2000 Server" and "Linux") – the complex of configured software allowing to realize the information exchange between AWP of users and to provide access to the resources of LAN by means of the different equipment of data transmission;
   - the operating systems for the realization of file servers ("Microsoft Windows 2000 Advanced Server / 2003 Server") – the kind of network operating systems providing the balancing of network loading and distributed transactions initiated by AWP of final users entering into this LAN, who subsequently are subject to processing by the software of server;
   - the operating systems of real time ("QNX" and "Unix") – the complex of software satisfying to the standard "POSIX", established on the certain computer for the realization of implementation of the software of user in the mode of rigid and soft real time;
   - the special operating systems ("Motorola" and "B&R") – software, intended for the installation on the controllers, operating by the principle of supervisory, distributed and local control, performing the functions of monitoring and data processing received on the channel of transfer of information by means of sensors, interfaces and network adapters;
   - the operating systems for a wide range of users ("Microsoft Windows 2000 / XP / Vista") – an integrated set of program modules (not unloaded and unloaded components of kernel), supporting the period of execution of software for the ordinary users.

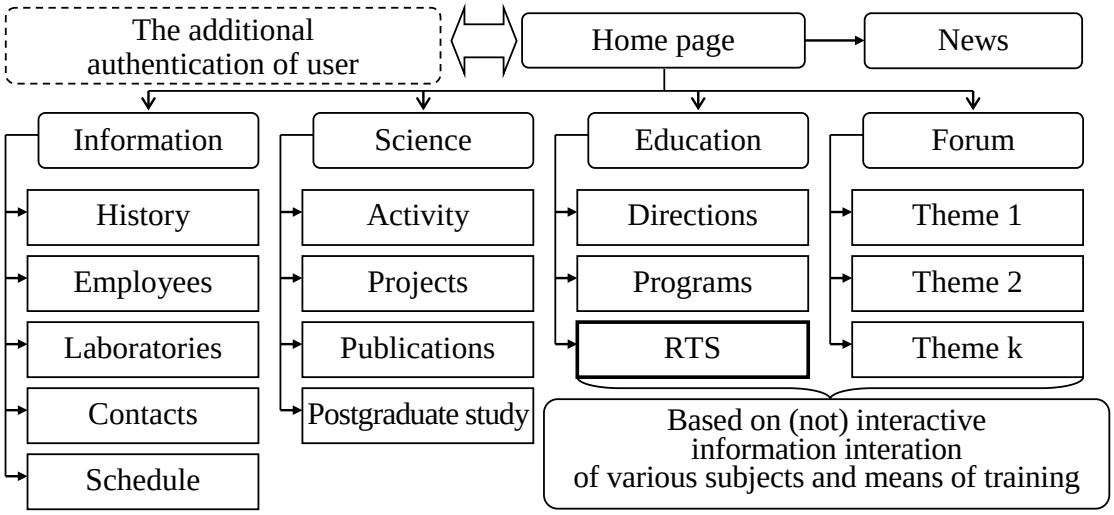
3. The covers and file managers for various operational systems:
   - the covers of operating systems with the command interface of user ("Symantec Norton Commander", "Volkov Commander", "DOS Navigator" and "Far");
   - the managers of file system of operating systems with the graphic interface of user ("Windows Commander" and "Total Commander").
4. The software of applied appointment, intended for the solution of additional tasks of users and service support of the system:
   - the packages of applied programs for the automation of document flow;
     - the text editors ("Microsoft Word");
     - the systems of spreadsheets ("Microsoft Excel");
     - the control systems of DB ("Microsoft Access");
     - the constructors of presentations ("Microsoft Power Point");
     - the integrated publishing systems ("Microsoft Publisher");
     - the post systems of delivery of electronic letters ("Microsoft Outlook");
     - the integrated environments of development of Web-resources ("Microsoft Front Page");
   - the packages of applied programs for the automated translation of text;
     - the complex systems of translation of text ("Prompt");
     - the systems of automation of translation of text ("Socrat");
     - the electronic dictionaries ("Translate It" and "Lingvo Dictionary");
     - the system of translation of information Web-resources ("ORFO" and "Prompt");
   - the packages of applied programs for the automation of designing, mathematical modeling, mathematical and engineering calculations;
     - the system of automation of the process of designing and development of drawings of the difficult engineering objects and constructions ("Mathsoft Autocad / Archicad");
     - the system of support of analytical-numerical calculations ("Mathsoft Mathcad");
     - the packages for modeling and engineering calculations ("Mathsoft Mathlab");
     - the packages for statistical processing of a posteriori data ("SPSS");
     - the graphic packages of formation of images with use of the technologies of raster and vector graphics ("Adobe Photoshop" and "Corel Draw");
   - the packages of applied programs for the automation of the process of creation of multimedia of rollers and processing of audio- and video-streams;
     - the audio- and video-editors ("Sonic Sound Forge" and "Adobe Premier");
     - the program environments for the development of dynamic images ("Macromedia Dreamwaver" and "Macromedia Flash");
   - the packages of applied programs for the scanning of the level of safety of the information systems;
     - the scanners of level of safety ("Shadow Security Scanner", "NetQ Security Analyzer" and "McAfee Sniffer Reporter");
     - the network scanners of safety ("Retina Network Security Scanner");
     - the means of fight against spam ("Spam Reporter" and "McAfee Spam Killer");

- the packages of applied programs for the ensuring of information security and decrease of virus danger;
  - the complex security systems ("Zone Alarm Security Suite", "Trend Micro PC Cillin", "McAfee Internet Security" and "F-Secure Internet Security");
  - the network firewalls ("OutPost Firewall Pro", "Zone Alarm Pro" and "Symantec Firewall");
  - the software for cryptographic coding ("Encryption Plus Folder", "F-Secure File Crypt" and "Encryption Plus Hard Disc");
  - the anti-virus programs ("Kaspersky Antivirus" and "Norton Antivirus").

5. The packages of service programs and utilities intended for the optimization of operating system and file system, and also the service of computer:
   - the packages of service programs, intended for the service and diagnostics of hardware and software on AWP of users;
     - the system of complex protection, diagnostics (testing) and service of computer ("Symantec Norton System Works");
     - the packages of programs for the scanning and defragmentation of file system and recovery of deleted data ("Symantec Norton Utilities");
     - the procedure of recovery of damaged software and data ("Symantec Norton Ghost / GoBack Enterprise");
     - the procedure of backup copy of data ("Symantec Norton Backup Pro");
     - the means of defragmentation of file system ("Defrag Pro");
     - the means of restoration of damaged file system and data ("On Track Easy Recovery" and "Zero Assumption Recovery");
   - the packages of utilities, intended for the configuration and service of the operating system, file system and data of final user;
     - the programs of scanning of the surface of optical disks for the laser storages of information ("Scan CD" and "Scan DVD");
     - the programs for the optimization of structure and editing of register ("Active registry monitor", "Advanced registry optimizer", "Registry editor" and "Registry vac");
     - the programs of diagnostics of the hardware of computer ("Sisoft Sandra Delux", "Memory Diagnostics" and "Dr. Hardware");
     - the programs for the marking of diverse storages of information on hard magnetic and electronic drives ("Fdisc" and "Power Quest Partition Magic");
     - the archivers ("Winrar", "Winzip", "Winarj", "Tar", "Gzip" and "7zip");
     - the multimedia drivers and the libraries of additional drivers ("Microsoft Direct X", "Indeo" and "Fraunhofer");
     - the configurators of expanded functions of the operating system ("Microsoft Plus", "Microsoft Turn Up", "Ashampoo Win Optimizer", "PC Booster" and "Win Boost").

6. The means of development and realization of software:
   - the environments of programming on languages of high level ("Borland of C++ Builder" and "ASP.Net");
   - the means of development of architectures and control systems of DB ("SQL Server").

The modern ART systems are implementing on the basis of technologically increased portals (pic. 2.5), placed on the Web-servers, allowing to provide the open access to the information resources of educational centre.



Pic. 2.5. The structure of the information-educational portal of educational centre

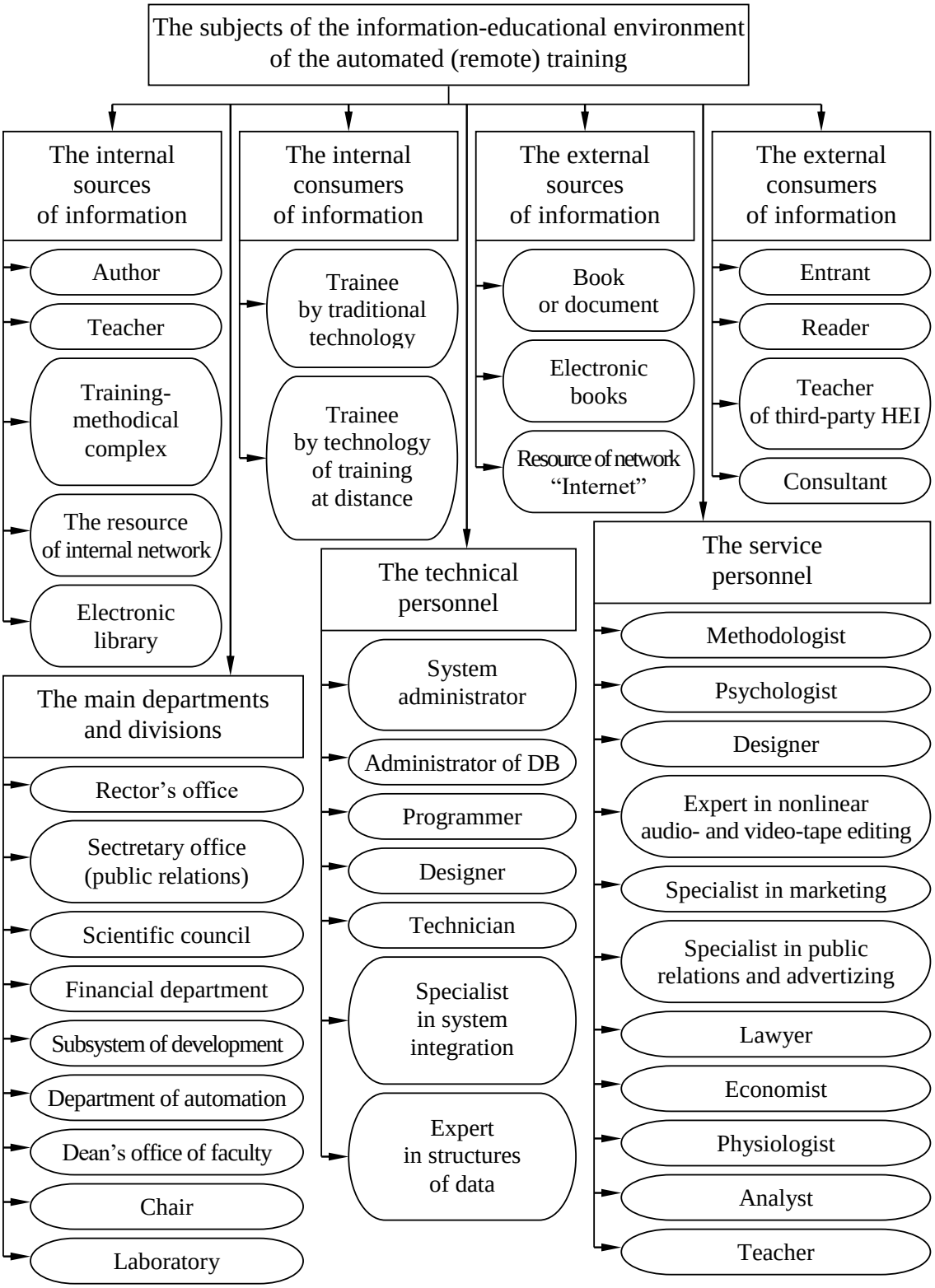
The server of open access provides the processing of inquiries of the external consumers of the diverse information resources, provided by the basic EEs, its certain virtual or regional representative office.

Directly after loading of the homepage at the work with the educational portal is providing the possibility of viewing of the various sections:

1. The section "Information" allows to the reader to receive the diverse data, which belong to the history of EEs, its employees, laboratories, contacts and allow to the subjects of training to study with the schedule of lessons:
   - the module "History" – contains the description of the features of creation and development, and also considerable (key) dates in the history of existence of EEs;
   - the module "Employees" – includes the diverse information (data) about the professor-teacher structure (faculty) of the various divisions of EEs;
   - the module "Laboratories" – is listed the list of diverse scientific-research laboratories, the sort and directions of their activity;
   - the module "Contacts" – allows to realize the feedback between the employees and the consumers of educational services;
   - the module "Schedule" – contains the schedule of lectures, practical training lessons and planned actions in the educational centre.
2. The section "Science" contains the data about current scientific activity, the list of projects and published works, and also provides the opportunity of acquaintance with the conditions of training in the post-graduate study and the list of specialties.
3. The section "Education" contains the list of directions, specialties and educational programs according to which the preparation is conducting.
4. The section "Forum" allows to carry out the discussion of various themes, relating to the preparation of diverse contingent of trainees.

2.5.2. The subjects of the information-educational environment of the automated training

The subjects of IEE act in the role of diverse external and internal sources and consumers of information of different appointment, hold the different position in the organizational structure of EEs or its representation and perform the various functions and tasks, including in ART system (pic. 2.6).



Pic. 2.6. The subjects of information-educational environment

The subjects of IEE work with the various components of ART system in the basic EEs or its territorially distributed divisions: the regional representative office or the training centre, the territorial point of access, the consulting centre or the virtual representation in the network "Internet".

According to the carried-out functions the subjects of IEE of ART system are differentiated in groups: the sources of information (tab. 2.2) and the consumers of information (tab. 2.3), the administrative-managerial, serving (tab. 2.4) and technician personnel (tab. 2.5).

Table 2.2

The sources of information (of the aggregate of knowledge on the subjects of studying)

№	Name	Description
1.	Author of course (teacher)	Carries out the development of educational-methodical and information resources, used by BEE in the training process through VP, or provided to the readers through the electronic library of VP
2.	Tutor-teacher of basic training institution	The teacher of BEE, providing the support of network training process or internal lessons
3.	Tutor-consultant of regional representative office of BEE	The certified person of BEE, having the right to conduct lessons (consultations) on programs, techniques and technologies given by BEE, in the context of disciplines, determined by the certificates

Table 2.3

The consumers of information (of information resources)

№	Name	Description
1.	Entrant (guest)	Gets the limited access for the acquaintance with the opportunities of IEE: the list of directions and specialties, requirements to entrants and conditions of providing of a set of educational services, short technical specification of functions of various components of ART system
2.	Trainee (student or pupil) of internal or correspondence form of training	Participates in the process of automated training, realized by means of use of the traditional and information technologies, is possible the access to information resources and services in IEE of the certain BEE or its distributed divisions on techniques, training plans and on the terms of BEE: training is conducting on the basis of the contract between trainees (students) and BEE
3.	Trainee of correspondence or remote form of training	Be trained in BEE, its distributed divisions or through VP by means of the hardware and software of ART system allowing to realize the remote access to a set of information resources
4.	Reader	Gets the access to various information resources, which are locating in the funds of electronic library of IEE of ART on the basis of the contract between reader and EEs or its representation

Table 2.4

The administrative-managerial and service personnel

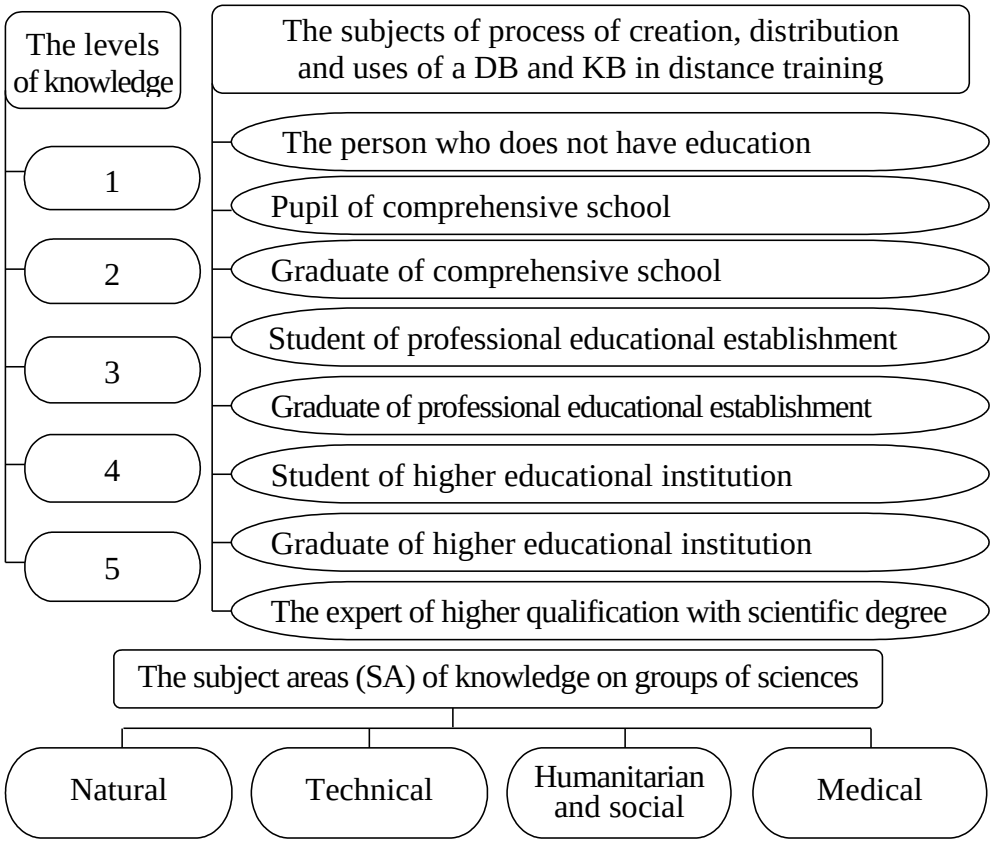
№	Name	Description
1.	Manager on innovations and development of strategies of evolution	The employee of BEE studying of dynamics of change of the strategic and perspective directions in the field of fundamental and applied science for introduction of achievements with the purpose of improvement of quality and organization of IEE of ART
2.	Methodologist	The employee of BEE who is carrying out the development of methods and strategies on the basis of achievements in the field of pedagogics for the subsequent realization of algorithms of ART and components of IEE
3.	Psychologist	The employee of BEE revealing the factors, which are influencing to the increase in efficiency of information interaction between the subjects and means of training, selecting and packing the tests for the diagnostics of IFPST (physiological, psychological, linguistic and others)
4.	Programmer	The employee of BEE who is guiding in the modern methods, approaches and technologies of programming, engaging in the program realization of different components of IEE of ART
5.	Designer	The employee of BEE owning the device of cognitive psychology and linguistics, the modern means of development of static and dynamic flat and volumetric schemes on the basis of technologies of vector and raster graphics
6.	Expert on nonlinear audio- and video-tape editing	The employee of BEE using the modern methods, technologies and program means of creation and installation of streamed audio and video
7.	Specialist on marketing	The employee of BEE conducting the marketing researches in the market of education services with the purpose of detection of consumer preferences and regularities of conjuncture of market, the change of supply and demand, develops the marketing strategies of advance of certain educational services
8.	Specialist on public relations and advertizing	The employee of BEE, developing the advertizing campaigns and actions, directed to the advance of a set of educational services in the market
9.	Lawyer	The employee of BEE, tracing the last novations and changes in the field of current legislation, who is engaging in the drawing up and introduction in the office-work of documentation for the internal and external contractors
10.	Economist	The employee of BEE, providing the attraction of sources of financing of project and distribution of means on the directions of development of ART

Table 2.5

The technical personnel

№	Name	Description
1.	Administrator of BEE or regional representative office	The employee of BEE providing the technical support of components of IEE of ART system in BEE or its regional representative offices
2.	Administrator of regional training centre or virtual representation	The employee of organization, supporting the operability of SW of regional training centre or VR, providing the support of created virtual representations and consultation of serving personnel
3.	Administrator of consulting centre	The employee of organization, providing the support of components of IEE, the creation of new VR and consultation of their employees on the technical questions of functioning of means of IEE

The subjects of IEE of ART are differentiating not only in the assigned functions and a circle of solvable tasks, but also in the categories allocated in dependence on LRKT in fact of the studying of discipline from the certain group of sciences (pic. 2.7).



Pic. 2.7. The categories of subjects of the information-educational environment of automated training and levels of their preparation on branches of scientific knowledge

Despite the complex of problems arising during the informatization of information environments of the diverse EEs and the centres of training, taking into consideration the admissible forms of training (at distance): internal, intramural-extramural, correspondence (remote – training at distance), the introduction of approaches, methods and technologies of ART gaining the special relevance, as allows to provide the accounting of requirements of a wide range of consumers and to intensify the operated technological cycle of training in IEE.

2.5.3. Components, means and technologies in the basis of the information-educational environment of the automated training

The structure of IEE of EEs provides a set of components (means of automation):

- the tool means – provide the service and technical support of AWP and network means of training in the basis of the automated IEE by the personnel which do not have the special preparation in the field of ICT;
- the electronic library – the department of EEs with a possibility of connection to the world territorially distributed network of electronic libraries by means of the diverse channels of data transmission through "WWW", and also to the certain information resources of different sort;
- the means of administrating of components – the configurating of means of IEE;
- the means of control of the process of training and the means of individual control of the level of residual knowledge, gained and acquired by the trainees;
- the means of work in the telecommunication environment, available in that region of RF, where the basic HEI and its regional representative offices is located.

It was emphasized with the need of optimization of the time of an educational cycle due to use of individually-oriented technologies and adaptive models at the realization of various components of IEE of ART system.

The analysis of diverse functions realized by the components of IEE allows to structure them in a row of subsystems at the basis of VR, the basic of which are:

- the administrative subsystem – the configurating of modules which are available at the basis of IEE, the registration of users and distribution of their access rights;
- the subsystem of personnel accounting (the electronic department of personnel) – the maintaining of personal records of users of all categories and support of electronic archive;
- the subsystem of accounting (the electronic accounting department) – provides the reflection of operations and results of financial-economy activity, including the charge of salary of employees and settlings with trainees, external contractors, state bodies and services;
- the library subsystem (the electronic library) – accumulation, storage and granting of information resources according to the powers of users according to the regulation, defined in the centre of training;
- the subsystem of organization of the training process (the dean's office) – the formation of training groups, schedules of lesson, control for the course of training process;
- the subsystem of control of knowledge and IFPST (the subsystem of testing) – the estimation of LRKT and IFPST for the current and final attestation and formation of CM;
- the subsystem of the analysis and collecting of statistics – collecting, formation and providing of statistical data about work of VR and recording of work;
- the subsystem of control for document-flow – the registration of documents in DB and release on a paper carrier of private and special documents;
- the subsystem of development and innovations – the search of new ICT for the development of IEE.

When developing IEE of ART it is necessary to consider a possibility of use of a set of traditional and modern means and technologies:

- the sources and carriers of information on subject area;
  - book – the author's work, aggregating the description of concept, approach, methodology and principle of solution of the certain problem or task;
  - dictionary and reference book – contains a set of the key concepts and definitions, used for the description of subject area and allowing to the reader to reveal the sense of studied object, process or phenomenon;
  - textbook – the main source of information, containing the verbalized description of a subject of studying for the increase of awareness of reader;
  - book of tasks – provides the development of practical skills of the solution of standard tasks by means of a specially picked up set of tasks;
  - methodical manual and laboratory practical work – allows to study the regularities of functioning of objects, processes and phenomena on macro- and micro-level by means of special models and descriptions with use of hardware (devices, materials and technical means of observation), software (packages of programs for the statistical analysis, engineering calculations, designing and modeling) and brainware (formalize the process of research);
  - normative documents and special literary sources (references) – contain standards, specifications, requirements and descriptions of difficult objects of research, devices, systems, their elements and units;
  - traditional and electronic carriers of information – allow to register the information of various type (paper, audio- and video-tapes, CD ROM, DVD-ROM and information carriers);
- the technical means of automation of display of information and increase in efficiency of process of formation of knowledge;
  - the means of display of information – allow to trace a condition of studied object, process or phenomenon (alphanumeric-digital board, device on punched tape, monitor, slide-projector and plasma panel);
  - the means of visualization – allow to provide the evident interpretation of shown information (tables, schemes, drawings and models);
  - the means of studying and monitoring – allow to watch to the difficult objects, processes and phenomena (laboratory stand, recorder-registrar, oscillograph, voltmeter, microscope, telescope and model);
  - the audial means – provide the possibility of record and reproduction of an audio-stream (tape-recorder, dictophone and language-phone office);
  - the video- and television means – provide the record and reproduction of video-flow of information (video-recorder, TV, multimedia-projector and satellite system of receiving of a television signal).

The modern technologies of realization of adaptive means of training:

- the text editors and the systems of spreadsheets ("MS Word / Excel");
- the graphic editors ("Adobe Photoshop") and the means of animation ("MM Flash");
- the control systems of DB ("MS Access", "SQL", "Oracle", "Informix" и "MySQL");
- the technologies of creation and work with hypertext ("HTML", "XML", "Perl" and "PHP");
- the multimedia-technologies ("Sound Forge" and "Sternberg Video");
- the technologies and means of development of the expert systems (the technology of creation of the "fast" prototype of the expert system);
- the technologies and means of the analysis and information support of the adaptive educational environments (offered by the author CMT and the structures of CM of the subject and means of training act as the information basis of the analysis of IEE).

The electronic textbook – the program-methodical complex, which is allowing to independently study the content of course or section, including the properties of traditional textbook, reference book, book of tasks and laboratory practical work.

The diagnostic module – the software means, intended for the automated estimation of LRKT, abilities, skills or diagnostics of IFPST.

The laboratory practical work – serves for the carrying out of observations over objects, processes, phenomena, their interrelations and properties, processing, numerical and graphic representation of results of observations and measurements, and also the studying of various theoretical aspects during practical use.

The exercise machine – develops the touch, motor and intellectual skills, includes the means for the estimation of reached level of experience adequately of the changes of intensity of training influences (complexity, speed of reaction and others).

The game programs – provide in comparison with the usual means and systems of training the additional didactic opportunities: the business games, oriented in the obtaining of the best results of solution of difficult polytypic tasks by the competing groups of trainees, and arising at the same time the information interaction between the subjects of training and the means of training in IEE is considering as the sequence of communicative steps and operations directed to formation of knowledge of trainees and studying of new subject areas by means of special approaches, algorithms and procedures in the environment of ART.

The subject-oriented environments – allow to consider the studied objects, processes and phenomena on micro- and macro-level of consideration, providing their modeling in the various scale of a spatial and temporary continuum taking into account the diverse influences of various factors of external environment.

Tasks and estimated objective of research is formulating by the teacher (tutor), and trainees at the same time provide their achievement by means of use of an admissible set of regulated operations which are carrying out in a stereotypic situation due to the choice of sequence of actions over the studied objects, pressing the buttons on the panels of interface of the means of training.

The multimedia technologies provide the support of the process of creation and introduction of multimedia-products: electronic books (textbooks), multimedia-encyclopedias, animation and others. The characteristic feature of these products is the association of textual, graphic, audio- and video-information. The technologies of multimedia and cognitive computer graphics in the basis of the automated IEE of type "virtual reality" allow to introduce and approve the innovative techniques, algorithms and technologies of personally-oriented training, assuming the displays of specially prepared audio- and video-streams.

Technologies of multimedia have turned the computer into the full-fledged interlocutor and have allowed the contingent of trainees, without leaving an educational class (house), to be systematically present in lectures of outstanding scientists and experts, to become the witnesses of historical events of past and present, to visit the known museums and cultural centres of the world, located in the different places of globe.

Multimedia-technologies have provided the emergence of book of a new generation – electronic book (textbook, dictionary, encyclopedia, reference book and book of tasks), containing, along with text and graphic images, the animation, allowing to increase of level of perception due to the parallel reproduction of an audio-stream.

The hypermedia technologies – the way of creation and formatting of electronic documents, including the text, graphic images and computer animation, the transition between information fragments in whom is carrying out by means of use of cross references in the table of contents and content.

Practically all modern help and information-searching (retrieval) systems are implementing on the basis of Web-technologies. The hypermedia-products of training appointment allow trainees to work with the large volume of material, presented in the view of text, graphics, active schemes, including a soundtrack accompanying and video-roller, that allows not only to read it, but to listen, watch, sort the materials, to do extracts and necessary documents (articles and abstracts).

Hypermedia-technologies initiated the development of geographic-information systems, which began to be applied in IEE of ART and allow to complexly submit the information about structure and principles of functioning of the difficult systems.

The network (communicational) technologies – the direction, providing the improvement of ways of exchange of information and opening the new opportunities of communication between subjects of IEE, besides, work in the local and global networks satisfies the various information needs of trainees, and also increases the level of computer literacy due to the telecommunication communication, broadens the horizons and motivates the interest to obtaining of new knowledge.

Open access to databanks and KB allows to trainees to get acquainted with scientific problems, the research of which was not completed yet, to work the small research collectives, to share the achieved results with representatives of scientific community being in the different countries of the world.

The scientific information, which was systematized and stored in databanks, allows to find new approaches, to verify own hypotheses, to create skills and receptions of the analysis, comparison and applied use of knowledge.

By means of use of the networks of telecommunications the teachers significantly increase the own information culture and have a unique opportunity of communication with the own colleagues in the whole world. It creates ideal conditions for professional communication, conducting of joint scientific, practical and methodical activity, exchange of knowledge, experience and scientific results.

The electronic mail (E-mail) acts as an economic way of automation of delivery of training materials at the presence of communicational equipment installed at various teachers and diverse trainees. Last time the given technology has received distribution as an additional way of communication at traditional and ART. The support of training process by means of use of electronic mail has caused the beginning of introduction of telecommunications in the sphere of education. The specifics of realization of process of (automated) training (at distance) demands the specific organization and coordination of flows of information, exerting the significant complex effect on the functioning of IEE of ART.

"The electronic messaging association" has conducted the researches, reflecting a tendency to the expansion of the sphere of use of E-Mail: in 1994 year the number of consumers of electronic mail has made 23 millions of users, and in 2000 year – 72 millions.

The virtual conference – allows the teachers and trainees removed from each other in considerable distance to organize the training process, which is an analog of traditional (not adaptive) training, and also to coordinate the collective work of territorially distributed trainees and to realize one of the active forms of the communicative interaction (round table, expert or business game, brain storming and others), it is implemented by means of the class of AWP on the basis of a tele-conference and "Internet"-conference.

The tele-conference – an active form of the organization of a dialogue between subjects of IEE by means of video-terminals on channels of communication (satellite and cable).

The "Internet"-conference – represent inside the modern communicational technology, which allows in the mode of real time to transfer to participants the audio- and video-stream, and also the various electronic documents, including text, tables, schedules, computer animation and video-files.

There are allocated two main modes of tele-conference, differing in the speed and regulation of exchange of information between the participants of virtual communication:

- *off-line* – there is some interval of time between the broadcast of an author's remark in conference and its reading by other participants, and it is in advance unknown the answer of each from participants of a conference;
- *on-line* – dialogue is carrying out in a real scale of time and trainee in the process of training similar to traditional, has the possibility of choice and obtaining of the necessary information at once in own computer.

The remote access to DB – allows to the users to operate with information which was stored in DB on the territorially distributed servers of network "Internet": to read, add, delete and modify the content of information resources.

The distributed architecture and technology of parallel calculations provide a gain of efficiency of functioning of information system.

"WWW"-technology – acts as the open system of hypermedia-resources, providing the transfer of hypertext, graphics, animation, audio- and video-information between a set of servers, located in the various segments of global network "Internet", and also the different local and regional segments of network "Intranet", acting as the most perspective way of virtual communication for the social, scientific, technical, educational and other purposes.

The network "Internet" is the progressive distributed information system realized on the basis of "WWW"-technology and acting as a set of regional (local) information systems (segments of network), providing by means of communicational technologies the interactive access to the information resources, containing the information on the various subject areas: science, technics, education, medicine, economics, psychology, policy, religion, jurisprudence, biology, sociology, geography, computer science, science of language and others.

According to forecasts, the informatization of establishments of education at the 4th stage of development of educational IT causes a tendency to the progressive development of methods and technologies of development of organizational, methodical and technical support of educational process for the support of the automated IEE, using in the own basis a set of technical means of automation of information processes, characteristic for the traditional (classical) educational activity: ET, laboratory practical works and books of tasks, DM, software of applied appointment, realizing the solution of auxiliary tasks of the subject of training as the final user.

The technologies of nonlinear audio- and video-tape editing – support all technological process of creation and distribution of audio- and video-streams (files, DB and computer programs) which are located on the various types of carriers (magnetic, optical and electronic), containing the various, in particular, educational information (interactive training courses, lectures, practical works and others), intended for the wide contingent of consumers differentiated on age groups, professional status and kind of activity.

The technologies of compression of information – are differentiating on archivers, audio-codecs and video-codecs, which provide the essential reduction of size of files which were stored on electronic media by the means of special algorithms.

The technologies of protection and restriction of access to information – allow to realize, along with organizational actions, the hardware and software protection of confidential information which was stored on PC and in databanks of information systems with territorially distributed architecture.

The needs of consumers of educational services in more perfect and effective approaches, methods and means of training are continuously increasing, therefore the new hardware, software and brainware for the support of IEE expedient to create only in the case of achievement of the set level of quality of technical characteristics of the existing means and technologies of ART. The relevant task is forecasting of the achieved result by means of use of the certain means of training with new architecture in IEE.

The technologies of ART in difference from traditional (classical) assume the wide use of network communicational technologies, allowing to provide access to the various information resources of IEE, and also to introduce the technologies of intellectual systems based on knowledge and methods of adaptive control (control system of adaptive training).

ART assumes the self-contained (independent) work of trainees with ET, containing the structured information on discipline (subject of studying), and also giving an opportunity to the teachers to fill the content by the information on new subject areas (problem spheres), being guided on the existing diverse information resources and due to the involvement of qualified specialists-experts.

The leading role have got the electronic libraries and virtual universities, which along with the practical use of traditional scientific and technical literary sources (references), methodical manuals, multimedia, audio- and video-information resources contain the electronic books and ET.

ET provides an intensification of efficiency of formation of knowledge of the contingent of trainees by means of, that:

- concentrates the structured information on subject area;
- provides the practically almost instant feedback with the trainee;
- helps quickly to find the necessary information, as in the traditional book search causes the considerable temporary expenses;
- at repeated requests to hypertext references and explanations allows to display the earlier studied headings by the certain color;
- allows to integrate and use the technologies of multimedia, providing the evident interpretation of information of different sort;
- contains the selections of questions in the context of each section, allowing to realize the intermediate and total testing of LRKT by means of DM;
- allows to practically use the cross references between the different sections and information fragments of a discipline, and also to activate the display of a content of external information resources.

In the dissertation by the author is presented the developed architecture of adaptive ET, operating on the basis of the created adaptive representation of information processor, including a set of diverse control modules, procedures and algorithms, allowing to realize the individually-oriented model of formation of knowledge of trainees in the automated educational environment due to the accounting of IFPST and LRKT.

2.5.4. The models and the technologies of organization of interaction of the subjects and the automated means of training

The forms of RE are choosing in dependence on requirements, purposes and tasks of training, at the same time the introduction and practical use of IT is significantly depending on the certain form of organization of training as technological process.

The level of organization and automation of IEE defines by the degree of use of IT, the quality of various regional representative offices and divisions, the complexity of topology of LAN and architecture of used means of training:

- low – IT are practically not used, for example in the traditional IEE;
- high – it is characteristic for IEE of ART and virtual universities;

In the classical IEE is possible the introduction of IT for the realization of ART and support of internal, intramural-extramural and correspondence forms of providing of educational services to the diverse contingent of trainees as the subjects of training, and also are provided the external studies or a combination of various forms of organization of process of training (at distance) on the basis of various models and technologies.

IEE of modern EEs bases in generally on use of IT of ART and allows the creation of virtual representations (universities), providing to users the open access to different information resources.

Allocate a set of models used at the organization of IEE of ART:

1. The classical models, which are applied in the traditional IEE:
   - the class-lesson model – is applied in the establishments of general (average) professional education and is implemented in the equipped classes;
   - the design-group model – is used in the establishments of higher and general (average) professional education, allows to provide the formation of groups of trainees for the certain subject of studying;
   - the individual model – is applied at holding of individual occupations of the teacher directly with the trainee (is unprofitable);
   - case model – is carried out by means of mailing of packages with materials;
2. The modern models, which are applied in the automated IEE:
   - the interactive model of automated class – ensures the systematic work of the contingent of trainees by means of specially equipped AWP in the basic EEs, its regional representative office or educational centre (also it can be successfully applied in the traditional IEE);
   - the model of distributed network training at distance with systematic control – provides the cycle of ART by means of networks “Intranet” / “Internet” through the territorial points of access to the diverse information resources by means of use of specially equipped AWP of trainees, located on the place of residence or the main work of trainee, who systematically comes in the certain consulting centre directly for the receiving of explanations and next tasks;
   - the model of virtual university – provides the full cycle of ART by means of ICT, which are maximally excluding a separation of trainees from the main work (activity).

2.6. The comparative characteristic of opportunities of the automated training systems

Tab. 2.6 directly contains the comparative characteristic of functional opportunities of various ART systems of RF and USA.

Table 2.6

The comparative characteristic of functional opportunities

№	Components	The automated (network) training systems				
		VR of IEE OE of RF (Open Net)	Cerro Coso Com College, USA	University of California, USA	San-Francisco University, USA	Jones Int. University, USA
1.	The structural units at the basis of the means of training reflecting the content of course					
1.1.	Training material	+	+	+	+	+
1.2.	Additional lectural materials	+	+	+	+	+
1.3.	Add. inf. materials	+	+	+	+	-
1.4.	Centres of inf. resources	+	+	+	+	+
1.5.	Dictionary	+	+	-	+	-
1.6.	Questionnaire of students	+	+	-	-	-
2.	The means providing automation of communication in the network "Ethernet" and (or) "Internet"					
2.1.	Room of discussions of group on-line (chat)	+	+	+	+	+
2.2.	Board of course on-line	+	+	+	-	-
2.3.	Board of HEI on-line	+	+	+	-	-
2.4.	Access to the list of students of group (Email)	+	+	+	-	-
2.5.	Access to the teacher of discipline (Email)	+	+	+	+	+
2.6.	Access to the consultant of course (Email)	+	+	-	+	-
2.7.	Consultation	+	-	-	+	-
3.	The means of testing of level of residual knowledge and individual features					
3.1.	Schedule of passing	+	+	-	-	-
3.2.	Tests of LRKT, IFPST	+	+	+	+	+
4.	The possibility of use of additional information resources (DB)					
4.1.	Addresses of students	+	+	-	-	-
4.2.	Access to estimates	+	+	-	-	-
4.3.	Board of bulletins	+	+	+	-	-
4.4.	Frequently asked questions	+	+	-	-	-
4.5.	Questionnaire of estimation of quality of course (discipline)	+	+	-	-	-
	Integrated estimation of system (component)	20/20 100%	19/20 95%	11/20 55%	10/20 50%	6/20 30%

"The scientific-research institute of informatization of the higher education" develops the requirements to IEE of automated (remote) training, and also offers the standard set of functions of virtual representation (VR) of certain EEs (educational, training or scientific centre), operating on the principle of open training (OT) in global network "Internet".

2.7. The main parameters of estimation of the modern means of training and the development of their functional opportunities

The modern experience of practical use of the electronic means of training in the automated educational environments allows to allocate a set of parameters of estimation:

- the features of architecture and the technology of realization of the components of IEE;
- the functional opportunities and consumer properties of the means of training;
- the costs on introduction and increase in efficiency from use.

The features of architecture of modern means of trainings used in IEE of ART are caused directly by existence of various components (ET, DM, laboratory practical work and book of tasks), realizing the adjacent functions and tasks:

1. The means of support of work of the teacher (surplus subject):
   - the means of formation and filling of content: designers, system of extraction and representation of knowledge, textual and graphic editors and others;
   - the means of designing of training tasks and creation of purposes of training;
   - the means of formation of algorithms of training and presentation of information;
   - the means for the realization of automated diagnostics of IFPST;
   - the means for the support of automated estimation of LRKT;
   - the means of monitoring, collecting, processing, sorting, configuration and the analysis of information, reflecting the work of trainee for the set period of time;
   - the means of processing of a posteriori data of testing of LRKT and IFPST.
2. The means of support of self-contained (independent) work of the trainee (scarce subject):
   - the means of display of information, reflecting the content of discipline (ET);
   - the means and algorithms of stimulation of studying of information and development of its understanding with a possibility of submission of explanations and directing questions, which application allows to increase the level of perception and LRKT;
   - the means of development of skills of the solution of standard tasks on the certain subject of studying (ET combining laboratory practical work and book of tasks);
   - the means of development of ability to solve the applied problems in the subject area – means of access to the scientific-technical information, means of modeling and designing, analytical and calculation-logical systems;
   - the means of generation of tasks in dependence from the individual features of trainee (IFPST) and achieved results during training (LRKT);
   - the means of development of recommendations on the basis of the analysis of a condition of the trainee;
   - the means of estimation of LRKT on the studied disciplines and IFPST.

The estimation of architecture of ET is made according to existence (YES) or absence (NO) in its the certain diverse components, realizing the certain functions in dependence from the needs of subjects of IEE of ART. The consumer usefulness of components is characterized by the list of technical capabilities, given to the teacher and the trainee as the final users of the means of training.

The consumer properties of the means of training (ET) for the teacher are shown in the support of following diverse technical and methodical opportunities:

- textual and graphic editors for the ensuring of evident submission of various information on the screen of display at developing content;
- automated creation of semantic (structural) models of discipline;
- designing of new models and algorithms at the basis of components of IEE;
- formation of tasks for the carrying out of training in the automatic (under control of the means of training on the basis of model of submission of the content of discipline) and automated (under systematic guidance of the teacher) modes, realizing the self-contained (independent) work of trainees;
- modification of algorithms and methods, realizing the testing of IFPST;
- adaptive representation of information taking into account the parameters of IFPST and LRKT;
- systematic estimation of LRKT on the basis of different scales and functions of estimation;
- the statistical analysis of a posteriori data, characterizing the resultativity of training (at distance) of the contingent of trainees for the certain period of time;
- obtaining of results of testing of knowledge on a cycle of the studied disciplines.

The consumer properties of ET for the trainee are shown in the support of the following technical and methodical capabilities of this means of training:

1. The preliminary preparation of a trainee to the work with the automated means of training, operating on the basis of TMM on subjects of studying:
   - acquaintance with various technical capabilities of the means of training of the educational centre (virtual representation) by means of instructions;
   - providing of a possibility of the choice of educational program (course);
   - differentiation of users on various groups on the level of proficiency of basic disciplines and automated means of training.
2. The work at discipline under the control of the means of training (in the automatic mode) and under the leadership of the certain teacher (in the automated mode):
   - the choice of an algorithm, technique and technology of studying of material of discipline on the various level of statement on relation to the contingent of trainees;
   - accounting of individual features (parameters) of the trainee for the realization of the automated individually-oriented and adaptive training.
3. The possibilities of means of IEE of ART for the self-contained studying of discipline:
   - in the mode of mastering of diverse information (studying of contents), when the certain means of training carry out the following functions: granting for the studying of structural model of discipline (subject of studying); the search of diverse information (on the entered key concept or word, on the table of contents, on card file – by subject and alphabetic indexes); the generation of information fragments by means of HTML and XML code; the initial, current and total control of level of assimilation of information (data); the providing of the list of references on different literary sources and information resources;

- in the mode of development of understanding (content) of information (ET and DM), when the various functions of the certain means of training include: the identification of information fragments reflecting of a theoretical part of the set subject of studying (discipline) with a low estimation of LRKT on the basis of the analysis of level of proficiency of material by means of use of a set of advance prepared tests (methods of research); the display of explanations (sub-explanations) in the case of need (mistakes); the providing of recommendations on studying of content of information fragments (viewing of semantic models of discipline, indication of possible reasons of difficulties; viewing of the list of questions, in which the trainee has given wrong answers; detection of sections (quants of information) with the low indicators of LRKT for the repeated representation of certain information fragments);
- in the mode of development of ability to solve the standard tasks of a subject of studying (book of tasks), when the various functions of the certain means of training include: the representation of statements of standard tasks in the subject area; the training of record of the formal description of standard tasks with a control of correctness; the demonstration of a set of algorithms and procedures of their application for the solution of tasks of different type; the training (at distance) to the solution of tasks in the step-by-step mode with the control of actions of the trainee and the indication of reasons of mistakes; the estimation of skills of the solution of standard tasks; the preparation of a task for the decision by means of PC; the providing of possibility of dialogue input of a task in the internal language of PC; the support of the analysis of process of performance of the certain task in the step-by-step mode directly at using PC; the display of protocol of performance of the certain task in PC; the (primary) analysis of resultant data in the dialogue mode; the (secondary) analysis of received results of performance of a task; the development of new algorithms of display of diverse information;
- in the mode of development of ability to solve the applied tasks of a subject of studying (laboratory practical work is considered as a hybrid of ET and DM), when the certain means of training support a set of various functions: the granting of expanded opportunities of formation of mathematical statements of tasks; the access to information resources from the adjacent subject areas; the display of references in special (scientific) and help literature (reference books); the possibility of visualization of the procedure of creation of an algorithm of solution of a task; the ensuring of evident representation of strategy of reasoning in the process of development of decision; the granting of necessary tool means of modeling and statistical processing of a posteriori data of experiments; the improvement of diverse methods of representation and the analysis of data;
- in the mode of estimation of level of residual knowledge, abilities and skills of the trainee (DM) created at the studying of discipline (subject of studying), when the certain means of training realize a set of various functions: the control of advance of the trainee on an educational trajectory and the identification of reached by him level of understanding of a subject of studying; the estimation of LRKT and the formation of electronic record book on the basis of achieved results and the identification of reasons of difficulties taking into account of IFPST.

4. The opportunities and functions of modern means of training for the realization of individually-oriented and adaptive training (at distance) are:
   - in the mode of adaptation of process of ART to the current level of knowledge of trainee (LRKT), when the certain means of training carry out a set of various functions: the analysis of current LRKT on stages of training; the comparison of current LRKT with demanded; the change of an algorithm of training on results of the analysis of condition of a trainee (selection of level of complexity of tasks, change of sequence of performance of tasks and modification of character of recommendations); the possibility of formation and differentiation of tasks on the level of complexity (with the set configuration and answer, and with standard and heuristic procedures of decisions); the correlation of developed by a trainee solution of a task with a reference set of decisions; the support of step-by-step control at the solution of certain tasks; the development of algorithms of detection of difficult sections for the subsequent correction of content of semantic (structural) model of discipline; the generation of content of information fragments in dependence on LRKT;
   - in the mode of adaptation of process of training to the individual features of the identity of a trainee: the analysis of anomalies of perception of information by visual and acoustic sensory systems of a trainee (identification of anomalies of refraction; perception of space and color vision); the allocation of features of information processing of the certain type (convergent and divergent intellectual abilities, learning ability and cognitive styles); the identification of features of understanding of content of information fragments (level of proficiency of language of statement of material and dictionary of key terms and level of proficiency of the elements of interface), and also accounting of technical capabilities of the means of training at generation of TI: parameters of display of information fragments (parameters of background: type of pattern, color; parameters of font: set of font, color of symbols, size of pointtype of symbols; color schemes for achromats and bichromates: protanop, deyteranop and tritanop), type of information (textual, tabular, flat scheme, volumetric scheme, sound as main, sound as accompanying, combined and special scheme); style of presentation of information (complete / detailed display, automatic / manual switching, constant / variable type of information, deep specification / abstract statement, simplicity / complexity of statement, broad enrollment / narrow set of terms), speed of statement of information (fast and slow), additional opportunities of the means of training (correction of sequence, navigation on course, addition of modules, choice of look and style of display of information, choice of speed of display, creative tasks, additional modules and sources of information), level of statement of information (level of statement of material, set of key terms and definitions and set of elements of interface of the program).

A set of consumer properties of the components of IEE of ART (ET, DM and others) characterize their quality from the point of view of a teacher and a trainee. The estimation of quality at the same time is made according to the existence (YES) or absence (NO) of this consumer property (technical characteristic).

The efficiency of application of the automated means of training estimated from the positions of achievement of a final goal of training – formation of knowledge by the trainee. Knowledge is considered as the active information, formed during ART by means of the components of IEE, capable to generate the new information in the process of functioning of a psychophysiological construct of head brain.

The estimation of knowledge of trainees in subjects of studying in IEE of ART is made on the basis of a set of tests by means of DM and includes a set of actions:

- the estimation of the level of proficiency of declarative information (formulations);
- the estimation of the skills of possession created by means of the training procedures;
- the estimation of the level of understanding, when is estimated: ability to answer the questions and to aggregate information, to form the algorithms of solution of standard tasks, ability to combine the various methods of decision on practice;
- the estimation of abilities to solve the theoretical tasks in the subject area in results of studying of content of ET and information resources of IEE of ART;
- the estimation of the skills of use of the theoretical provisions on practice in results of performance of tasks presented in a laboratory practical work;
- the estimation of ability to solve the applied tasks in the subject area in results of carrying out of a course (term), additional and practical works;
- the current, intermediate and total (examinational) estimation of residual knowledge in results of studying of the certain discipline (subject of studying) (DM).

The modern techniques of the analysis and estimation of the indicators of efficiency (resultativity) of training are based on the various criteria (indicators), allowing to significantly increase the accuracy and to reduce the accident of estimates, at the same time they can be oriented to accounting of parameters reflecting the dynamics of change of the indicators of functioning of the components of IEE of ART, and also IFPST and LRKT:

- the features of chosen educational trajectory, assuming the certain specialization, contents of educational program, planned schedule of studying of material of the certain discipline and other;
- the results of testing, which can be estimated both in the point system (five-point scale), and the level system (various number of levels of measured sign) by means of the set functions of estimation;
- the results of diagnostics of IFPST (at realization of individually-oriented and adaptive training), characterizing features of perception, processing and understanding of information-educational influences.

At the developing of architecture of the components of IEE it is necessary the accounting of features of ART.

2.8. The features of information interaction of the subjects and means of training in the automated educational environment

Considering the functioning of IEE of ART system it is possible to allocate a set of features, which are caused by the purpose appointment of its components:

1. The components of ART system interact among themselves by means of the equipment of data transmission in the communication environment of network "Intranet" / "Internet" on the basis of the certain organizational model at the transfer of information of different sort:
   - SW of information centre – provides the support of functioning of hardware and software of innovative IEE and components of ART system of basic EEs, its virtual representations, coordinates the directions of introduction and questions of operation of the means of training in its regional representative offices and training centres;
   - SW of planning and management – allows to form and process the calendar and training plans on specialty, the model of required knowledge, information about parameters of algorithms at the basis of the software and means of training for the increase in efficiency of formation of knowledge of trainees, information about used in the process of ART mathematical and program support (methodical materials, computer courses, systems of testing and other), the diverse registration information about trainees (subjects of training), the model of current knowledge of each trainee and change of indicators of IFPST;
   - SW of automation of cycle of ART – ET, DM, PCMB and electronic library;
   - SW and the technical support, realizing communication between the components of IEE – realizes the reception and transfer of various information on channels of communication, reflecting the content of a subject of studying (discipline) and technical data, providing the maximum interactivity of information interaction between subjects and means of ART in the process of self-contained (independent) work with the diverse information resources of the educational centre, and also providing the access to information DB of the other educational centres;
   - SW of analytical department – provides the processing of information and a posteriori data, reflecting the dynamics of change of resultativity of training for several years, and also the volume of provided diverse educational services on the various directions and specialties of educational preparation;
   - electronic library – provides the open access to the databank located on "WWW"-server of information centre of EEs or in the network "Internet", containing the information-search (retrieval) catalog of available TMM, the auxiliary software, the technical specification of components, including the name, authors and short annotation (bibliographic card), and also the electronic variants of theoretical courses of lectures, the autonomous and network electronic textbooks and programs for the implementation of diagnostics of LRKT.

2. The subjects of ART system solve the various tasks and operate in the automated IEE by means of the hardware and software, established on AWP, that is reached by means of a set of network services:
   - reception / transmission of messages of electronic mail – this service realizes the mode "OFFLINE" in exchange of messages between different subjects of IEE;
   - tele-conference in a real scale of time – allows to realize the mode "ONLINE" without interruption of connection until the end of information exchange on the various channels of information transfer (satellite and cable);
   - exchange of interactive messages in the mode of real time – realizes the expeditious communication of trainees with teachers in the mode "ONLINE" and "OFFLINE", allowing to hold the local and remote consultations (discussions), the discussion of projects, realizing a possibility of joint making of decision, and also allows the teachers to watch the process of digestion of material and to correct the process of ART, providing the analysis of LRKT and IFPST;
   - remote access to computing resources, warehouses of information, DB (databanks), file servers, resources of the centre of training, allows to provide the rational use of modes "OFFLINE" and "ONLINE", to lower the traffic on channels of data transmission and to provide the balancing of network loading;
   - work with the distributed information resources is the network service, provided by means of use of the information center of EEs and AWP of subjects of IEE ART, at the same time is not excluded providing the open access of the contingent of trainees to the resources of the global network "Internet".

The components of ART system in dependence from the solvable functions and tasks allow to continuously process the requests to the diverse information, located in the databank, including the several DB of applied appointment.

The channel of information interaction realizes the exchange of diverse information between the subjects and the means of IEE of ART and has a set of specific features:

1. In dependence from the features of realization of process of information exchange between the subjects and the means of IEE in the channel of information transfer:
   - at the practical use of traditional (classical) IT;
     - simplex channel – is reached at using of a board and posters, that is characteristic for a typical lecture or ordinary seminar;
     - duplex channel – is reached at the individual occupation of a teacher and a trainee, allowing them to mutually exchange the remarks;
   - at the practical use of new (innovative) IT;
     - simplex channel – is reached at the using of ET, DM, other components of IEE of ART, plasma panel, audio- and video-broadcasting, multimedia-presentation, hypermedia and flash-presentation;
     - duplex channel – is realized at the carrying out of video-conferences, and also occupations by means of use of AWP in a language-phone class.

2. In dependence from the prevailing type of used information:
   - a set of basic ways of representation of information is singled out;
     - verbal – is used in generally submission of information in the view of text, reflecting a subject of studying (humanitarian branches of knowledge);
     - tabular – information is provided by means of use of tables (it is used in a combination with a verbal, visual or sound kind);
     - visual with static graphic elements – is reached by means of display of flat and volumetric graphic schemes;
     - visual with dynamic graphic elements – is supported by means of display of flat and volumetric active graphic schemes;
     - sound – is carried out due to the reproduction of audio-stream to the contingent of trainees, reflecting the content of a subject of studying;
   - it is possible to use of the combined views with division and without division in time during the display of an object, process and phenomenon;
     - verbal with static graphic elements – textual information is followed by graphic information for the increase in efficiency of formation of knowledge (technical branches of knowledge);
     - verbal with dynamic graphic elements – textual information is followed by the reproduction of a video-stream during limited time (it is characteristic for natural-science branches of knowledge);
     - verbal with sound accompanying – information presented in the view of text is displayed to the trainee and is followed by means of audio-stream which is contained in previously prepared file;
     - visual by means of static or dynamic graphic elements with parallel reproduction of an audio-stream – is reached due to the display of static image or active graphic scheme and parallel reproduction of an audio-stream.

In a different measure the efficiency of information exchange between the subjects of training and the means of training and the network capacity (bandwidth) of a channel of information exchange between the components of IEE of ART in the network "Intranet" / "Internet" is defined by the rate of statement (representation) of verbal information, the speed of visual and sound accompanying of material (information fragments) reflecting the content of the certain subject of studying (discipline), and also the speed of storing (making of abstract) of a lecture by the specific trainee.

The most difficult for the analysis is the network distributed information system of training, as it is actualized the task of mutual exchange of information between the components of IEE in several EEs. In particular, information reflecting: the content of a set of profile disciplines, the values of parameters of IFPST, LRKT, the list of educational programs and specialties, the training plans and working programs, the individual schedules of passing of the program of training, the office and internal information.

Directly the greatest interest presents the information interaction of the subjects of training and the means of training in IEE of ART at studying technical disciplines:

- at the first stage (display of main block of information) – at first it is carried out the representation of information fragments in a verbal kind, the speed is identified by the tutor and / or automated means of training;
  - depends on the complexity and information content of information fragments, reflecting the content of discipline presented by the teacher or expert in the subject area: the level of statement for studying of material is higher, the speed of processing and storing is lower, as there are repetitions at the statement of additional fragments;
  - is defined by technical capabilities of the components of IEE of ART – a set of the functions of ET and DM, the parameters of algorithms of training, the diagnostics and display of information fragments to the contingent of trainees, the characteristics of equipment of data transmission and channel of data transmission;
  - depends on IFPST – is defined by the speed of perception, processing, understanding and making of abstract of content of information fragments, which can not be increased without use of special technical means (devices of audio-, video- and photo-registration of information in the form of data);
- at the second stage (the perception and processing of content of a set of information fragments, reflecting a theoretical part) – is carried out the choice of a way of representation and parameters of display of information is adequately to IFPST, that is implemented on the program level at the basis of ET;
  - the processing of physiological, psychological and linguistic IFPST;
  - the choice of an optimum set of the values of parameters of display of information fragments taking into account the technical opportunities of the means of training (ET) is adequately to a set of parameters, characterizing IFPST;
- at the third stage (the perception and processing of content of a set of information fragments with parallel reproduction of video- and audio-stream);
  - there is a complexity of synchronization of loading and display of elements of information content at the level of interface of ET and the subsequent determination of speed of representation of text and reproduction of multimedia files, containing the accompanying of main block of information (fragments);
  - the analysis of dynamics of efficiency of formation of knowledge of the contingent of trainees under the influence of various factors and identification of degree of influence of factors;
- at the fourth stage (the development of skills of the solution of a standard and applied tasks);
  - the selection of a set of standard tasks and filling of content of (adaptive) ET combining the various functions of the book of tasks on the program level;
- at the fifth stage (the estimation of LRKT by means of a set of the picked-up tests);
  - the choice of strategy of realization of the procedure of testing at the basis of DM and algorithm of processing of a posteriori data of testing (diagnostics).

2.9. The factors influencing on the efficiency of the formation of knowledge of trainees in the automated educational environment

ART system is considered at the same time: at-first, as the independent component of infrastructure of EEs supporting the realization of various forms of training and providing the automation of operations accompanying of educational activity; secondly, as the integral part of IEE of EEs, allowing to provide the open access to the differentiated contingent of consumers to a set of information resources, products and services due to the means of automation realized on the basis of various modern achievements in the field of ICT.

The process of formation of knowledge of trainees in the automated educational environment acts as difficult and multi-factorial: the external factors – the requirements of state and international bodies, interested in a problematics of quality of functioning and development of IEE, and also the preferences of diverse consumers of educational services; the internal factors – the features of organization of technological process of ART and the used technologies at the realization and support of means of IEE.

The heterogeneity and versatility of the analysis of this problem causes the need of elaboration of differential approach to the consideration of key factors and groups of factors, influencing on the efficiency of information interaction of subjects of IEE and formation of knowledge of trainees by means of ART system:

- at-first,- the general or system factors;
  - significantly depend on the features of organization of IEE – accounting of types and features of EEs on the different levels of the system of education;
  - are caused by the models and technologies, used at the development of ART systems – the functions of means of automation of educational process;
  - are defined by the preferences of consumers of educational services and requirements of the state bodies (regulating the policy);
- secondly,- the private, technical and personal factors;
  - are defined by the complexity of the components of IEE and the means of training, determined by a set of functions and class of solvable tasks;
  - are characterized by the way of representation of TI to the contingent of trainees;
  - are caused by the individual features of the subjects of training;
- thirdly,- the private, the factors of casual origin, which level of influence is negligible small on comparison with the degree of influence of TI, generated by the means of IEE of ART (in many cases they are not considered):
  - are caused by the mistakes, arising in the process of measurement of parameters;
  - depend on the features, conditions and requirements of organization of an experiment;
  - are caused by the correctness of selection of a set of various methods for a research of the contingent of examinees, their validity and reliability;
  - by a set of methods and features of processing of a posteriori data;
  - by the consistency and interpretation of revealed regularities.

2.10. The influence of components of the automated training system on the health of consumers

The ensuring of comfort of work and accounting of influence of the computer on the health of human are studied by ergonomics, which provisions allow to say, that the illiterate development of design of the interface of software and the organization of AWP of users of different categories cause the harmful influence on a biological construct of an organism, fast physiological and psychological fatigue.

The main problems are caused by the essential discrepancy to GOST of the means of automation of the process of training, used by trainees in EEs.

A secondary set of problems is caused by the violations by the final users of safety measures at the using of the automated means of training in IEE, as 91% of teachers do not know "The sanitary regulations and norms" in the safe use of PC in the specially equipped classes.

It is necessary to understand, that video-display terminals in the information environments of EEs have the violations of color scale of a polychromatic range at display of information, leading to an intensification of exhaustion of visual sensory system of the human and negative impact on the mentality of person (psychophysiology of perception).

By the scientific-research organizations of RF constantly are improved the approaches, methods and technologies allowing to exclude and compensate the negative impact on health of the human, for example, at the organization of formation of knowledge in IEE of ART system functioning on the basis of ICT.

By experts in the field of ophthalmology is emphasize the essential increase of load in the visual sensory system during the work of the person at the video-display terminal, that promotes a syndrome of the visual fatigue.

From the point of view of psychophysiology of perception, the made experiments demonstrate about increase of fatigue of the nervous system of a trainee during the work in the usual and computer classes supporting the equipped AWP:

- on the basis of traditional IT – with increase of operating time is observed the general fatigue at 19% and fatigue of eyes at 8,6% of trainees;
- by means of innovative computer technologies of training – the similar dependence at 24,2% and 38,3% is observed accordingly.

By many experts attention is focused in this problematics, are offered the approaches, methods, technologies of research and improvement of video-display terminals (Andrianov U.N., Arshins V.I., Brunner J., Vekker L.M., Croll V.M., Lomov B.F., Naysser U., Rakitov A.I., Sukhobskaya G.S., Haymen A. and others).

The main reason of development of pathologies consists in the imperfection of technologies of production of the units of information display (especially at a stage of their emergence), that allows to speak about significantly poor quality of released production and a narrow set of operational characteristics (resolution ability, depth of color and frequency of regeneration of image formed on the screen of display).

In particular, presence at the equipment located on the certain AWP the various certificates of conformity according to the developed existing "The sanitary regulations and norms" guarantees the safety of use of video-display terminals at the visual display of information to the final user in the various modes of symbolical and graphic display of information.

Today to the main normalized parameters characterizing the video-display terminals the expert organizations carry: the level of electromagnetic and ionizing radiation, the frequency of regeneration of image on the screen at the various indicators of resolution and depth of color, the step of dot per inch, the error of convergence of a straight line, the unevenness of distribution of brightness on the surface of display, the level of contrast, the existence of demagnetization and others.

At the same time the rational organization of AWP has essential value.

The arrangement of monitor (video-display terminal) has to provide the falling of a light stream on the right on the surface of screen, and the level of illumination of room must has to provide an admissible ratio of contrast and brightness at the display of elements of image on the surfaces of display. It is not recommended to work in the dark room, and lighting in the room must has to be mixed: natural (not pulsing) – the glow lamp and others; artificial (pulsing) – the fluorescent lamp and others. The existence of natural lighting and a window indoors creates optimum conditions for the normal functioning of the mechanism of accommodation of the visual sensory system, as provides an opportunity to the user to periodically move a point of review on much remote subject on relation to the displayed on the display image. The recommended distance from eyes to the surface of display has to be not less than 50-60 cm, and the geometrical sizes of a table and chair have to correspond to the height of a user.

There is the important problem is ensuring of electromagnetic compatibility of interaction of the subject and means of display of information (at training). Each AWP in a display class creates the electromagnetic field with the radius 1,5 m. and more, radiation proceeds not only from the display, but also from the various peripheral equipment.

The problems of emergence of harmful ionizing radiation of various wavelength are caused by the imperfection of technology of manufacture, the errors of assembly and principle of functioning of electronic gun at the basis of the electron-beam monitor. The liquid-crystal matrix at the basis of units of display of information excludes this problem.

The level of electromagnetic and ionizing radiation is registered by the special devices and has to correspond to the admissible doses for the human according to "The sanitary regulations and norms" operating (current) in the territory of RF.

The full list of recommendations can be found in "The sanitary regulations and norms 2.2.2.542-96 (03)" "The hygienic requirements to terminals, personal computers and organization of work", including the subsequent their changes and additions.

On the basis of conducted research we'll form the conclusions on the second chapter:

1. There was carried out the analysis of modern standards in the field of quality of diverse IEE, regulating the creation and the use of the adaptive means of training, allowing to realize the individually-oriented formation of knowledge of the contingent of trainees in the automated educational environment.
2. There were presented the main directions of informatization of the information environments of EEs, there was allocated the problematics of introduction and practical use of the different means of automation for the solution of various tasks of users.
3. There were listed the basic principles of the organization of IEE, the modernization of existing and introduction of new components of ART system, the features of support and service of the automated means of training on the basis of new IT.
4. There were presented the main stages of development of different information technologies and means of automation of IEE, and also the characteristic features and principles, which are considered at the developing of various components at the basis of ART system.
5. There were presented the various distinctive features at the organization of IEE, the realization and the use of ART system, and also there were allocated the main components, models and technologies used for the ensuring of information interaction between different technical means and subjects of various categories.
6. There was given the classification of the subjects of IEE involved in ART system, solving the various tasks and performing the certain functions at the work with the means of automation, in which acts a set of hardware and software used on the equipped AWP.
7. There was presented the organization and the structure of IEE, there were allocated the functions of separate components, different subsystems, means of automation, sources and carriers of information.
8. There were considered the specifics of use and distinctive features of sources and carriers of information, and also the means of automation of technological process of ART.
9. There was carried out the analysis and systematization of existing classical (traditional) and modern (computer) models and technologies of realization of information interaction between the subjects of training and the means of training.
10. There were given the results of the comparative analysis of the technical characteristics and operation opportunities of some ART systems and their components.
11. There were presented the main parameters of estimation of the modern means of training used at the basis of the automated IEE, and also their opportunities.
12. There were marked out the features of information interaction between the subjects and means of training in IEE of ART, and also factors, having significant effect on efficiency of formation of knowledge of the contingent of trainees.
13. There was proved the influence of components of ART system on health of consumers, there were considered some provisions of "The sanitary regulations and norms", operating (current) in the territory of RF and regulating the organization of AWP directly at the work of different categories of users with video-display terminals of various type.

3. The environment of automated training with the properties of adaptation based on the cognitive models

The creation of the contour of adaptation in IEE of ART system initiates the addition of PCMB, containing CM of the subject of training (parameters, reflecting IFPST) and CM of the means of training (parameters, characterizing a potentially possible set of types and kinds of TI generated by the means of training). At the same time the application of the traditional organizational models and technologies (class-lesson and design-group) at the basis of IEE of ART system with the properties of adaptation based on PCMB gets the special interest, as allows to introduce and approve the innovative approaches, methods, models and technologies at the realization of software, methodical and other types of support of the process of training.

The realization of ART system with the properties of adaptation based on PCMB affects on organizational, technical and methodical support, and also comes down to:

- the creation of the new (innovative) IEE of EEs – the development of infrastructure of educational environment of EEs and various components of ART system;
- the modifications of existing IEE (the modernization and conversion of components) – the change and addition of components, their algorithms and principles of functioning, increasing the efficiency (resultativity) of functioning of ART system.

ART represents inside the operated technological process including a set of reserves (stages, phases) providing the transformation and transfer of the initial structured data (information) from the consciousness of a teacher into the consciousness of a trainee: the extraction of primary information (the knowledge of expert in subject area); the representation of structured information by means of the certain model, reflecting the content of a subject of studying; the saving of information in DB with filling on a subject of studying; the extraction of information from DB by the means of training; the information processing taking into account a given set of parameters of display; the generation of information fragment (the sequence of information fragments); the perception of TI by the visual and acoustic sensory systems of a trainee (subject of training); the information processing by a psychophysiological construct of head brain of trainee and its understanding; the selection by an operational structures of a brain of actual information and its use in the various educational situations; the development of decision (answer the question); the analysis of correctness of received decision (answer), which content significantly influences on the efficiency of formation of knowledge, skills and experience of a trainee.

At the realization of IEE it is necessary to consider IFPST and specifics of the process of information interaction between the subjects and the means of ART system.

At the basis of the created structure of IEE there is the computer ART system, realized on the modular principle (classically), but, along with ET and DM, structurally including the module of adaptation based on PCMB, that allows to realize the individually-oriented model of training and to carry out the approbation of new algorithms and technologies at the basis of the automated means of training.

3.1. The essence of approach to the complex solution of the problem and the statement of research tasks

The offered approach to the analysis and increase in efficiency of functioning of IEE of ART system with the properties of adaptation based on the parametrical CM is the complex scientific problem, initiating a complex of various tasks, oriented on the creation of new and modification of existing components:

- the entering of modifications into the organization of ART – the addition of new functions to the diverse structural divisions of EEs (training or scientific centre);
- the introduction of modifications at the various stages of technological process of ART – addition in the scheduled planes of new actions, allowing to realize the contour of adaptation based on PCMB (CM of the subject of training and CM of the means of training);
- the improvement of algorithms and principles of functioning of the components of IEE – the realization of architecture of the adaptive ET (means of training) operating on the basis of the adaptive representation of information fragments processor, providing the accounting and processing of IFPST and LRKT, which are contained in PCMB;
- the creation of CMT, including a set of techniques and algorithms in its basis, allowing to carry out the analysis and estimation of efficiency of functioning of IEE of ART;
- the formation of structures of CM of the subject of training and CM of the means of training;
- the development of complex of programs for the automation of tasks of research.

CMT is intended for the creation, the analysis and increase in efficiency of functioning of IEE of ART system with the properties of adaptation based on CM.

The technique of use of CMT formalizes the sequence of stages of CMT, appointment and features of use for the system analysis of IEE of ART system.

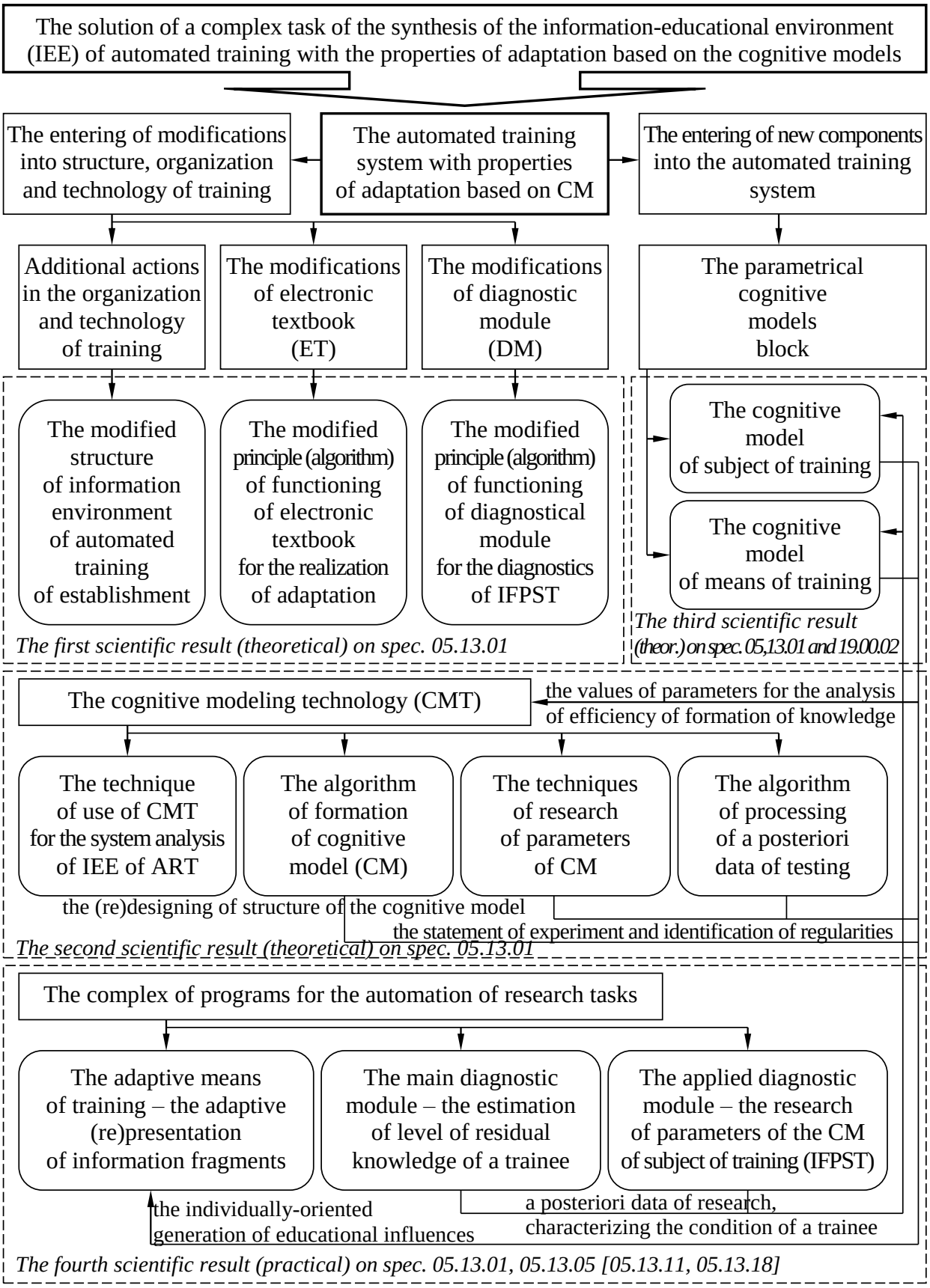
The algorithm of formation of the structure of CM allows to make the (re)designing of CM presented by means of one from the created ways of representation (the oriented graph with elements of the theory of sets, the structural scheme and others).

The technique of research of the parameters of CM provides the statement and carrying out of series of experiments directed to the research of parameters of CM by means of the applied DM, containing in DB a set of special methods of research.

The algorithm of processing of a posteriori data of testing (diagnostics) allows to form an interval scale and function of estimation, and also to calculate the values of a set of coefficients (on the basis of parameters of CM), allowing to estimate the quality of the certain test (method of research), including a set of questions and condition of a trainee (LRKT and IFPST).

The techniques and algorithms offered further are used at the various stages of iterative cycle of CMT, providing the complexity of the system analysis by means of use of the reconstructed repertoire of parameters of CM and modification of IEE of ART system with the properties of adaptation based on PCMB, including two CM.

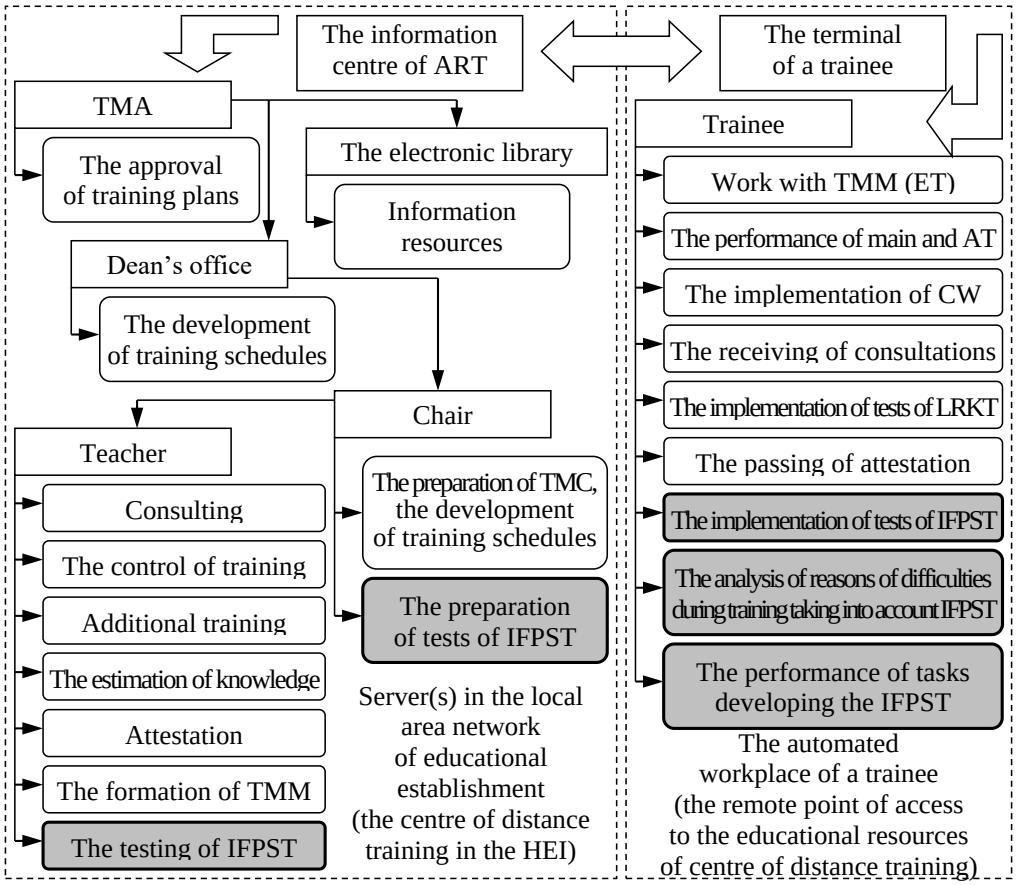
The structure of complex approach to the analysis, synthesis and increase in efficiency of functioning of IEE of ART system with the properties of adaptation based on PCMB is presented directly in pic. 3.1, including CMT, CM and a complex of programs.



Pic. 3.1. The complex approach to the creation and the analysis of the information-educational environment of automated training with the elements of adaptation based on the parametrical cognitive models block

3.2. The modifications in the organization of the information-educational environment for the realization of accounting of the individual features of the contingent of trainees

The features of organization of IEE of ART system with the properties of adaptation based on CM assume the introduction of a set of modifications presented in pic. 3.2.



Pic. 3.2. The modifications in the organization of the information environment of educational establishment for the support of accounting of the individual features of personality of the subjects of training

IC of EEs of higher education or its regional representative office serves a set of divisions: training-methodical department (TMD), dean's office of faculty, chair, laboratory, providing an educational cycle on the complex of disciplines according to the training plan, using for this purpose TMC in disciplines and involving the various teachers, owning IT of training.

IC of EEs includes AWP of teachers and trainees, equipped with technical means of access to the main components of IEE of ART system (ET and DM) and to educational resources (electronic library and resources of network "Internet").

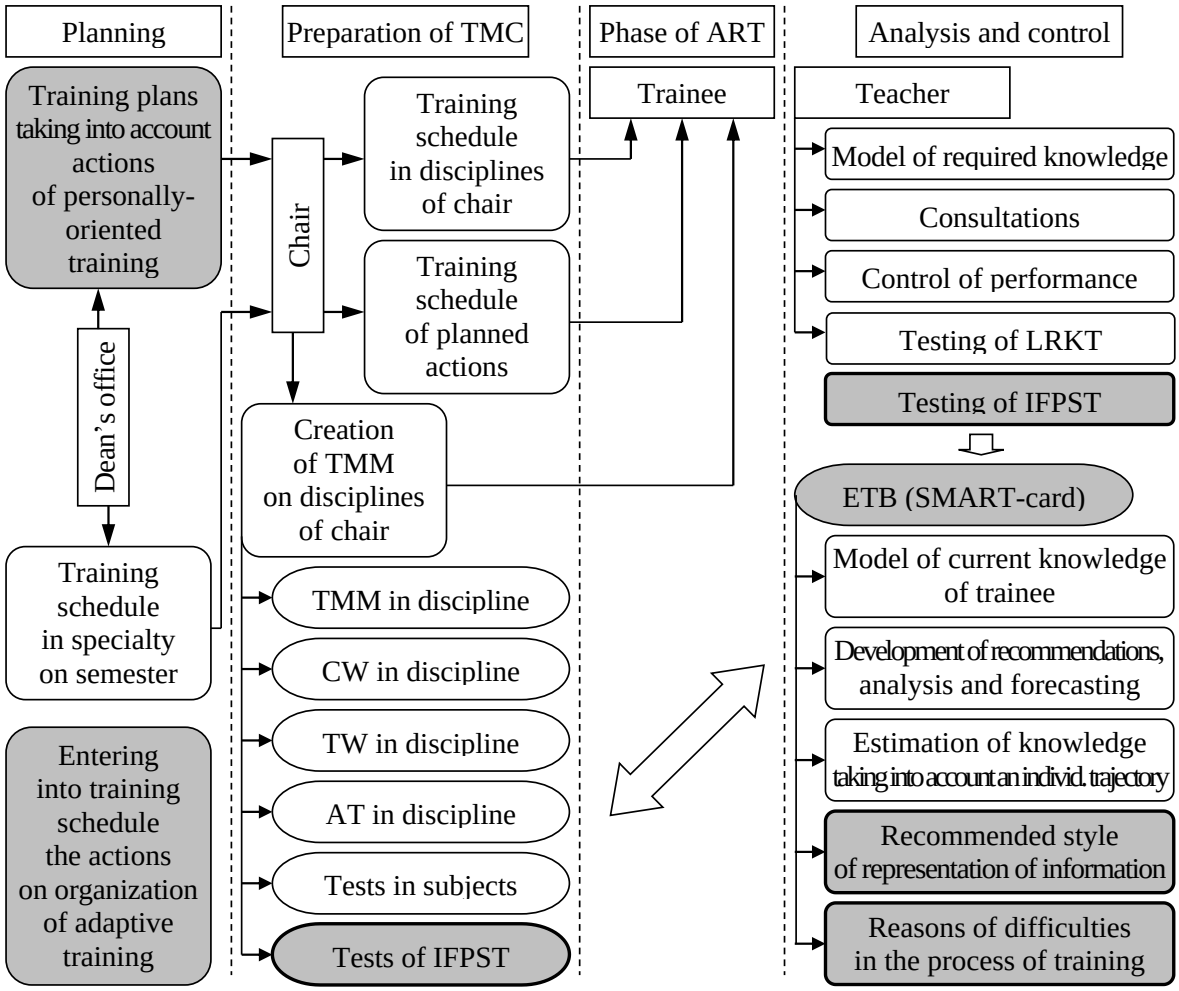
For the realization of an additional contour of adaptation on the basis of IFPST in IEE it is necessary to the organizational units to execute a set of actions (functions):

- information centre – to provide the preparation of tests of IFPST (chair or division), to carry out the testing of IFPST (teacher);
- AWP (terminal) of a trainee – at the initial stage to execute tests of IFPST and if necessary the tests of developing of IFPST (trainee).

3.3. The modifications in the technology of automated training for the realization of the contour of adaptation based on the cognitive models

ART – is the information process, constructed on the principle of a feedback and including the sequence of stages of information processing (pic. 3.3):

- the planning of the process of training on a semester – is carried out by dean's office;
- the preparation of TMC in disciplines – the formation of TMC take place at chairs;
- the phase of ART in disciplines – is realized by SW of support of a cycle of the training and the adaptive means of training (ET), exercising control of process of ART on the basis of LRKT and IFPST in the process of IW of a trainee over a complex of disciplines, using TMM on paper and electronic carriers;
- the analysis and the control – the teacher communicates with the contingent of trainees by means of a set of the technical means of IEE of ART, and also at personal contact: holds consultations, additional training and estimation of LRKT.



Pic. 3.3. The modifications in the technological process of the formation of knowledge at the realization of the automated personally-oriented training

At the stage of preparation of TMC it is required to prepare the tests of IFPST, at the stage of the analysis and control to test IFPST, and then to establish the recommended style of representation of information, the reasons of difficulties of a trainee in the process of training and to enter results in the electronic test (record) book (ETB).

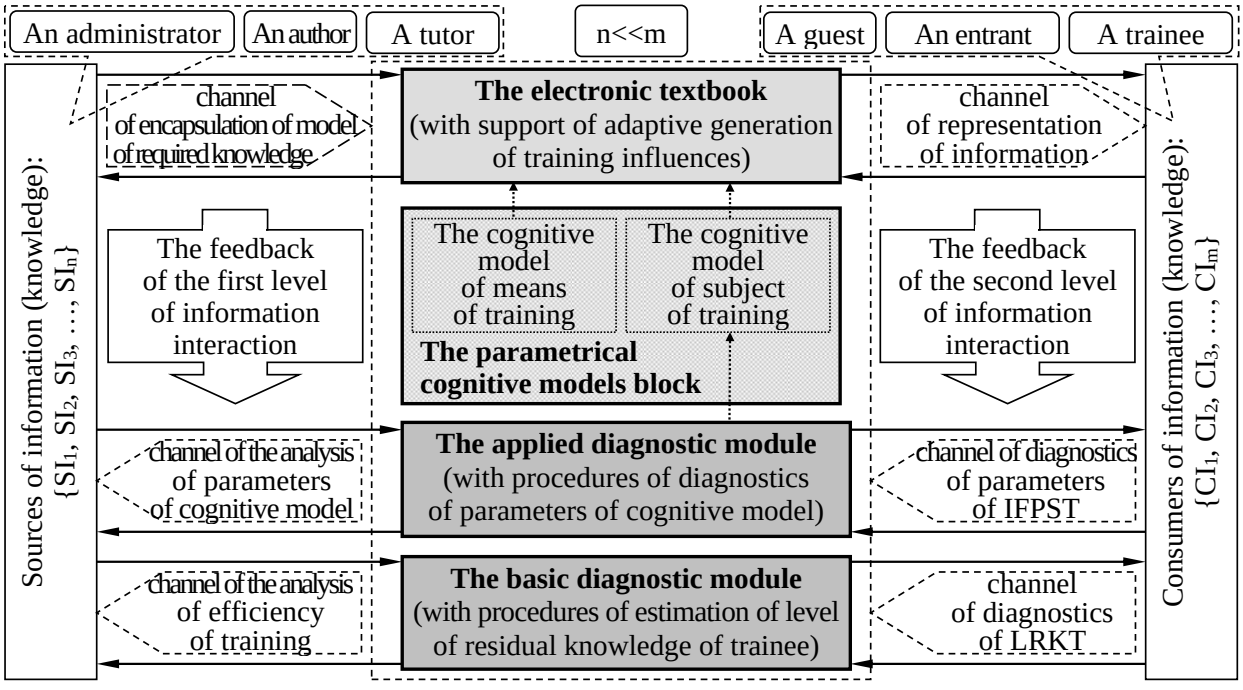
3.4. The structure of the environment of automated training with the properties of adaptation based on the cognitive models

The information environment of ART with the properties of adaptation based on CM integrates in the own basis the hardware, software and brainware at the realization of the various components (as the technical system) and the subjects of training of different categories, performing a certain set of functions in the process of solution of tasks (as a social system).

The general structure of ART system with the properties of adaptation based on the parametrical CM (pic. 3.4) includes 6 channels and 2 levels of information interaction (the direct and return connections at consideration of regularities of information interaction of the subjects of training and the means of training are researched):

- the first level – the channel of encapsulation of information as an antiderivative of knowledge (semantic model of content of discipline), the channel of the analysis of parameters of CM of the subject of training and the channel of the analysis of efficiency of training (LRKT);
- the second level – the channel of representation of structured information as a unit of knowledge, the channel of diagnostics of IFPST and the channel of testing of LRKT.

The process of information interaction as the exchange of a set of information fragments (messages) between the subjects and means of training in the certain IEE of ART system is significantly mediated – the information sources (teachers, experts in subject area and methodologists) interact with the consumers of information (entrants and trainees) by means of the use of various hardware and software components. A set of functions and tasks allows to allocate the certain components of IEE of ART.



Pic. 3.4. The structure of the automated (remote) training system with the properties of adaptation based on the cognitive models

The offered structure of IEE of ART system with the properties of adaptation based on CM includes a set of the components and channels of information exchange and forms the closed contour, in which circulates the information in the view of data of various type.

Each of the considered channels of information interaction is considered on relation to the certain component of IEE of ART system, performing a set of the functions and tasks: ET, PCMB, basic and applied DM.

The channel of encapsulation of model of required knowledge allows the teacher (expert, methodologist and psychologist) to introduce in DB of ART systems the previously structured information, reflecting the content of the certain subject of studying.

The channel of representation of information realizes the display of a set of information fragments providing the formation of knowledge of trainees.

The channel of diagnostics of IFPST provides the continuous receipt of a posteriori data of the automated research of the values of parameters of PCMB.

The channel of the analysis of the parameters of CM allows to provide the opportunity to find the statistical dependences and to reveal the regularities on the basis of a posteriori data obtained during the research of parameters of CM, which are contained in PCMB.

The channel of testing of LRKT allows to realize the broadcast of resultant values gained in the process of automated diagnostics of the level of residual knowledge of the contingent of trainees on the basis of an interval scale and function of estimation by means of a formed set of tests in the studied disciplines.

The subjects of IEE of ART system are differentiated in two categories: sources of information (tutor, teacher and expert) and consumers of information (guest, entrant and trainee) as the aggregate of knowledge of a set of disciplines. The mediation of information interaction between the subjects of training of various categories, interacting by means of the means of IEE of ART system significantly influences on the level of formation of knowledge, skills and experience of a trainee, therefore it is staticized the need of consideration of physiological, psychological and linguistic features of the channel of information exchange in IEE of ART system. The usage of presented scheme of the organization of IEE of ART system is justified, if the number of trainees (m) significantly surpasses the number of teachers (n).

Each of the presented components of IEE assumes the differentiation of access rights to the information of a different kind, which is contained in the databank, including a set of DB: DB of users of the training system, DB with content on the subjects of studying of ET, DB of tests on subjects of studying (LRKT), DB of methods of research (tests) of IFPST, DB of a posteriori results of research (diagnostics in the form of testing).

ART system – is the integral part of the modern IEE of EEs, that affects on the program realization of its components and the organization of AWP of users, at the same time are provided the various technologies of access to its resources: local – directly from the network “Intranet” of educational (scientific) centre; opened – by means of the regional educational networks and global network “Internet”.

3.4.1. The appointment and functions of the adaptive electronic textbook

The adaptive ET acts directly as the component of IEE of ART system and realizes the individually-oriented model of training by means of the adaptive representation of information fragments processor, operating on the basis of PCMB.

The saving and extraction of previously structured information in the adaptive means of training (ET) is realized by means of DB allowing to use the semantic model of representation of a content of discipline.

The general characteristics and requirements to the modern ET include:

1. It is necessary to provide a possibility of representation of each information fragment in various way: text, table, static graphic image (flat scheme or volumetric scheme) and dynamic graphic image.
2. The realization of maximum individual orientation and adaptation of the process of ART to a condition of a trainee (subject of training) is reached due to accounting of LRKT and IFPST.
3. The development of brainware and program realization of ET for the purpose of a possibility of achievement and excess of the set LRKT comparable with reached by means of use of traditional technologies (lecture and seminar).
4. For preparation and filling of ET by the content in discipline requires to previously structure the available information on a basis of the certain model of representation of knowledge (structured data) used in the architecture of ET, realizing the flexible access to DB with filling on subjects.
5. For the filling of ET by the content of a theoretical course of lectures it needs to be transformed for the storage of data on the electronic carrier of information, which subsequently can practically be used in IEE of ART, and also quickly to print out its content, that is convenient for the dynamically changing disciplines, under which works the collective of authors (experts).
6. On illustrations in ET, reflecting the difficult models, processes or devices, it is necessary to provide the possibility of change of scale of consideration, the instantly emerging hints, appearing or disappearing synchronously with the movement of cursor on the separate elements of card, plan, scheme, drawing of assembly of product, the control panel of object, the element of system and other.
7. The consideration of difficult objects in ET demands to use the multi-window interface, when each subsequent pressing of the button by the user initiates the opening of a new window containing the connected information: basic window – general plan of building; primary derivative window – plan of room or its panorama; secondary derivative window – additional information and subsequent windows.
8. ET is required to supply with the dictionary with the list of key terms and definitions, the alphabetic index, the search subsystem on a set of indexes, and the text displayed in its windows of interface must be followed by the numerous cross references, allowing to facilitate the navigation in the structure of a course and to reduce the time of search of necessary information.

The distinctive features of the developed adaptive ET are:

1. The features of realization of architecture of the adaptive ET (means of training):
   - the architecture of ET includes a set of levels: interface – provides the interaction of various categories of users in the different modes of functioning of program; kernel – a set of procedures and algorithms, realizing control and processing of data, and also the events initiated by the final user and system; access to data – contains the program mechanism of processing of inquiries for the search, saving and removal of content of information fields in DB;
   - the support of authentication of final users of various categories, registration of new and modification of personal data of existing users;
   - ET operates on the basis of the adaptive representation of information fragments processor considering IFPST which are contained in PCMB, acts as a component of the developed complex of programs for the automation of research tasks of IEE of ART and is realized with the use of object-oriented approach in the integrated RAD-environment of programming Borland C ++ Builder (and ASP.NET);
   - the architecture of ET provides a potential possibility of its functioning in coordination with DM, that allows to reveal the difficult for studying sections of discipline by means of intermediate and total control and estimation of LRKT, realizing the feedback of a teacher with a trainee for the removal of uncertainties in case of emergence of difficulties (errors) during the whole cycle of ART.
2. Requirements to information, reflecting the content of discipline (subject of studying):
   - the saving of information of various type on subject of studying is possible: text, table, graphic image, audio- and video- flow of data;
   - the information in the certain discipline or a training course needs to be deeply structured and presented in the view of a set of finished information fragments, including a set of new concepts (are added to the list);
   - it is necessary to provide the selection of model of representation of knowledge with accounting of the subsequent structuring and the use of information on discipline.
3. The features of display of the sequence of information fragments:
   - the support of change of a way of representation of the information fragments, reflecting the content of discipline (text, flat scheme, volumetric scheme, table, audio-, video-stream, active graphic elements and others);
   - the presentation of information of different type with division in time – the display of content of information fragment by the certain way adequately to the features of perception and processing of information of the subject of training;
   - a possibility of representation of information without division in time – the combined display of information fragments presented by various way for the increase of level of perception of information;
   - the preliminary installation of parameters of algorithms and determination of sequence of display of information fragments of various type.

4. The program realization of ET provides a set of various functions:
   - the support of fast authentication of users of various categories (guest, entrant, trainee, author of course, tutor and administrator);
   - the possibility of loading of personal data of a trainee, including the parameters of CM regulating the way and parameters of display of information fragments adequately to the individual features of a trainee (IFPST and LRKT);
   - the maximum flexibility at input of previously structured information, reflecting the content of discipline (subject of studying) due to the available in the mode of administration the designer of displayed content of ET;
   - supports the integration with the components realizing the laboratory practical work and the book of tasks, providing the maximum effect of perception during ART.
5. The features of realization and the use of the interface of ET (means of training):
   - the multi-language support of display of identifiers of elements of interface with a potential possibility of addition and removal of language dictionaries;
   - it is implemented the display of emerging hints (explanations) directly at start and performance by the user of incorrect actions and operations;
   - dynamic forms for each from the modes of functioning of ET;
   - each form of interface of the program is segmented on diverse groups, in which the elements, performing a certain set of functions are located;
   - the existence of elements of navigation, allowing to switch modes of operating and to choose for viewing the discipline, section, module, paragraph or page.
6. The features of realization of the modes of functioning of ET (means of training):
   - the mode of administration allows to introduce the list of groups of users, to modify their parameters and to save the structured material;
   - the mode of adaptive training allows to provide the adaptive generation of information fragments adequately IFPST (parameters of PCMB) and LRKT.
7. The realization of storage and extraction of information in ET (means of training):
   - the semantic model of saving and extraction of information allows to provide the filling of content of ET and to provide the consecutive display of a set of information fragments in various ways (text, table, flat scheme, volumetric scheme, audio-stream and video-stream);
   - the direct saving and extraction of data of information fragments, which are contained in the information fields of forms of the interface of program is carried out in the various DB, operating on the basis of relational model of data: DB of account records of users, DB with filling on subjects of studying, DB of tests of subjects, DB of tests of IFPST, DB of inactive users and reserve DB;
   - DB supports several formats and is realized on the basis of Paradox for Windows and MS SQL Server, and (micro-)program environment and environment of its execution is provided by the operating system MS Windows 2000/XP/Vista/8.1/10.

3.4.2. The appointment and functions of the basic diagnostic module

The monitoring of training (at distance) as the operated technological process providing the formation of knowledge of the contingent of trainees demands the realization of current and total estimation of LRKT by means of DM and controlling programs.

Main characteristics and requirements to the modern DM include:

1. A possibility of use of the information of various type (text, flat and volumetric scheme, static and dynamic graphic image) at display of content of each question and variants of answer to the examinee.
2. The development of the program realization of DM on the basis of innovative algorithms, providing the various strategies of display of test tasks and creation of methods of processing of answers of examinee on the basis of various scales and functions of estimation, which are directly providing the maximally possible accuracy of estimation of LRKT.
3. The realization of new algorithms at the basis of the means of monitoring and processing of a posteriori results of testing which are saved up for several years.
4. The support of structuring of elements of a test task on the basis of one from models of presentation of data (knowledge) for the optimization of storage in DB, the time of formation of the list of questions and installation of values of their parameters (quantity of possible variants of answer, type of selector of the correct variant of answer, interval of time on development of the correct answer and other parameters).
5. The realization of continuous registration of data, reflecting the answers of examinee and displayed questions, generated by the algorithm of formation of tasks of DM with support of the function of automatic selection of the list of questions taking into account the several variants of answer of examinee and LRKT, and also support of their saving on the electronic carrier of information and output on printing at necessary for the final user.
6. The support of the possibility of navigation and scaling of the displayed graphic elements accompanying the formulation of questions of test tasks, and also the realization of function of display of explanation containing the correct answer the question (with comments in case of the incorrect answer of examinee).
7. The providing of possibility of DM the function of switching between questions during the taken-away interval of time for the development of answers by the examinee.
8. The possibility of compulsory restriction of an interval of time (is set in advance), which is directly taken away during the whole cycle of automated diagnostics of LRKT and (or) on the development of answer, which is given by the examinee on each question in separateness.
9. The realization of saving of parameters of the status of examinee in DB, a possibility of configuration of a posteriori data and creation of selections for the subsequent analysis.

The support of DM a possibility of display of the list of disciplines, sections, modules, paragraphs and information fragments of discipline with a low estimate of LRKT, which are subject to repeated (additional) studying by the trainee (subject of training), and also the ensuring of fast transition to their content by means of the use of the system of references of rather semantic model of content of a subject of studying at the basis of ET.

It is necessary to carry to the main distinctive characteristics of basic DM:

1. The interface of basic DM is developed taking into account the multi-language support both at the level of identifiers of the elements of interface, and at the level of content of the displayed questions and answers, and also has the emerging hints.
2. DM provides the authentication of users of various categories, which are carrying out the various tasks and functions at the work with the basic DM.
3. The basic DM operates in several modes (are chosen by the user):
   - the mode of administrating – allows to provide the designing of a question-answers structures of test tasks, to set the parameters of display of each question, to adjust the interval scale and function of estimation of answers of examinee, to enter and modify the list of groups and personal data of examinees, and also to analyze a posteriori data of testing of LRKT;
   - the mode of diagnostics – realizes the automated testing of LRKT and formation of status of examinee (subject of training), including the quantity of correct and wrong answers, the sum of gained points, LRKT measured on various scales, providing rough and exact estimate.
4. The designer of the test tasks automates the technological process of creation of a question-answers structures and allows to modify a set of parameters of diagnostics:
   - the quantity of variants of answer on each question in the structure of test (method of research);
   - the type of selector of answer the question – the unambiguous choice (1 correct from N possible) or multiple-valued (M correct answers from N potentially possible);
   - the type of variant of answer: the fixed answer – the examinee chooses one or several variants of answer from the preset list; the opened (free answer) – it is entered by the examinee (final user) by means of the keyboard into the special empty information field; the associative answer – is reached due to installation of accessory of each element (answer) from one column (the list of answers) to the element located in other column (the list of answers);
   - the kind of information, used in formulations of a question and the list of answers: textual – contains the formulations in the view of text (textual content); graphic – contains the static and dynamic graphic elements and audio-visual – provides the reproduction of audio- or video-stream (file);
   - the existence of subsystem of explanation – allows to display to the trainee of an explanations to the certain questions in case of the choice of incorrect variant of answer the question;
   - the emerging hints – provide the display of comments about the purpose of elements of interface of DM and the arising mistakes at performance by the user of incorrect operations or the sequence of actions.
5. The procedure of testing with the use of the basic DM is implemented by means of use of a set of test tasks and algorithms of the estimation of LRKT, which are realized on the certain language of programming and are differentiated in dependence from a set of the used parameters (criteria of estimation).

3.4.3. The appointment and functions of the applied diagnostic module

The applied DM provides the automated diagnostics of IFPST by means of the use of a set of the specialized methods, allowing to reveal the physiological, psychological and linguistic features of the contingent of trainees.

The main distinctive characteristics of applied DMs are:

1. The interface of applied DM is similar to the interface of basic DM – supports the several languages, providing the choice from the available list, the addition or removal of languages and corresponding to them dictionaries:
   - the procedure of authentication of users provides the addition of new and registration in the system of the existing users of various categories.
2. The applied DM functions in the several various modes:
   - the mode of administrating – allows to provide directly the designing of the question-answers structures of test tasks, to set the parameters of display of each question (task), to adjust an interval scale and the function of estimation of examinees, to enter and modify the list of groups and personal data of examinees, and also to analyze a posteriori data of testing of LRKT;
   - the mode of diagnostics – realizes the testing of LRKT and formation of status of examinee, including the quantity of (not)correct answers, the sum of gained points, LRKT measured on various scales, providing rough and exact estimate.
3. The designer of test tasks automates the technological process of creation of a question-answers structures and allows to modify a set of parameters of diagnostics:
   - the list of names of localizations and adaptations of the method of research;
   - the list of names of blocks of questions (subtests) of the method of research;
   - the parameters of display of each question (elementary task);
     - the type of information which is contained in the formulation of question (task);
     - the parameters of display of graphics (before or synchronously with a question);
     - the kind of information, used in the formulations of question and the list of answers: textual; graphic; audio-visual; mixed and others;
   - the parameters of variants of answer the question of the method of research (test);
     - the quantity of variants of answer the question (task) entering into the subtest;
     - the type of information which is contained in the content of variants of answer the question;
     - the type of variant of answer: fixed, opened (free) and associative;
     - the way of display of variants of answer the question of the method of research (test);
     - the type of selector of the answer the question – the unambiguous choice (1 correct from N possible) or multiple-valued (M correct answers from N possible).

The procedure of testing with the use of the applied DM is implemented by means of the use of a set of test tasks and algorithms of estimation of LRKT, which are realized in the certain language of programming and are differentiated in dependence from a set of the used parameters (criteria of estimation of examinee).

3.4.4. The appointment and structure of the parametrical cognitive models block

The developed PCMB directly provides the functioning of adaptive means of training (ET) and together with it is located at the basis of structure of IEE of ART system with the properties of adaptation based on PCMB.

PCMB forms a basis for the realization of a contour of adaptation in IEE of ART system:

- CM of the subject of training – the modified in width and depth repertoire of parameters, characterizing the individual features of perception, processing and understanding of the content of information fragments, displayed to the trainee;
- CM of the means of training – accumulates a set of diverse parameters of visual and sound representation of information of various kind, provided to the trainee (subject of training) in the different way by means of the use of the certain style with the preset speed, which reflect the technical characteristics of the means of training at the individually-oriented generation of information fragments.

The structure of both CM is (re)designed by means of the use of the algorithm of formation of the structure of CM, entering in the basis of CMT (it is offered further).

At developing of the structure of parametrical CM the scientific bases of psychophysiology of perception, cognitive psychology and applied linguistics were considered.

A set of parameters of CM of the means of training is constantly specified during the whole life cycle of the program realization of adaptive ET (means of training), and their values are getting out and establishing on the basis of the technical description.

The parameters of CM of the subject of training need to be previously diagnosed by means of the applied DM, which DB contains in advance picked up a set of methods allowing to research the features of perception, processing and understanding of the certain sequence of information fragments from the field of physiology of sensory systems, cognitive psychology and applied linguistics.

Both CM concentrate the parameters, characterizing the factors, having the significant effect on efficiency of formation of knowledge of the contingent of trainees by means of the use of the means of training, located in the basis of IEE of ART.

The adaptive ET realizes the individually-oriented model of ART and contains in own basis the adaptive representation of information fragments processor, including directly two procedures of extraction of the values of parameters and three control modules providing the processing and installation of an optimum combination of physiological, psychological and linguistic parameters of display of information is adequately to IFPST by means of algorithms and procedures.

At switching off the mode of adaptive training of ET (means of training) the loading and processing of the values of parameters of PCMB is not carried out, and the adaptive representation of sequence of information fragments processor uses the values of parameters of display by default (are previously established).

PCMB directly allows to carry out the complex system analysis of information interaction between the diverse subjects and means of training, and also to characterize the efficiency of formation of knowledge of trainees in IEE of ART.

3.5. The processing and extraction of information, the structuring of data and the representation of knowledge for the filling of the electronic textbook

At developing of the adaptive intellectual means and environments of training the extraction of information, structuring and formalization of received data acts as a complex scientific problem (theoretical and practical), as it initiates the selection and the use of special methods and procedures, assuming the practical use of various means of automation on the basis of modern achievements in the field of IT, applied in the sphere of education.

The solution of this problem initiates the analysis of various stages of ART:

1. At the stage of development, modernization and reorganization of components of IEE taking into account the existence of an innovative contour of adaptation on the basis of PCMB:
   - the allocation of requirements, tasks and restrictions to the information, used in the certain component of ART system entering into the infrastructure of IEE;
   - the reorganization and modification of architecture of the components of IEE and allocation of structure of information streams between the information resources and means of training at the basis of the automated educational environment;
   - the integration of new components on the basis of features of architecture of IEE of ART system formed by the existing diverse components;
   - the allocation of essential shortcomings in the brainware and program realization of the existing components of IEE of ART system;
   - the modernization of algorithms and principles of functioning of the diverse components of ART system taking into account the made changes in the basis of IEE;
   - the installation of areas of admissible values and limits of variation in the parameters allowing to adjust the algorithms of functioning of the components of IEE of ART system and influencing on the selection of an optimum combination of the values of parameters at the generation of information fragments is adequately IFPST.
2. At the stage of configuration of the adaptive means of IEE of ART on the basis of PCMB:
   - the choice of an optimum configuration of hardware of PC and preparation of an operating system for the realization of environment of a program environment, allowing to adjust, start and execute the various components of IEE of ART, providing the support of technological process of formation of knowledge;
   - the analysis of technical capabilities of display of information by the different ways and selection of an actual set of parameters of CM of the means of training;
   - the input of identifiers of parameters of CM of the subject of training characterizing IFPST at using of the automated means of training with the elements of adaptation based on the innovative PCMB;
   - the development of manual for the users and technical specification on the software, realizing the various functions;
   - the creation of templates, containing the parameters of the automated means of training for the various categories of users.

3. At the stage of filling of DB located at the basis of the complex of programs:
   - the obtaining of information – assumes the selection of information resources, search and extraction of information from the various sources and carriers;
   - the structuring of data – the allocation of key objects and their properties, entities and concepts, relating to the considered subject of studying;
   - the formalization of received metadata – the use of one from formal or informal models of the presentation of data and knowledge (metadata);
   - the input of the values of parameters characterizing the list of groups of users of various categories and their distinctive features (IFPST);
   - the input of an actual set of parameters characterizing the features of generation of information fragments by the adaptive means of training and defining a kind of shown information, style and way of its display.
4. At the stage of preliminary diagnostics of LRKT and IFPST in the form of testing:
   - the use of basic DM for the formation of selections of questions of test by means of the certain designer of the sequence of questions, each of which assumes one or several variants of answer;
   - the selection of parameters entering the certain algorithm of testing, the setup of scales and functions of estimation of the basic and applied DM;
   - the selection of localized and adapted for the use in the certain country and region of the special methods and techniques of research of IFPST (physiological, psychological, linguistic and others), allowing to realize the collecting of reliable a posteriori data by means of the applied DM realizing the automated diagnostics;
   - the viewing of a posteriori data of diagnostics of IFPST and filling of PCMB.
5. At the stage of ART with the use of adaptation based on the innovative PCMB:
   - the setting up of the adaptive means of training (ET), assuming the check of correctness of an actual set of parameters taking into account the used requirements to the display of information, the introduced restrictions and conditions on values, characterizing the mathematical admissible limits of their variation;
   - the check of structural integrity of DB containing a set of previously established values of parameters of CM of the means of training and parameters of CM of the subject of training diagnosed by means of a set of methods at the stage of preliminary testing by means of the applied DM;
   - the primary initialization of PCMB by the values of parameters by default in case of absence of a priori preset nominal value of the certain parameter in DB of complex of programs, allowing to realize the adaptation;
   - the start of ET (means of training) in the mode of adaptive training allowing to the contingent of trainees to study the sequence of information fragments, which are individually-oriented displayed taking into account IFPST and LRKT.

6. At the stage of current (intermediate) and total testing of LRKT:
   - the formation of selections containing a set of the control questions adequately to the structured content representing inside a set of modules, sections, heads, paragraphs and information fragments of the subject of studying;
   - the development of algorithms of generation and presentation of the sequence of control questions, allowing to realize the automated diagnostics (estimation) of LRKT;
   - the development and installation of the values of parameters relating to the scales and functions of estimation of LRKT by means of a set of methods of research (tests);
   - the installation of language of statement, variant and difficulty of test, allowing to realize the automated diagnostics of LRKT of the contingent of trainees;
   - the choice of standardly the only one or several correct variants of answer to each question displayed to the examinee from in advance the formed selection of questions relating to the certain subject of studying.
7. At the stage of mathematical processing by means of a set of statistical methods:
   - the development of plan of the statistical analysis, assuming the use of various mathematical methods of processing of a posteriori data;
   - the formation and filtration of selections, the identification of emissions and artifacts;
   - the detection of compliance to the normal law of distribution of the sequence of nominal values in the selections of indicators which are the subject to the statistical analysis with use of various mathematical methods of processing of a posteriori data;
   - the selection of an optimum combination of mathematical methods from the field of statistics for the processing of received selections of data taking into account their properties and features;
   - the formulation of preliminary conclusions by means of statistical methods.
8. The identification of statistical regularities and justification of the reasons of difficulties in the process of formation of knowledge of the contingent of trainees taking into account a combination of the previously revealed values characterizing IFPST and LRKT:
   - the identification of the essential factors influencing on the increase of the efficiency of information interaction between the subjects and means of IEE of ART;
   - the analysis and improvement of the structure of CM by means of the reduction and expansion of a set of parameters of CM at the basis of PCMB in dependence on degree of their influence on efficiency of functioning of the cycle of ART in IEE;
   - the development of a new and modernization of existing brainware and software, the interface of interaction of the subjects of training and the means of training in IEE of ART, allowing to take into account IFPST and LRKT;
   - the receiving of conclusions about the possible reasons of difficulties in the technological process of formation of knowledge of trainees at the basis of the obtained statistical data and the search of ways of increase in efficiency of functioning of IEE of ART;
   - the development and modernization of algorithms in the basis of the automated means of training, the selection of optimum values of parameters of display.

The technology of extraction of knowledge of expert for the creation of TRM of ET by means of the models of representation of knowledge is based on the theory of intellectual systems, considering:

- the formalization of training as the technological process organized on the principle of feedback, including the sequence of stages;
  - the organization of IEE, including the various structural components, performing the various functions at the realization of the exchange of information of the different appointment between the diverse subjects of the process of ART;
  - the planning of the process of ART, assuming the development of the training plans, working programs, methodical support on the electronic carriers, and also methods, algorithms and automated means of training;
  - the development of approaches, principles and methods of the selection, distribution and the use of the means of automation of ART as the operated technological process;
  - the search of adequate hardware, software and methodical support on the basis of the existing and innovative achievements in the field of IT, allowing to realize ART with the use of models and technologies of individually-oriented and adaptive training (at distance);
  - the formation of knowledge of a trainee for the achievement of various levels of knowledge: the studying of subject area, the development of understanding of essence of a subject of studying and the development of ability to solve the standard tasks of subject area;
- the selection of sources and carriers of information of various type and appointment, providing the directly support of functioning of IEE of ART;
- the choice of various criteria of selection of information reflecting the most interesting regularities in the subject area (problem sphere);
- the development of models reflecting the semantic descriptions of entities and objects in the subject area for the realization of structuring and modeling with the use of achievements in the field of IT and means of automation.

TRM provides the support of process of training at the stage of selection of information, filling of the content of ET (means of training), representation and mastering of information.

The extraction and structuring of information, reflecting the content of discipline need to be made taking into account the semantic model of discipline (subject of studying), allowing to provide the saving and selection of data from DB with filling on subjects of studying by means of the adaptive representation of information fragments processor in the process of functioning of the adaptive ET (means of training).

The extraction of knowledge assumes the procedure, oriented on obtaining of information from the different sources: the competent specialist-expert in the subject area and the traditional or electronic carrier of information.

The features of architecture and the principle of functioning of adaptive ET cause the need of preliminary structuring of extracted information and its formalization by means of one from models of presentation of data (knowledge), that allows to facilitate its subsequent saving and use.

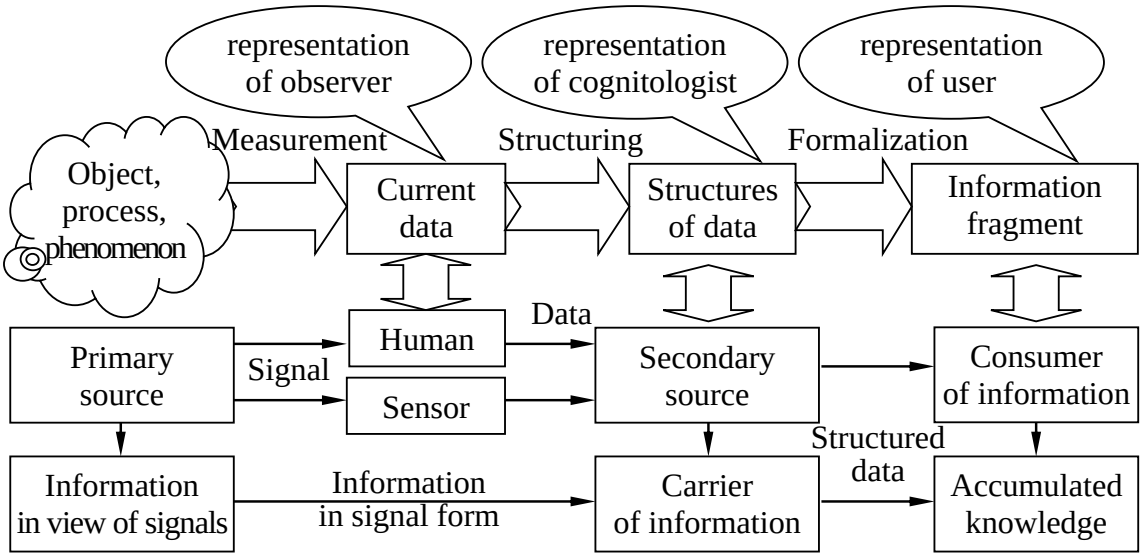
3.5.1. The classification of the sources of information

There is a large quantity of the various sources of information, providing a possibility of the use of their content in IEE of ART.

We'll mark out the several criteria of classification of the sources of information:

1. By origin (the type of carrier of information or source of information):
   - natural – a teacher (expert and author of training course), acting as the carrier of rare knowledge in one or several subject areas;
   - artificial – the traditional and electronic carriers of information, the system of artificial intelligence (the model of activity of expert), acting as the innovative hardware-software complex, functioning on the basis of DB and accumulated knowledge of expert and a limited subset of values of the facts of achievement of a goal by means of use of the decisive device (solver).
2. By position (location) in the structure of process of information exchange:
   - the primary source of information – an object, process or phenomenon, which computable (observed) isomorphism is followed by the generation of signals (information is provided in the signal form), registered by means of sensors, and the values of an observed (actual) set of parameters characterize its initial, current or final condition;
   - the secondary source of information – contains the information, which is obtained and saved up from the primary source, expressed in the form of data and intended for processing by means of the use of technical means of computer technics and its subsequent relaying to the consumer (addressee).

Object, process or phenomenon acts as a source of information and turns into the studied phenomenon, and the current data about its condition are registered and analyzed by the observer (expert or sensor), are saved on the carrier of information, are structured for the use in IEE of ART and in the view of a set of information fragments are displayed to the trainee by a different way (pic. 3.5).



Pic. 3.5. The transformation of information in the technological process of the formation of knowledge

The analysis of existing information resources, external and internal sources of information, selection of actual information, its subsequent structuring and representation for the filling of DB with content on a sets of subject areas (disciplines), and also the realization of a possibility of its use in the mode of ART is recommended to be carried out in the following sequence:

- the search of sources of information in the global information space, regional warehouses and local banks and DB, the analysis of its content;
- the carrying out of classification of information resources from the different branches of scientific knowledge (natural, technical, humanitarian and other sciences);
- the check of adequacy of the found information to the requirements, restrictions, tasks and purposes, the allocation of opportunities of its use in IEE of ART;
- the formation of information massifs and TMC, in particular reflecting the content of separate discipline (course) for the filling of various DB;
- the structuring of information on a set of quants (information fragments), relating to a part, module, section, chapter, paragraph and page, and also the choice of model of its representation in the banks and DB of components of IEE of ART system;
- the selection and installation of initial values of parameters, characterizing the ways of display of information fragments of various type of ET;
- the preparation of a set of control questions for the formation of test tasks, allowing directly to realize the systematic control of LRKT.

The components of IEE of ART in the different modes allow to accumulate and process the polytypic information by means of the use of carriers of different sort (tab. 3.1).

Table 3.1

Classification of the carriers of information, their features

№ o.a.	The name of a carrier	Indicators						Modes of work			
		Visualization	Autonomy	Replicability	Modificability	Reliability	Cost	On-line	Off-line	Training	Diagnostics
1.	Printing carriers	High	High	High	Low	High	Low		+	+	+
2.	Storages on flexible, hard, optical and electronic drives	Average	Average	High	High	Average	Average	+	+	+	+
3.	Information warehouse on Web-server	Low	Low	High	High	High	High	+		+	+

3.5.2. The knowledge acquisition methods on subject area

The extraction of information (data) of expert for the purposes of creation of TRM of ET on the basis of MRK includes the automated formation of semantic (structural) model of a subject of studying (discipline) by means of the various methods and procedures, including the selection of control questions for the support of procedure of testing.

The architecture of ET (means of training) assumes the dialogue interaction of the subjects and means of training in IEE of ART by means of a set of the forms of interface containing the various information fields and elements of interface, intended for the input and display of information of various kind, and switching between the pages with information fragments is reached by the means of the use of various panels of navigation for the final user.

Under *the information fragment* is understood the electronic book, its part, section, module, head, paragraph, subparagraph, that is the information block, having the semantic content, which decomposition is impossible or inexpedient, presented in the different way within limits one displayed screen page.

The formation and filling of information fragments by the content on the certain subject of studying is carried out on the basis of information, received from the expert (communicative basis – in the process of dialogue) or from the certain source (textual basis – in the process of studying of the sources of information).

For the optimization and automation of the process of extraction of information are applied the various methods, approaches, technologies and technical means.

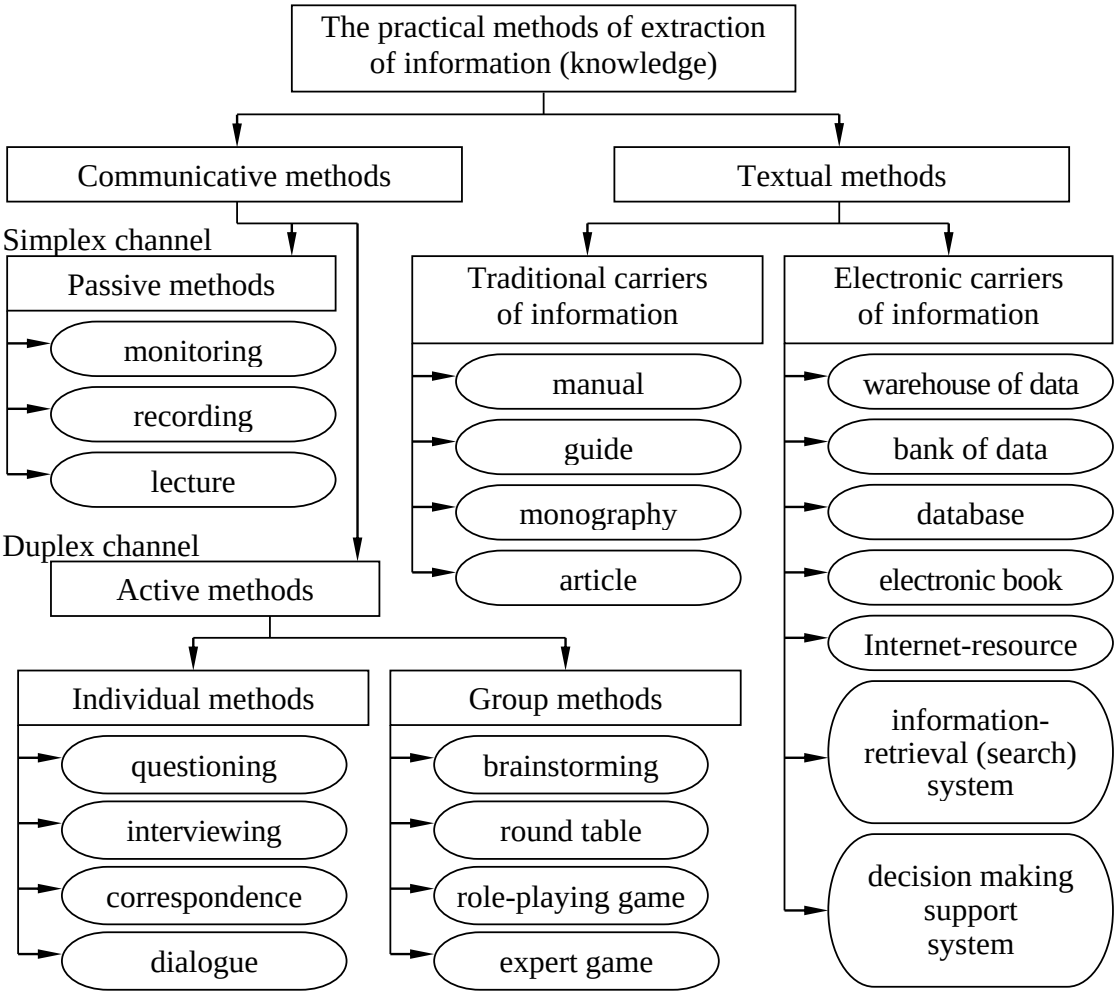
A set of practical methods of extraction of information is allocated (pic. 3.6):

1. The communicative methods – a set of methods, providing the extraction of knowledge by means of the direct contacts with the carrier of information (knowledge), which is the certain specialist-expert in the subject area.
2. The textual methods of obtaining of information – are based on the use of traditional and electronic carriers (secondary source of information), at the same time they have an essential shortcoming – the absence of stable and constant feedback with the primary source of information (expert).

The procedures of processing of traditional and electronic carriers are poorly formalized, demand the preparation and have the considerable temporary and transaction expenses, the high awareness and qualification of personnel in this subject area, therefore the textual methods of extraction of knowledge are less preferable on relation to the various communicative methods of extraction of knowledge.

The communicative methods demand the preliminary preparation of personnel: the formation of an algorithm and regulation of carrying out of extraction of knowledge with the use of one from methods of obtaining of information, the formation of the list of questions taking into account the purposes and tasks of collection of information, and also the requirements and restrictions on relation to a possibility of the use of the certain method in the given conditions (situation).

The textual methods assume the search and systematization of content of a set of various information resources containing the information of leading experts in the subject areas, access to which is implemented by means of IT.



Pic. 3.6. The practical methods of extraction and transmission of information

The communicative methods are most preferable, as they allow to ask the questions to the specialist-expert and to render the various impacts on an object of research for the intensification of receiving of necessary information:

- the passive methods – realize the simplex channel of receiving of information, at which the observer does not ask the questions to the expert and does not make any impacts on the object of research during the extraction of information;
- the active methods – cause a possibility of receiving of information (knowledge) in the process of communicative act with the specialist-expert in the subject area or at the realization of duplex information interaction between the object of research and observing device;
    - the individual methods – the receiving of information is realized in the process of a dialogue only with one carrier of knowledge or due to the registration of a condition of the only object of research at its computable isomorphism by means of the use of special sensors (registrars);
    - the group methods – the extraction of information is directly provided in parallel or consistently at the several carriers of knowledge in this subject area, or by means of observation for the several real objects, processes or phenomena, and also their models.

Each communicative method has the advantages and shortcomings:

- the communicative passive methods (monitoring, recording and lecture) – allow the use of technical means of registration of information, reflecting the knowledge of expert (computer, video-camera, dictophone and other);
- the procedure of extraction of information by means of active methods easily gives in to algorithmization, therefore is justified the application of software, automating the process of extraction of information of expert;
    - the individual methods (questioning, interviewing and dialogue) – come down to the formation and subsequent filling by the expert in subject area of the special questionnaires and forms for the poll, containing the questions and allowing to obtain the interesting information;
    - the group methods (brainstorming, round table, expert and role games) – allow to realize the receiving of information in the certain problem, and also to organize the actions for joint discussion of interesting questions and problems by the created group of experts.

Monitoring – provides the tracking of a current condition of examinee, object or technological process, and also operator, specialist or expert.

Recording – assumes the monitoring and continuous registration of a condition of the object, process or phenomenon, and also the recording of the sequence of actions of expert, who is carrying out the certain kind of activity.

Lecture – the single or systematic broadcast of information in the certain subject area by means of the simplex channel of transfer.

Questioning – assumes the preliminary selection of actual questions in subject area and formation on their basis of the special questionnaire, by means of which the manual or automated poll of expert is implemented.

Interviewing – the poll of carrier of knowledge by means of the use of the previously formed list of questions, which can be modified in the process of communicative act on the certain step of a dialogue according to the development of situation.

Dialogue – assumes the information exchange of source and consumer of information (knowledge) of natural and artificial origin by means of a duplex channel of transfer of information in the process of communicative act including a set of steps with division and without division in time.

Brainstorming – is offered the problem actual for the analysis and several participants make active the expert for the purpose of the fastest development of decision.

Round table – regulation assumes an initial formulation of problem, its consecutive discussion by the several subjects and obtaining of decision.

Role-playing game – the procedure assuming the preliminary placement of roles between the participants, and also the subsequent use and improvement of theoretical and practical skills necessary for the solution of problem.

Expert game – an analog of role-playing games, but the experts are participants.

3.5.3. The main models of the representation of knowledge

In the theory of artificial intelligence and engineering of knowledge there is a set of models of presentation of data and knowledge, among which are:

- the models for the representation of procedural data (algorithms and procedures);
  - the formal logical model – uses the Boolean algebra of logic, based on the calculation by statements and predicates of the 1st and 2nd order;
  - the productional model – is based on a set of productional kernels, each of which is equivalent to the rule of the certain structure "If [condition], then [action], else [alternative action]", including the antecedent (condition) and consequent (action) parts, which also may contain the logical operations and expressions;
- the models for the representation of declarative data (data and meta-data);
  - the frame model – represents inside the hierarchy, formed by the protoframes of the top level and frames-copies, presented in the view of tables or corteges: the identifier of frame corresponds to the name of object (essence); the identifiers of slots (fields) designate the names of properties (signs) together with their values;
  - the semantic network – represents inside the graph, in whose tops settle down the concepts (essences), and its arches reflect the relations between them;
- the models for the representation of data in the poorly formalizable subject areas;
  - the ontology – the informal way of schematic representation of structure of concepts, reflecting the connections and regularities in the subject area;
  - the universal field of knowledge – is formed on the basis of the hybrid models of representation of knowledge providing not only the high level of visualization and interpretation of declarative knowledge, but also allowing to include the procedures and methods of processing of the available structures of data allowing to combine in own basis several traditional models (logical, productional and frame models and semantic network).

The models of representation of procedural data are used at the program realization of various procedures and algorithms, providing the loading, processing, transformation and unloading of information in the process of functioning of various components at the basis of IEE of ART, allowing to realize the control of flows of information submitted by means of the models of representation of declarative data.

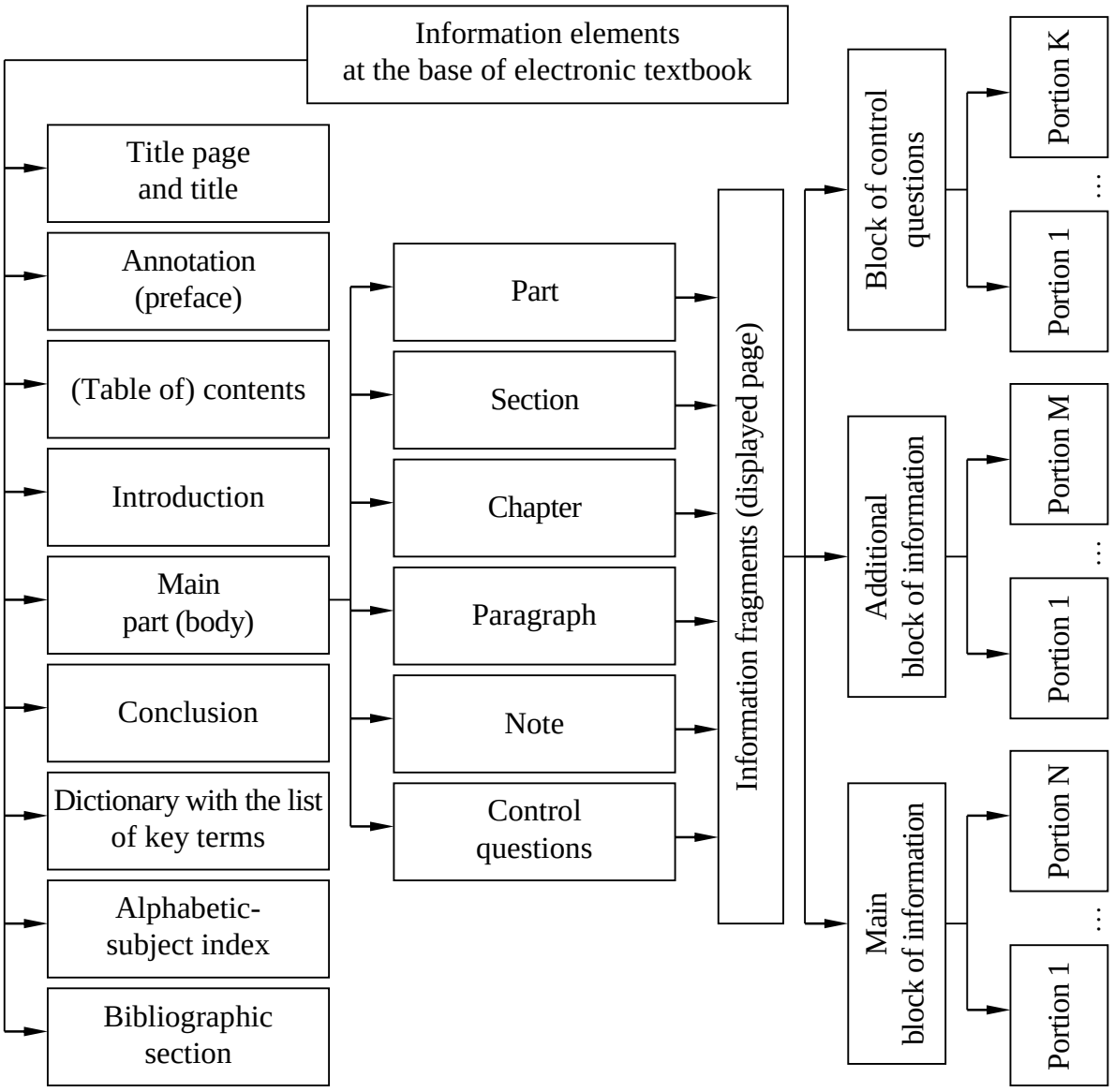
The models of representation of declarative data allow to provide the structuring, saving and extraction of information, intended for use by the various components of IEE of ART, operating on the basis of algorithms and procedures realized by means of procedural models of representation of data.

The integration of various components of IEE of ART system provides the transfer of information between them, and also allows to expand the list of solvable tasks and carried-out functions by the user, belonging to the certain category.

3.5.4. The information structure of the electronic textbook

Traditional and ET include a set of information elements (pic. 3.7):

- title page and title – the cover (page) containing the name, authors and output data about this source of literature;
- annotation (preface) – reflects the appointment and short description of source;
- (table of) contents – reflects the name of structural units of source;
- introduction – contains the introduction information on subject area;
- main part – contains the part, section, chapter, paragraph and control question;
- conclusion – contains the list of received conclusions and results;
- dictionary with the list of key terms and definitions – allows to carry out the transition to the page containing the description of certain term;
- subject index – acts as the subject rubricator of source;
- bibliographic section – includes the list of sources of literature (references).



Pic. 3.7. The information structure of the subject of studying, displayed at the level of representation of data by means of the electronic textbook

The main part in the basis of structure of ET includes the sequence of information fragments, reflecting the content of part, section, chapter, paragraph, a set of notes, displayed to the trainee, and also including the block of control questions for the realization of procedure of current and examination testing.

The information fragments, containing the main and additional parts of information, are displayed by various ways on the page of ET by means of the adaptive representation of information fragments processor, operating on the basis of PCMB. Switching between information fragments is carried out or manually with the use of the navigational panel, or automatically by means of the algorithm of training and parameters which are contained in DB.

For the purposes of saving and extraction of information the important value has the representation of information structure of a subject of studying, which allows:

- to develop the semantic model of discipline, providing;
  - the declarative part, presented by means of frame model and including the information structure of subject of studying (pic. 3.7), the alphabetic-subject index and the tree of purposes of training;
  - the procedural basis, including a set of procedures and algorithms, providing the saving, extraction, processing and individually-oriented display of content of information structure of a subject of studying (the adaptive representation of information processor);
- to realize the computing processor (kernel) in the basis of program realization of the means of training (ET), representing inside a set of procedures, providing the control of process of processing of declarative and procedural parts of data located in the semantic model of discipline;
- to create the infological scheme of databank, including the several DB, providing the fast search, saving and extraction of information of different appointment, which is contained in the view of the values of fields, located on the various forms of interface, used by the components of IEE of ART.

The main block of information includes a set of portions of TI ($\{1, M\}$), reflecting the previously structured main content of a subject of studying, displayed to the trainee in the certain sequence according to the parameters of algorithm of training and results of performance of a set of control tasks.

The additional block of information includes a set of portions of TI ($\{1, N\}$), reflecting the content of expanded sections of a subject of studying, which are displayed or are not displayed in dependence from the answers the questions of a trainee.

The block of control questions includes a previously formed set of control questions ($\{1, K\}$), allowing to realize the diagnostics of LRKT in fact of the studying of content of material, shown to the contingent of trainees by means of algorithms and procedures in the basis of ET (with and without taking into account IFPST).

3.5.5. The sequence of filling of the content of the electronic textbook by the structured information

The received information by means of the use of one from the methods of extraction of data (knowledge) is subject to saving in DB with subject content, entering into the architecture of adaptive ET, located in the basis of IEE of ART.

Information and data, which ET operates with is differentiated on declarative (values of parameters, reflecting the content of chapters, sections, paragraphs and other elements) and procedural (methods and algorithms of processing of data).

The standard architecture of ET irrespective from its functional and technical capabilities assumes the existence of several structural elements:

- kernel, including a set of procedures and algorithms, providing the processing of information of various type (procedural basis) – assumes the use of formal logical or productional model;
- databank, including a set of various DB (declarative basis) – contains the structured data of various type and appointment, formalized by means of one from the models of representation of data (frame model, semantic network, expanded field of knowledge or ontology);
- interface of user (dual basis) – includes a set of elements of interface located on the forms of application (information fields, menu, buttons and others), and also the procedures of processing of events, initiated by the user, providing the dynamic display of various information.

At the basis of DB of the means of training (ET) contains the certain model of representation of previously structured information (data and meta-structures of data).

At filling of the content of ET it is offered to adhere to the following sequence of actions and operations, which are subject to performance by the user:

1. The accumulation of information on a subject of studying is realized by means of use of one from methods of extraction of data (knowledge of expert).
2. The formation of MRK on the basis of the obtained information in this subject of studying, including the purposes, tasks, requirements, restrictions and other.
3. The structuring of information in a studying subject on the basis of MRK, allocation of modules, quants of information, information fragments (chapters, sections and paragraphs) and control questions for the testing of LRKT and IFPST, at the same time the formed selections of questions are subsequently used in general by DM.
4. The saving of formed meta-structure of data in DB with filling in the subjects of studying by means of the mode of administration of ET (means of training), operating on the basis of semantic model of discipline (subject of studying), directly providing its effective functioning.
5. The modernization of semantic model of a subject of studying taking into account the introduced novations during the whole life cycle of program realization of ET.
6. The modification of a set of parameters in the basis of the structure of CM of the means of training and CM of the subject of training (only for the mode of adaptive training).

The main requirements to the structure and content of information in the basis of ET:

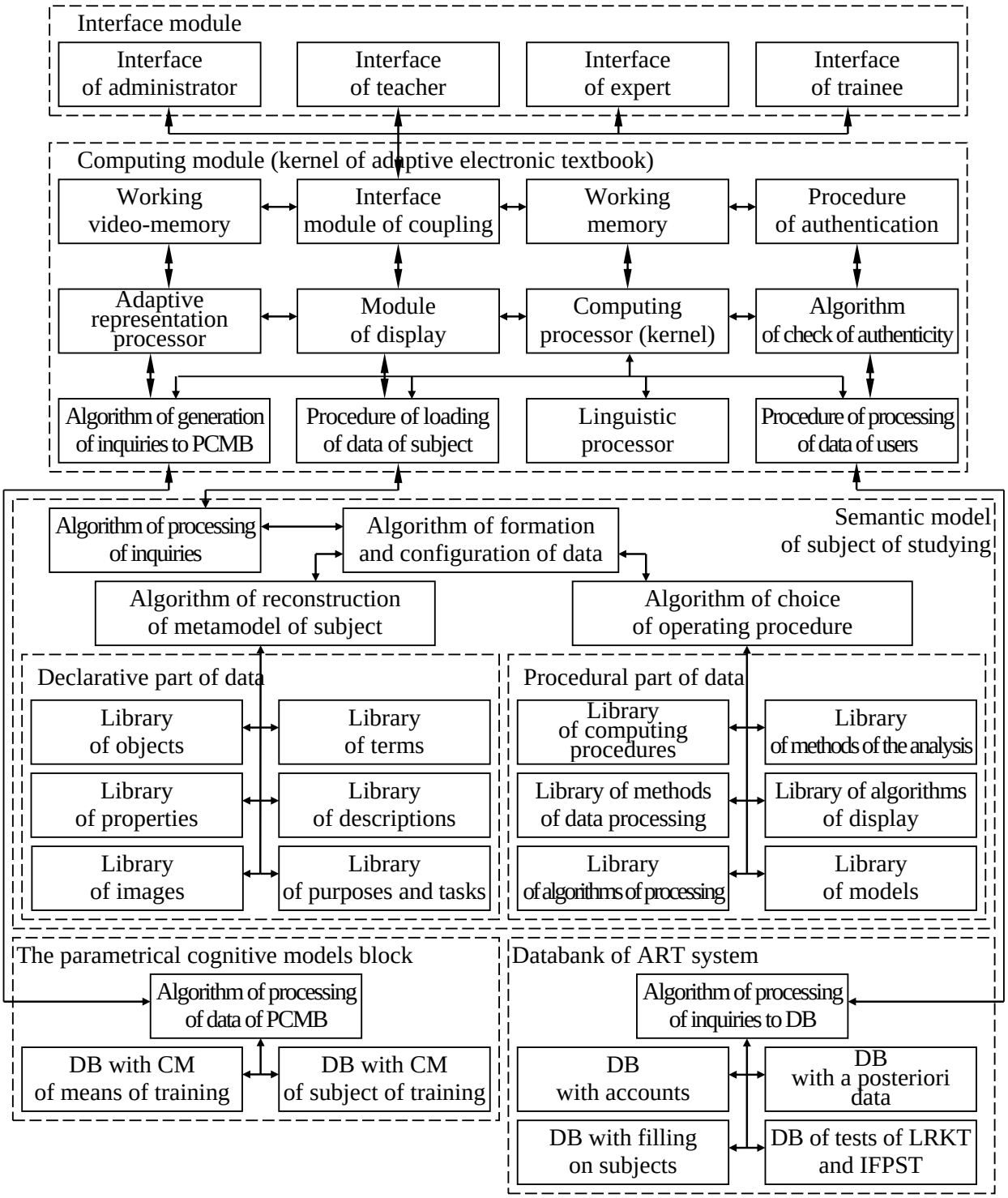
1. It is necessary to provide the structuring of obtained information of different sort and its subsequent formalization on the basis of the certain model of representation of data, providing its subsequent display by means of ET:
   - the structuring of information needs to make adequately to the presented information structure of a subject of studying (pic. 3.7);
   - the structures of data remain in DB by means of procedures on the basis of the semantic model of a subject of studying, and the extraction of data and subsequent display is realized by the adaptive representation of information processor.
2. The realization of process of ART by means of the use of ET including the dictionary of key terms and definitions for the trainees with basic level of preparation, which are getting out and adding by the author, and then are automatically displayed in the content of ET and allow to increase the level of perception of content.
3. The principle of spatial compatibility of an arrangement of elements, which are subject to display – the achievement of optimum level of perception of content of information due to the selection of optimum arrangement of information fields and areas, containing the information fragments of various kind and appointment.
4. The principle of temporary compatibility at the forming of sequence of following of information fragments – the display of text, graphic images, audio- and video-stream is realized or without division in time (parallel reproduction with the selection of a combination of the used type of information), or with division in time (consecutive reproduction of information of various type realized by an algorithm in the basis of ET).
5. The use of emerging hints with explanations at the reproduction of audio- and video-stream, and also at the display of static and dynamic information fragments, containing the flat and volumetric schemes.
6. The selection of an optimum combination of type (set of font) and size of font: the figures of correct form, containing in the own basis the straight lines and lowercase letters are perceived better, at the same time the relation of thickness of lines to the height of font must be 1:5, and the relation of height of symbol pointtype to the interval between symbols is recommended to be established within the limits from 1:0,375 to 1:0,75.
7. At the formatting of content in the traditional ET it is necessary to take into account the psychophysiological features of sensory perception of various colors of polychromatic range, which are making active and inducing the various mental conditions: the stimulating colors influence as irritants (red, orange and yellow), the disintegrant colors calm and cause a sleepy condition (violet, dark blue, blue and green), the neutral colors (pink, brown and gray), some combinations of various colors significantly increase the fatigue and can cause a stress (subject of ergonomics), especially at the using of technology of virtual reality.

8. The selection of the certain optimum combination of the color of background and font (white on darkly-blue, yellow on purple, yellow on blue and black on white).
9. The creation of high-informative two- and three-dimensional graphic images at the consideration of information interaction in the ergatic system, operating in the interactive mode by means of the display of static graphic image (the recommended size 200x150 mm) and reproduction of sound stream (the recommended duration 1 min.) irrelevant to the subject of studying causes the dispersion of attention, essential decrease of efficiency of formation of knowledge of a trainee, his fast visual, mental and respectively the general fatigue, and reproduction of video-stream in parallel with audio-stream (video-film and animated-film) allows to act the significant effect on the subconsciousness of a trainee and provides a possibility to the significantly increase in efficiency of formation of knowledge.
10. For the creation of DB with the description of new subjects of studying it is required to use the textual or communicative methods of receiving of information:
    - the textual traditional methods assume the studying of various carriers of information (instructions, manuals, guides, monographies and articles), are applied in case of absence of a direct possibility of the use of communicative methods for the formation of DB on the well structured fundamental subject areas;
    - the textual modern methods of receiving of information assume the analysis of content of specialized information resources (warehouses, databanks, DB, resources of network "Internet" and inf.-retrieval (search) systems), are applied on relation to the highly-technological and dynamically developing advanced subject areas (problem spheres);
    - the communicative passive methods (monitoring, recording and lecture) are recommended to be used in the case of impossibility of a separation of experts of the certain profession, acting as the carriers of rare knowledge and experience, who are carrying out the certain kinds of professional activity in the difficult technological processes of (non)material production;
    - the communicative active individual methods (questioning, interviewing, correspondence and dialogue) are used for the organization of extraction of information in any conditions without restrictions at the experts act as the carriers of rare knowledge and professional skills;
    - the communicative active group methods (brainstorming, round table, role and expert games) are used at the receiving of information by means of involvement of group of experts in the various subject areas and the subsequent collective discussion of dynamics of development of developed situation or functioning of difficult object, process or phenomenon according to the established technological regulation (GOST and (R)ISO).

3.5.6. The features of architecture of the adaptive electronic textbook

The architecture of adaptive ET (pic. 3.8) includes the several components:

- the interface module – contains the several interfaces for the different users;
- the computing module (kernel) – the operating procedures, algorithms and modules;
- the semantic model of the subject of studying – the declarative and procedural parts of data, relating to the content of a subject of studying;
- PCMB – includes CM of the subject of training and CM of the means of training;
- the databank – includes a set of DB of various functional appointment.



Pic. 3.8. The features of architecture of the adaptive electronic textbook

The interface of administrator provides the modification of account records.

The interface of teacher allows to provide the modernization of parameters.

The interface of expert realizes the possibility of viewing and modification of the information fragments reflecting the content of subject of studying.

The working video-memory is intended for the storage of intermediate (temporary) values of parameters, characterizing the condition of elements of interface on dynamically formed form of program realization of the adaptive ET.

The interface module of coupling provides the relaying of the values of parameters from the various DB by means of the semantic model of representation of information of the adaptive ET and a set of operating modules and procedures in its basis.

The working memory is intended for the storage of intermediate values of parameters, used by the computing procedures and algorithms of the kernel of ET.

The procedure of authentication realizes the registration of a new and existing user, the differentiation of rights of access to the information of different appointment.

The algorithm of check of authenticity provides the verification of entered data by the user on the compliance to the given template and account record in DB.

The procedure of processing of data of users forms and processes the requests to DB for the saving and extraction of the values of parameters of account records.

The adaptive representation of information fragments processor realizes the individually-oriented generation of TI by means of the selection of an optimum combination of the values of parameters of display of information of ET on the basis of accounting of potential opportunities of the means of training (values of parameters of CM of the means of training) and IFPST (nominal values of parameters of CM of the subject of training).

The module of display forms the queue of information fragments as subjects to display by the adaptive ET taking into account an optimum combination of the calculated values of parameters of display of information on the basis of PCMB.

The computing processor (computing kernel) provides the control and coordination of flows of declarative data and service information by means of the operating procedures and algorithms, realizes the coordinated functioning of all components which are available at the basis of architecture of the adaptive ET.

The algorithm of generation of inquiries to PCMB realizes the formation of inquiries to PCMB for the loading and saving of the values of parameters, which are contained in CM of the subject of training and CM of the means of training, supporting the mode of adaptive training.

The algorithm of data processing of PCMB realizes the serial processing of inquiries, search of data of a trainee in PCMB, extraction and saving of the values of parameters characterizing IFPST (physiological, psychological and linguistic), and also allows to load and modify the parameters of CM of the means of training reflecting the technical capabilities of the means of training.

The linguistic processor realizes the multi-language support of interface, the user has the possibility of choice of the certain language at the work with ET.

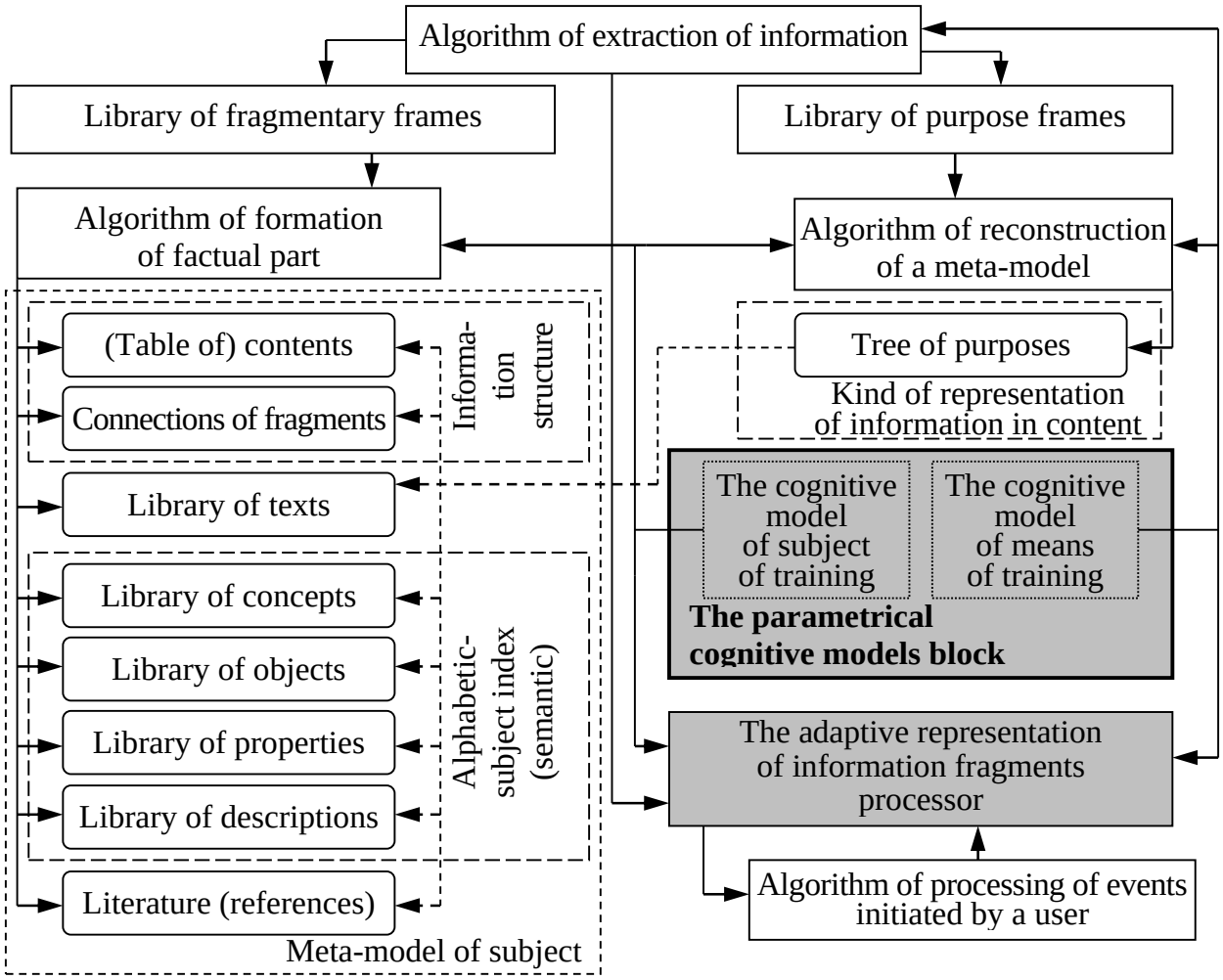
3.5.7. The semantic model of representation, saving and extraction of information

The structural (semantic) model of ET (pic. 3.9) – is based on the information structure (meta-model) of a studied subject, acts as the universal structure of data and supports a possibility of encapsulation of information in a set of disciplines.

The meta-model of the subject of studying (pic. 3.9) own represents inside the hierarchy, includes:

- the information structure – aggregates the references, allowing to get access to the content of basic elements of the meta-model of a subject of studying;
  - (the table of) contents – contains the system of references, reflecting the list of sections, modules, paragraphs, elementary pages containing the information;
  - the connections between fragments – a set of cross references between the non-adjacent information fragments, providing the navigation;
- the alphabetic-subject index – includes a set of key terms, concepts and their values, and also objects, their properties and descriptions.

The work of a teacher is followed by the extraction of his knowledge and represents inside the iterative process, on each iteration of which is realized the filling of slots of frame, corresponding to the current information fragment.



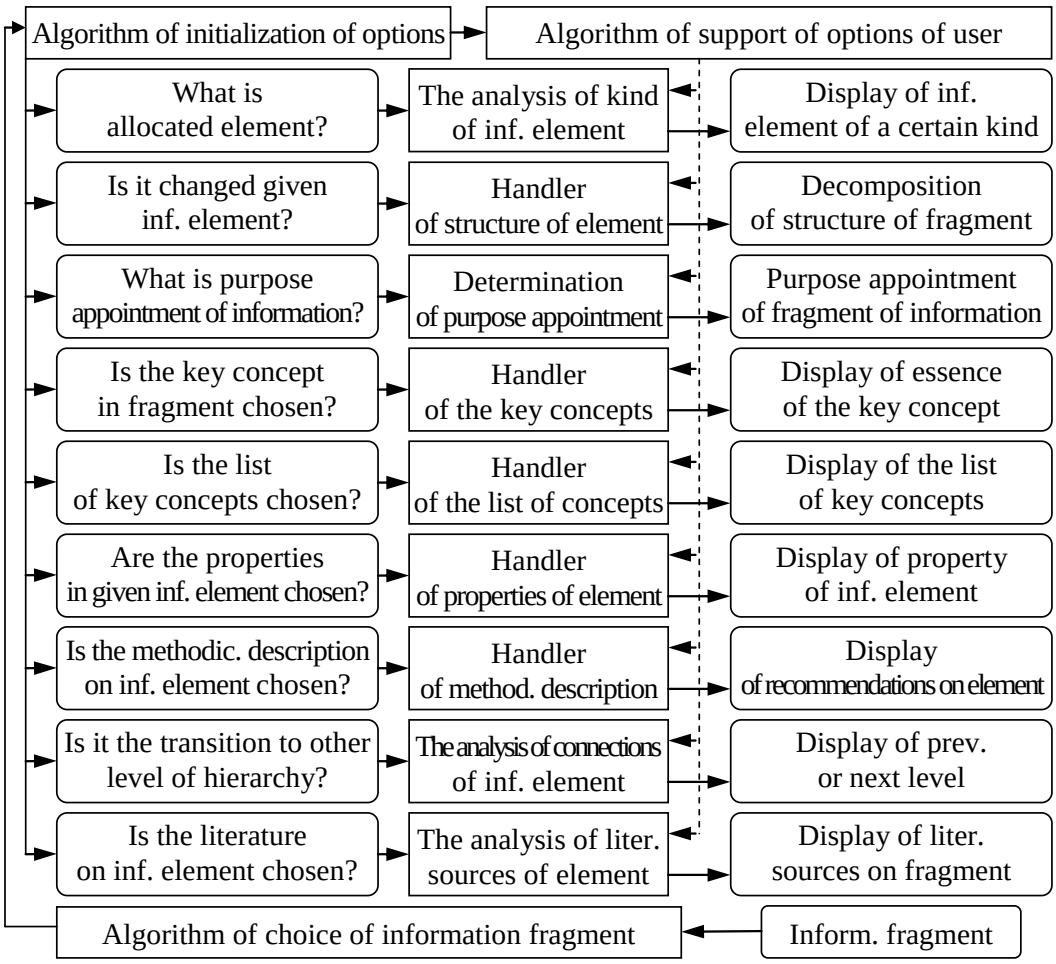
Pic. 3.9. The structural (semantic) model of representation of information in the adaptive means of training (electronic textbook)

The sequence of operations of a user come down to the issue of answers the questions, formed from the certain semantic links of derivative frames. The procedure of extraction of structured data begins with the information fragments of the top level and consistently passes to the consideration of its components.

The formation of the parts of the semantic structural model happens on the basis of the corresponding derivative frames by means of various algorithms: the frame, making the factual part of the structural model of a subject of studying (fragmentary frame) and frame, making the tree of purposes (purpose frame).

The technology of formation of the tree of purposes includes the choice of purpose appointments of information fragments from the factual part of the structural model, in result of which the certain list of purpose appointments is formed; the choice from the list the purpose appointment and filling for its the purpose frame (formation of classifications, allocation of concepts-categories in purpose appointment, decomposition of purpose appointment, the critical analysis of compliance of purpose appointment and fragment); formation on the basis of the obtained information the current condition of the tree of purposes; the choice of following purpose appointment at the display of information by means of ET.

The algorithm of processing of events initiated by the user (pic. 3.10) – the support of work of a teacher on the filling of fragmentary frames and the tree of purposes.



Pic. 3.10. The algorithm of processing of events initiated by the user in the adaptive means of training (electronic textbook)

The work of a user operating in the certain mode of functioning of program is followed by the pressing of buttons, modification of content of fields of form, that initiates the start of various procedures and algorithms, which are carrying out the data processing and arising events in the environment of program environment.

The algorithm of extraction of information operates in the coordinated mode with the adaptive representation of information processor and provides the processing of the tree of purposes of training and factual part of semantic model of the subject of studying.

The algorithm of formation of the factual part of the semantic model of a subject of studying realizes the selection of content of information fragment, including the components of the information structure of ET and library of texts, and also the elements of alphabetic-subject index (concepts, objects, their properties and descriptions).

The algorithm of processing of events initiated by the user operates the processing of events accompanying the activity of a teacher at the processing of existing fragmentary frames and modification of the tree of purposes of training. It includes the algorithms of information support of operations of a user, initiation of operations, extraction and saving of information at the work of a teacher with the semantic (structural) model (modification of fragmentary and purpose frames).

The algorithm of initialization of operations displays the information fragments (modules and questions for testing) to the teacher for the subsequent modification.

The algorithm of information support of operations of a user, functioning together with the adaptive representation processor and algorithm of extraction of information from the structural model, provides to the consumer the necessary information about current condition of the tree of purposes and factual part of structural model.

It is similarly organized the algorithmic support of the work of a teacher at the forming of tree of purposes by means of the algorithm of reconstruction of meta-model.

The semantic model is a subject to the automatic check on the completeness and consistency of data which are contained in it, that is implemented by the algorithm of a choice of information fragment, which defines the features of its processing.

TRM of ET can be used by the trainee for the self-contained (independent) work in the mode of training, and also in the mode of operated mastering of information, which is carried out by the principle of feedback (at the same time the accounting of LRKT and IFPST is implemented). In this mode the fragmentary and purpose frames, filled by the author, are a basis for the generation of questions to the trainee and the control of correctness of his answers.

The use of this technology considerably will facilitate the procedure of the analysis of IEE of ART system, and also the work of a teacher directed on the creation of ET.

Considering the features of realization of the components of ART system the need of the use of the structure of expert system is singled out, which in the best way allows to embody all listed above principles of functioning in ET. The generation of the certain information fragments is adequate to IFPST and automatic creation of a dialogue are realized on the basis of heuristic algorithms.

3.6. The formal description of the adaptive information-educational environment on the basis of the theory of control

The main requirement to the modern IEE of ART systems consists in the providing of maximum degree of individualization of the process of training by means of the realization of adaptation to IFPST on relation to each specific trainee, that is not feasible at the traditional methods of mass training.

IEE and the system of training (at distance) can include a large quantity of components, realizing the various functions. The complexity of formalization and the analysis of multi-component and multi-agent IEE, and also the realization of contours of adaptation in ART systems significantly increases with the increase of an actual set of parameters characterizing LRKT and IFPST, and also reflecting the technical characteristics and ways of presentation of information fragments.

The trainee acts as a difficult object and its exact aprioristic model does not exist, but, according to the theory of automatic control, without adaptation is impossible the creation of effective control of this object. For the formation of model of a trainee the various approaches and principles are used, in particular the attraction of innovative device of psychophysiology of perception, cognitive psychology and applied linguistics is expedient. Formalization from the point of view of the theory of automatic control causes the consideration of general principles of creation of ART systems with the model of trainee and specifics of synthesis of structure of models, including the selection of parameters.

The carrying out of research of IEE of EEs causes the allocation of the system of training from environment. The functioning of the system of training (at distance) needs to be considered taking into account the certain diverse connections of its components operating in IEE.

ART system includes ET, basic and applied DM, acts as the closed contour: ET generates a set of TI oriented on the subject of training (trainee) and providing the technological process of formation of his knowledge; DM provide the diagnostics of parameters, characterizing a condition of a trainee (LRKT and IFPST).

Many people believe, that the concepts "the system of training" and "the training system" are not identical: under the system of training understand the trainee and the training system (him), operating in IEE of certain EEs.

The training system performs as the control system of a difficult object – the trainee with his model. For the purposes of formalization the training system aggregates in own basis ET and at least one DM (actually it is necessary to use both DM).

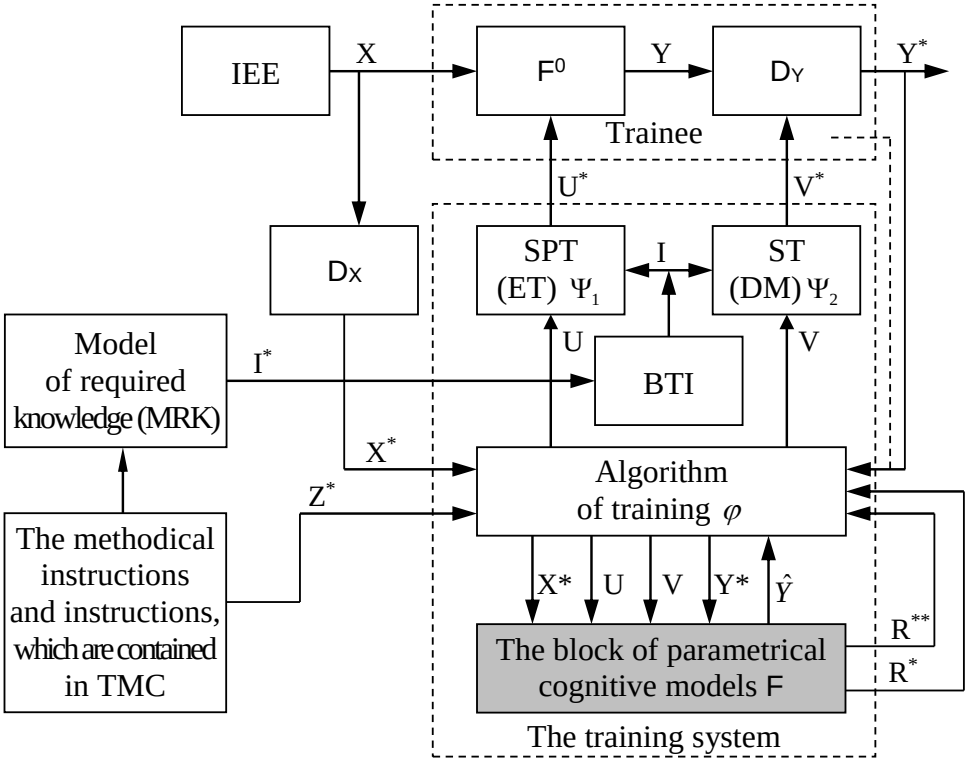
The training system on the basis of algorithm of training (linear, branched and adaptive) provides the generation of a definitely fitted set of TI oriented on the trainee adequately to the given purpose of training.

The purpose of training acts the multi-factor, as it gets out on the basis of the requirements stated in the educational standards, preferences of consumers of educational services, technical capabilities of the means of training, and also the potentially possible condition of a trainee (LRKT and IFPST) reached in IEE.

We'll formulate now the task of training more particularly and we'll formalize:

- the purpose of training Z^* – is defined by the methodical recommendations and requirements to the vocational and special preparation, the certain state educational standards and leading experts;
- TI – a set of information fragments, reflecting the content of subject of studying, shown to the trainee, under the influence of which he is provided the formation of the certain level of knowledge, abilities and necessary skills, developed according to the initial purpose of training;
- CM – a set of parameters characterizing the features of perception, processing and understanding of the content of information fragments by the subject of training, and also reflecting the potential technical capabilities at display of information in the various ways by the certain means of training (ET);
- algorithm of training – solves a dual task in IEE of ART;
  - at-first, it is as the rule of generation of the next portion of TI in the process of ART by means of the shaper of portion of TI (ET), defines the address and parameters of display of information fragments, reflecting the content of a subject of studying and which are stored in DB of the means of training;
  - secondly, realizes the formation of sequence of the question-answers structures in the part of test tasks (DM), and also provides the generation of references and parameters of display of information fragments reflecting the content of control questions and tasks entering into the test.

The training system as the element of the system of training is shown in pic. 3.11.



Pic. 3.11. The block scheme (flowchart) of the adaptive system of training with the cognitive models

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

Directly to the elements of training system are applied:

- *CM* – describes the estimation $\hat{Y}$ of the vector of condition *Y* of a trainee in the function of condition of environment *X* and TI *U*: $\hat{Y} = F(X^*, U, V, Y^*)$, and the condition *Y* of a trainee at the same time is defined by the operator *F*°: $Y = F^0(X, U^*)$, where the operator *F* of model of a trainee (subject of training) is subject to definition and adaptation in the process of training (at distance);
- *the algorithm of training* has dual appointment. At-first, it defines, what should to teach the trainee (forms the sequence of TI): $U_{in} = \varphi(X_n^*, \hat{Y}_{n-1}, Z_n^*, C_{n-1})$, where φ – algorithm of training; $\hat{Y}$ – estimation of condition of knowledge of a trainee, received by means of model F; Z^* – purpose of training, given by the tutor (a methodologist or a teacher); C – resource of training, consisting of the two components: $C = (C^*, C^{**})$, where C^* – external resource, determined by the capabilities of the system of training, C^{**} – internal resource, allocated by the trainee F^0 on the training (for example, time on training). Secondly, the algorithm of training defines the tests V, answers on which carry the information about CM F of a trainee: $V_{in} = \varphi(X_n^*, \hat{Y}_{n-1}, Z_n^*, C_{n-1})$, where Ψ – algorithm of synthesis of question-answers structures of test V;
- *the bank of training information (BTI)* contains a set of information fragments I, necessary for the assimilation by the trainee in the process of training;
- *the shaper of a portion of training (SPT)* defines the portion of information, transferred to the trainee for studying on the step of training: $U^* = \Psi_1(U, I)$, where Ψ_1 – algorithm of formation of a portion, U – addresses in BTI, and U^* – content;
- *the shaper of tests (ST)* works the similarly: $V^* = \Psi_2(V, I)$. The trainee in the system of training represents inside the "converter" of a condition of environment X and portion of training information U^* into the condition Y. Information about this condition can be obtained by means of test questions V^*: $Y^* = D_Y(Y, V^*)$, where D_Y – operator of transformation of test task V^* and condition Y of a trainee into the answer Y^* (it is realized by the own trainee).

Possible chance $U = V$, that considerably simplifies the training system.

In the presented structural scheme (block diagram) act as the key elements the model of trainee F, algorithm of training φ in the basis of the adaptive means of training (ET) and algorithm of diagnostics Ψ_2 realized in the basic and applied DM.

For the simplicity we'll assume, what takes place $U = V$, i.e. $\varphi = \{\Psi_1, \Psi_2\}$.

The previously structured material of discipline breaks into a set of information fragments (main part and additional part), to each of which there corresponds a selection (set) of the control questions.

The control questions provide the opportunity to estimate LRKT.

3.6.1. The kinds of algorithms of functioning of the main components of the automated training system

The ideas of automation of training were traced in the theory and practice of training before the emergence of cybernetics (cognitive computer science) as the scientific direction. In the middle of 20th y. of our century Pressi S.L. (USA) has created the first training machine. The training devices and programs were developed in the 50th y. by a set of scientists: Skinner B.F. (USA), Krouder N.A. (USA), Pask A.G.S. (Great Britain) and others. The concept and the term "programmed training" are entered in 1954 y. in the work of Skinner B.F., who has stated the basic principles of conception of programmed training. In our country works in the field of programmed training have begun in the 60th y. by a set of scientists: Berg A.I., Bespalko V.P., Galperin P.Ya., Glushkov V.M., Dovgyallo A.M., Yershov A.P., Itelson L.B., Leontyev A.N., Mashbits E.I., Pospelov D.A., Skibitsky E.G., Talyzina N.F., Yushchenko E.L. and others.

The development of means of computer technics causes the use of ideas of programmed training in IEE of ART, which are at present time widely developed and operated in our country and abroad. ATS – is a set of organizational actions, means of automation, methodical materials, psychological-pedagogical and mathematical methods, allowing to carry out the individualization of the process of training (at distance). ATS own includes the computer means of training with the corresponding terminal equipment, applied SW of the educational appointment and the control of LRKT, electronic library.

The modern hardware, software and brainware allows to realize the various innovative components of IEE of ART. At realization of ET and DM the key value has the brainware, allowing directly to provide the various strategies of presentation of portions of information, reflecting the content of a discipline, and also the various methods of estimation of LRKT, to improvement of which is devoted a large quantity of scientific works of many experts in the field of ICT.

The training process (at distance) in ATS is carried out in the standard scheme: the trainee is shown one or several information fragments, which he has to study, and then is defined the quality of their assimilation by means of DM providing the display of a set of questions and registering the answers, entered by the examinee. In DM is realized the automated check of correctness of answers the questions, and ET generates the next portion of TI, rendered on the trainee in IEE of ART. The check of correctness of answers of a trainee is realized by means of various algorithms.

The sequence of presentation to the trainee of portions of information, reflecting the content of discipline is defined by the training program. The training program is under construction on the basis of algorithm of training, which represents inside the rule of synthesis and selection of parameters of the algorithm of control of process of training, allowing to define on each step of process of training the next TI. There are most widespread two types of training programs – linear and branched. The branched programs divide on the internally and externally adjustable.

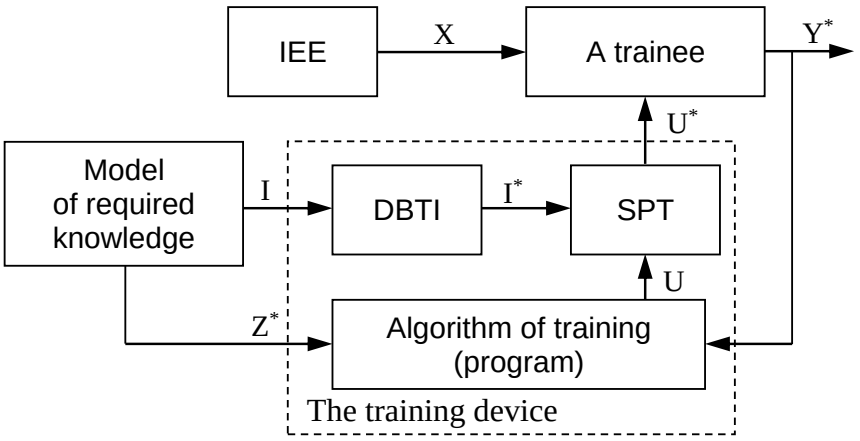
In the linear training programs the presentation of portions of TI is carried out consistently, invariantly to the answers of a trainee questions. In this case the individualization of training is not realized – the difference between trainees is expressed in the duration of passing of educational program – all trainees pass the uniform trajectory irrespective from the degree of assimilation of portions of TI by them.

Analyzing the linear training programs with positions of the theory of control, allocate the rigid (programmable) control of the process of training, which is realized without feedback. Training is under construction the irrespective of a condition of the subject of training, and the model of a trainee is supposed the known (without it the program control is impossible). The trainee (subject of training) receives the next portion of TI irrespective from the level of assimilation of the previous portion of TI, and the result is fixed in ETB.

In the linear program there is no the obvious model of a trainee (the subject of training), but implicitly it presents in the model of control of training (at distance). The portions of TI are under construction on the basis of experience and preferences of a teacher in the assumption, that the trainee, perceiving a portion of TI, surely acquires it and passes to the next portion of TI. By such principle are given the tele-bridges, lectures, seminars and conferences.

All TI breaks on N portions, renumbered from 1 to N: $I = <U_1^*, U_2^*, ..., U_N^*>$, which are given consistently to the trainee in time-points $t_1, ..., t_N$ (in it and consist the specifics of an algorithm of program training). However and into the linear program it is possible to enter the feedback Y^* (it is shown in pic. 3.12), which informs about the fact of assimilation of the next portion of TI by the trainee in IEE of ART:

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



Pic. 3.12. The black-scheme (flowchart) of the training system with linear program

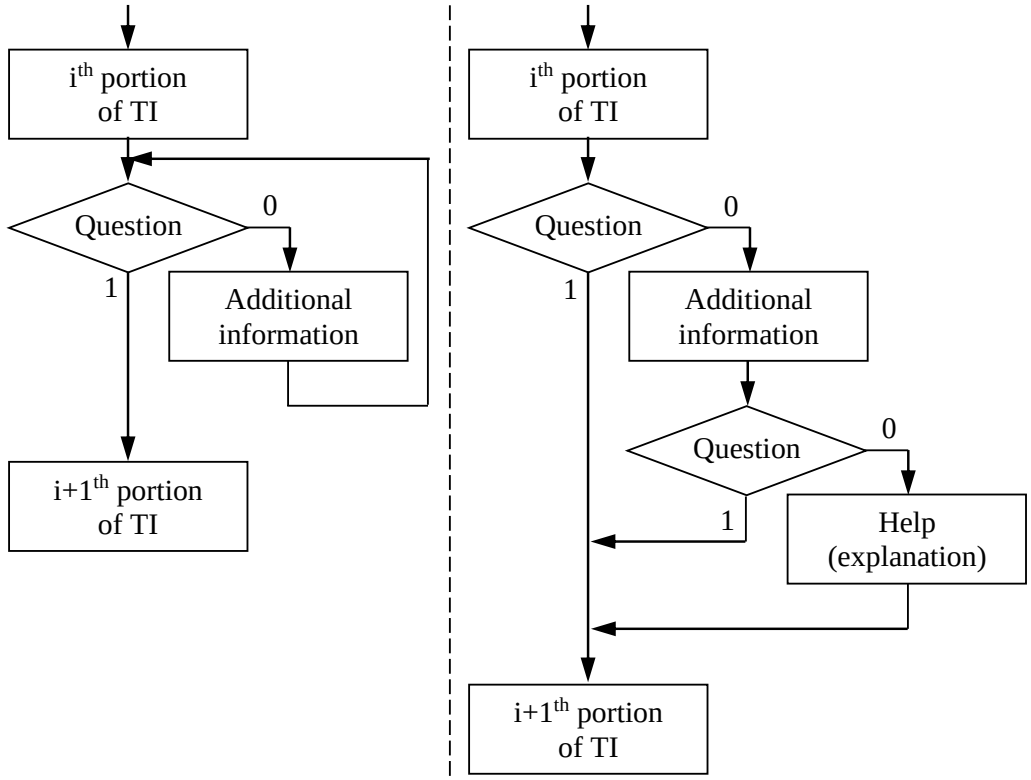
Then in the moments $t_i (i = \overline{1, N})$ the fact of assimilation of a portion of TI is defined by the algorithm of training and is reflected the one level of signal ($Y^* = 1$) in the feedback.

The model of a trainee $F(X, U^*)$ has to reflect his temporary opportunities on assimilation of the certain information: $F(X, U_i^*) \Leftrightarrow t_i - t_{i-1}$, i.e. to specify the time, necessary for the assimilation of the certain portion U_i^* in the conditions of environment (IEE) X.

Then the signal of feedback Y_i^* on the i^{th} stage of training is defined so: $Y_i^*(t) = \begin{cases} 0 \\ 1 \end{cases}$, at $t_i \le t \le t_{i+1}$.

The purpose of training in the linear training program: the trainee needs to consistently give all N portions of information (TI) and to diagnose LRKT.

The branched internally adjustable training programs work directly for the final user on the expanded scheme: to the trainee is generated the portion of TI, then is set up a set of questions for the check of LRKT after the assimilation of this information, then, in dependence from the answers of a trainee: correct answer – is formed at once the next certain portion of TI; wrong answer – is displayed or additional information (explanation) and the question is again set, or the hint (correct answer the question). In pic. 3.13 are shown the examples of schemes of branching of algorithmic structure.

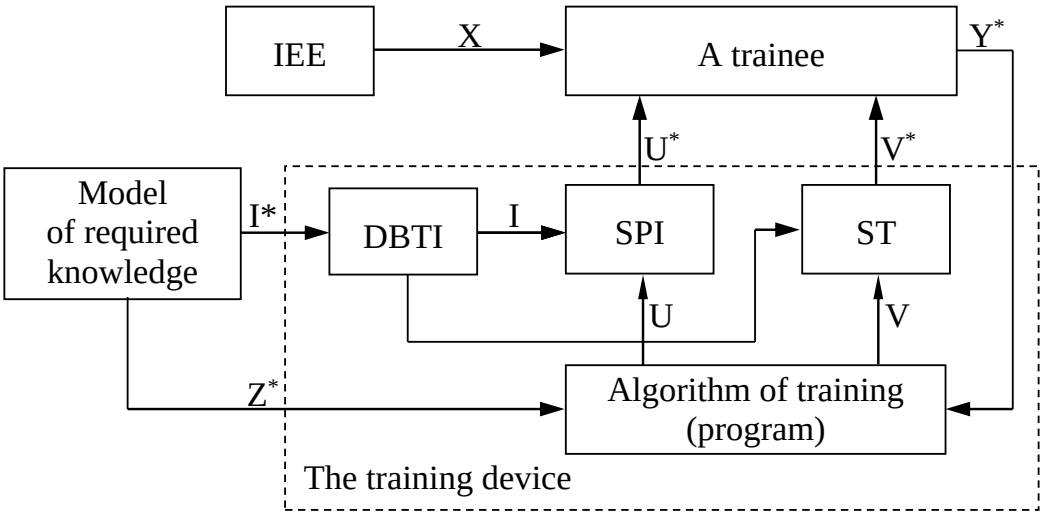


Pic. 3.13. The schemes of realization of branching (1 – correct answer, 0 – wrong answer): at the left – linear model and at the right – branched model

Training (at distance) on the branched program (algorithm) in difference from the linear program (algorithm) is under construction in dependence from the fact of assimilation by the trainee of the current TI, that is determined on his answers the questions. Each subsequent TI provides the formation of knowledge of a trainee.

In pic. 3.14 the shaper of a portion of training information directly provides the formation of the certain portion of additional information for the n^{th} portion of main information U_n. We'll designate them directly through the parameters with indexes $U_{n1},U_{n2},...,U_{nl}$, where l – number of portions of additional TI for the main TI. Every portion of additional TI concretizes the portion of main TI.

Every portion (including the main) is followed by the test (question), which is directly formed by the block of ST (shaper of tests). At the scheme channels U and V work simultaneous with division in time, therefore the portions of TI contain the test tasks (question-answers structures) for the realization (of automation) of the current (intermediate) and total control.



Pic. 3.14. The block-scheme (flowchart) of the training system with branched internally adjustable program

The quantity of portions q_n of additional information, issued to the trainee, depends from his answers the questions of tests on this n^{th} portions of TI ($0 \le q_n \le l$). Training process (at distance) directly is realized by the algorithms of automated means of training (at distance), formalizing the sequence of couples: $< U_{ni}, y^*_{ni} >$ ($i = 0,1,...,q_n$), where i – certain number of portion of additional information (at $i = 0$ – main portion); y^*_{ni} – estimation of answer the i^{th} question:

$$y^*_{ni} = \begin{cases} 0 \\ 1 \end{cases}, \text{if answer wrong and correct respectively.}$$

At $y^*_{ni} = 0$: $q_n = q_n + 1$, i.e. q_n is equal to number (in)correct answers in a row. At $y^*_{ni} = 1$ and $q_n = \max$ the additional information is not given and system passes to U_{n+1}.

The quality of assimilation of material is connected with number q_n, which characterizes the level of knowledge by the trainee (subject of training) of the n^{th} portion of information, but on the definition of the next portion of main TI U_{n+1} the value q_n has no significant effect (in dependence from the features of used algorithm of training).

In result each certain trainee (subject of training) passes all certain portions of TI from the first to the N^{th}, but a trajectory of training on every portion is various for the different trainees. Formally LRKT in this 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 general contingent.

The purpose of training in the branched scheme, as well as in linear, is trivial – to pass all sequence of certain portions of TI from I, and also to respond to the greatest quantity of test questions without errors.

The branched, externally adjustable training programs operate at the condition of fact, that trainees are divided by progress on the m groups. For each group there is the certain training program with the own way (level) of statement of the same material. For example, at the $m=3$: in the first program the material is represented the very in detail and is designed for the poorly prepared; in the second this material is more compressed and designed for the average prepared; in the third it is stated concisely and designed for the strongly prepared trainees. For the definition of belonging of a trainee to this or that subgroup on the $n+1^{\text{th}}$ step of training is calculated the relative number of correct answers on tests on the n^{th} portion of TI. If this value goes from the limits of some previously set up interval, then the trainee (subject of training) is transferred into the other subgroup – best or worse prepared in dependence from the certain estimation of LRKT.

In considering case all sequence of TI is broken on portions $U_1,...,U_N$. Studying by the trainee of all portions of TI corresponds to training (at distance) on the program with the most detailed level of statement of material on a subject of studying. The less detailed ways of statement will differ by the absence of some portions of TI.

For every portion of TI is set up a set of thresholds $a_1^n < ... < a_i^n < ... < a_m^n$, by means of which the trainee corresponds to the certain group k_n on the decisive rule: $a_{i-1}^n \le q_n < a_i^n \Rightarrow k_n \in [1,m]$, where k_n – number of group, in which the trainee is transferred, who has made q_n wrong answers the questions of tests on the n^{th} portion of TI.

The block-scheme (flowchart) of the system of training on the branched externally adjustable program does not differ from the provided in pic. 3.14 for the internally adjustable program. The algorithm of training analyzes LRKT and IFPST, defining the numbers of groups of trainees, in which they are transferred in 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 $k_i^n \in \{\overline{1,m}\}$, $i \in \{\overline{1,l}\}$ is formed in the process of training and allows to compare a set of trainees.

The purpose of training consists in the "bringing" of trainee to the last portion of TI.

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

The author of course (a teacher) not only sets up the parameters of algorithm of the training program, but also forms the sequence of following of TI as subjects to display. The quality of such program depends from the qualification of a teacher.

The experience of construction of the optimum sequence of presentation of portions of TI demands the model of subject of studying, and the sequence of presentation of portions of TI is under construction before the beginning of training in ATS, and training is carried out either on linear, or on the branched scheme with a possibility of accounting of IFPST and LRKT.

The training programs are created before the beginning of the process of training or in the process of their performance in ATS. Under the generating training system directly understand its ability to form the certain sequence of presentation of TI and to set up the parameters of algorithm of functioning of its components in the process of ART.

3.6.2. The features of realization of adaptation in the automated educational environment

The main requirement to the modern ATS consists in the providing of maximum degree of individualization of the process of training (at distance), its adaptation to each specific trainee (subject of training), that is not feasible at the traditional methods of mass training. The trainee acts as a difficult object and his exact aprioristic model does not exist, but, according to the conception of classical theory of automatic control, without adaptation is impossible the construction of effective control by this object. Under adaptation in the classical theory of automatic control understand "the process of change of parameters and structure of system, the operating influences on the basis of current information for the purpose of achievement of the certain (optimum) condition of the system at the initial uncertainty and changing conditions of environment". Applying this traditional definition to the process of training (at distance), say, that adaptation in the (automated) training system (at distance) – the process of change of structure and parameters of model of subject (a trainee) and TI on the basis of current information, obtained during training (at distance), with the purpose of achievement of an optimum condition of object of control at his initial (aprioristic) uncertainty in the changeable environment (IEE), which is connected with almost total absence in the training system of information about a trainee.

Adaptation has several hierarchical levels, corresponding to the various stages of control of a difficult object: parametrical adaptation of model, structural adaptation of model, adaptation of object and adaptation of purposes of control.

The parametrical adaptation is connected with the correction of parameters of model. If in the process of evolution of an object of control changes its structure, the parametrical adaptation not always allows to construct the model, adequate to an object. Then realize directly the structural adaptation of model of an object of control. For example, uses the procedure of choice on each step of control from a set of alternative models of the best (in sense of proximity to an object) models. At the same time the various methods of parametrical adaptation carry out the identification of a set of the values of parameters of alternative models.

If and structural adaptation of model does not increase the efficiency of control of an object, then adapt directly the structure of an object of control by means of change of connections between elements and revision of border, dividing an object and environment.

If it does not introduce due effect, then is carried out the adaptation of purposes of control due to the formation of a new set of purposes, which achievement is provided directly by the system of control with earlier created structure.

We'll consider, how are realized these levels of adaptation in the traditional ATS.

In the linear training program the adaptation in an explicit view is absent. As a priori are known the exact models of training system and object of training, on the basis of which is under construction the optimum in sense of some criterion (time of passing of quants of TI) sequence of statement of a training material. A set of TI is formed in the process of training (at distance) on the tough previously defined scheme without the realization of feedback on the basis of current information.

The training programs operating on the basis of a branched algorithm of training include the model of a trainee (the subject of training) assuming a set of answers the sequence of questions, which is shown to the trainee (subject of training) in fact of the completion of studying of each certain portion of TI. In dependence from the quantity of correct answers the questions of a method of research (test) is formed a conclusion about the level of assimilation of this portion of TI and is made the decision about need of transition to the next portion of TI. The linear branched algorithm of training is simplified, as also does not assume the existence of feedback, that allows to speak about the low level of adaptation.

In the training programs on the basis of a branched algorithm of training assuming the several ways and levels of statement of training material the model of a trainee is defined by one parameter – the rank or category of a trainee (group of trainees), calculated on the basis of IFPST and LRKT. In this case the process of training assumes the one-parametrical adaptation, which acts as a private case of the parametrical adaptation of model of a trainee.

Having defined a rank or category of a trainee, realize the process of formation of knowledge of group of trainees on the basis of one from the optimum algorithms of training, which is not considering the psychological, physiological and linguistic parameters.

The results of the analysis of various algorithms in the basis of existing training systems allow to make the following main conclusions:

- the training systems with the linear and branched-out algorithms of training are a private case of the general scheme of realization of training programs;
- the application of basic provisions of the theory of automatic control in the training assumes the accounting of specific regularities of process of formation of knowledge;
- the review of principles, models and algorithms of formation of knowledge of trainees shows, that yet there is no the universal model, and the majority of models are constructed in a concrete situation for the solution of private tasks;
- there are no individually-oriented models and algorithms at the basis of the automated means of training (at distance), which have the scientific justification in the context of the device of cognitive computer science, private physiology of analyzers, cognitive psychology and applied linguistics, allow to consider the dynamics of a condition of mentality of a trainee (the subject of training) under the influence of a set of the displayed information fragments of TI;
- the realization of IEE of ART on the basis of adaptive means of training initiates the specification of the structure of training system, its elements and parameters, and also the development of model of a trainee for the increase in efficiency (resultativity) of process of formation of knowledge of the contingent of trainees;
- at the initial stage of ART it is necessary to provide the installation of required LRKT, the primary initialization and diagnostics of the values of parameters of CM;
- the estimation of efficiency of training demands the statement of purpose and algorithm of training, and also the criterion (functional) allowing to display the achievement of purpose.

The specified conclusions initiate the modification of definition of task of training and approaches to the realization of structure of IEE of ART, including a set of components, realizing the automated control of process of individually-oriented formation of knowledge of a trainee as a difficult object control.

The training system represents inside the system of control by the difficult object,- the trainee with his model,- we'll formulate the task of training more particularly and we formalize:

- the purpose of training Z^* – is defined by the different methodical recommendations and requirements of experts to the professional vocational (special) preparation;
- TI, shown to the trainee (the subject of training) by means of the means of training, under the influence of which is realized the process of formation of his knowledge, abilities and necessary skills, determined by the given purpose and tasks of training;
- the model of a trainee (the subject of training) – a set of parameters characterizing the features of perception, processing and understanding of content of information fragments;
- the algorithm of training – the rule of generation of portions of TI in the process of training.

The process of training (at distance) we'll present in the view of the sequence of sessions (lessons), beginning in the time-points $t_0, t_1, ..., t_n, ...$, in general case not equidistant. In the initial time-point the subject (a trainee) is in some condition Y_0. It is required to construct the certain sequence of TI $\{U_n\}$, $n = 0,1,...$, which will transfer the trainee (subject of training) into the previously given final condition Y^*. And the (remote) process of translation of a trainee from the condition Y_0 into Y^* must be, in the certain scientific sense, optimal (effective). In the tasks of training (at distance) the best should consider that algorithm of training, which makes this transfer for the shortest time (optimum in time).

For the analysis of the efficiency of training we'll enter the function of quality Q of training, which depends from the current condition of the subject of training (a trainee) Y, and we'll calculate it nominal values in the discrete time-points $t_0, t_1, ..., t_n, ...$:

$$Q_n = Q(Y_n),$$

where Y_n – condition of the subject of training (a trainee) in the moment of beginning of the n^{th} session of training t_n.

The criterion Q_n characterizes the level of proficiency of the subject of training at the moment t_n. Without restriction and essential loss of community we believe, that $Q(Y^{**}) = Q^*$, where level Q^* will correspond to the absolute proficiency of the subject of training.

The purpose of training (at distance) Z^* consists in the selection of optimal value of the function of quality Q by means of the minimal quantity of certain TI U:

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

where U – a set (enrollment) of TI, and u – a set of admissible information fragments, translating the trainee from the condition Y_0 into Y^{**} – condition of absolute proficiency. In view of the real properties of memory of person (subject of training) the condition Y^{**} and respectively the level of absolute proficiency Q^* are almost not achievable.

The (automated) training (at distance) directly should be finished, when the criterion of the quality of training Q_n reaches the given threshold value δ:

$$Q_n \approx \delta,$$

where δ – nominal value of LRKT (the contingent of trainees), close to Q^*.

The purpose of (automated) training (at distance) Z^* consists in the achievement of threshold value δ for the minimal possible quantity of steps (sessions of training). At the same time we believe, that the algorithm of training A_1 is better than the algorithm of training A_2, if it provides the achievement of threshold (level) δ for a smaller period of time or smaller number of steps (sessions of training) by means of a certain set of TI.

The purpose of (automated) training (at distance) Z^* is formalized:

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

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

We formalize the generation of TI: we'll consider such processes of training, in which the certain TI can be presented in the view of a final set of renumbered elementary portions (information fragments): $U = \{U_1, U_2, ..., U_N\}$. The substantial sense of TI is defined by the subject area of training (at distance). From a set of portions U on the every n^{th} session by means of an algorithm of training is under construction directly a subset $U_n = \{u_1, u_2, ..., u_{M_n}\}$, $u_i \neq u_j$ at $i \neq j$, $u_i \in U$, containing the M_n elementary portions (elements) of TI with numbers $1, ..., M_n$, forming the volume of material for the n^{th} session of training (at distance) $(1 \leq M_n \leq N)$.

We'll consider the trainee (subject of training), whose condition on the n^{th} session we'll describe by the vector of probabilities of ignorance of each from the elements of TI:

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

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

The condition of j^{th} trainee (the subject of training) changes directly by means of the use of various portions of TI and is described in the view:

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

where F^j – operator of the model of j^{th} trainee (the subject of training); P_n^j – condition of a trainee after studying of U_n^j portion of training information; C_{n-1}^j – parameters of a trainee (the subject of training) directly before that, how he will pass the n^{th} session of training (at distance) by means of a set of TI U_n^j.

The model directly represents inside the recurrent formula of transition from one condition P_{n-1} to another P_n under influence U_n at the parameters C_{n-1}. We do not use the index of trainee j for the simplicity, as he only concretizes a task.

Therefore the condition of any trainee after studying of a portion of TI is expressed:

$$P_n = F(P_{n-1}, U_n, C_{n-1}).$$

The kind of operator F of the model of the subject of training should be set up adequately to the specifics of memory of person at the training on material of given structure and semantics. The kind of operator F can change at the change of structure of TI and its semantics.

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

We'll consider the simplest test in the view of check of LRKT in the result of studying of a portion of TI U_n. The reaction of a trainee $R_n = (r^n_{u_1},...,r^n_{u_{M_n}})$ is based on a set of answers of examinee the questions of test on TI U_n, which has the view: $R_n = F^0(P_n, U_n)$, where F^0 – operator of a trainee.

The parameter $r^n_{u_i} = \begin{cases} 0 \\ 1 \end{cases}$ characterizes the result of execution of test: if the trainee has given the correct or wrong answer after studying of the u_i th element U_n on the n th step.

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

Here χ – algorithm of estimation of the condition of a trainee (the subject of training) in the results of previous step of training $<U_n, R_n>$ and previous condition P_{n-1}.

The algorithm of training allows to define the next portion U_{n+1} and consists in the minimization of indicator Q on each step of training. Then the task of optimization of the algorithm of training comes down to the following 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 $\Phi(R)$ – a set of portions of TI, satisfying to the resource R; R_n – certain resource, allocated to the n th session of training (at distance) (the estimated duration of lesson T or the machine time, available to the trainee and other); U^*_{n+1} – locally-optimal portion of TI, given to the trainee on the $n+1$ th session of training.

The training (at distance) by means of such algorithm of training insufficiently well provides the solution of task of achievement of the given purpose of training Z^*, which has been put. The matter is, that the number of sessions of (automated) training (at distance), received on this algorithm of training, can not be minimal in time. But the minimization of criterion Q on each step of training, certainly, gives the optimal nominal value of decision, close to minimal, as the value Q with each session of training (at distance) decreases in the most intensive way and time-point $Q(Y^*) \approx \delta$ comes enough quickly. At the same time it will be received the quasi-optimal solution (nominal value), which in some cases directly coincides with the optimal (on time). For each subject of studying the optimal (required) LRKT can vary owing to the various factors, therefore it is necessary previously to set up the admissible range of deviation of resultativity of training for the trainee operating in ART system.

3.6.3. The specifics of the algorithm of training with the model of a trainee

The parametrical and structural adaptation of model of a trainee is possible. In the latter case the structure of model of the subject of training changes in the process of training.

The condition of a trainee (the subject of training) on the n th session of training (at distance) is described directly by the vector of probabilities of ignorance of the elements of TI. As the element of TI can be the concept, rule, definition, task and other. In the task of training in the understanding of texts in the certain language by the elements of TI are the lexical units: separate words or phrases.

In the result of storing by the trainee of the portion of TI on the n th session of training, he owns with the elements of this portion with the probability one: $p_i(t_n)=0$, $i \in U_n$, i.e. the probabilities of ignorance of information fragments from U_n in the moment t_n are equal to zero, however with eventually there is the inferention back (forgetting). Using the data of (cognitive) psychology in the field of research of memory, as the model of a trainee F_n we choose the exponential dependence. Then the probabilities of ignorance of the elements of TI change by the rule (dependence):

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

where α_i^n – speed of forgetting of the i th information element of TI on the n th session of training; t_i^n – time from the moment of last approach to the studying of the i th information element of TI.

It is naturally to assume theoretically (from the scientific point of view), that the speed of forgetting of each information element of TI decreases, if this information element is given to the trainee (subject of training) for storing, and practically does not change, if he is not studied any more:

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

where $\gamma', \gamma'', \alpha_i^1 (i = 1,2,...,N)$ – parameters, reflecting the individual features of memory of subject; $0 < \gamma' < \gamma'' < 1$, $\alpha_i^1 > 0$ – initial speed of forgetting of the i th information element of TI.

As on each session of training (at distance) the i th information element of TI or is given for storing $(i \in U_n)$, or is not given for storing $(i \notin U_n)$, then in the model of a trainee (the subject of training) it is directly necessary to take into account the time of forgetting of information (information element) 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 $\Delta t_n = t_n - t_{n-1}$ – interval of time between two sessions of training (at distance); $(t_0, t_1, ..., t_n)$ – time-points of presentation and studying of portions of TI within the limits of sessions of training. The probabilities of ignorance of the i th inf. element of TI before the first studying on the n th session are equal to one (before the beginning of training the i th information element of TI is unknown with one probability):

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

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 change of probabilities of ignorance of the elements of TI depends from the speeds of their forgetting, which are defined by the individual properties of memory of a trainee (the subject of training) and the time of forgetting of information elements of TI after their presentation for the studying.

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

As the criterion of the quality of training (at distance) Q_n is chosen such, which characterizes the level of knowledge and condition of proficiency of a trainee (the subject of training). For the task of training (at distance) to the understanding of a text in the certain language this level is characterized by the probability of ignorance of a portion of TI, chosen in a random way directly from DB of TI: $Q_n = \sum_{i=1}^{N} p_i(t_i^n) q_i$, where $p_i(t_i^n)$ – probability of ignorance of the i^{th} inf. element of TI $(0 < p_i(t_i^n) < 1)$; q_i – frequency of emergence of the i^{th} element of TI in the considered text (without repetitions of elements of TI $q_i = 1$). The values of frequencies $q_i (i = 1,2,..., N)$ are determined by the certain text, reflecting the content of the subject of studying before the beginning of the process of training (at distance).

At $n = 0$, $Q_0 = \sum_{i=1}^{N} q_i = 0$, $P_0 = \sum_{i=1}^{N} p_i(t_i^0) = 1$ be supposed, that the trainee knows nothing.

For the other tasks of training the value q_i can characterize the importance of the i^{th} concept and other. The purpose of training (at distance) Z^*, for the achievement of which it is offered on each step of training to solve the local task of optimization, which for the criterion Q_n can be rewritten in the view of $Q_n = \sum_{i=1}^{N} p_i(t_i^n) q_i \to \min_{U_n \in \Phi(L_n)} \Rightarrow U_n^*$.

As the result of solution of this task is the locally-optimal portion of TI U_n^*, which is given to the trainee (the subject of training) on the n^{th} session of training (at distance). The criterion Q_n is calculated to the moment t_n of the beginning of the n^{th} session of training. At the same time the task of optimization of the algorithm of training can have the several decisions. For example, it is possible to include in a set U_n^* only those TI, which storing on the n^{th} session of training provides the greatest reduction Q_n to the end of session of training. We'll call directly this procedure of optimization "zero-step".

By the other solution of task of optimization can be inclusion in a set U_n^* only of those TI, which storing on the n^{th} session of training will provide the greatest reduction of Q_{n+1}, i.e. the values of criterion of the quality of training to the beginning of the next $n+1^{\text{th}}$ session of training. We'll call this procedure "one-step". It is similarly possible to construct the k-step procedure, on which U_n^* is under construction with the purpose of minimization Q_{n+k} to the beginning of the $n+k^{\text{th}}$ session of training. For the solution of task we'll build zero-step procedure as the simplest and not demanding labor-consuming calculations.

For the selection of optimal value (minimal) of Q_n to the end of session of training naturally in the U_n^* join TI, having the smallest value of multiplication $p_i(t_i^n)q_i$, as in the result of their storing this multiplication tends to the zero and by that the significantly influences on the decrease of nominal value of Q_n.

For the ensuring of optimum value of Q_n to the end of the n^{th} session of training, having the resource L_n, it is necessary to find the M_n maximal members in the sum, whose indexes will define the next certain portion of TI, shown to the trainee for the studying,- this algorithm is registers in the view of:

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

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

Let $L_n = T_n$ – duration of the n^{th} session of training (at distance), or time (the interval of time), allowed for the studying of a portion of TI U_n, and time of studying of the i^{th} inf. element of TI in inverse proportion to the probability of its ignorance. This assumption is based on the natural basis (from the scientific point of view): than less the probability of ignorance of inf. element, that less the time is necessary in its studying. Then the volume M_n of next portion U_n is defined 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 – average time of storing of the element of TI at the first its presentation to the trainee; $u_1,u_2,...,u_M$ – numbers of information elements of TI, determined by the rule. Parameter k is a priori unknown and therefore it has to be estimated adaptively in the process of (automated) training (at distance) in dependence from the time, spent by the trainee (the subject of training) on the performance (studying) of a portion of TI:

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

where v – dimensionless coefficient of speed of adaptation of technological process of training, and $T_n^{'}$ – time, spent by the trainee (the subject of training) for the storing of U_n.

The training comes to the end, when Q_n reaches the required level of proficiency δ. The number of sessions of training (at distance) n, for which it is reached $Q_n \to \delta$, determines the duration of (automated) training (at distance).

Thus, the algorithm of training includes the sequence of iterations:

- it is shown a set of TI belonging to the subject of studying taking into account IFPST;
- the check of level of residual knowledge of trainee in fact of studying of a portion of TI U_n is realized, in result of which a set R_n is formed;
- the adaptation of parameters of a trainee (the subject of training) C_n is carried out;
- it is corrected and formed the vector of probabilities of ignorance of inf. elements of TI P_n;
- it is calculated the criterion of quality of (automated) training (at distance) Q_n;
- if the nominal value $Q_n \approx \delta$ is reached, then the training comes to the end.

At $Q_{n+1} > \delta$ is defined the next portion of TI U_{n+1}, which is given for the studying. Then at the following cycle of training (at distance) again the items 1 – 5 are repeated.

The accuracy of received vector R_n depends from the complexity, validity and accuracy of the used questions in a method of research (test), that is especially important at the estimation of IFPST.

Considering the system of training (at distance) it is necessary to allocate two ways allowing to reflect the adequacy of developed principles, and also the degree of their reliability:

- the analytical way on the basis of formalization of the contour of adaptation;
  - it is necessary to carry out the choice of the algorithm of training and its parameters at the basis of the presented formalization of the training system, generating the information fragments by means of the use of the shaper of portions of TI, oriented on the trainee (the subject of training), and also measuring LRKT and IFPST with the use of the shaper of test tasks;
  - to realize the modeling of the (automated) system of training (at distance) by the disconnected principle with the purpose of identification of admissible limits of deviation of a resultativity of training (at distance) of the contingent of trainees;
  - to form the structure of the model of a trainee (the subject of training), which is a priori unknown (causes the selection of structure of operator in a large extent describing the properties of a real trainee);
  - to choose a set of parameters, characterizing the features of generation of TI;
  - to carry out the installation of initial nominal values of parameters;
  - to realize the modeling by the closed principle with connection of the adaptive algorithm on the basis of initial values of the model of a trainee;
- the experimental way, allowing to reflect the increase in efficiency of formation of knowledge of the contingent of trainees at the basis of the statistical analysis of a posteriori data of series of the experimental researches;
  - for the realization of a contour of adaptation is required to realize directly the diagnostics of the values of parameters of CM, reflecting IFPST and LRKT;
  - to provide the analysis of received values for the exception and inclusion of various parameters of CM, allowing to form a relevant set of parameters influencing on efficiency of training in various measure.

3.6.4. The estimation of parameters of the (cognitive) model

At the research of the model of a trainee (the subject of training) there is a task of estimation of the nominal values of its unknown parameters. Such parameters of model are γ' and γ'' corrections of speeds of forgetting, and also the initial nominal values of these speeds $\alpha^1 = (\alpha_1^1, \alpha_2^1, ..., \alpha_N^1)$.

Parameters γ', γ'', α^1 reflect the individual features of memory of a trainee.

The initial values of speeds of forgetting α^1 can be estimated in the process of training on the results of the first examination by the method of maximal credibility.

Let on the n^{th} session for the first time the trainee is given the information elements of TI, forming a set of information fragments $U_n = \{u_1, u_2, ..., u_{K_n}\} \subset U$. For this inf. elements of TI $\alpha_i^n = \alpha_i^{n-1} = ... = \alpha_i^1 = \alpha (i \in U_n)$, and the trainee studies a portion U_n. The result of check of knowledge of a portion (information fragment) U_n through the time (interval of time) t after studying is presented in the view of vector R_n. For $i \in U_n$ we calculate the probabilities of ignorance: $p_i(t) = 1 - e^{-\alpha t} = p, (i \in U_n)$.

We'll write down the function of credibility: $P = p^x (1-p)^{K_n - x}$, which minimization on p gives the possibility to estimate of nominal value P, and consequently, and α.

Here $x = \sum_{i \in U_n} r_i^n$ – number of not remembered inf. elements of TI from K_n for the first time studied.

For convenience of calculations we replace P on $\ln P$, then for the finding of value α, at which the function P accepts the greatest nominal value, we take a derivative from $\ln P$ on α and we equate it 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 we receive the estimation of nominal value of parameter α: $\hat{\alpha} = -\frac{1}{t} \ln \frac{K_n - x}{K_n}$.

The estimation of parameters γ' and γ'' in the process of training is presented rather difficult. Therefore for their estimation it is offered before the beginning of training (at distance) to make the adjustment experiment (identification of parameters).

For a task of training to foreign lexicon this experiment has features. The trainee receives N unknown words in a foreign language and must to remember their translation. The studying is carried out daily during some fixed interval of time, is identical directly for each trainee (the subject of training). Before studying the examination is held, which results are presented in the view of vector $R_n = \{r_1^n, r_2^n, ..., r_N^n\}$, where $r_i^n = \begin{cases} 0 \\ 1 \end{cases}$, if the trainee has given the correct translation of the i^{th} words in the n^{th} test (step of training) and wrong translation respectively.

Then the trainee (the subject of training) finishes learning not remembered words, and the next day (at the following approach) is held the examination in all words. It repeats until the trainee (the subject of training) does not remember all words, i.e. after the examination directly all nominal values are $r_i^n = 0, i = 1,2,..., N$.

A posteriori data are the derivatives of considered model. In this case directly $M_n \Leftrightarrow N$ and $\Delta t_n = 1$ for all $n = 0,1,...,K$, where K – number of tests (approaches) till full storing of all N words, i.e.

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

The speeds of forgetting are change 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 ignorance take the view $p_i^n = 1 - e^{-\alpha_i^n}, (i = 1,2,...,N; n = 1,2,...,K)$. Every day ($\Delta t_n = 1$) are studied and remembered all words $M_n \Leftrightarrow N$.

As for the storing are pledged the unfamiliar words to the trainee, then $p_i^0 = 1$ for all $i = 1,2,...,N$. The initial speed of forgetting α can be estimated by the results of examination, which is taken on the next day after the initial storing of words:

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

The parameters γ' and γ'' are estimated by the method of maximal credibility.

For the analysis of estimation of nominal value γ'' we'll enter A_n – a set of numbers of words, which the trainee did not remember to the n th test; S_n – number of such words, i.e. $|A_n| = S_n$. Then for all $i \in A_n$ we directly had:

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

The experimental data are represented by a set R_n of realizations r_i^n of random values ξ_i^n, having the following mathematical distribution:

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

The value of x_n will be defined as the sum $x_n = \sum_{i \in A_n} (1 - r_i^n)$ expressing the number of words from S_n, remembered in the defined n th test (approach). We build the function of credibility in the view of probability of receiving of all possible set of data R_n of experiment,- it depends from parameter γ'':

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

We look for the value of parameter γ'', at which $\ln P$ reaches a maximum. Taking the logarithm of received mathematical expression, we receive:

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

For the finding of maximum of $\ln P$ we take directly the private derivative on $\gamma^{"}$ and we 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 $\gamma^{"}$ we receive directly the algebraic equation:

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

It is obvious, that to receive the exact solution of this transcendental equation relatively $\gamma^{"}$ is impossible already at $K \geq 6$, therefore we'll simplify it.

From the estimation of initial speed of forgetting $\hat{\alpha}$ follows, that $\hat{\alpha} \geq 1$ at $\frac{\sum_{i=1}^{N} r_i^0}{N} \geq 1 - \frac{1}{e}$, i.e. then, when the share of not remembered information elements of TI the next day (approach) after studying is more approximately 2/3. As have shown the experiments on storing of foreign lexicon, it happens extremely seldom. Therefore, in further all analysis it is expedient to carry out for $\alpha < 1$. Besides, with the growth of n value of α_i^n does not increase, i.e. $0 < \alpha_i^n < 1, (i = 1,2,..., N)$.

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

We receive $\sum_{n=2}^{K} (S_n - x_n)(n-1) = \alpha \sum_{n=2}^{K} S_n (n-1)(\gamma^{"})^{n-1}$.

We'll construct the approximate solution of this algebraic equation. For this we'll directly consider at first the certain case, when directly the size of nominal value $\gamma^{"}$ is close to one. We'll spread out $(\gamma^{"})^n$ into the algebraic set of Taylor in the vicinity of one:

$$(\gamma^{"})^n = [1 - (1 - \gamma^{"})]^n = 1 - n(1 - \gamma^{"}) + ...$$

Having substituted it in the previous mathematical expression, we'll receive:

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

from where it is possible directly to estimate the nominal value of $\gamma^{"}$:

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

If the nominal value $\gamma^{"}$ strongly differs from one, then the received formula can be used for the first approach to $\hat{\gamma}^{"}$.

For the estimation of parameter γ' it is necessary to find average in all tests number of not memorized words (we'll designate it through Θ) and its population mean (math. expectation) $M\Theta$.

On experimental data it is directly possible to calculate $\overline{\Theta}$:

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

The population mean (math. expectation) of average number of not memorized of words has 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 directly the nominal value $p_i^n = 1 - e^{-\alpha_i^n} \approx \alpha_i^n$, then:

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

We'll find directly the population mean (math. expectation) of a speed of forgetting $M\alpha_i^n$. We use the representation of the population mean of a random variable in the view of:

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

where $M(\xi \mid B)$ – conditional population mean of a random variable ξ concerning the event B.

As $\alpha_i^{n+1} = \begin{cases} \gamma'\alpha_i^n \\ \gamma''\alpha_i^n \end{cases}$ with probabilities $e^{-\alpha_i^n}$ and $1-e^{-\alpha_i^n}$ respectively, 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 it is evident, that $M\alpha_i^{n+1}$ depends from the second item,- we'll find $M(\alpha_i^n)^2$.

By the method of mathematical induction it is possible to show directly, that on the k^{th} time-point the nominal value of speed of forgetting has the 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 nominal value of parameter γ' we receive from the equality:

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

At the same time directly we build the consecutive approximations. As $M\alpha_i^1 = \alpha_i^1, (i = 1,2,..., N)$, then we receive the expression of $M\alpha_i^2$, we define $M\Theta$ for $K = 2$ and the received result we equate to $\overline{\Theta}$, calculated also at $K = 2$.

We receive the first approach of nominal value of $\hat{\gamma}_1'$, which we use for the calculation of $M(\alpha_i^2)^2$, after then we repeat the described procedure. In the result we receive the approach of nominal value of $\hat{\gamma}_2'$. So we repeat to $n = K$, in result we receive the nominal value of $\hat{\gamma}_{K-1}'$, which directly we taken for the estimation of nominal value of parameter $\hat{\gamma}'$.

Thus, in the results of a preliminary experiment it is possible to build the estimates of the nominal values of parameters γ' and γ'', and then to use in the process of training for the adaptation of speeds of forgetting.

On the basis of the carried out research we'll form the conclusions on the third chapter:

1. It was stated the essence of the complex approach to the solution of problem of creation of the environment of automated training with the properties of adaptation based on CM, assuming the entering of various modifications into the organization of IEE and technology of formation of knowledge of the contingent of trainees (the subjects of training), realizing the analysis of information interaction between subjects and means of training directed on the increase in efficiency of functioning of algorithms and procedures at the basis of components of ART system by means of the introduction of methods of the cognitive computer science and CMT.
2. There were presented the various modifications in the organization of IEE and technology of the process of formation of knowledge of the contingent of trainees at the realization of various components of ART system with the properties of adaptation based on CM with the use of modern achievements in the field of ICT, allowing to take into account IFPST.
3. There was described the specifics of the automated individually-oriented training as the operated process of formation of knowledge of the contingent of trainees in IEE: the structure of the process of ART, the features of semantic model of saving and extraction of the previously structured data reflecting the content of a subject of studying in different languages and levels of statement of material.
4. There was presented the structure and features of realization of the channel of information interaction between the subjects and means of training in IEE of ART system with the properties of adaptation based on CM, covering all cycle of ART.
5. There was presented the appointment, tasks, principle of functioning and a set of solvable tasks by the adaptive means of training (ET), the main and applied DM, and also was reflected the structure and appointment of developed PCMB.
6. There were presented the features of collection of information from the different sources, its primary processing and structuring for use by the components of IEE: the classification of sources of information and methods of acquisition of data, are listed the existing and are offered the developed models of representation of data, the information structure of ET and algorithm of its filling by the structured data, reflecting directly the content of a subject of studying.
7. There was presented the architecture of ET of the new generation functioning on the basis of the developed adaptive representation of information fragments processor, allowing to take into account the various IFPST, and also the semantic model of representation, extraction and saving of information at the basis of the means of training.
8. There was presented the formal description of the adaptive systems of training with the model of a trainee: the algorithms of training in ATS, the adaptation in IEE of ART, the specifics of the algorithm of training with model of a trainee (the subject of training) and features of estimation of parameters of CM.

In the third chapter two scientific results were received: the structure of IEE and the principles of functioning of the components of ART system with the properties of adaptation based on PCMB, allowing to realize the innovative contour of adaptation on the basis of IFPST, providing the increase in efficiency of functioning of IEE of ART system.

4. The cognitive modeling technology for the system analysis of the information-educational environment

CMT represents inside the iterative cycle – the closed sequence of stages, providing the return back on one and more iteration for the introduction of modifications with the purpose of identification and correction of the revealed mistakes and discrepancies.

CMT is intended for the carrying out of the primary system analysis of IEE, the development of requirements and restrictions, the structuring of received data, the formation of CM of the subject of training and CM of the means of training with use of two ways of representation (focused graph and structural scheme (block diagram) of an object in the given field), the placements of PCMB in IEE of ART system, the modeling, the statistical analysis and identification of regularities.

The contour of control of ART system is the closed contour, providing the feedback (collecting and accumulation of information, generation of TI, diagnostics of LRKT and IFPS and identification of dependences). The monitoring and control of the process of training consists in the purposeful accumulation of information with the subsequent its classification, streamlining and structuring. The structured information about a condition of the subject of training allows to form the new and to modify the existing algorithms of generation of TI in the operated process of controlled formation of knowledge, abilities and skills, considering IFPST during the work with TMC, to modernize the algorithms of training, to analyze the educational programs, to adapt the complex of programs, to introduce new means, methods and algorithms of training in the educational process. The creation of CMT is expedient and justified for the carrying out of complex research of IEE of ART system.

The presented technology (CMT) reflects the sequence of stages, providing a set of actions for the carrying out of the system analysis:

- the collecting of primary data about the object of research taking into account the purposes, tasks and restrictions in the given subject area;
- the selection of a set of scientific aspects disclosing the properties and dynamics of functioning of the certain object of research;
- the selection of necessary quantity of the portraits of CM necessary for the analysis;
- the (re)designing of structure of CM and change of a way of its representation;
- the implementation of the structural and parametrical analysis of formed CM;
- the use of CM of the object of research in the environment of its functioning;
- the modeling, directed on the diagnostics of the values of parameters of CM;
- the analysis of a posteriori data by means of the statistical methods for the identification of regularities in the process of functioning of the object of research;
- the interpretation of revealed regularities with the purpose of formalization of merits and demerits of the object of research in the environment of its functioning;
- the accumulation of new knowledge about the object, process or phenomenon of research.

CMT realizes a possibility of the system analysis and increase in efficiency of operated formation of knowledge of the contingent of trainees in IEE of ART.

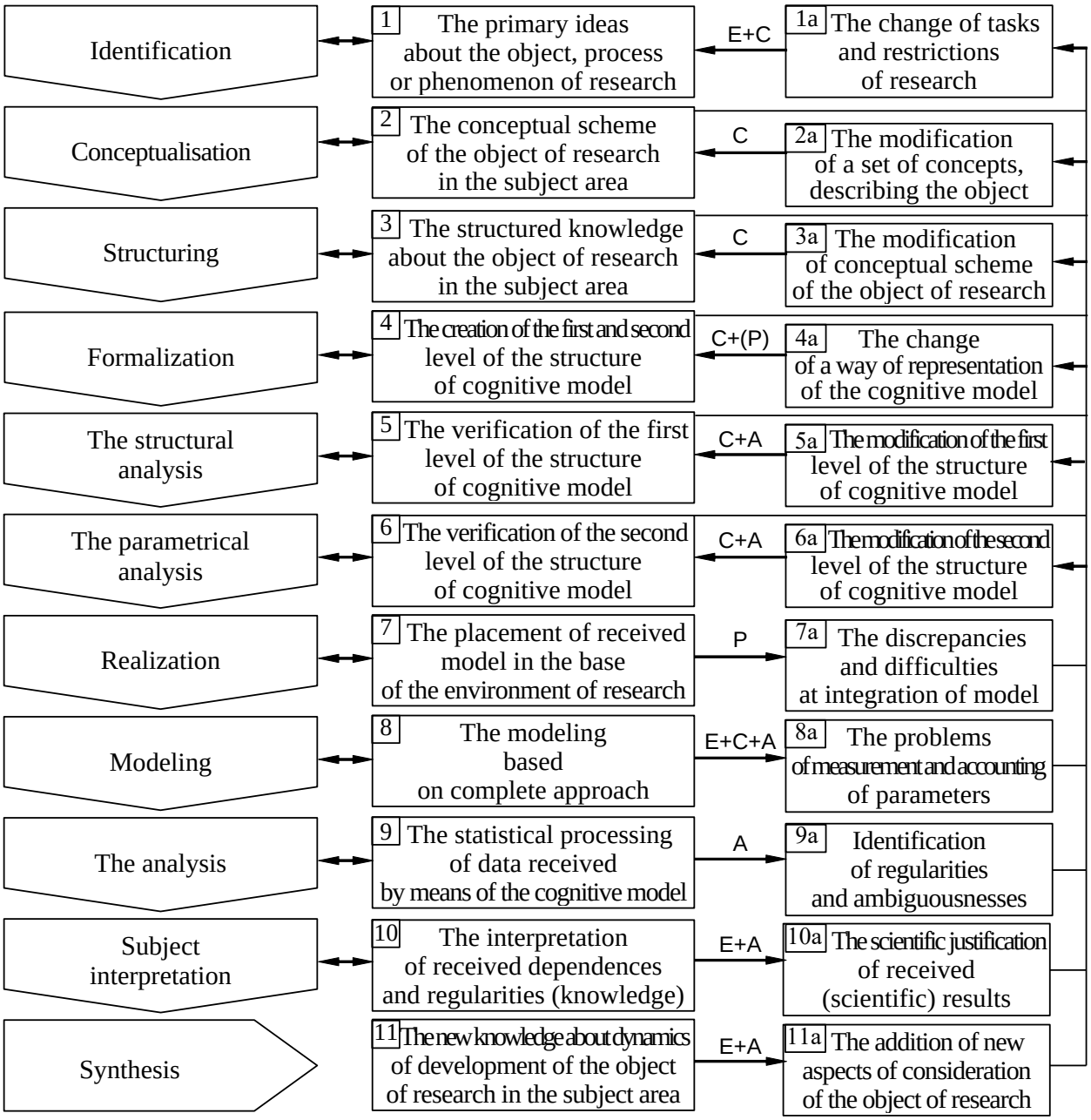
4.1. The iterative cycle of the cognitive modeling technology

CMT acts as the iterative cycle, which includes the sequence of stages realizing the carrying out of the system analysis, provides the return on previous stages for the correction of revealed discrepancies and mistakes, is the universal concerning to the object of research and subject area, supports a complicity (inclusion and exception) of a set of developed techniques and algorithms, which allow to realize the deep system analysis of the chosen object of research and justification of received results from the point of view of a wide range of the various scientific aspects of its consideration, and also to reveal the factors influencing on the increase in efficiency of functioning of an object in the environment and to develop the various approaches to modernization of its structure.

The practical use of CMT is reached in the different subject areas:

- IEE of ART system [the system analysis] (it was chosen for the carrying out of researches) – the analysis of information interaction between subjects and means of training, the identification of various factors of IEE having the significant effect on the increase in efficiency of functioning of IEE and estimation of degree of their influence on resultativity of process of formation of knowledge of the contingent of trainees;
- the information environment of financial market [the financial analysis] (demands the inclusion in CMT of additional techniques and algorithms) – the creation of methods and approaches to the realization of support of making of decision at the forming of a portfolio of purchase and sale of financial instruments turned in the foreign exchange and stock (market of capital) markets and market of precious metals, the forecasting of a tendency to growth or recession of the current market (quoted) cost of the various financial instruments (main and derivative securities);
- the information environment of organizational structure of the organization [the financial analysis] (demands the addition in the technology of additional techniques and algorithms) – the formation of system static and dynamic (time factor) indicators reflecting directly the efficiency (resultativity) of financial-economy activity of the certain (credit) organization (coefficients of fast and current liquidity and solvency in the short-term and long-term period, indicators of profitability of production, characteristics of efficiency of investment and turnover of capital) for the certain period of time by means of methods of the vertical, horizontal and trend financial analysis and planning;
- the information environment of accounting and audit of the (credit) organization [the financial analysis] (it is necessary to add the additional techniques and algorithms adequately to the specifics of subject area) – the financial analysis and audit of the accepted model of conducting of accounting of the results of financial-economy activity of the organizational structure by means of a set of standard forms of reporting and the subsequent identification of discrepancies on the basis of system of the acting rules and norms of maintaining of accounting.

The iterative cycle of CMT (pic. 4.1) reflects the sequence of main stages, providing the system analysis of the chosen object of research (IEE of ART system). At each stage of application of CMT are used the various techniques and algorithms, a set of which is defined by the chosen object of research and subject area.



Pic. 4.1. The iterative cycle of the cognitive modeling technology

For the "complex" IEE of ART CMT provides directly the attraction of a set of specialists-consultants, which are designated by the various letters: teacher, physiologist, psychologist, linguist or methodologist (E) – the expert in the certain subject area (problem sphere); cognitologist (C) – the expert in the field of engineering of knowledge (artificial intelligence), providing the correctness of received structure of the parametrical CM; system analyst (A) – the expert in the field of the system analysis and modeling of IEE; programmer (P) – the qualified specialist, owning the modern methods and approaches to the realization of high-technological means of IEE by means of environments of programming.

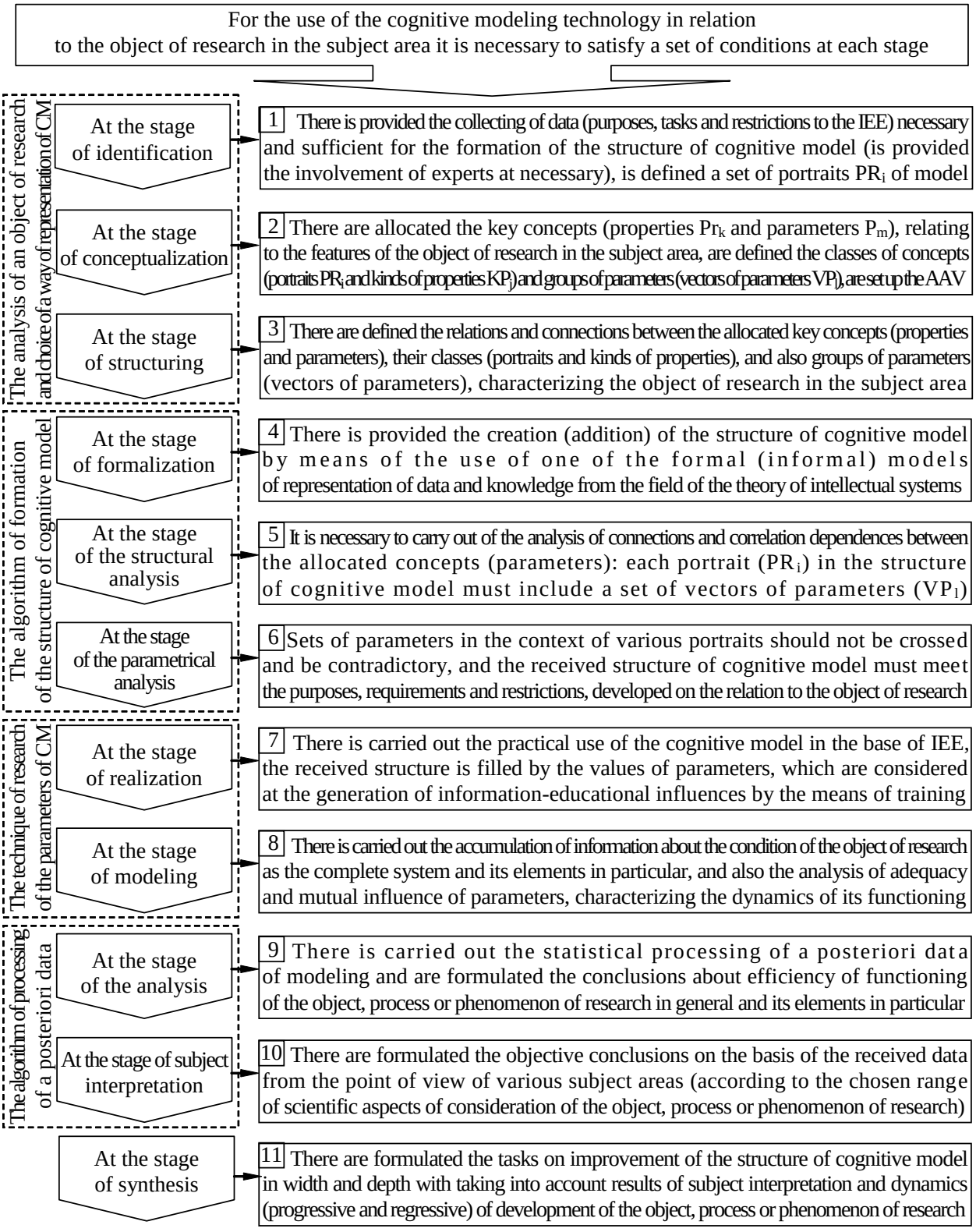
4.2. The technique of use of the cognitive modeling technology

The technique of use of CMT formalizes the sequence of carrying out of the system analysis oriented on increase in efficiency of functioning of the object of research in the context of the certain (given) subject area (it is offered to realize the system analysis of IEE of ART system based on CM):

- the preliminary analysis of the object of research and structuring of obtained data is adequately to the way of representation of the parametrical CM – is realized at the first three stages of CMT with the use of one or combination of methods of obtaining of information from the different sort of the sources, the accumulation of data characterizing a condition of the object of research singled out from the environment for the analysis or dynamics of development of a situation directly in the context of the certain subject area (to each scientific aspect of the analysis of the object of research is entered the portrait of CM);
  - identification – is realized the collecting of data by means of the use of one from the methods of obtaining of information (communicative or textual methods) from the different sort of sources (specialist-carrier of rare knowledge or traditional and electronic carriers of information expressed in data), the subsequent formation of descriptions and specifications on the allocated object of research (situation) for the carrying out of the system analysis;
  - conceptualization – the allocation (addition and removal or modification) of key concepts and entities, properties and elementary parameters, characterizing the object or situation which are subjects to research, the formation from them the groups (portraits with scientific justification and kinds of properties) and specific subgroups (vectors of parameters) on the basis of the principles of submission, inclusion, association and others, and also the introduction of system of designations (identifiers and codifiers) for each entered (new) information element taking into account the belonging to the certain group of information elements and the subsequent definition of admissible limits of a deviation of values each of them, the subsequent creation of conceptual scheme which is directly acting as the formal description of the initial object or analyzed situation on the basis of a set of received information elements and relations between them;
  - structuring – the specification of quantity of the allocated groups of information elements (portraits and kinds of properties) at the top-level of hierarchy, subgroups of information elements (vectors of parameters) at the average level of hierarchy containing the subordinated information elements (properties and parameters), located at the lower level of considered hierarchy, and also the determination of quantity of necessary hierarchical levels in the received conceptual scheme of the object, process or phenomenon of research (as offered further the way of representation of parametrical CM allows a reduction of some information elements at the different levels of hierarchy), the (re)designing of received (resultant) conceptual scheme on the results of specification of relations, connections and dependences between the allocated in it information elements (it is used at the formalization of CM);

- the formation and choice of the way of representation of the structure of parametrical CM – is realized by means of the use of the algorithm of formation of the structure of CM on the basis of the certain model of representation of structured data;
  - formalization – the choice of a way (model) of representation of the received structure of CM: one from the existing models of representation of structured data (formal logical or frame model, semantic network and ontology) or one from the innovative (developed) and offered (graph combining the theory of sets and multilevel structural scheme);
  - the structural analysis – the carrying out of the statistical analysis for the identification of correlation dependences and connections between information elements of CM;
  - the parametrical analysis – the identification and exception (at need) of contradictory information elements in the basis of received CM, the comparison of the nominal values of parameters of the parametrical CM and areas of their admissible values, identification of limits of variation;
- the research of parameters of CM of the subject of training and CM of the means of training – are offered directly two techniques of the research of parameters;
  - realization – the received CM is placed in the basis of environment of research, come to light the nominal values of parameters and are verified their admissible limits of deviation by means of the involvement of experts and automated means of diagnostics (testing), operating on the basis of a set of methods of research (tests);
  - modeling – is realized the real or imitating modeling, which is directed on the identification of potentially possible conditions of the object of research taking into account the requirements and restrictions in the subject area;
- the mathematical processing of a posteriori data by means of statistical methods is provided on the basis of the algorithm of processing of a posteriori data received during the developed series of automated experiments;
  - the analysis – the preliminary processing of selections with a posteriori data, the identification of type of distribution of the nominal values of measured sign, the analysis of restrictions and areas of application of the existing methods of data processing, the selection of a set of statistical methods of processing of a posteriori data, the realization of mathematical processing with the use of the picked-up statistical methods, the check of adequacy and reliability of the received parametrical CM on the basis of the contained in them nominal values and secondary data obtained in the result of use of the statistical methods of data processing;
  - subject interpretation – the scientific justification of revealed various correlation connections and dependences, tendencies and regularities with the point of view of a set of scientific areas adequately to a picked up set of scientific aspects of consideration of the object of research, laid directly in the basis of each portrait of the parametrical CM;
- synthesis of new knowledge – the publication in the (periodical) scientific publications and registration in the bodies (banks) of scientific-technical information of the confirmed tendencies, dependences, regularities and connections and relating to the features of functioning of the allocated object, process or phenomenon of research in the certain environment (subject area).

The technique of the use of CMT formalizes the use of sequence of stages of CMT for the solution of various classes of tasks during the system analysis of IEE of ART system by means of the application of techniques and algorithms which are contained in its basis, presented in pic. 4.2 on the left and selected with the shaped line (is admissible the addition of new and removal of existing techniques and algorithms at the changing of the object, process or phenomenon of research in the subject area).



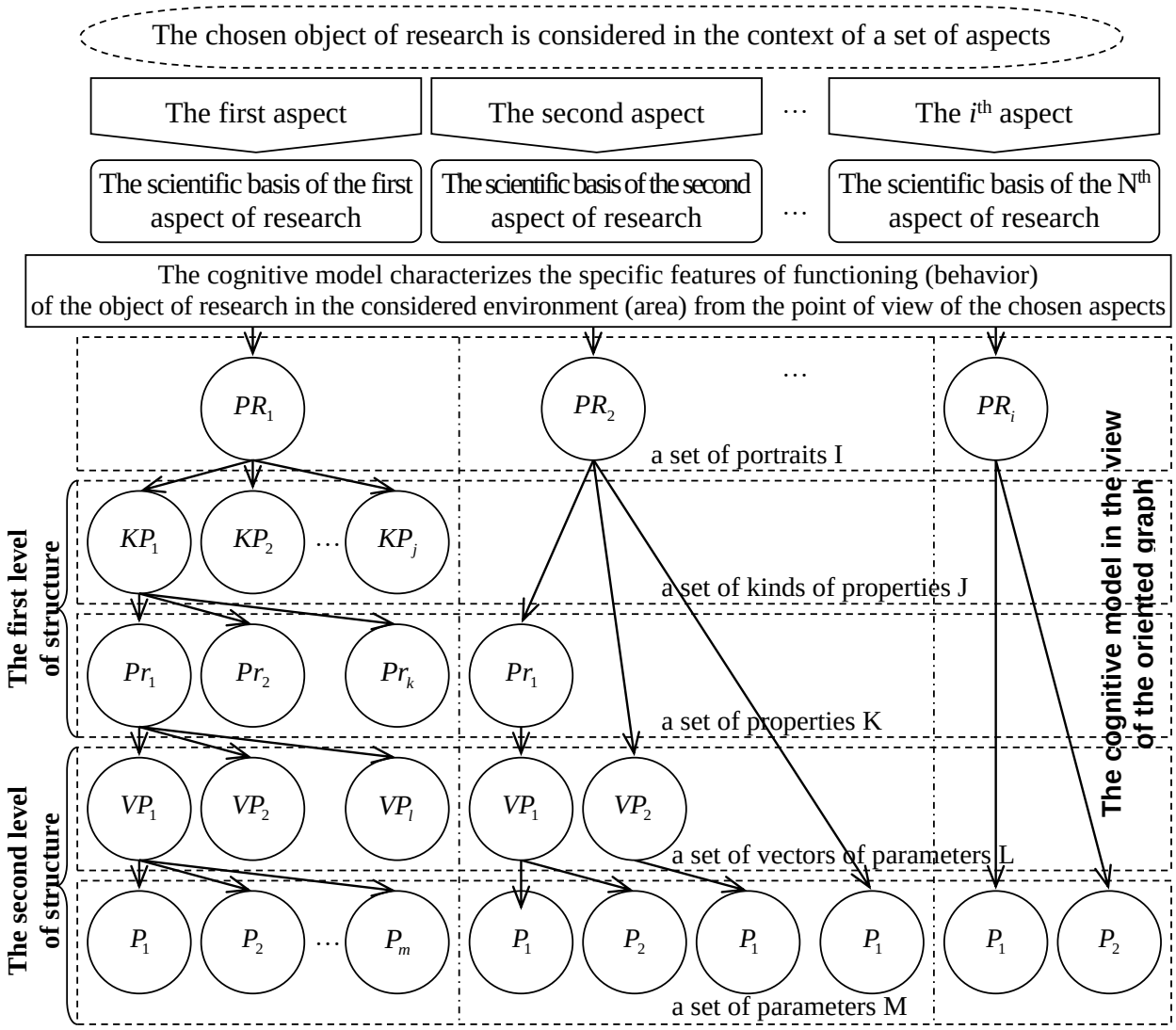
Pic. 4.2. The technique of use of the cognitive modeling technology

4.3. The ways of representation of the structure of the cognitive model

CM – the (re)designed repertoire of parameters in width and depth, reflecting a set of aspects of the system analysis of the object of research, echeloned on a set of portraits $(PR_1, PR_2, ..., PR_i, ...)$ with scientific justification and stratified in a several mathematical sets: sets of the kinds of properties $(KP_1, KP_2, ..., KP_j, ...)$ and properties $(Pr_1, Pr_2, ..., Pr_k, ...)$, sets of the vectors of parameters $(VP_1, VP_2, ..., VP_l, ...)$ and parameters $(P_1, P_2, ..., P_m, ...)$.

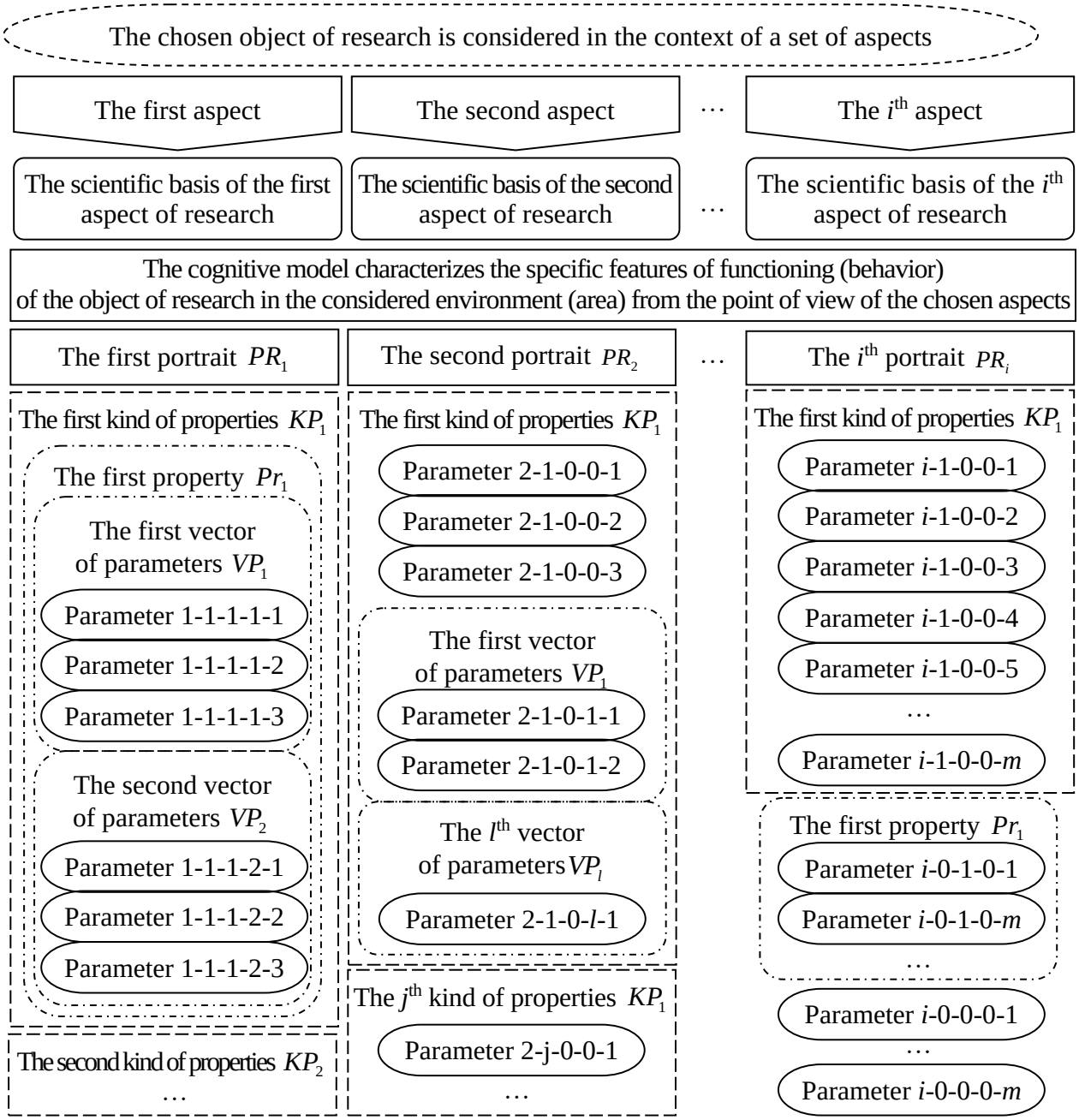
For the formalization of the received structure of the parametrical CM two ways (models) of representation of the repertoire (hierarchy) of parameters are offered: oriented graph combining the theory of sets (formal model) and multilevel structural scheme (block diagram) (informal way).

Using the device of theory of graphs, the parametrical CM represents inside the oriented graph, in whose tops are concentrated (from top to down): portraits, kinds of properties, properties, vectors of parameters and parameters, which form the corresponding sets, characterizing the object of research in the subject area (pic. 4.3).



Pic. 4.3. The recommended basis for the construction of the structure of the cognitive model in the view of the oriented graph (formal representation)

In pic. 4.4 the way of representation of CM in the view of the structural scheme (block diagram) is presented.



Pic. 4.4. The recommended basis for the construction of the structure of the cognitive model in the view of the structural scheme (block diagram) (informal representation)

It is recommended to each scientific aspect of consideration of the object of research to create and further to associate with it the certain portrait of CM, in limits of which are arranged the kinds of properties and properties, the vectors of parameters and parameters. In the process of (re)designing of CM is admissible the reduction and accretion of its structure.

In pic. 4.3 and 4.4 are entered and are used the following designations for a sets and calculating indexes on the different levels of CM: PR_i – a set of portraits I and index of portrait i, KP_j – a set of kinds of properties J and index of kind of property j, Pr_k – a set of properties K and index of property k, VP_l – a set of vectors of parameters L and index of vector of parameters l, P_m – a set of parameters M and index of parameter m.

4.4. The algorithm of formation of the structure of the cognitive model

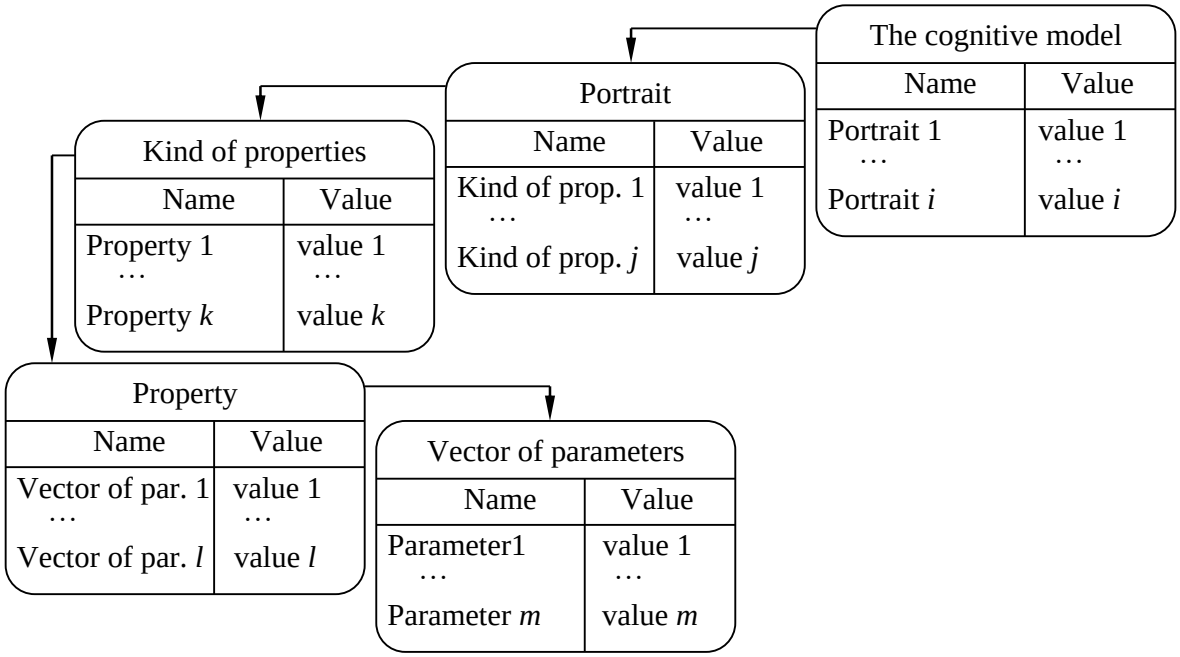
The algorithm of formation of the structure of CM covers the several first stages of CMT and provides the support of procedure of (re)designing of the structure of CM on the basis of one from the offered ways of representation of the structure of CM:

- identification – on the basis of collected data, tasks and restrictions is selected the list of scientific areas of the consideration of the object of research and is selected the necessary quantity of the portraits of CM (PR_i) sufficient for the realization of the system analysis of the object, process or phenomenon of research;
  - for the system analysis of IEE of ART system and increase in efficiency of information interaction between the subjects and means of training it is offered in further to form two parametrical CM (of the subject and means of training) and to enter into each model three portraits (physiological, psychological and linguistic), which allow to provide its scientific justification in the context of three subject areas (physiology of sensory systems, cognitive psychology and applied linguistics);
- conceptualization – in the object of research are allocated the key concepts and names of entities (elementary parameters – P_m and properties – Pr_k) and their classes, groups of signs (kinds of properties – KP_j and vectors of parameters – VP_l);
  - on the basis of the allocated classes and groups of signs of the object of research sets of kinds of properties (KP_j) and elementary properties (Pr_k) are formed;
  - from a set of key concepts and names of entities sets of vectors of parameters (VP_l) and elementary parameters (P_m) are formed;
- structuring – it is necessary to form the structure capable to aggregate the allocated information elements (KP_j, Pr_k, VP_l, P_m), which in further lays down into the basis of CM formalized by means of one from the existing models of data representation, or by means of the offered further models (graph combining the theory of sets and scheme), at the same time it is necessary to adhere to the hierarchical principle of construction of the structure of CM (are entered two levels containing on two layers in everyone);
  - as CM is the reconstructed repertoire of parameters (elements entering in the basis of its hierarchy) providing a possibility of expansion in width and depth, then is provided the addition of the portrait (PR_i) which is subject of the procedure of further filling by the various elements which are settling down on the various levels of hierarchy and forming a set of sets, each of which is characterized by the certain power (capacity): set of kinds of properties (KP_j) with the power J, set of properties (Pr_k) with the power K, set of vectors of parameters (VP_l) with the power (capacity) L, set of elementary parameters (P_m) with the power (capacity) M;

- at the beginning it is considered the first level of hierarchy in the formed CM characterizing the main (basic) signs of the object of research allocated for the analysis and includes two layers on each of which are allocated the corresponding sets of information elements – kinds of properties (KP_j) and elementary properties (Pr_k), and the cumulative quantity of information elements which are contained on this level is not limited and is calculated on the basis of powers (capacities) of each from the considered layers J+K;
- then the filling of the second level of hierarchy in the formed CM is made, and each element of this level describes and specifies the appointment of earlier entered elements located on the first level: are entered the parameters (P_m) and vectors of parameters (VP_l) characterizing each elementary property (Pr_k) of the object of research, the quantity of elements which are contained on this level is not limited, the power (capacity) of a sets of the second calculates L+M;
- the cumulative power of all sets of information elements which are located on two levels entering into CM is calculated by the formula J+K+L+M;

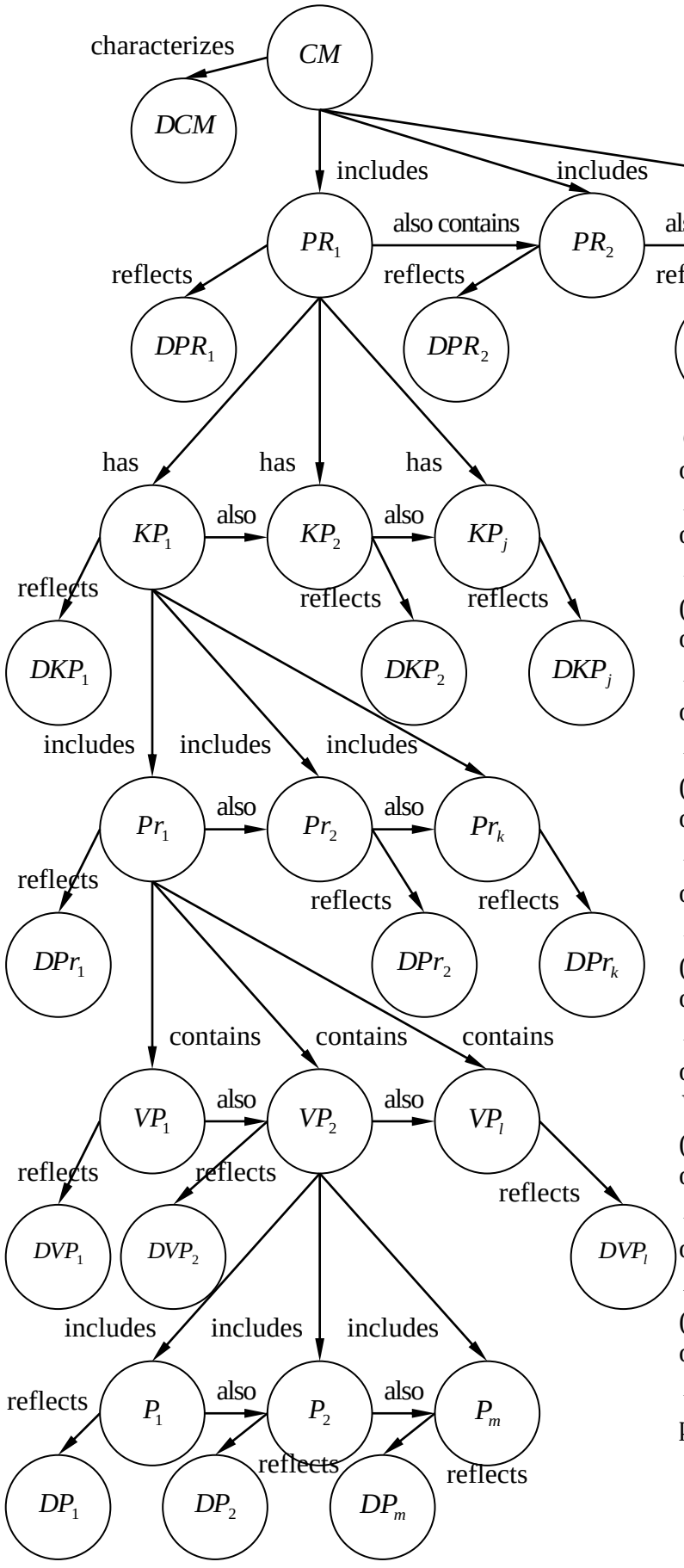
- formalization – is chosen the optimum model of data representation (is offered the oriented graph combining the theory of sets and multilevel scheme) necessary and sufficient for the representation of CM on the basis of the received hierarchical structure, including two levels;
  - at the choice of the oriented graph for the support of representation of the structure of the formed CM (pic. 4.3) – each information element represents inside the top of graph, which settles down on the certain level of hierarchy and belongs to a certain set (I, J, K, L, M), and the relations (on the basis of the principle of taxonomy, inclusion and others) between elements of the formed hierarchy are reflected by means of the arches of graph (identifiers of arches by default are not entered, but are provided);
  - at using the multilevel structural scheme (block diagram) (fig. 4.4) for the display of the received structure of CM it is necessary to fill the values in slots corresponding to the portraits (PR_i), kinds of properties (KP_j), properties (Pr_k), vectors to parameters (VP_l) and elementary parameters (P_m), and the specifics of this way of representation of CM is the absence of connections between the information elements located at the different levels of hierarchy, the easy program realization, the increased presentation and fast interpretation of presented information elements, a possibility of reduction of some information elements which are located on the various levels of hierarchy regardless of their type;

- at the choice of the frame model of representation of structured data the formation of the structure of CM comes down to the indication of identifiers and values of fields of hierarchically coordinated named tables (pic. 4.5);
  - the identifier of frame of the top level (proto-frame) corresponds to the name of the object of research (the name of CM of the certain object), and its fields contain the list of names of portraits;
  - the identifier of frame of the first layer (the first level) corresponds to the name of the portrait of CM (PR_i), and its information fields contain the list of the available kinds of properties (KP_j) and their descriptions (values);
  - the identifier of frame of the second layer (the first level) corresponds to the name of the certain kind of properties (KP_j), and its fields include the list of the elementary properties (Pr_k) and their descriptions (values);
  - the identifier of frame of the third level (the second level) corresponds to the name of the certain property (Pr_k), and its fields contain the list of the vectors of parameters (VP_l) and their descriptions (values);
  - the identifier of frame-copy of the fourth level (the second level) corresponds to the name of the vector of parameters (VP_l), and its fields include the list of the elementary parameters (P_m) and their values (including the areas of admissible values and limits of variation);



Pic. 4.5. The representation of the structure of the cognitive model by means of the frame model

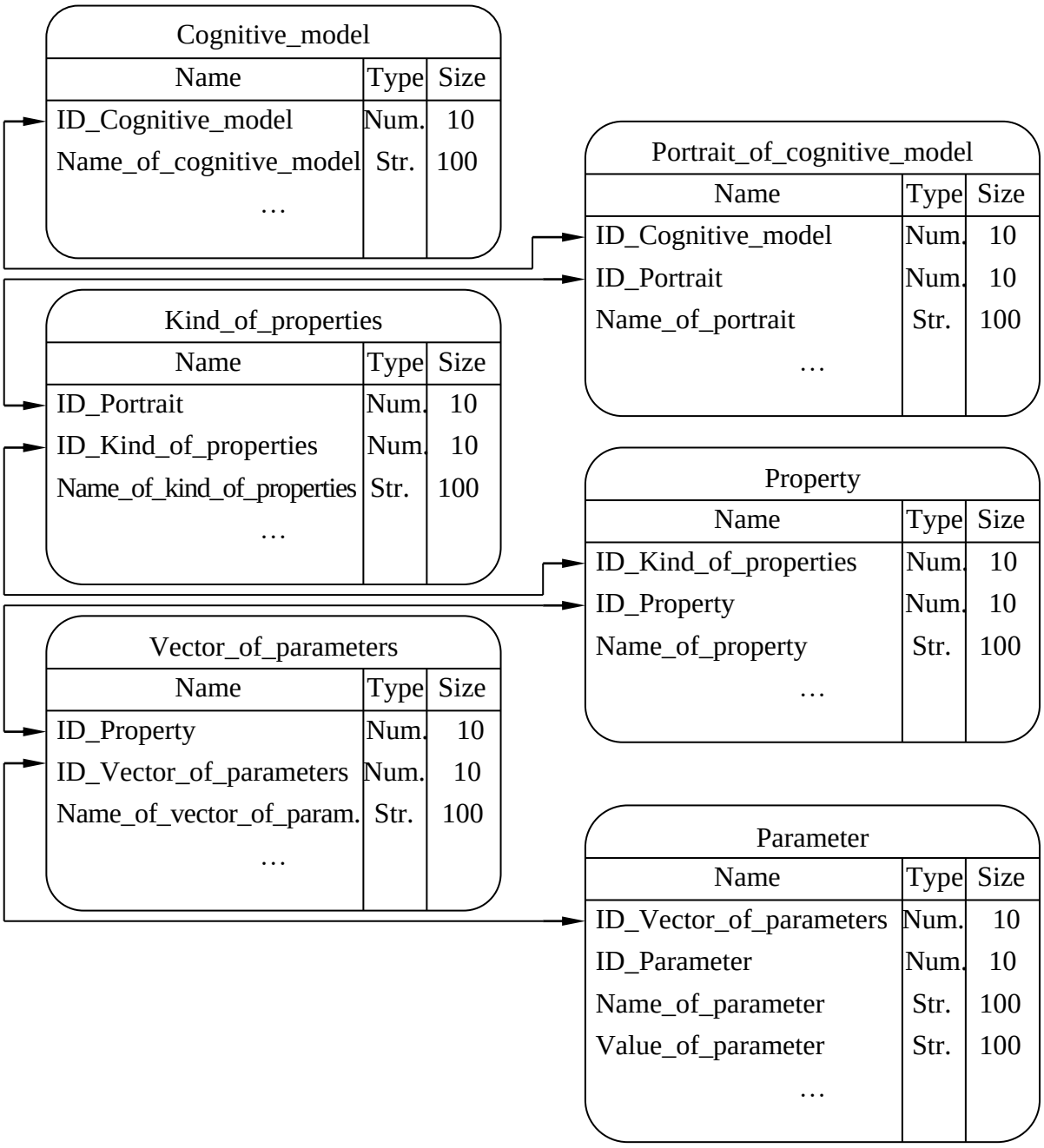
- at using of the semantic network for the representation of the structure of CM of the object of research is entered a set of tops each of which corresponds to the elements located on the various levels of hierarchy of the formed CM, then are displayed the connections between them having the various identifiers, each of which reflects the mutual coordination of information elements from each other, at the construction of the semantic network it is necessary to be oriented on the principle of hierarchy (pic. 4.6);



CM – the cognitive model of the object of research;
DCM – the description of cognitive model of the object, process or phenomenon;
PR_i – the identifier (name) of the i^{th} portrait of the cognitive model;
DPR_i – the description of the i^{th} portrait of the cognitive model;
KP_j – the identifier (name) of the j^{th} kind of properties of the cognitive model;
DKP_j – the description of the j^{th} kind of properties of the cognitive model;
Pr_k – the identifier (name) of the k^{th} property of the cognitive model;
DPr_k – the description of the k^{th} property of the cognitive model;
VP_l – the identifier (name) of the l^{th} vector of parameters of the cognitive model;
DVP_l – the description of the l^{th} vector of parameters of the cognitive model;
P_m – the identifier (name) of the m^{th} parameter of the cognitive model;
DP_m – the description of the m^{th} parameter of the cognitive model.

Pic. 4.6. The representation of the structure of the cognitive model in the view of semantic network

- the structural analysis – is realized the analysis of the first level of the structure of CM (in separately or common on relation to each portrait PR_i) with the purpose of identification of degree of depth and completeness of the description of chosen for research of object, process or phenomenon (it is offered to research IEE of ART);
  - at the research of IFPST are of interest the features of perception (anomalies of refraction, perception of space and color vision), processing (convergent and divergent abilities, cognitive styles and learning ability) and understanding of information (level of proficiency in language of statement of material and software means in the basis of IEE of ART);
  - for the research of potential opportunities of the means of training is offered to consider the features of visual representation (parameters of background, font, color and sound schemes), way of display of the sequence of information fragments (kind, style and speed of representation of information and additional parameters), level of representation of information (level of statement of material and a set of elements in the basis of the interface of program component of ART system);
- the parametrical analysis – is carried out the analysis of the second level of the structure of CM with the purpose of identification of degree of coherence of the elements which are in its basis specifying the properties of the object of research and allowing to accumulate the information, allowing to define the narrowness of connections between the elements of the structure of CM directly after the mathematical processing of a posteriori data with the use of various special statistical methods;
  - it is carried out the analysis of completeness, consistency and coherence of the received vectors of parameters (VP_l) characterizing each elementary property (Pr_k) or kind of properties (if takes place the reduction of the certain property) forming the mathematical set with the power (capacity) L;
  - it is carried out the analysis of compliance of value of the elementary parameter (P_m) which value is measured in the course of experiment with in advance given limits of variation (area of admissible values of parameter);
- realization – on the basis of the received theoretical structure of CM is available the opportunity to form the experimental structure of CM including a set of parameters relevant for the carrying out of the analysis of the efficiency of functioning of the object of research by means of the use of the means of automation (special computer program);
  - it is carried out the configuration of software for the realization of the procedure of research (diagnostics), for example DM, and then ET;
  - at the developing of the infological scheme of DB realizing the storage and extraction of values corresponding to the elements of the structure of CM was considered a possibility of its expansion in width and depth (pic. 4.7).

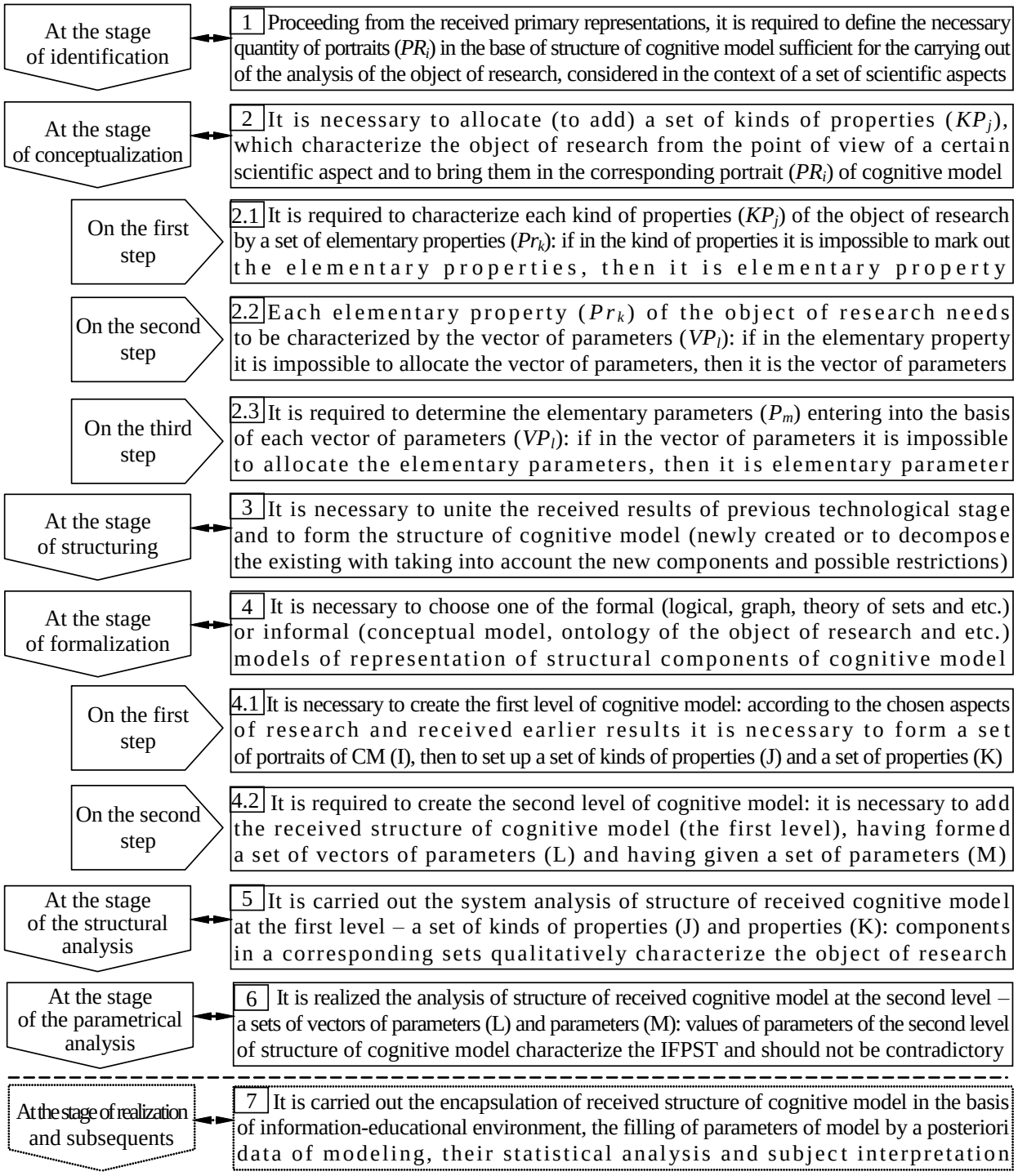


Pic. 4.7. The infological scheme of database
for the representation of the structure of the cognitive model

In pic. 4.7 is presented the fragment of the infological scheme of DB, including the several named tables and a set of information fields, some of which act as the key and provide the connection between different tables:

- the table “Cognitive_model” – contains the list of CM of the various objects;
- the table “Portrait_of_cognitive_model” – reflects the list of portraits entering into the certain CM each of which has the scientific justification;
- the table “Kind_of_properties” – includes a set of kinds of properties;
- the table “Property” – a set of properties, entering into each kind of properties;
- the table “Vector_of_parameters” – contains the list of vectors of parameters;
- the table “Parameter” – a set of identifiers of parameters and their values.

For the formalization of the sequence of (re)designing of the structure of CM is offered the algorithm of formation of the structure of CM (pic. 4.5), which allows to form CM on the basis of two ways (models) of representations of its structure: the oriented graph combining elements of the theory of sets and the structural scheme.



Pic. 4.8. The algorithm of formation of the structure of the cognitive model

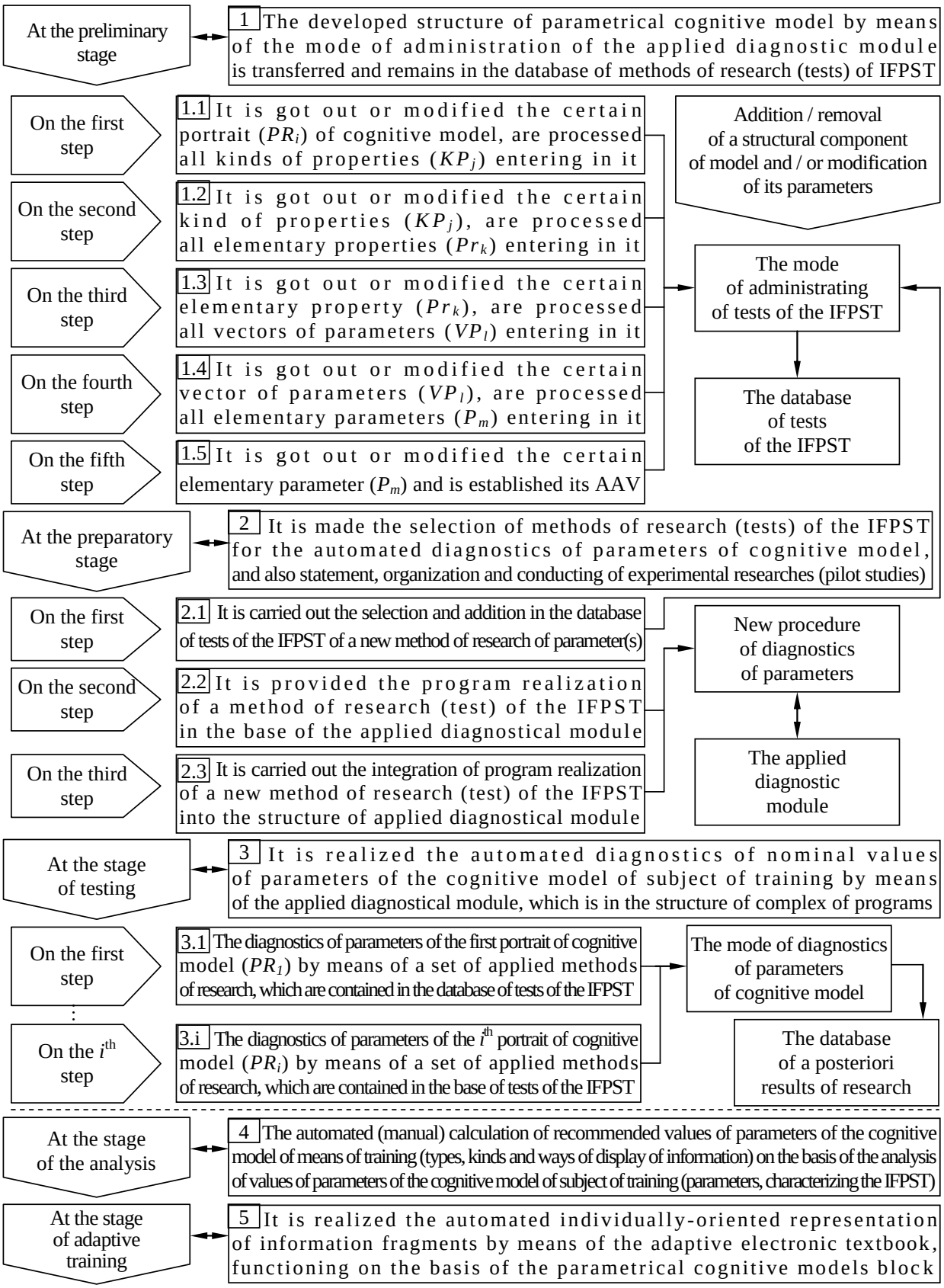
It is recommended to each scientific aspect of consideration of the object of research to associate (to bring in compliance) the certain portrait of the parametrical CM, within the limits of which are arranged the different kinds of properties (KP_j) and properties (Pr_k), vectors of parameters (VP_l) and elementary parameters (P_m). In the process of (re)designing of CM is admissible the reduction of its structure, some information elements in its basis can be absent.

4.5. The technique of research of the parameters of the cognitive model of the subject of training

The offered technique includes several stages in the context of which is realized the technological process of preparation and statement of a series of experiments, setting up the software, carrying out an experiment for the support of possibility of the subsequent processing of a posteriori data which are saved up in DB:

- the preliminary stage – setting up the software for the automation of carrying out of research of the parameters of CM of the subject of training;
  - the initial (theoretical) structure of CM is subject to transfer (input) in DB of software means, providing the full cycle of research;
  - it is started the mode of administrating of software means (applied DM) and activating the panel of input of identifiers and values of parameters of CM of the subject of training, are set up the nominal values by default;
- the preparatory stage – according to the formed repertoire of parameters of CM (parameters which are available earlier and entered in the course of modification of its structure) is selected directly a set of methods of research in the form of diagnostics (observation, recording, poll in the form of natural dialogue, discussion in the context of a round table, automated testing and others) allowing to define the values of each parameter as the subject to research;
  - it is provided the development of special brainware, program realization and subsequent addition of the found method of research for the diagnostics of the values of new parameter brought in DB of the applied DM;
  - it is realized the analysis of DB containing the various methods of research of IFPST, and also the identification and subsequent removal of the outdated methods of research;
  - it is carried out the copying of temporarily not used methods intended for the support of automated diagnostics into the reserve DB;
- the stage of testing – is applied the applied DM for the automation of the process of diagnostics of the values of parameters characterizing IFPST by means of the use of the certain method which is contained in DB;
- the stage of the analysis – is realized the mathematical processing of a posteriori data with the use of the certain statistical method of the analysis;
  - it is carried out the formation of selections with a posteriori data, which characterize the dynamics of a selected set of indicators;
  - it is realized the primary analysis of the nominal values of indicators in the received selections with a posteriori data (search of emissions, artifacts, determination of correctness and limits of variation of the values of observed signs, detection of compliance to the certain law of distribution of the values of signs which are subjects to the analysis by means of a set of methods);
  - it is provided the secondary mathematical analysis of selections with a posteriori data by means of the certain statistical methods.

The technique allows to provide the sequence of actions directed on the organization and performing of automated diagnostics (in the form of testing) of the values of parameters of CM of the subject of training by means of the applied DM (pic. 4.9).



Pic. 4.9. The technique of research of the parameters of the cognitive model of the subject of training

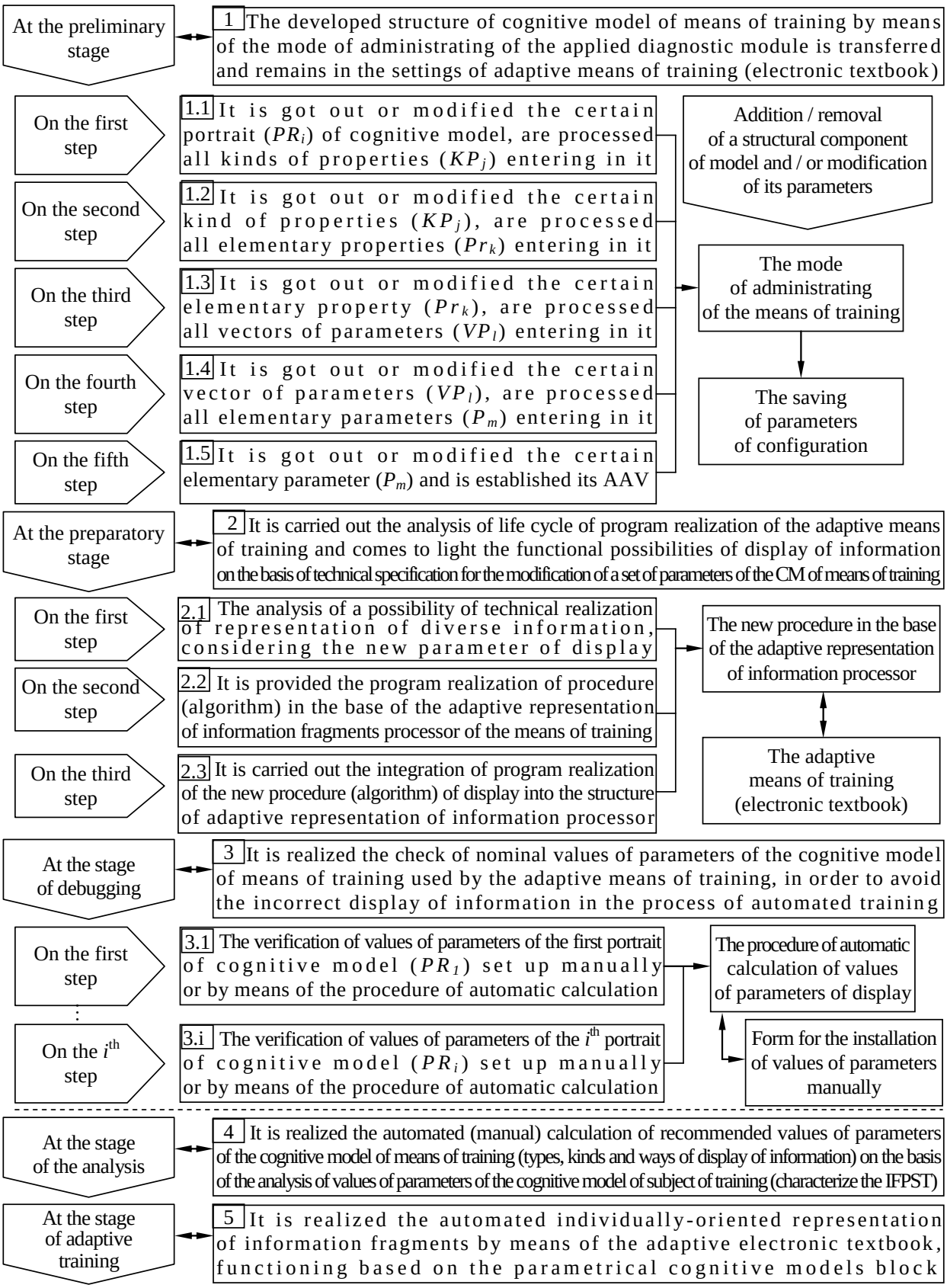
4.6. The technique of research of the parameters of the cognitive model of the means of training

The presented technique allows to provide the installation of the parameters of CM of the means of training characterizing the technical capabilities of the means of training at the representation of the sequence of information fragments by various way:

- the preliminary stage – is provided the preparation of the adaptive means of training (ET) operating on the basis of the adaptive representation of information fragments processor and realizing the individually-oriented formation of knowledge of the contingent of trainees taking into account the technical capabilities of the means of training (parameters located in the parametrical CM of the means of training) and IFPST (parameters in the parametrical CM of the subject of training);
  - the theoretical structure of CM of the means of training is specified on the basis of the available technical capabilities of the certain means of training, and the experimental structure of CM of the means of training includes a set of parameters characterizing the features of display of information fragments (physiological: color of background, font, color schemes for trichromats and dichromats, volume, timbre, type of stream, sound scheme and others; psychological: kind of information, style and speed of representation of information fragments; linguistic: level of statement, a set of key terms and definitions, a set of elements of interface);
  - at work with the adaptive means of training in the mode of administrating of DB for each discipline are set up the parameters of display of information by default, which are used in case if the mode of adaptive training is switched off or it is impossible to calculate the optimal nominal values of parameters of display of information on the basis of IFPST, and then are entered the previously structured data, which characterize the content of one or several subjects of studying;
- the preparatory stage – there are brought to light and specified the technical opportunities of the means of training (ET), the admissible modes of its functioning on the basis of technical specification and guide of user, and also are set up and corrected the values of parameters of CM of the means of training (by results of the preliminary analysis) and are entered the values of parameters of CM of the subject of training (by the results of preliminary diagnostics of IFPST);
  - the check of correctness of the entered values of parameters of CM of the means of training characterizing a possible set of features, ways, methods and styles of display of information by means of the support of comparison their with the actual technical characteristics of the means of training;
  - addition into the basis of the adaptive representation of information fragments processor of the procedures and (or) algorithms providing the support of calculation of the value of new parameter of display of information;

- the stage of debugging of software means – search of possible discrepancies and incorrectnesses in the algorithmic structures and data supporting the process of functioning of the means of training (ET) operating in the various admissible modes directly on the basis of the adaptive representation of information fragments processor, and also the entered values of parameters of CM of the subject of training and CM of the means of training which are contained in PCMB for an exception of incorrect display of the sequence of various information fragments;
  - the check of compliance of the areas of admissible values of each available value of parameters of CM of the means of training and CM of the subject of training, which are contained in DB of the means of training, and also the control calculation of the optimal values of parameters of display of TI taking into account IFPST and technical capabilities of the means of training;
  - the identification and elimination of incompatible for the subject the modes and parameters of display of information fragments by means of creation and addition of rules limiting the input of inadmissible combinations of the values of parameters of display of information to the contingent of trainees;
- at the stage of the analysis – it is realized the consecutive manual input (values previously are calculated and entered by the specialist-expert) or the automated calculation of the values of parameters of display of information fragments (it is realized just before start of the mode of adaptive training);
- at the stage of adaptive training – it is realized the individually-oriented generation of TI by means of the adaptive representation of information fragments processor of ET functioning based on PCMB;
  - directly after the start of the software means of automation, the choice of the subject of studying and registration of a user the loading of the values of parameters of CM of the subject of training and CM of the means of training is provided;
  - the start of the mode of adaptive training is possible if is reached the filling of DB by the previously structured data, which reflect the content of the subject of studying or several subjects, and also if the values of parameters of CM of the means of training by default reflecting an admissible set of ways of display of information for each discipline are entered and if are set the values of parameters of CM of the subject of training reflecting IFPST which are needed to be previously diagnosed by means of use of the applied DM;
  - after the start of the mode of adaptive training by the adaptive representation of information fragments processor is provided the automatic calculation of the optimal values of parameters of display of information for the certain trainee taking into account his IFPST (CM of the subject of training) and technical capabilities of the means of training (CM of the means of training);
  - in the mode of adaptive training the display of hints is realized.

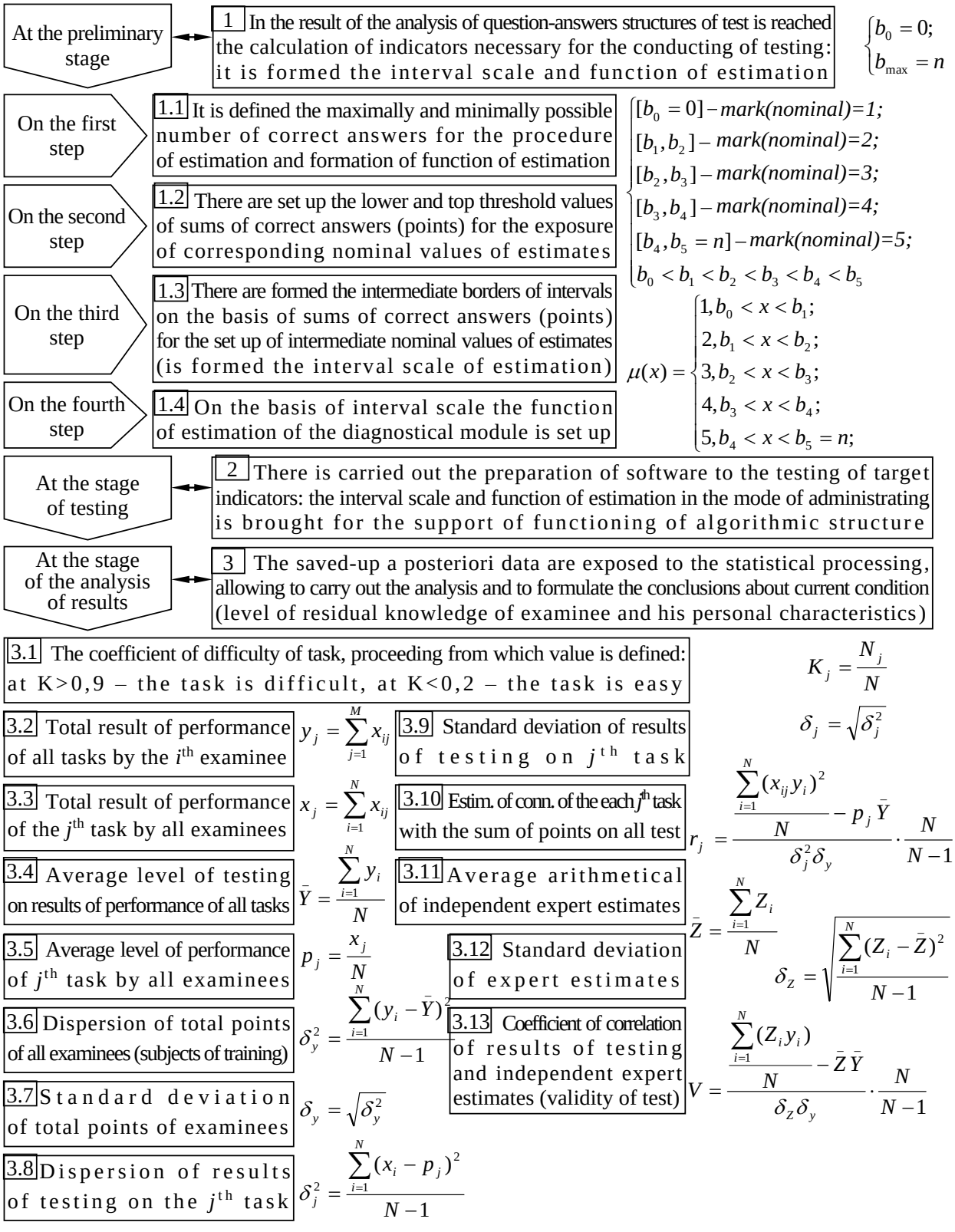
Allows to watch over the technical capabilities of the means of training in the course of its life cycle and to fill DB of its program realization by the values of parameters on the basis of the structure of CM of the means of training (pic. 4.10).



Pic. 4.10. The technique of research of the parameters of the cognitive model of the means of training

4.7. The algorithm of processing of a posteriori data of testing

It allows to form the interval scale of estimation and function of estimation, to realize on its basis the testing (algorithm is realized in the basis of program), and then to carry out the analysis of the condition of an examinee and to estimate the quality of test (pic. 4.11).



Pic. 4.11. The algorithm of processing of a posteriori data of testing of the contingent of trainees

For the improvement of quality of the procedure of testing the key value has the methodology of construction of the question-answers structures entering in the basis of test as in form so in a content, as it influences on reaction of trainees and accuracy of received a posteriori data, and also the quality of estimation of LRKT and IFPST.

A set of requirements, imposed to the quality of a method of research (test) are allocated:

- validity – the complex characteristic of test, defining it ability to reveal the values of key indicators in the process of diagnostics;
  - substantial – is defined by the author of test, forming the selection of questions and reflects the degree of adequacy of picked-up questions to the tasks of diagnostics and content of the subject of studying, which is formed on the basis of requirements and state educational standards;
  - predictive – a possibility of forecasting of the resultativity of training on the basis of obtained a posteriori data by means of test;
  - differential – combines in the own basis two previous kinds;
- reliability – the stability of received results with the use of test;
  - retestual – the stability of results of testing in time at the performing of repeated diagnostics with the use of this test;
  - internal – the formation of selection of tasks of test, at which is observed the positive correlation between the results received by the examinees in two and more groups and their stability;
- discriminativity – the ability of used test to differentiate the examinees of rather minimal and maximal nominal value of estimation taking into account the chosen scale and function of estimation.

During the automation of the procedure of testing of LRKT and IFPST by means of software it is possible to allocate a set of advantages:

- the objectivity of testing – the independent estimation of the results of performance of tasks by the examinee with the use of various algorithms and methods;
- the possibility of the use of several designers of test tasks;
- the differential estimation and possibility of connection and the use of various scales, functions, methods and algorithms of the procedure of estimation;
- the optimization of temporary expenses and economy of different kinds of resource support due to the reduction of labor-costs on preparation and processing of the forms containing a posteriori results of testing of LRKT and IFPST;
- the automatic registration, processing and sorting of a posteriori data – the analysis of answers of examinee, their saving in DB with a posteriori results, the choice of scale and function of estimation, the mathematical processing of selections of data with the use of various statistical methods;
- the possibility of the use of multimedia and hypermedia technologies – allow to reproduce audio- and video-stream in parallel with display of task, that is almost unattainable at the traditional testing.

Tests for assessment of LRKT and IFPST belong to the category of the tests of achievements and abilities of examinees, allocate the various variants of performing of control:

- the entrance control – is realized at the first stage of ART by means of DM and consists in the consecutive performance by the examinee of a set of tasks formed by an algorithm, assumes the primary diagnostics of the initial values of LRKT and IFPST, which are brought into CM of the subject of training;
- the current control – is carried out systematically according to fact of studying of each information fragment (paragraph), assuming the existence of a set of control questions, which are shown by the algorithm of DM;
- the intermediate control – is reached due to passing by the examinee of the procedure of testing on the basis of the resultant selection of control questions which are contained at the end of each section (module) of the subject of studying;
- the total control – is carried out by means of the use of DM on the basis of the control selection of questions generated on the basis of all control questions which are contained at the end of each from all information fragments.

Today there is a set of approaches to the interpretation of the sum of points gathered by the examinees in the course of testing, from whom distinguish two main:

- the standard-oriented approach – allows to compare the indicators of the resultativity of performance of tasks of several trainees among themselves on the basis of the comparison of received and demanded (given) levels (estimates);
- the criteria-oriented approach – realizes the estimation of the degree of performance of a set of offered tasks (tests) by each trainee on the basis of the certain criterion (function of estimation), allows to form groups.

For the estimation of the degree of execution of test is defined the quantity of test tasks, allowing to determine the sum of gained points by the examinee on the basis of the quantity of correct answers and corresponding to it the threshold value (estimation) for the elimination of examinees who have not passed testing based on the chosen criterion.

For the realization of the procedure of testing with the purpose of estimation of LRKT it is necessary to form the interval scale and function of estimation.

The interval scale is formed proceeding from the quantity of levels, defining the gradation of the indicator characterizing the estimation of LRKT or IFPST.

The function of estimation allows to establish the unambiguous compliance between each nominal value of estimation of LRKT or IFPST and the interval, including the minimal and maximal threshold values of sums of correct answers or gained points by the examinees in the course of the procedure of testing.

According to fact of the completion of procedure of testing the examinee gains the certain quantity of correct answers the questions of test or gains the certain sum of points in the result of choice of each correct variant of answer.

The results saving in DB with a posteriori data of testing and are subject to the further processing (identification of tendencies, regularities and other).

On the basis of the carried out research we'll form the conclusions on the forth chapter:

1. It is submitted the description of CMT including a set of techniques and algorithms for the realization of the system analysis of IEE and providing the increase in efficiency of functioning of the components of ART system, and also allowing to conduct the automated researches of information interaction between the subjects and means of training.
2. It is presented the iterative cycle of CMT reflecting the sequence of stages, realizing the complex analysis of IEE of ART system based on PCMB.
3. It is presented the technique of use of CMT, which formalizes the features of application of CMT for the analysis of the object of research in the subject area.
4. There are offered two ways (models) of representation of the structure of the parametrical CM: the graph combining the theory of sets and the multilevel structural scheme (block diagram).
5. It is presented the algorithm of formation of the structure of CM providing the (re)designing of CM by means of the use of the existing models (the frame model and the semantic network) or one of the ways offered by the author (the graph combining the theory of sets and the multilevel structural scheme (block diagram)) of representation of structured data, having the declarative basis.
6. It is offered the technique of research of the parameters of CM of the subject of training formalizing the process of statement and carrying out of a series of experiments, which are directed to the diagnostics of IFPST by means of the use of the applied DM.
7. It is presented the technique of research of the parameters of CM of the means of training reflecting the sequence of research of the technical opportunities of the means of training (ET) throughout the life cycle of its program realization.
8. It is offered the algorithm of processing of a posteriori data of testing, which are received in the course of research of LRKT by means of the basic DM and (or) are saved up in the process of diagnostics of IFPST at using of the applied DM.

In the forth chapter is received the complex scientific result – CMT, including a set of techniques and algorithms (are selected for each object of research in the certain subject area), which are intended for the realization of the system analysis of IEE directed to the increase in efficiency of information interaction between the subjects and means of training in the process of functioning of the various components of ART system using in the own basis the different procedures and configured algorithmic support:

- the technique of use of CMT for the analysis of the chosen object of research in the certain subject area (the analysis of IEE of ART system is realized);
- two ways (models) of representation of the structure of the parametrical CM (the graph combining the theory of sets and the multilevel structural scheme (block diagram));
- the algorithm of formation of the structure of CM on the basis of the offered ways;
- the techniques of research of the parameters of CM of the subject of training and the means of training;
- the algorithm of processing of a posteriori data of testing of IFPST and LRKT.

5. The parametrical cognitive models block for the analysis and the increase in the efficiency of functioning of the automated educational environment

CMT contains a modified set of different techniques and algorithms, which allow to realize the system analysis based on PCMB, containing CM (re)designed by means of the available algorithm of formation of the structure of CM.

CM acts as the universal information basis for the carrying out of the system analysis of the chosen element, system, object, process or phenomenon, which is directed to the increase in the efficiency of functioning of the object of research, is the reconstructed repertoire of parameters expanded in width and depth, it is represented due to use of one from the standard models of representation of structured data (the frame model – pic. 4.5 and the semantic network – pic. 4.6) or by means of the use of one from the offered innovative ways (the graph combining the theory of sets – pic. 4.3 and the multilevel scheme – pic. 4.4).

For the creation, the analysis and the increase in the efficiency of functioning of IEE of ART system it is offered to develop PCMB including CM of two types:

- CM of the subject of training allows to analyze the efficiency of the process of the formation of knowledge of trainees, arriving from the flows of information generated by means of IEE of ART and which are adsorbed at the level of a psychophysiological construct of head brain of the subject of training, acts as the parametrized repertoire, echeloned on a set of portraits;
  - physiological – allows to explain the features of the sensory perception of information by the visual and acoustic analyzers of human;
  - psychological – reflects the convergent and divergent intellectual abilities, learning ability and cognitive styles of the subject of training;
  - linguistic – the natural-language aspects of virtual communication (level of proficiency in language of statement and a set of elements of interface);
- CM of the means of training accumulates the parameters characterizing a set of technical characteristics of the means of training influencing on the display of the sequence of information fragments reflecting the content of the subject of studying by the different way and it is differentiated on a set of portraits;
  - physiological – characterizes the features of visual representation: parameters of background, font and color schemes of display of a content;
  - psychological – the way of representation of TI to the contingent of trainees: kind of displayed information, style and speed of representation of sequence of information fragments by the algorithm of a program;
  - linguistic – reflects the language aspects of communication in IEE of ART.

The parameters of CM reflect the most important aspects of information interaction of the subjects of training and the means of training in IEE of ART, allows to qualitatively explain the reasons of difficulties in the process of the formation of knowledge of trainees.

The coherence of generation of information influences and IFPST is reached by means of simultaneous use in IEE CM of the subject of training and CM of the means of training located in PCMB of ART system.

CM of the subject of training is technologically applicable in the contour of IEE of ART, if the means of training are capable to generate the information-educational influences in coordination with the parameters of CM of the means of training, that is reached by means of the adaptive representation of information fragments processor.

The technique of research of the parameters of CM of the subject of training allows to realize the procedure of research of the parameters of CM of the subject of training by means of use the applied DM operating on the basis of a set of special methods from a set of applied areas, allowing to obtain the reliable a posteriori data and to scientifically prove the revealed dependences: private physiology of sensory systems, cognitive psychology and applied linguistics.

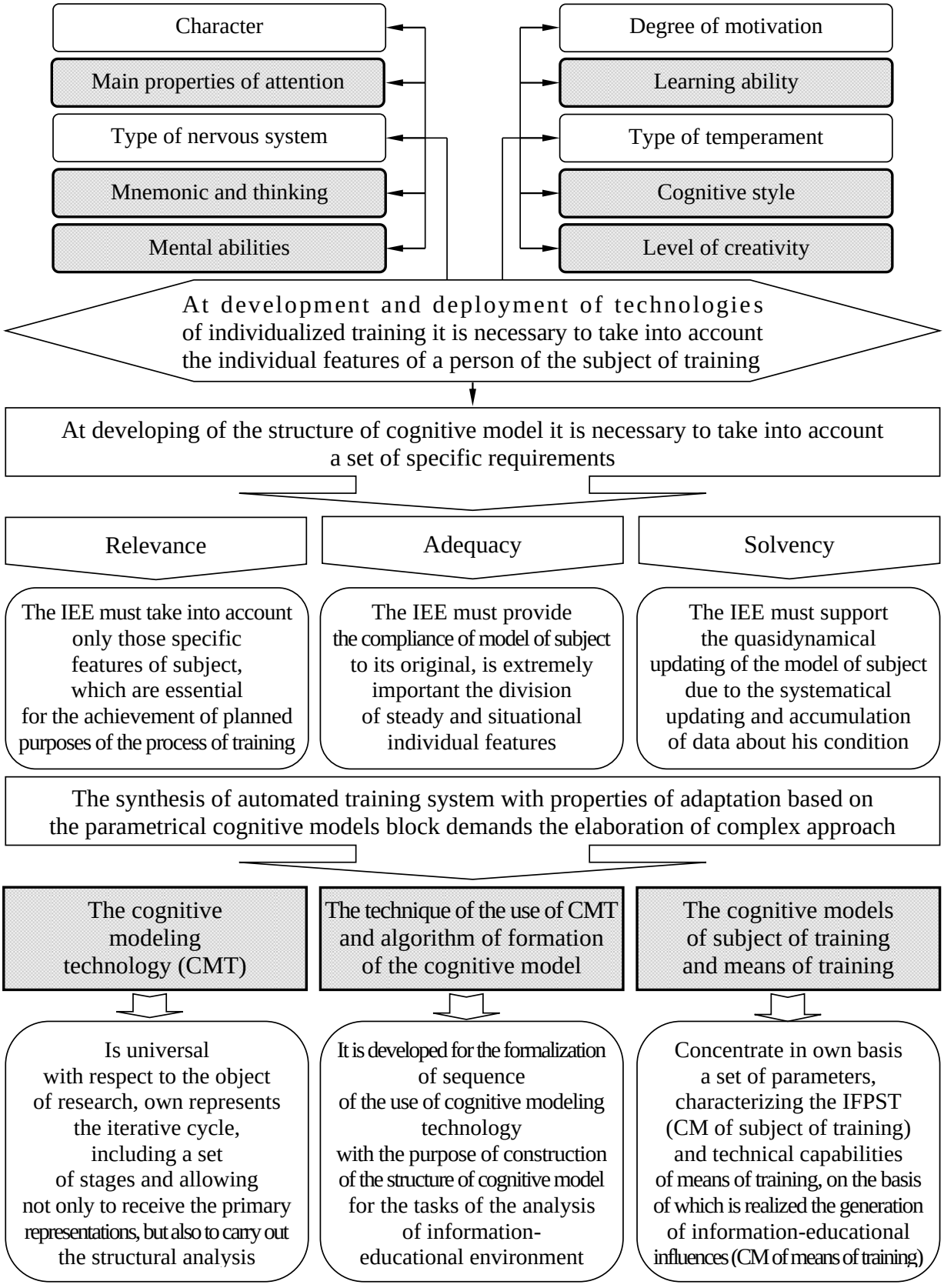
The technique of research of the parameters of CM of the means of training regulates the sequence of research of the parameters of CM of the means of training, which are set up by the results of the analysis of technical capabilities of the automated means of training and are modified parallel to the life cycle of the certain program realization of the means of training (in particular, ET), acting as the component of IEE of ART. For each certain means of training it is created the separate CM and characterizes a certain set of its technical characteristics.

For the realization of the contour of adaptation based on PCMB it is necessary to carry out the modernization of the program realization of the appropriate means of training with the purpose of realization of the presented earlier principles of functioning of various components, providing the performance of certain tasks of the subjects of IEE of ART.

As CMT acts as the universal on relation to the object of research (it can be applied not only for the system analysis of IEE of ART) and is the iterative cycle, including the closed sequence of stages:

- at the stages of identification, conceptualization and structuring – is admissible the change of the initial tasks, requirements and restrictions, that causes the need of specification of the parameters reflecting the condition and properties of the object;
- at the stages of formalization, the structural analysis and the parametrical analysis – it is possible the change of a way of representation of CM by means of the use of frame model of representation of data, semantic network, graph combining the theory of sets and multilevel scheme, at the same time is admissible the modification of the first and (or) the second level of the structure of CM;
- at the stages of realization and modeling – the identification of discrepancies and difficulties at the integration of CM, the solution of problems of measurement and accounting of parameters;
- at the stages of the analysis and subject interpretation – the identification of regularities and not uniformities, and also the scientific justification of received results;
- at the stage of the synthesis of new knowledge – addition of new scientific aspects.

At developing of CM of the subject of training it is necessary to take into account a set of requirements and restrictions, allowing to increase the level of its adequacy, and also subsequently to select the methods of research of its parameters for the increase of reliability and accuracy of a posteriori data obtained in the course of diagnostics (pic. 5.1).



Pic. 5.1. The main requirements to the structure of the cognitive model

The problematics of research of the process of information interaction between the subjects of training and means of training in IEE of ART orients on the consideration of the process of formation of knowledge as technological process in the various foreshortenings:

1. The physiological factors (psychophysiology of analyzers):
   - the existence of anomalies of a sensory perception of information by the visual analyzer at one of the subjects of dialogue of natural origin (human): anomalies of refraction of beams of light in the carrying-out environment of an eye, anomalies of perception of space caused by the shift of normal position of focus of a convergence of beams of light concerning the surface of retina of an eye (myopia (shortsightedness) and hypermetropia), the anomalies of color vision caused by the partial (abnormal trichromatia or insignificant dichromatia, at which is possible the application of schemes of color compensation) or full dysfunction of one of the component of coneal device of a retina of an eye (dichromatia: protanopia, deuteranopia and tritanopia, at which the scheme of replacement of the certain color is applied);
   - the existence of anomalies of sensory perception of information by the acoustic analyzer at one of the subjects of a dialogue of natural origin (person): anomalies of inner, middle and external ear or its sink significantly distorting the absolute acoustic sensitivity (minimal force of a sound wave registered by the ear), thresholds of sensitivity on the various frequencies of a sound wave at the various levels of volume and timbre of a sound stream (sound pressure);
   - the underestimated technical characteristics of means of collecting and registration of information transferred in the view of video-flow of data: overall dimensions reducing the mobility; high energy-consumption reducing the autonomy; the need of connection to a channel of transmission of data in the certain physical environment (radio-frequency wide-broadcasting: satellite, cellular; wire: coaxial cable, twisted pair; optical: infrared, fiber-optical); low resolution, depth of color and frequency of discretization of video-camera at the registration of static and dynamic image or Web-camera allowing to realize the dialogue in the global network "Internet"; a limited set of functions in the software for the realization of processing of dynamic images by means of technologies of non-linear video-tape-editing;
   - the technical parameters of means of collecting, accumulation and transfer of information representing inside the audio-data: low sensitivity of microphones, sensors and heads for removal of sound, low frequency of discretization of a sound stream, narrow frequency range of standard (loud)speakers and incorrect location of the elements of acoustic systems (stereophonic 2.1, quadraphonic: standard 4.1 and expanded 8.1).

2. The psychological factors (cognitive psychology):
   - the variation of the values of indicators in the selections of data characterizing the convergent and divergent intellectual abilities of the subjects of a dialogue: differences in predispositions of perception of information of different type (text, table, static and dynamic graphic image represented by means of flat or volumetric graphic scheme), and also the possibility of the use of an audio-stream as basic (without the inclusion of visual channel) and as accompaniment (in parallel without division in time or in consecutive with division in time);
   - the predisposition of a trainee to the implicit learning ability: in one case the algorithm in the basis of the automated means of training realizes the fast display of sequence of information fragments (it is characteristic for the methods of psychological correction and development); in other case the trainee works independently and at the same time the algorithm of the training program realizes the monitoring of sequence of performed operations and the analysis of their correctness, displays the hints;
   - presence at the trainee of the explicit learning ability causes a possibility of systematic gradual formation of knowledge of a trainee in advance on created program with the accretion of level of difficulty of statement of content of a subject of studying by means of the means of training (ET);
   - the cognitive styles define a set of bipolar properties of personality formed in early ontogenesis and influencing in the individual ways of processing of continuously arriving information of different kind.
3. The linguistic factors (an explained from the point of view of applied linguistics):
   - the types of subjects – on their origin the person is allocated (carrier of rare knowledge and their consumer) or the automated means of training (the system based on knowledge) providing the modeling of a dialogue;
   - the purpose of a dialogue – a set of purposes, tasks, functions and results of a dialogue;
   - conditions and restrictions of a dialogue – the strategic and practical purpose of each subject of a dialogue; theme of a dialogue (mono-thematic and poly-thematic); composition of communicative steps and organization of a dialogue (scheme of a dialogue and dynamics of communication), speech style, degree of artificiality of a dialogue;
   - the environment of a dialogue – traditional or automated, supporting a possibility of simplex or duplex exchange of information;
   - the features of dialogue – properties, kind of used information and way of its transfer (natural speech and letter or virtual conference and electronic letter), the volume of information transferred between the subjects of a (virtual) dialogue;
   - characteristics of the subjects of a dialogue – the social relations, the accumulated experience of interaction with the interlocutor (person and PC), the degree of cognitive activity, the chronological period and an interval of course of a dialogue.

5.1. The structure of the cognitive model of the subject of training

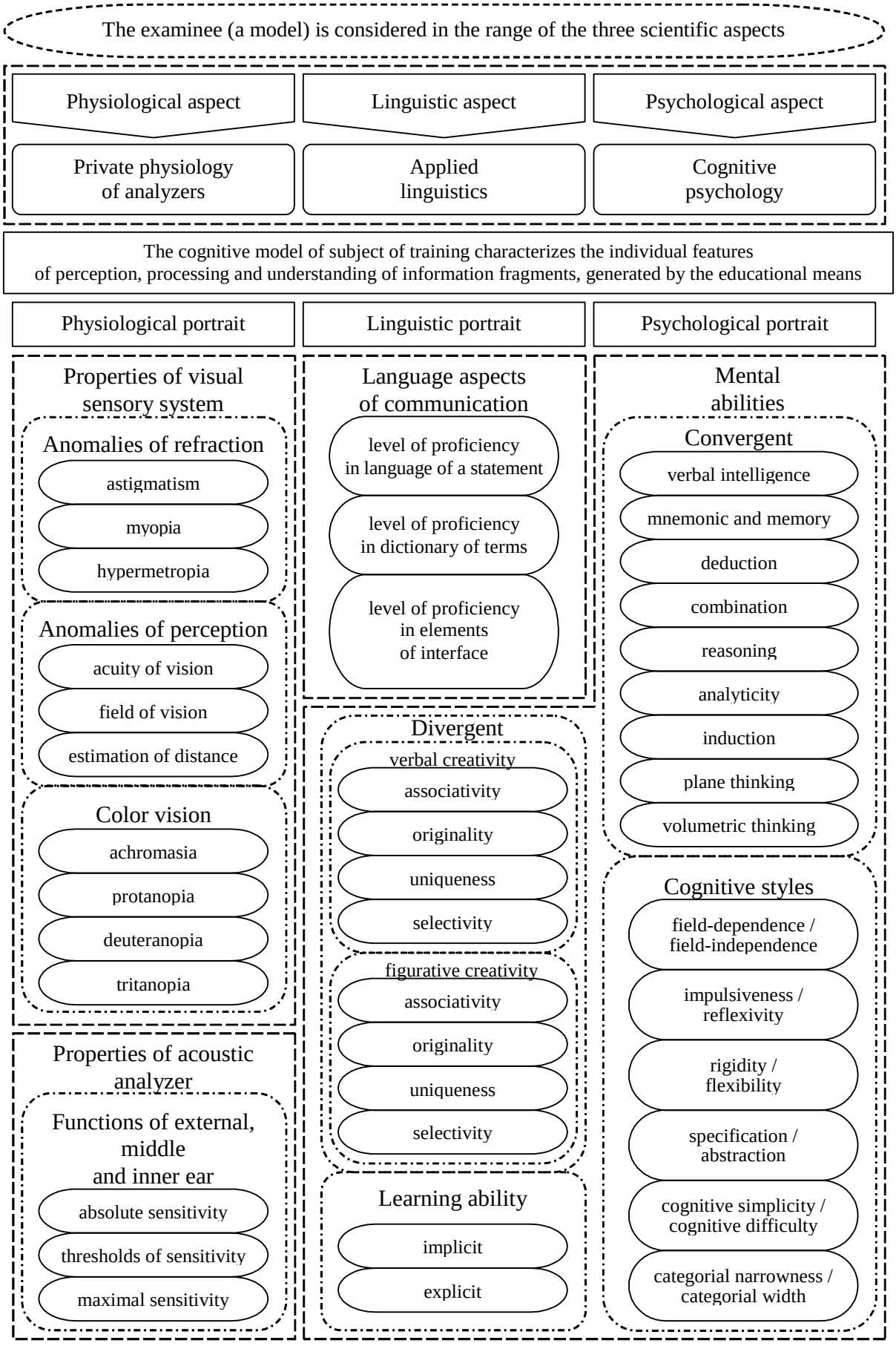
CM of the subject of training is developed by means of the use of CMT:

- CM of the subject of training directly acts as the information basis for the carrying out of the system analysis of IEE on the side of the subject of training allowing to reveal the factors influencing on the resultativity of technological process of the formation of knowledge of the contingent of trainees, to provide the increase in efficiency of information interaction between the subjects and means of training, to improve the brainware and the program realization of various components in the basis of ART system;
- at the creation of the structure of CM of the subject of training into its basis are entered three portraits (physiological, psychological and linguistic) and are respectively used three various scientific areas (physiology of analyzers, cognitive psychology and applied linguistics) allowing to form and to (re)design the repertoire of parameters entering into CM, and also to prove the statistical dependences and regularities revealed in a posteriori data;
- the process of (re)designing of the structure of CM is regulated and controlled by the algorithm of formation of the structure of CM (pic. 4.8), which provides the possibility of representation of CM by means of the use of one of the traditional models of representation of declarative data (the frame model – pic. 4.5 or the semantic network – pic. 4.6), or one of the offered ways of representation of the structure of CM (the graph combining the theory of sets – pic. 4.3 or the multilevel structural scheme – pic. 4.4);
- the statement and carrying out of series of experimental researches directed on the diagnostics of the nominal values of parameters of CM of the subject of training is regulated by the technique of research of the parameters of CM of the subject of training (pic. 4.9) and is realized by means of the use of the applied DM entering into the complex of programs for the automation of the tasks of research (pic. 6.1), which kernel includes a set of algorithms and procedures, and DB contains the previously structured data of the techniques of research of the parameters.

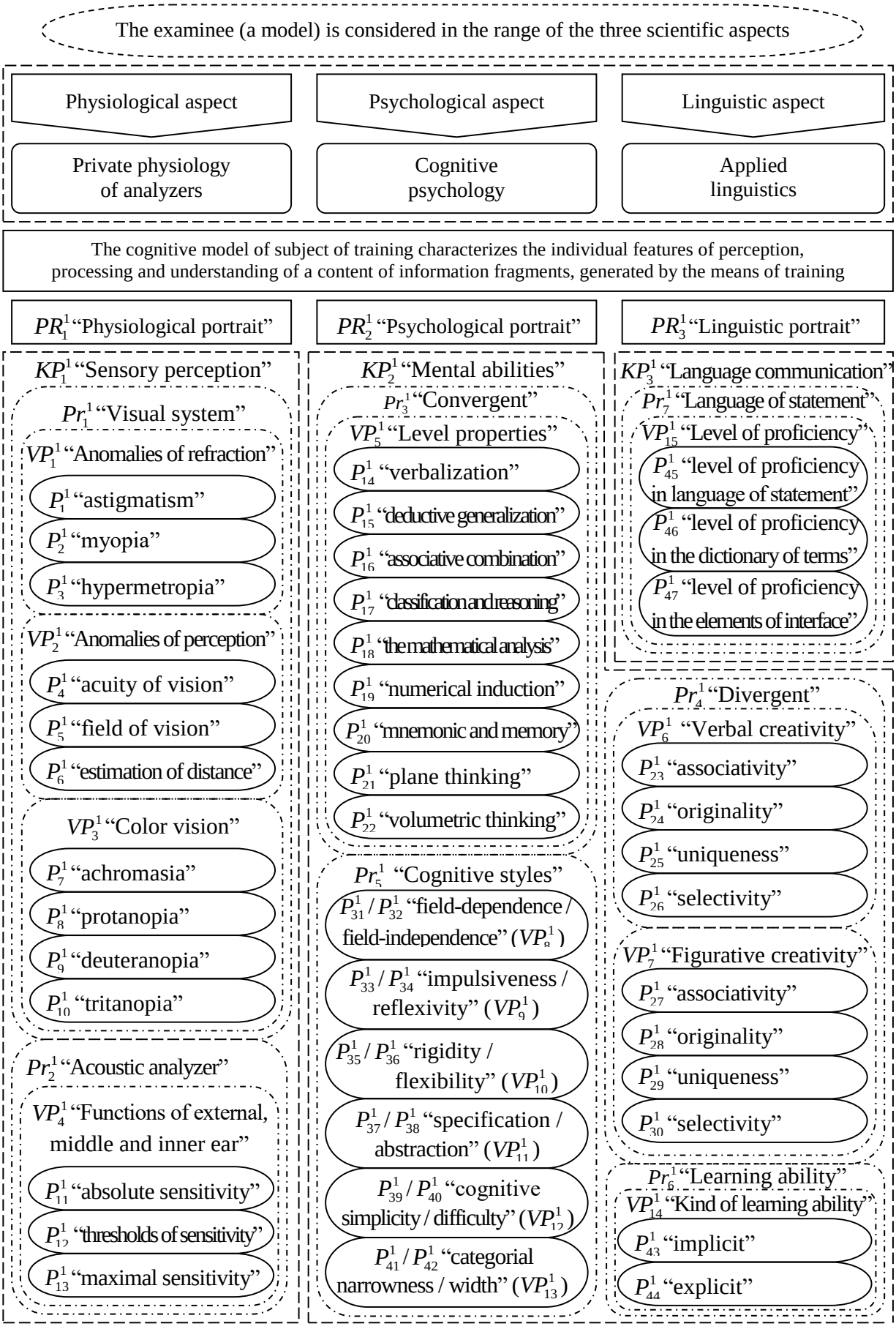
CM of the subject of training acts as the repertoire of parameters, echeloned on a set of portraits (PR_i) (physiological, psychological and linguistic) and stratified on a set of mathematical sets (J, K, L, M): a set of kinds of properties (KP_j) and a set of elementary properties (Pr_k), a set of vectors of parameters (VP_l) and a set of elementary parameters (P_m), allows to reveal a set of essential IFPST, and also to provide the scientific justification of a posteriori data and revealed on their basis the dependences and regularities:

- of primary perception of information (psychophysiology of perception);
- of processing at the level of a mental construct (cognitive psychology);
- of understanding of content of information fragments (applied linguistics).

The received structure of CM of the subject of training is presented in pic. 5.2 and 5.3.



Pic. 5.2. The cognitive model of the subject of training (the multilevel structural scheme)



Pic. 5.3. The cognitive model of the subject of training
(the multilevel structural scheme combining the theory of mathematical sets)

The elements of the repertoire of the parameters of CM of the subject of training have the index 1.

1. The physiological parameters (PR_1^1) reflect the sensory perception (KP_1^1) of information by the visual (Pr_1^1) and acoustic (Pr_2^1) sensory systems (analyzers) of the subject of training:
   - the anomalies of refraction of an eye (VP_1^1) are caused by the pathologies of an eye as biological construct, that leads to the emergence of non-uniformities in the carrying-out environment of an eye as optical device at the passing of beams of light;
     - astigmatism (P_1^1) – the anomaly of an eye as optical device, caused by an essential deviation of natural unevenness of the coefficient of refraction of a light bunch in the carrying-out environment of eye of a person as biological construct, leading to the decrease of clearness of perception;
     - myopia or shortsightedness (P_2^1) – is caused by the inaccuracy of positioning of light bunches on the sensitive surface of an eye and the arrangement of focus of convergence of a light bunches proceeding from the observed objects to the retina of an eye which is in the weakened condition;
     - hypermetropia or farsightedness (P_3^1) – the anomaly of carrying-out environment of an eye of a person, which degree of expressiveness is caused by the inaccuracy of projection of a light bunches proceeding from the objects, which are watched near to the arrangement of focal distance behind the surface of retina of an eye which is in the weakened condition;
   - the anomalies of perception of a space of the visual sensory system (VP_2^1) are caused by the impossibility to unambiguously identify the image of observed subject owing to the decrease of clearness of its perception;
     - acuity of vision (P_4^1) – the potential ability of an eye as optical device to register the relative position of two shining points located from each other on the distance 1 angular minute;
     - field of vision (P_5^1) – they understand the property of the visual sensory system, characterizing the ability of directly looking eye to register an arrangement according to black-and-white (achromatic) or color (chromatic) target in the space of the main (vertical and horizontal) and additional (a set of diagonal) meridians;
     - estimation of distance (P_6^1) – the ability of the first or the second (monocular) or two eyes at the same time (binocular) to identify the distance to an observed object, which image is projected respectively on the first or the second or at once both surfaces of the retina of the visual sensory system of organic individual, in particular person (stereoscopic vision or sight by both eyes);

- the anomalies of color vision (VP_3^1) are directly caused by the partial or full dysfunction (dystrophy) of the coneal device of retina of an eye of a person;
  - achromasia (P_7^1) – the anomaly of the visual sensory system, which is shown in the absence of the possibility of perception of all chromatic shades according to the three-component theory of color vision, caused by the dysfunction of coneal device (photopic vision) of the retina of an eye of a person;
  - partial or full dichromatia – the anomaly of the visual sensory system, caused by the partial or full dysfunction of one type of ganglionic cells, acting as the receptors in the basis of retina of an eye;
    - protanopia (P_8^1) – the absence of sensitivity to the red color and to the shades of red color, entering into the polychromatic range of photonew radiation, instead of which the retina of an eye registers the half tones of gray color;
    - deuteranopia (P_9^1) – is caused by the damage of the path of retina of an eye, providing the registration of green and shades of green colors;
    - tritanopia (P_{10}^1) – the impossibility of perception by the coneal device of retina of an eye the violet and blue colors, and also their shades;
- the violations of functions of an external, middle and inner ear (VP_4^1) are caused by the congenital and acquired anatomic anomalies of arrangement of the components of snail (inner, middle and external ear);
  - absolute sensitivity (P_{11}^1) – characterizes the minimal value of level of a sound wave registered by the path of snail of an ear;
  - thresholds of sensitivity (P_{12}^1) – the definition of a set of ranges of frequencies, having the certain nominal values of upper and lower bound, on which the acoustic sensory system of a person is capable to register a set of fluctuations of a sound wave with the minimal value of level;
  - maximal sensitivity (P_{13}^1) – the definition of degree of deviation of the minimal and maximal threshold values of frequency, in the interval between which the acoustic sensory system of a person has the greatest sensitivity at the registration of fluctuations of a sound wave.

2. The psychological parameters (PR_2^1) reflect the intellectual abilities (KP_2^1), in particular the convergent abilities (Pr_3^1) and the divergent abilities (Pr_4^1), cognitive styles (Pr_5^1) and learning ability (Pr_6^1) of the subject of training at the processing of information:
   - the level properties of intelligence (VP_5^1) directly characterize the individual productivity of deductive thinking and potential ability of subject to choose the standardly only variant of answer among several offered, are connected with the degree (level) of development of a differential set of the structural components of intelligence as the psychodynamic property of a head brain of person, which become more active in the process of performance by the examinee of the blocks of same-type tasks (subtests) and are directly measured in the view of a set of the values of coefficients counted in the process of estimation of correctness of performance of each task entering in the test, allow to define the predisposition of the subject of training at the perception and processing of information of the certain kind, shown by the various ways (are diagnosed by means of the method of R. Amtkhauer in the localization and adaptation of Voronin A.N., "IP" of "RAS");
     - verbal intelligence (P_{14}^1) – is caused by the knowledge of a large quantity of the values of concepts and definitions, and also the ability of the subject of training to operate with lexical units from the different subject areas in the oral speech and letter, is defined by means of the subtest "Logical selection (addition of sentences)" and is measured by the coefficient of value of which is incremented at the correct answer of an examinee;
     - verbal deductive thinking (P_{15}^1) – is caused by the ability of the subject of training to the fast disclosure of sense of a set of concepts, their generalization and identification of discrepancies on the certain criterion, is defined on the basis of the block of questions "Search of general signs";
     - verbal combinatory abilities (P_{16}^1) – are caused by the ability of subject to find the analogies and to reveal the connections between the concepts and their values, which have the various rank of definiteness and is defined by means of the use of the subtest "Search of verbal analogies";
     - ability to reasoning (P_{17}^1) – is caused by the possibility to single out and correlate the classes of concepts and their definitions, to find the basic class, which generalizes the values of several concepts, which value is diagnosed by means of the block of questions "Classification of concepts";
     - analytical thinking (P_{18}^1) – becomes more active at the solution of mathematical tasks directed to the analysis of a content and development of decision in the view of nominal value, which is the answer to the task, parameter is defined by means of the subtest "Arithmetic tasks";
     - inductive thinking (P_{19}^1) – becomes more active at the solution of tasks oriented on the finding of regularity of formation of the sequence (row) of numbers and is defined by means of the subtest "Numerical rows";

- mnemonic abilities (P_{20}^1) – cause the ability of the subject of training to perceive a large quantity of information (iconic memory), to remember it (medium-term and long-term memory) and (or) incidentally, or is associative to restore it as far as required, is diagnosed by means of the subtest "Mnemonic and memory";
- plane thinking (P_{21}^1) – becomes more active at the performance by the examinee of the tasks oriented on the structural decomposition and integration of separate flat graphic images into the uniform composition, is measured by means of the subtest "Flat figures";
- volumetric thinking (P_{22}^1) – becomes more active in the process of solution of tasks assuming the spatial (re)designing of the volumetric geometrical images and finding of degree of compliance between two and more geometrical figures, is defined by the subtest "Cubes";

- the verbal creativity or verbal creative abilities (VP_6^1) – the potential ability of examinee to generate a set of original and different from the traditional variants of answer acting as the generalizing concepts for each shown verbal incentive representing inside the verbal triad (three of words) from the different areas;
  - associativity (P_{23}^1) – the parameter, which nominal value is calculated on the basis of the relation of the total quantity of variants of answer entered (formulated) by the specific examinee to the total quantity of tasks presented in this part of the method of research;
  - originality (P_{24}^1) – the parameter calculates by means of the summation of the values of indexes of originality of all answers entered by the examinee consistently in each task, at the same time the originality of each variant of answer formulated by the examinee and being in the resultant selection of his variants of answer calculates as an inverse value to the frequency of occurrence of this variant of answer in the certain task, entering a method of research (diagnostics);
  - uniqueness (P_{25}^1) – the value of parameter calculates in the view of the relation of the sum of unique variants of answers of the certain examinee (the index of originality of variant of answer is approximately equal to one) to the total quantity of variants of answer formulated by this examinee;
  - selectivity or the index of selectivity (selectivity) of the process of thinking (P_{26}^1) – the value of parameter calculates by means of the summation of all the most original variants of answer chosen by the examinee in each task, whose identifiers (names) coincide with the variants of answer entered by the expert on each task;

- the figurative creativity (VP_7^1) – characterizes the potential possibility of an examinee to perceive by the visual sensory system each shown visual incentive and to generate a set of resultant graphic images of high composite difficulty (differing from the traditional) by means of the reconstruction of shown image with the use of simple geometrical figures (circle, square, ellipse and others) and elements (point, direct line, curve line and others), and also the ability to formulate the name to the picture received in the result;
  - associativity (P_{27}^1), originality (P_{28}^1), uniqueness (P_{29}^1) and selectivity (P_{30}^1);
- the cognitive styles (Pr_5^1) – act as a set of genetically caused, rather the steady and developing in the early ontogenesis the bipolar properties of personality of the subject of training reflecting his approaches, ways and individual features of processing of continuously arriving information of different type at the level of operational structures of a mental construct of a head brain (Holodnaya M.A., Druzhinin V.N., ""IP" of "RAS""");
  - the bipolar style "field-dependence" / "field-independence" (VP_8^1);
    - field-dependence (P_{31}^1) – assumes the strict sequence of following of information fragments reflecting the content of a subject of studying formed by the algorithm of the means of training owing to the inability of trainee "to switch" between the subjects of studying;
    - field-independence (P_{32}^1) – defines the ability of the subject of training quickly to switch over to the various subject areas, that causes the possibility of the use of experimental and innovative algorithms in the basis of the means of training, providing the support of representation of a set of information fragments in any sequence taking into account IFPST;
  - the bipolar style "impulsiveness / reflexivity" (VP_9^1);
    - impulsiveness (P_{33}^1) – causes the potential ability of the subject of training quickly to form the individual aggregate of knowledge on the basis of information reflecting the content of one or several subjects of studying and quickly to generate the mind-conclusions;
    - reflexivity (P_{34}^1) – the examinee is predisposed to the long acquaintance with the content of formulation of task as a subject to performance, and also the slow development of own decision;
  - the bipolar style "rigidity / flexibility" (VP_{10}^1);
    - rigidity (P_{35}^1) – the inability of the subject of training independently to form the field of knowledge necessary for the realization of process of interpretation and disclosure of dependences in the other subject area;
    - flexibility (P_{36}^1) – the high adaptation of the subject of training in IEE and ability "to quickly switch" between the different subjects, means and algorithms of training in ART system;

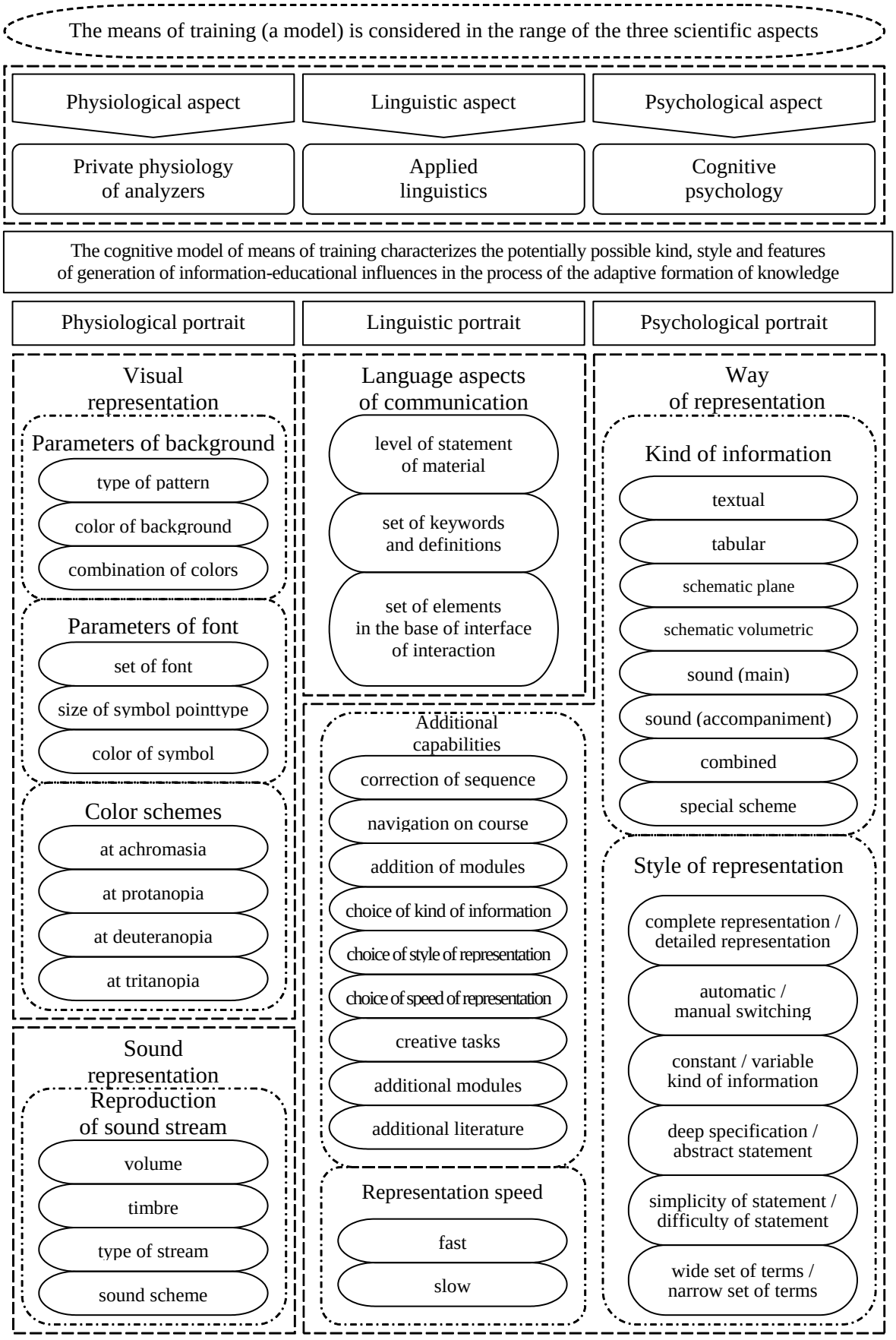
- the bipolar style "specification / abstraction" (VP_{11}^1);
  - specification (P_{37}^1) – the potential ability of the subject of training to perceive the information fragments, reflecting the content of the subject of studying at the certain level of specification;
  - abstraction (P_{38}^1) – defines the ability of the subject of training to perceive the information, reflecting the content of the subject of studying presented by various means (abstract statement);
- the bipolar style "cognitive simplicity / cognitive difficulty" (VP_{12}^1);
  - cognitive simplicity (P_{39}^1) – is caused by the ability of the subject of training to perceive the information fragments, reflecting the content of the subject of studying with the use of low level of statement;
  - cognitive difficulty (P_{40}^1) – is used the high level of statement of the content of the subject of studying in the displayed information fragments;
- the bipolar style "categorial narrowness / categorial width" (VP_{13}^1);
  - categorial narrowness (P_{41}^1) – at the statement of the content of the subject of studying is used a limited set of concepts and definitions;
  - categorial width (P_{42}^1) – is used a large quantity of various concepts, disclosing the essence of the certain subject of studying;

- the kind of learning ability of the subject of training (VP_{14}^1);
  - implicit learning ability (P_{43}^1) – allows the trainee to work independently under the observation of the algorithm of the training program realizing the monitoring of sequence of carried-out actions (check of correctness and display of hints) and realizes a possibility of the use of the algorithm of training, which provides the fast switching at the display of sequence of information fragments;
  - explicit learning ability (P_{44}^1) – causes the possibility of systematic gradual formation of knowledge of a trainee in beforehand formed program with the accretion of the level of difficulty of statement of the content of the subject of studying by means of the certain means of training (ET);

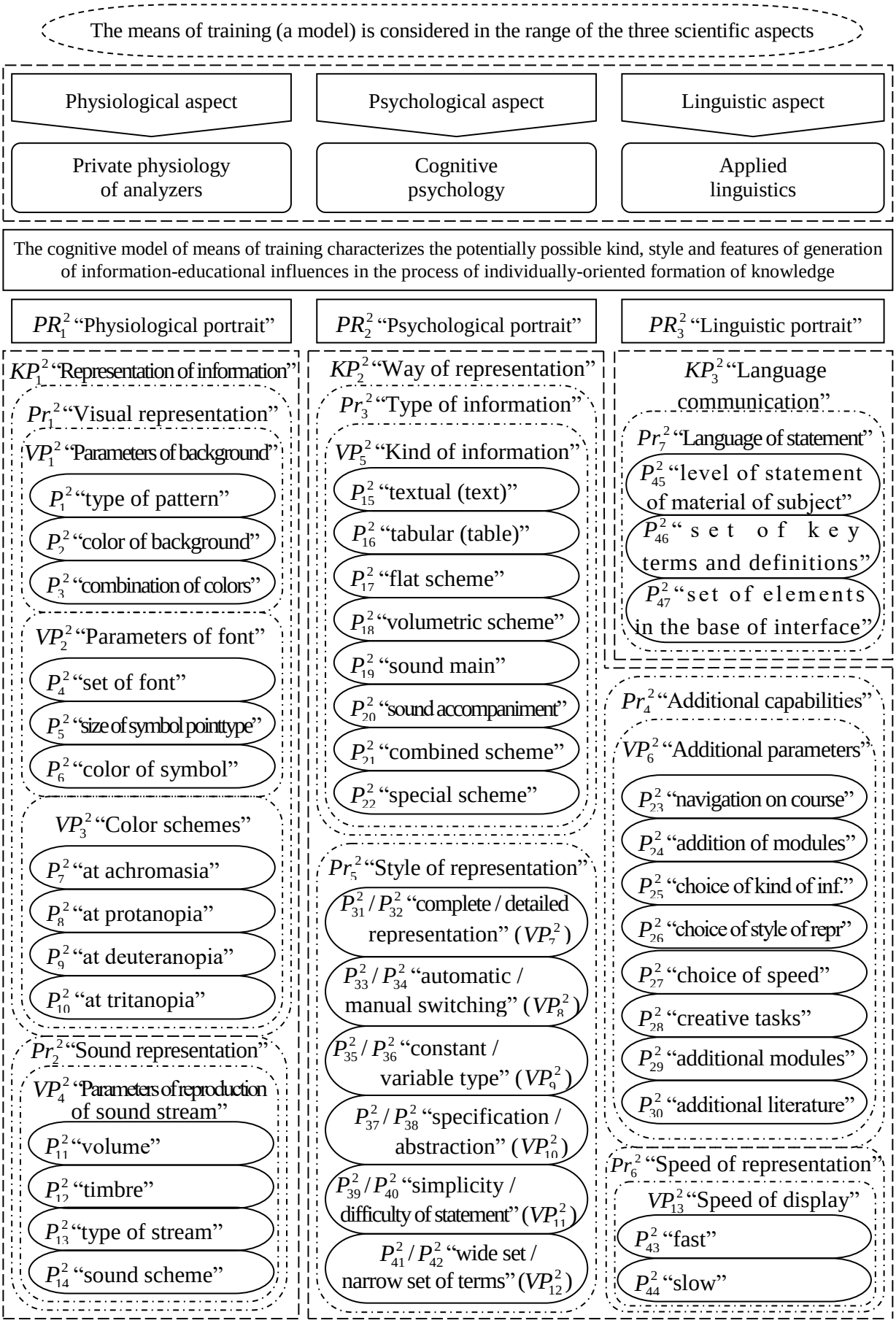
3. The linguistic parameters (PR_3^1) characterize the features of language communication (KP_3^1) by means of a national or (international) foreign language of statement (Pr_7^1) at understanding by the subject of training of the content of information fragments:
   - the level of proficiency in language of statement of the content of the subject of studying (VP_{15}^1);
     - level of proficiency in language of the statement of material (P_{45}^1) – causes the potential ability of the subject of training to study the information fragments reflecting the content of subject of studying stated in the certain national language and level of representation of material;
     - level of proficiency in key terms and definitions (P_{46}^1) – is characterized by the total quantity of concepts the value of which the trainee knows;
     - level of proficiency in elements of interface of the program (P_{47}^1) – is defined by the level of knowledge, mastery skill and developed skills at the work with the interface of certain application.

5.2. The structure of the cognitive model of the means of training

The received structure of CM of the means of training is presented in pic. 5.4 and 5.5.



Pic. 5.4. The cognitive model of the means of training (the multilevel structural scheme)



Pic. 5.5. The cognitive model of the means of training
(the multilevel structural scheme combining the theory of mathematical sets)

The elements of the repertoire of the parameters of CM of the means of training have the index 2.

1. The physiological parameters (PR_1^2) reflect the visual (Pr_1^2) and sound (Pr_2^2) representation of information fragments (KP_1^2) by the means of training:
   - the parameters of background (VP_1^2) – is realized the installation of a type of pattern (P_1^2), color of background (P_2^2) and combination of colors (P_3^2) at the display of information fragments;
   - the parameters of font (VP_2^2) – installation of set of font (P_4^2), size of pointtype (P_5^2) and color of symbols (P_6^2), forming the sentences (pictures) and reflecting the content;
   - the color schemes of display of information (information fragments) (VP_3^2) (for the partial dichromatia is used the principle of compensation of colors, in case of the full dichromatia (P_7^2) is realized the special scheme of replacement of colors at the display of a set of information fragments and at the generation of TI of different type);
     - for protanopes (P_8^2) – the scheme of compensation or replacement of red color;
     - for deuteranopes (P_9^2) – the scheme of compensation or replacement of green color;
     - for tritanopes (P_{10}^2) – the scheme of compensation or replacement of violet color;
   - the parameters of reproduction of sound stream (VP_4^2) – is provided the installation of volume (P_{11}^2), timbre (P_{12}^2), type of stream (P_{13}^2) and sound scheme (P_{14}^2) of reproduction of audio-stream at the display of a set of information fragments;
2. The psychological parameters (PR_2^2) reflect the way of representation of information (KP_2^2), in particular the type of information (Pr_3^2), additional capabilities (Pr_4^2), style (Pr_5^2) and speed (Pr_6^2) of representation of information fragments by the means of training:
   - the kind of provided information (information fragments) (VP_5^2);
     - textual (P_{15}^2) – the information fragments are presented in the view of the text, displayed on the page of the adaptive means of training (ET);
     - tabular (P_{16}^2) – the information fragments are presented in the view of the table, including a set of information fields, acting as the identifiers of columns and their values which are written down line by line and forming a set of records, containing the data of different appointment;
     - flat scheme (P_{17}^2) – the display of information fragments by means of flat schemes reflecting the structure of the object, process or phenomenon;
     - volume scheme (P_{18}^2) – the representation of information in the three-dimensional space of coordinates, allowing to reflect the content of the subject of studying;
     - sound stream as the main (P_{19}^2) – the reproduction of file with a sound stream, reflecting the description of dynamics of the object, process or phenomenon;
     - sound stream as accompaniment (P_{20}^2) – the reproduction of a sound stream for the realization of support of textual, tabular or schematic representation of the content of the subject of studying;
     - combined scheme (P_{21}^2) – the choice of combination of two ways of representation of information with consecutive or parallel reproduction;
     - special scheme (P_{22}^2) – the installation of parameters of an algorithm of switching of schemes of display of information (information fragments);

- the additional parameters of display of information fragments (VP_6^2);
  - correction of sequence of presentation of information fragments – allows to realize the manual (panel of navigation) or automatic (the algorithm of the means of training) switching of information fragments, sequence of which is picked up for each trainee or for all;
  - navigation on course (P_{23}^2) – realizes the possibility of navigation on structural units of ET, which reflect the content of the subject of studying, is reached by means of the use of panels of navigation of two types;
  - addition of modules (P_{24}^2) – allows to the trainees to add new sections, modules, pages and control questions or references on the information resources (fragments), and to the teachers to improve the content of the subject of studying;
  - choice of kind (P_{25}^2) and style (P_{26}^2) of representation of information – granting the opportunity to the trainee independently to choose the kind and style of representation of information and to track the individual dynamics of resultativity (efficiency) of the formation of knowledge in IEE of ART system;
  - choice of speed of representation (P_{27}^2) – granting the opportunity to the trainee to choose the value of interval of time of display of information;
  - creative tasks (P_{28}^2) – granting the opportunity to the trainee to choose a set of test and additional tasks;
  - additional modules (P_{29}^2) – the realization of algorithms and methods for the psycho-correcting and developing training in the automated IEE;
  - additional literature (P_{30}^2) – the possibility of selection of the list of additional literary sources (references) adequately to the revealed LRKT;
- the bipolar style of submission of information (Pr_5^2) – is defined by the means of training on the basis of the individual features of processing of information of the subject of training:
  - complete (P_{31}^2) or detailed (P_{32}^2) representation of information (VP_7^2) – the studying of the system of a new quality as the whole consisting from the different parts or the structural decomposition of the object, process or phenomenon of research on a set of parts for their consecutive studying;
  - automatic (P_{33}^2) or manual (P_{34}^2) switching between pages (VP_8^2) – is realized automatically by the algorithm of the means of training or manually by the user;
  - constant (P_{35}^2) or variable (P_{36}^2) kind of information (VP_9^2) – the choice of a constant or variable kind of information at the display of information fragments;
  - deep specification (P_{37}^2) or abstract statement (P_{38}^2) (VP_{10}^2) – the structural decomposition of the object, process or phenomenon of research on a set of parts for their detailed studying or the abstract studying of the system of a new quality as the whole consisting from the different parts;
  - simplicity (P_{39}^2) or difficulty (P_{40}^2) of statement (VP_{11}^2) – is realized by means of the use of several levels of statement of material of the subject of studying;
  - wide (P_{41}^2) or narrow (P_{42}^2) set of terms (VP_{12}^2) – a wide or narrow set of keywords and definitions at the display of information fragments;
- the speed of presentation (representation) of information fragments (VP_{13}^2);
  - fast speed (P_{43}^2) – fast display of information fragments;
  - slow speed (P_{44}^2) – slow switching of pages (information);

3. The linguistic parameters (PR_3^2) reflect the language communication (KP_3^2), in particular the language of statement (Pr_7^2) at the display of information by the means of training:
   - level of statement of material (P_{45}^2) – the manual or automatic choice of level of statement of material;
   - set of key terms and definitions (P_{46}^2) – the automatic choice and formation of the list of keywords and definitions;
   - set of elements as a part of the interface of interaction (P_{47}^2) – the automatic choice of type of the interface of program and configuration of its elements.

On the basis of carried out research we'll form the conclusions on the fifth chapter:

1. It is offered PCMB including CM of the subject of training and CM of the means of training, intended for the realization of the additional contour of adaptation allowing to realize the analysis of IEE and to provide the individually-oriented formation of knowledge of the contingent of trainees in ART system.
2. The creation and subsequent reconstruction of the structure of CM of the subject of training and CM of the means of training is carried out by means of the use of the offered algorithm of formation of the structure of CM, entering into the basis of CMT.
3. CM is displayed by means of the use of the various ways (models) of representation (the existing – the frame model and the semantic network or the offered – the graph combining the theory of sets and the multilevel scheme), represents inside the (re)designed in width and depth repertoire of parameters echeloned on a set of portraits (PR_i) and stratified on a number of sets: a set of kinds of properties (KP_j) and a set of elementary properties (Pr_k), a set of vectors of parameters (VP_l) and a set of parameters (P_m).
4. It is offered CM of the subject of training accumulating the parameters characterizing the individual features of a sensory perception (physiological portrait), processing (psychological portrait) and understanding of the content of information fragments (linguistic portrait).
5. For the diagnostics of the values of parameters of CM of the subject of training are used the applied methods having the justification in the context of physiology of sensory systems, cognitive psychology and applied (cognitive) linguistics.
6. It is submitted CM of the means of training concentrating the parameters reflecting the potential technical capabilities of the means of training (ET) functioning on the basis of the adaptive representation of information fragments processor, which generates TI by the different way according to the measured IFPST.
7. For the research of the values of parameters of CM of the means of training it is necessary to carry out the analysis of the technical capabilities of the means of training used in the basis of the automated IEE, in particular to realize the specification of the values of parameters in the course of life cycle of the program realization of ET.

In the fifth chapter the new scientific result is received – PCMB, including CM of the subject of training and CM of the means of training.

PCMB is a basis for the carrying out of the system analysis of IEE directed on the increase in efficiency of functioning of the components of ART system, provides the support of functioning of the adaptive representation of information fragments processor located in the basis of ET and allows to realize the technology of individually-oriented training.

The developed CM allow to pick up an optimal combination of the nominal values of parameters of display of information fragments taking into account the technical capabilities of the used means of training on the basis of IFPST.

6. The complex of software for the automation of research tasks

The architecture of the program complex includes three levels: the level of interface – supports the interaction between the components of IEE and final users of various categories; the level of kernel – a set of special procedures and algorithms, providing the processing of events initiated by the components of IEE of ART system and carrying out of a set of functions and tasks at the work of users; the level of warehouse of data – the databank, supporting several DB of different appointment.

The level of interface of the complex of programs supports the work of several categories of users (a guest, a trainee, a teacher, a consultant and an administrator) in the various modes of functioning (adaptive training, diagnostics of IFPST, testing of LRKT, viewing and the analysis of a posteriori data of research).

For the start of work of a final user in the system it is necessary to undergo the procedure of authentication, which is performed by two main ways: primary (in case of absence of the account record of a user in DB) and subsequent registration.

After the authentication of a user it is supposed the transition to one of the possible modes of functioning of the complex of programs, realized by the certain structural component: the adaptive means of training (ET) – the modes of adaptive training and administrating of filling (content) in the subjects of studying; the basic DM – the modes of diagnostics of LRKT and administrating of tests in studied disciplines; the applied DM – the modes of diagnostics of the parameters of CM and administrating of tests, allowing to provide the research of IFPST.

The start of the certain mode of functioning of the complex of programs initiates the implementation of the procedure of primary initialization of parameters and processing of events, causing the possibility of performance of a set of procedures entering in the basis of the kernel of system and providing the access to DB, which are a part of the databank.

The level of the kernel of system includes a related set of the program components, which are carrying out the processing of data and operations of the final user: the adaptive representation of information fragments processor of the means of training, the procedure of authentication and addition of users, the procedure of a control of the process of diagnostics, the module of language support at display of elements, the procedure of processing of events of a user, the procedure of choice and the analysis of data of testing, the procedure of modification of the structure of CM of the subject of training, the procedure of modification of the structure of CM of the means of training, the procedure of administrating of tests of LRKT, the procedure of administrating of tests of IFPST, the procedure of check of correctness of data and the procedure of reserve copying of data.

The adaptive representation of information fragments processor is the innovative component in the basis of the architecture of the automated means of training and provides the individually-oriented generation of TI taking into account the values of parameters, entering into CM of the subject of training and CM of the means of training.

The procedures of support of the access to the data and processing of inquiries provide the interaction with the databank, including a set of DB: DB of (final) users of the training subsystem, DB with filling subjects of the adaptive means of training, DB of tests in objects and DB of a posteriori results of the research of LRKT and IFPST.

DB of users contains a set of the account records of users and allows to differentiate their rights of access to the various information used in IEE of ART.

DB with filling on subjects (content) includes the previously structured information, reflecting the content of a set of the subjects of studying presented by means of the semantic (structural) model (pic. 3.9).

DB of tests on subjects contains a set of question-answers structures, entering into the test tasks on the section, module, paragraph and fragment of a discipline, allowing to realize the current (intermediate) and total testing of LRKT.

DB of tests of IFPST contains a set of question-answers structures, entering into the test tasks, relating to the certain technique allowing to research the parameters, characterizing IFPST and entering into CM of the subject of training.

DB with a posteriori results of research contains a systematized set of the values of parameters of CM of the subject of training, characterizing IFPST and parameters, reflecting the resultativity of training in the cycle of disciplines.

In the purpose of archiving and backup copying of data the architecture of the complex of programs provides the reserve warehouse of data: DB of temporarily inactive users, reserve DB with information on subjects of studying, reserve DB of tests of IFPST and archive with results of testing of last years.

DB of inactive users contains a set of the account records of users, who temporarily at any reasons are not allowed to use the components and resources of the automated educational environment.

The reserve DB of information in studied disciplines realizes the backup copying and archiving of structured information, reflecting the content of a set of disciplines, allowing to increase the free disk space.

The reserve DB of tests in studied disciplines allows to archive a set of tests on the cycle of subjects of studying, allowing to realize the estimation LRKT.

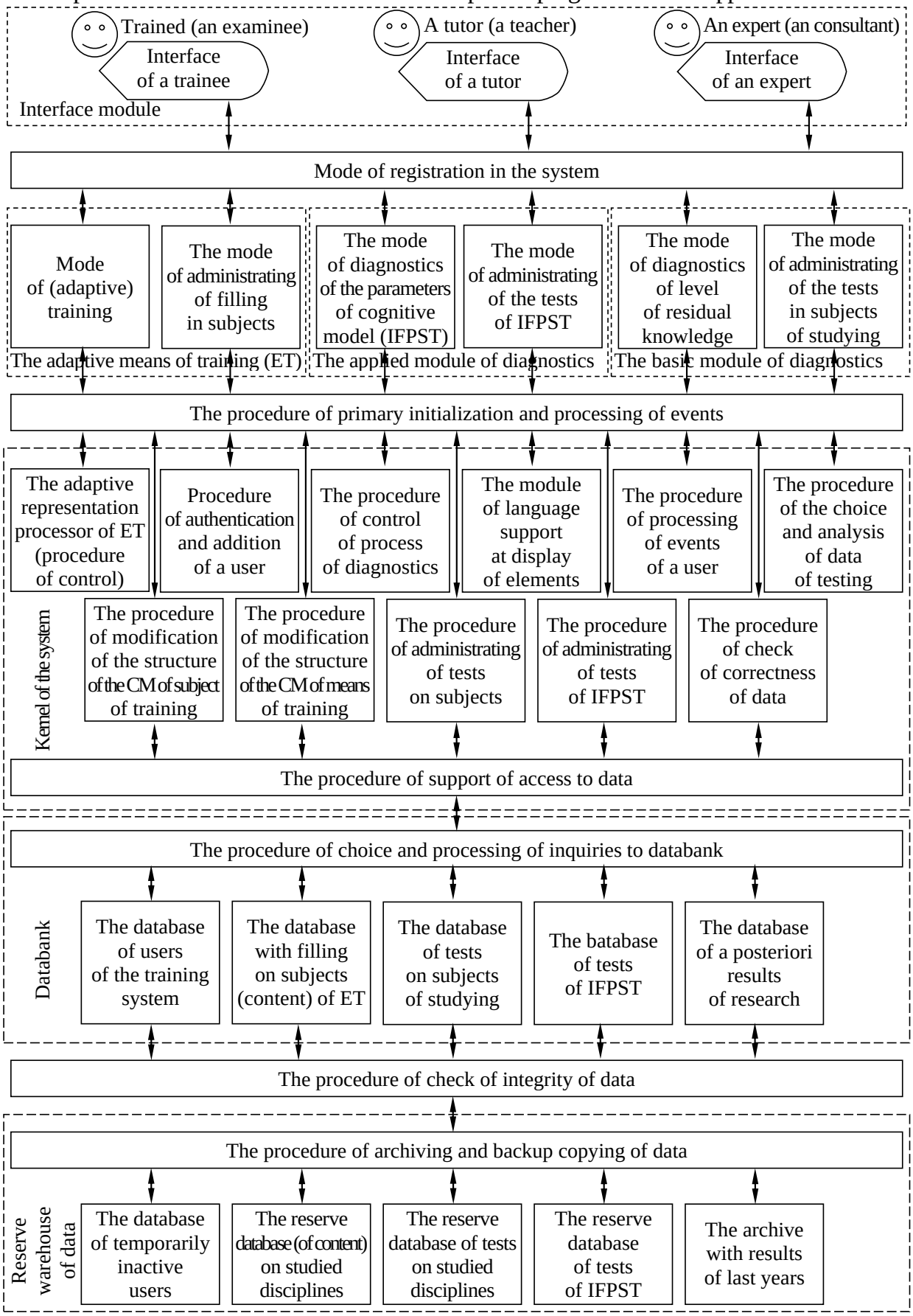
The reserve DB of tests of IFPST provides the backup copying, archiving and storage of tests of IFPST, allows if necessary to restore the information in case of its damage in the main DB of tests of IFPST.

The archive with results of last years accumulates a chronologically ordered set of records, containing the results of diagnostics of LRKT and IFPST.

The practical use of the presented complex of programs was carried out in the training process of “SPbSETU "LETI"” and “IBI”, and the subsequent statistical processing of a posteriori data has shown the increase of resultativity of training of the contingent of trainees in the experimental groups.

6.1. The complex of programs for the automation of the tasks of research

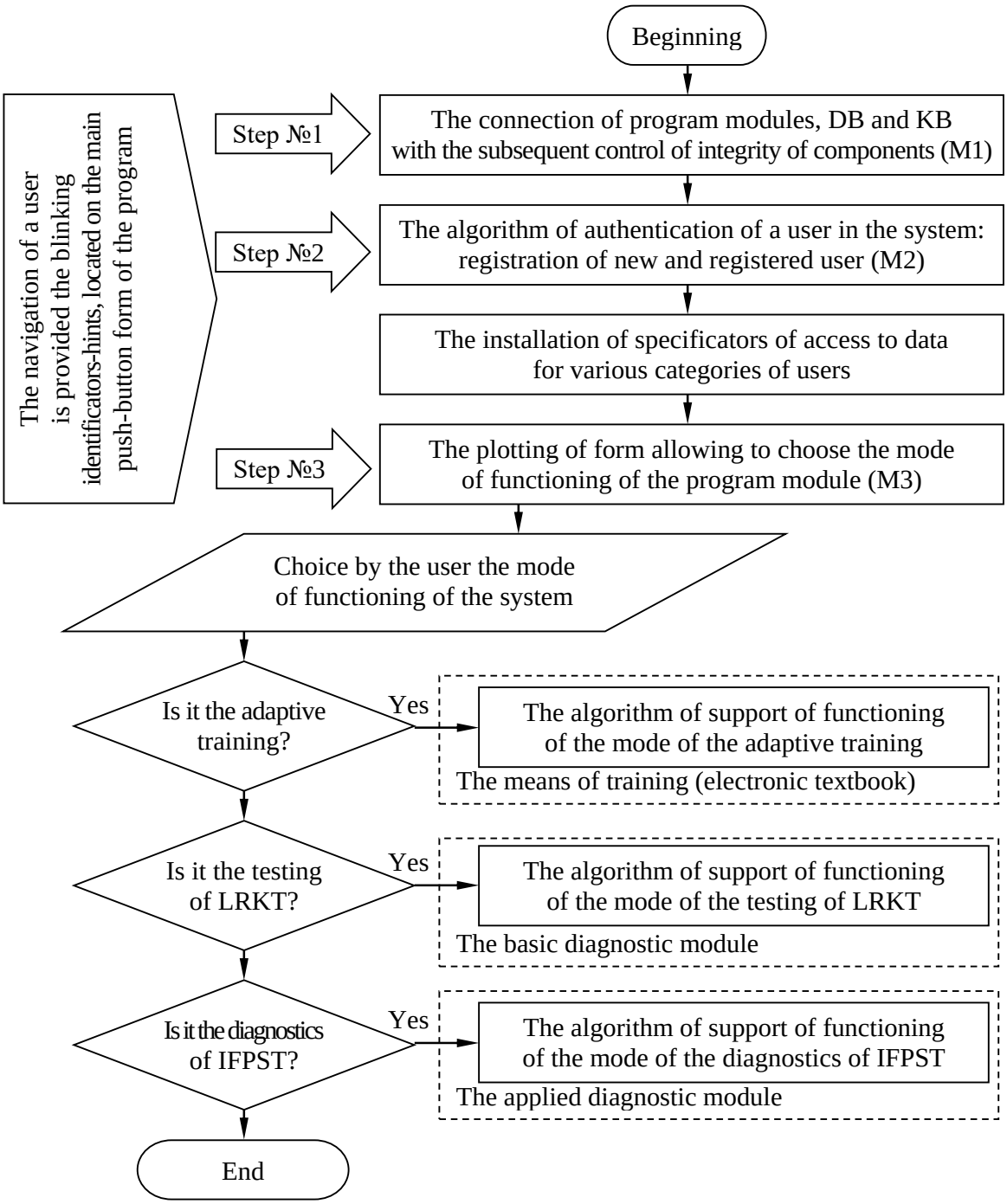
In pic. 6.1 is reflected the structure of the complex of programs for the support of IEE of ART.



Pic. 6.1. The structurally-functional scheme of the complex of programs

Directly after the start of one of the components of the complex of programs (adaptive ET, basic DM and applied DM) displays the main push-button form of application, which allows to choose the certain mode of functioning of the started component (administrating of a content of ET or DM, adaptive training and diagnostics of LRKT and IFPST), realizing the performance of certain functions and tasks at the work of users of various categories.

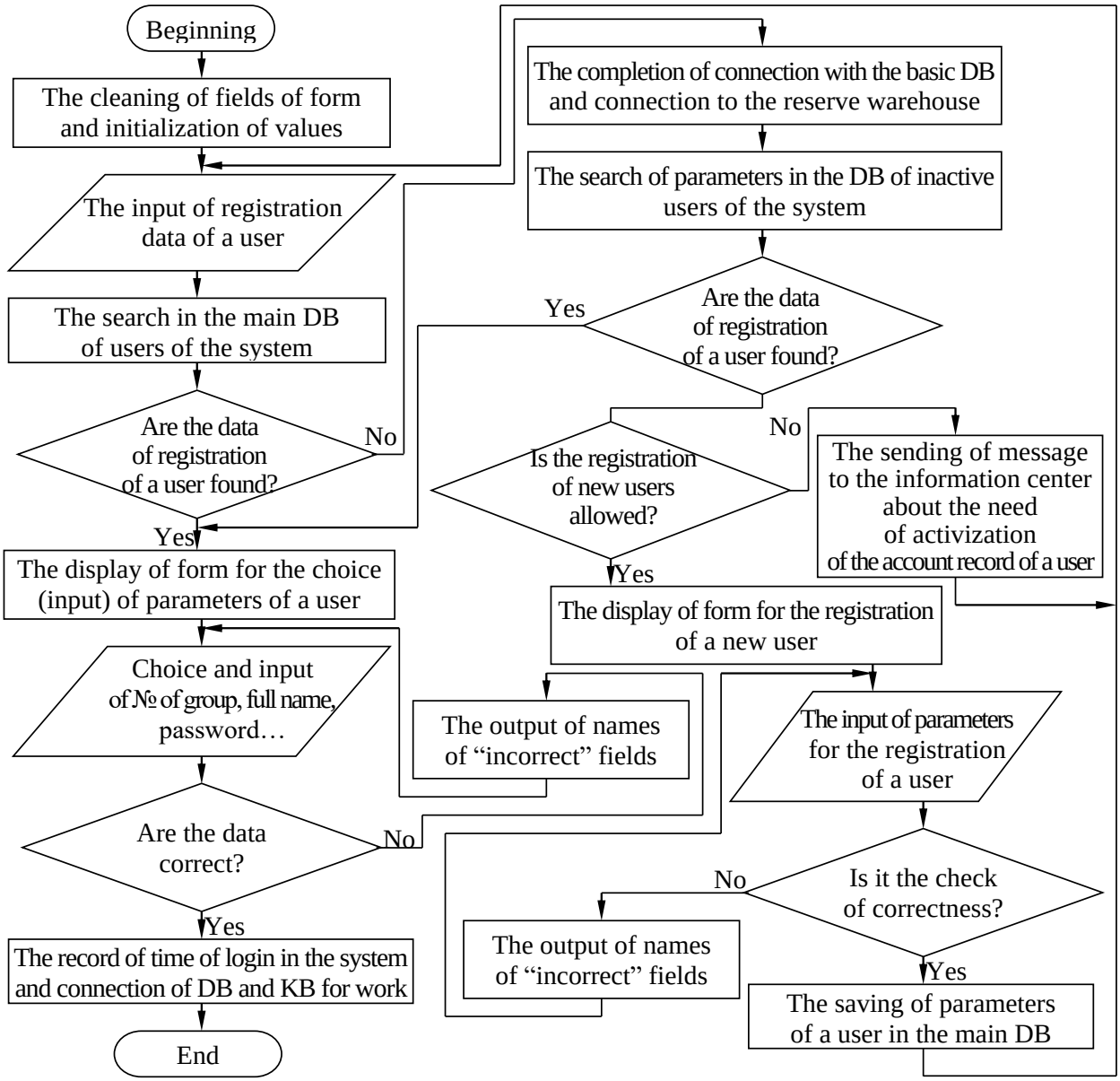
In pic. 6.2 is presented the algorithm of switching of the modes of functioning of the complex of programs, on the basis of which the start of different components is provided.



Pic. 6.2. The algorithm of switching of the modes of functioning of the program complex

Directly after the start of the system of training out the connection of program modules, DB, KB and the start of procedure of authentication of a user is carried.

The algorithm of authentication of a user in the system is presented in pic. 6.3.



Pic. 6.3. The algorithm of authentication of a user in the system

After the start of the procedure of authentication there is the primary initialization of the values of fields of form, providing the search of account record of a user at the beginning in the main DB of the system, then in DB of temporarily inactive users.

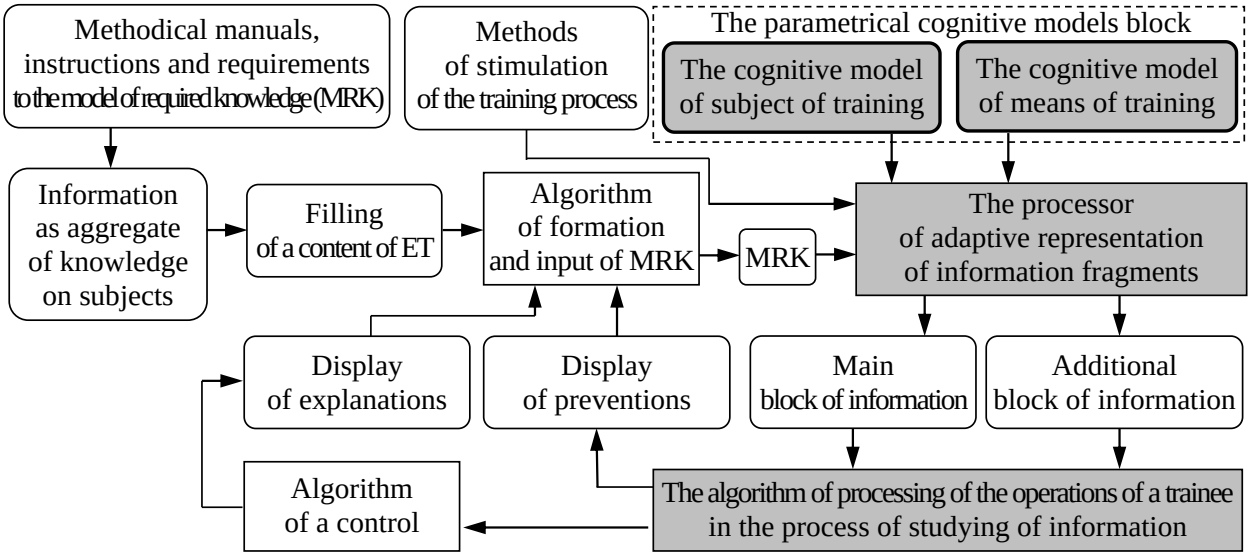
If the account record is not found in the main DB of users and in DB of temporarily inactive users, and also is not allowed the registration of new users, then is carried out the sending of message to the information centre about the need of compulsory activization of the account record of a user.

If the data of a user are found, then the user is offered to choose the group and to enter the password for the implementation of login in the system, at the same time is realized the record of date and time of login of a user in the system, and also the connection of necessary DB and KB for the work in the context of this session.

6.2. The adaptive electronic textbook

The adaptive means of training (ET) is the key component of IEE of ART system with the properties of adaptation based on PCMB, providing the individually-oriented formation of knowledge of a trainee by means of the use of the adaptive representation of information fragments processor, located in the basis of its innovative architecture. The adaptive means of training operates in the several modes of functioning, providing the performance of different tasks of the final users of different categories.

The principle of functioning of the adaptive means of training (ET) on the basis of PCMB provides the accounting of IFPST and is presented in pic. 6.4.



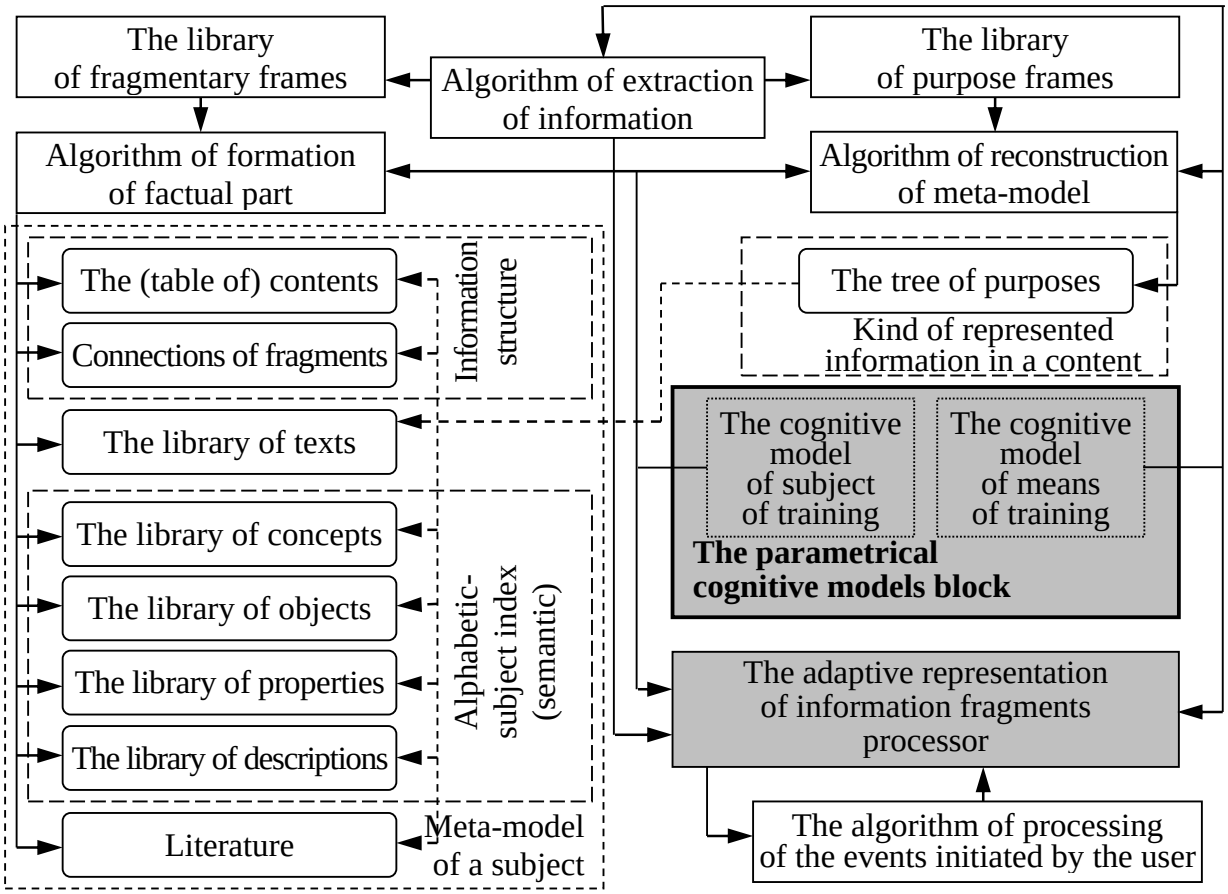
Pic. 6.4. The scheme, reflecting the principle (algorithm) of functioning of the adaptive means of training

According to the presented principle of functioning of the adaptive means of training the teacher, being guided by TMC on a set of disciplines (methodical manuals, instructions and requirements to the model of required knowledge), carries out the filling of a content of the means of training (ET) by the information by means of the algorithm of formation and input of the model of required knowledge in the accepted language of formal description (model of representation of data), which saves in DB with filling on subjects (content) on the basis of the semantic (structural) model of a discipline.

The adaptive representation of information fragments processor provides the individually-oriented generation of TI – information fragments (main and additional block of information) on the basis of the values of parameters of CM of the subject of training (IFPST) and CM of the means of training (potential technical capabilities of display of TI).

The algorithm of processing of operations of a trainee in the process of studying of the content of information provides the reaction of the system on the events initiated by the user.

The semantic (structural) model of discipline is presented in pic. 6.5 and provides the saving (the mode of administrating) and extraction (the mode of adaptive training) of a content of a set of information fragments on the certain discipline at the work of various categories of users.

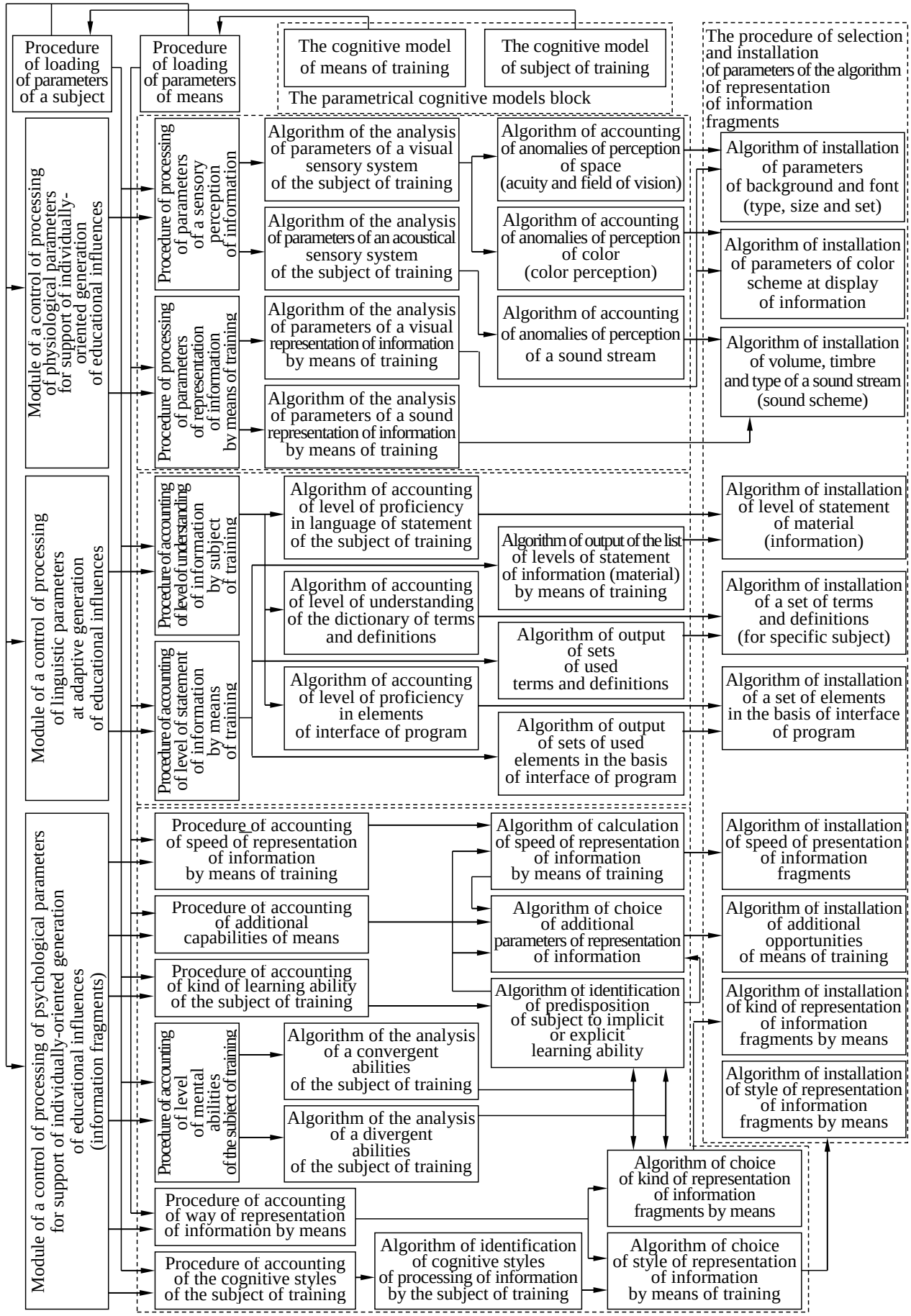


Pic. 6.5. The semantic model of storage and extraction of information

The algorithm of extraction of information fragments (pic. 6.7) operates in coordination with the adaptive representation of information fragments processor (pic. 6.6) on the basis of the tree of purposes of training and a set of the frames of information fragments (reflect the content of discipline), by means of the algorithm of formation of the tree of purposes of training (defines the sequence and the way of presentation of information) and the algorithm of formation of the factual part of information structure: the alphabetic-subject index acts as the element of navigation on the structure of discipline; the information structure reflects the content of information fragment (text, graphic image and multimedia stream from the library of fragmentary texts); connections between the information fragments (cross references); the properties of information fragment (type of contained information); the description (appointment of information fragment); the sources of literature (main, additional and help (reference) literature on the section, paragraph or module of discipline).

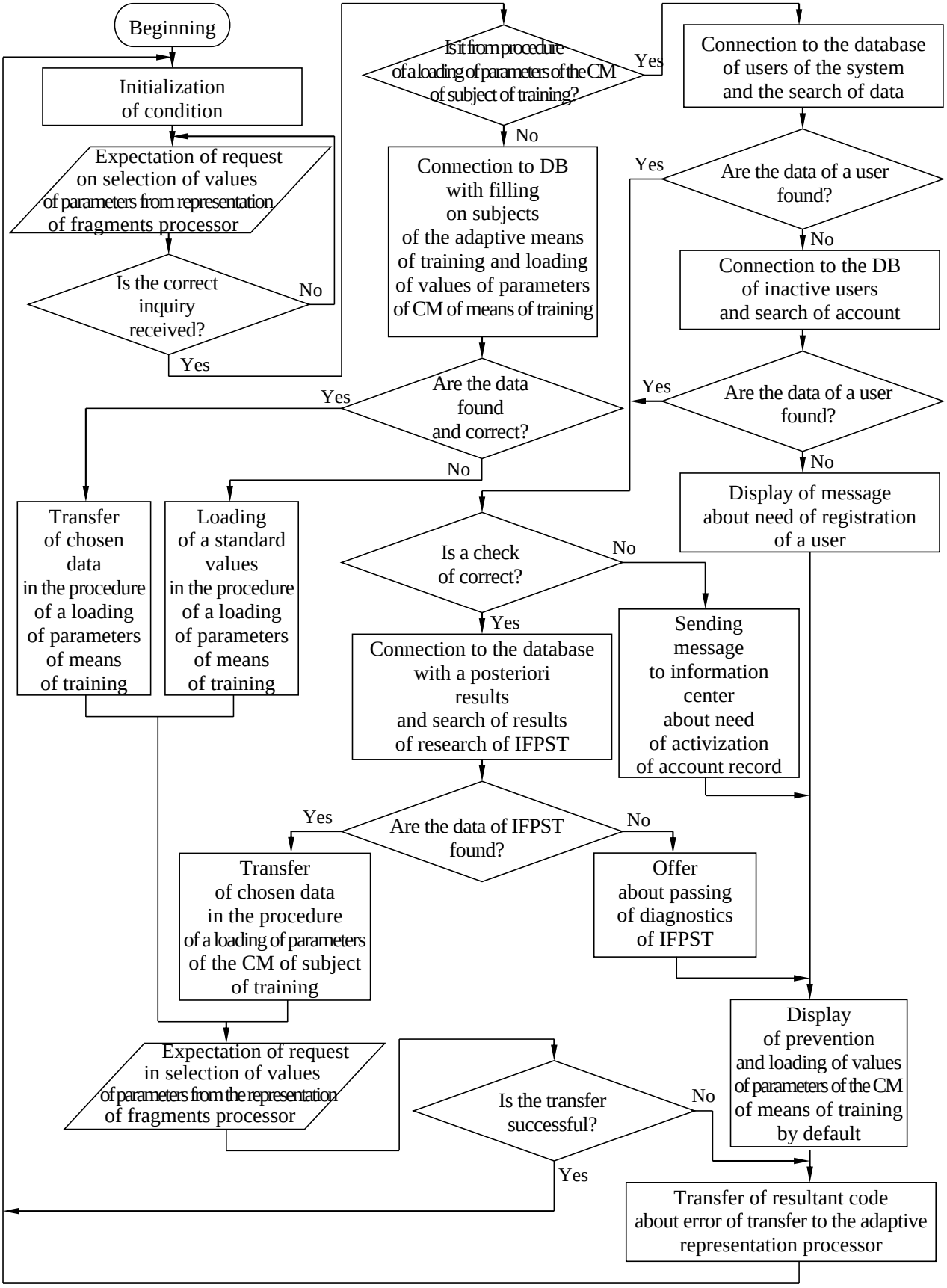
PCMB includes CM of the subject of training and CM of the means of training, whose parameters are loaded in the mode of training and are processed by the adaptive representation of information fragments processor of the means of training.

The adaptive representation of information fragments processor (pic. 6.6) of the automated means of training realizes the individualization of ART and operates in the context of a limited set of kinds and types of TI (CM of the means of training), at generation of which are considered IFPST (CM of the subject of training).



Pic. 6.6. The structure of the adaptive representation of information fragments processor

The support of functioning of the adaptive representation of information processor of the adaptive means of training is provided by the algorithm of extraction of information (pic. 6.7).



Pic. 6.7. The algorithm of extraction of information fragments of the adaptive means of training (electronic textbook)

The adaptive means of training (ET) operates in the several modes:

- the mode of administrating – provides the filling of DB of users of the training system by the account records, allows to save the previously structured information, which reflects the content of a discipline and is stored in DB with filling on subjects (a content) of the adaptive ET;
- the mode of adaptive training – realizes the individually-oriented generation of information fragments of different type on the basis of PCMB.

The program realization of the adaptive means of training directly provides the function of switching of language, used on the identifiers of the elements of interface – display of names in the Russian and English languages.

Directly after the start of the program realization of the adaptive means of training is carried out the display of the main push-button form, allowing: on the first step – to establish the name, language and the level of statement of the content of discipline; on the second step – to realize the authentication of a user, on the third step – to choose the mode of functioning of the means of training.

The procedure of authentication of a user is intended for the differentiation of the rights of access of the various categories of users to DB and elements of interface in the various modes of functioning of the means of training (ET).

Each category of users operates in the certain mode of functioning of the program realization of the means of training: administrating – a teacher, a methodologist, an analyst; adaptive training – a trainee.

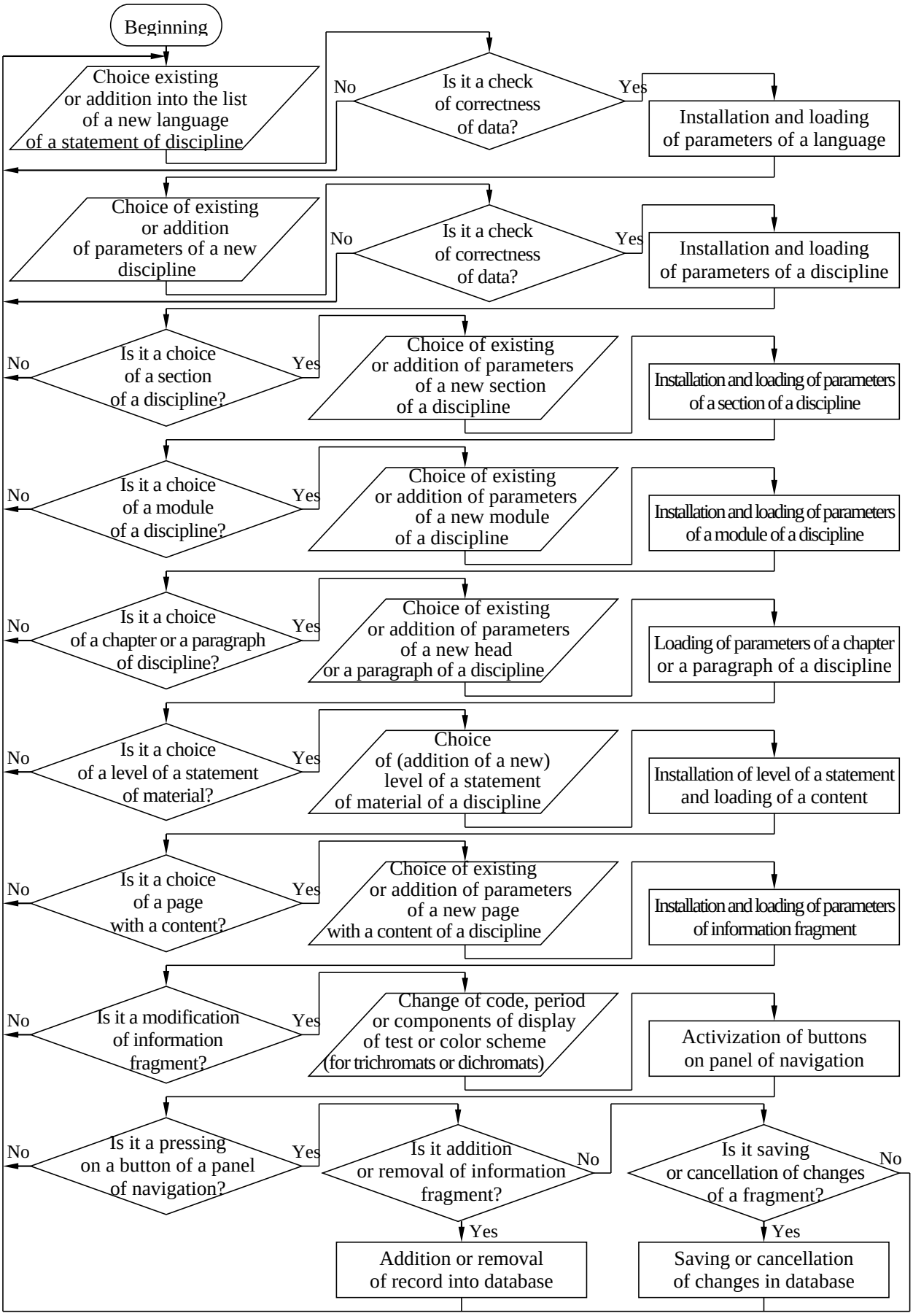
The program realization of the adaptive means of training in the mode of administrating allows to provide the filling of DB with content on subjects (content) by means of the semantic (structural) model of discipline, which realizes the saving and extraction of previously structured information on a set of quants: a section, a module and a page (information fragment).

As the methodical support acting as the source of information at the filling of a content of ET it is necessary to use the available electronic TMC on the certain discipline, containing a set of requirements, the tree of purposes of training and information, reflecting the content of the subject of studying.

Before the filling of the structures of data of DB of ET it is necessary to define the list of available languages of statement and the levels of difficulty of statement of a content of a discipline, and then it is required to add the list of available disciplines and their descriptions.

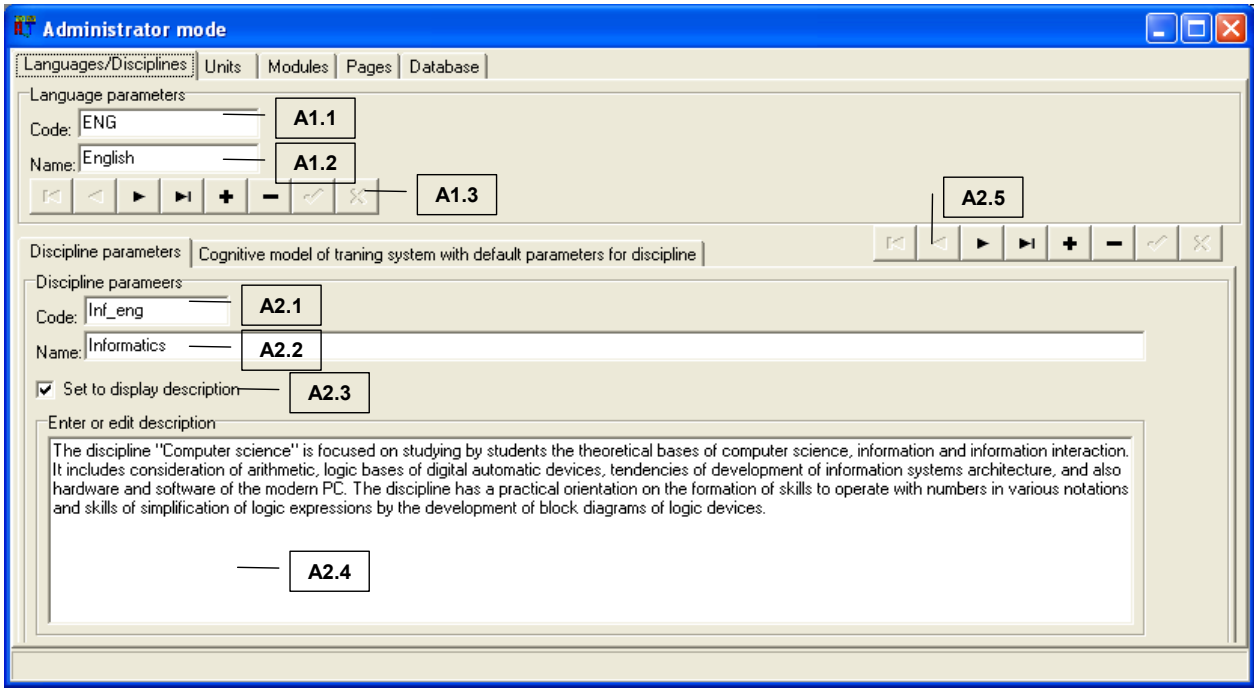
For the filling of DB with filling on subjects (content) of the adaptive means of training according to the semantic (structural) model of a discipline it is necessary to provide the structuring of information, reflecting the content of a discipline on a set of quants: a section, a module, a paragraph and a page (information fragment).

The algorithm of formation of DB with filling on subjects (content) of the adaptive means of training (pic. 6.8) – the sequence of operations, which allow to provide the filling of a content of the adaptive means of training in the mode of administrating.



Pic. 6.8. The algorithm of formation of the database (knowledgebase) with filling on subjects of the adaptive means of training (electronic textbook)

In the mode of administrating directly is carried out the saving of parameters of a national or foreign language of statement of material (pic. 6.9): A1.1 – code (it is generated automatically), A1.2 – the name of language of statement of material, A1.3 – the navigator providing the transition on the first / the last, previous / following element of the list and addition / removal, saving / cleaning of entered values, and also is realized the modification of parameters of the chosen discipline: A2.1 – code (it is generated automatically), A2.2 – the name of discipline, A2.3 – the status of display of the description of discipline (subject of studying), A2.4 – the field of input of the description of a discipline, which is the subject to studying.



Pic. 6.9. The form of interface of the adaptive means of training in the mode of administrating

By means of the elements of interface A1.1-A1.3 is provided the opportunity of formation of the necessary list of national or foreign languages of the statement of material for the subsequent representation of previously structured information, reflecting the content of a set of disciplines, and also is realized the possibility of presentation to the trainees of the material of the certain discipline at the different levels of statement.

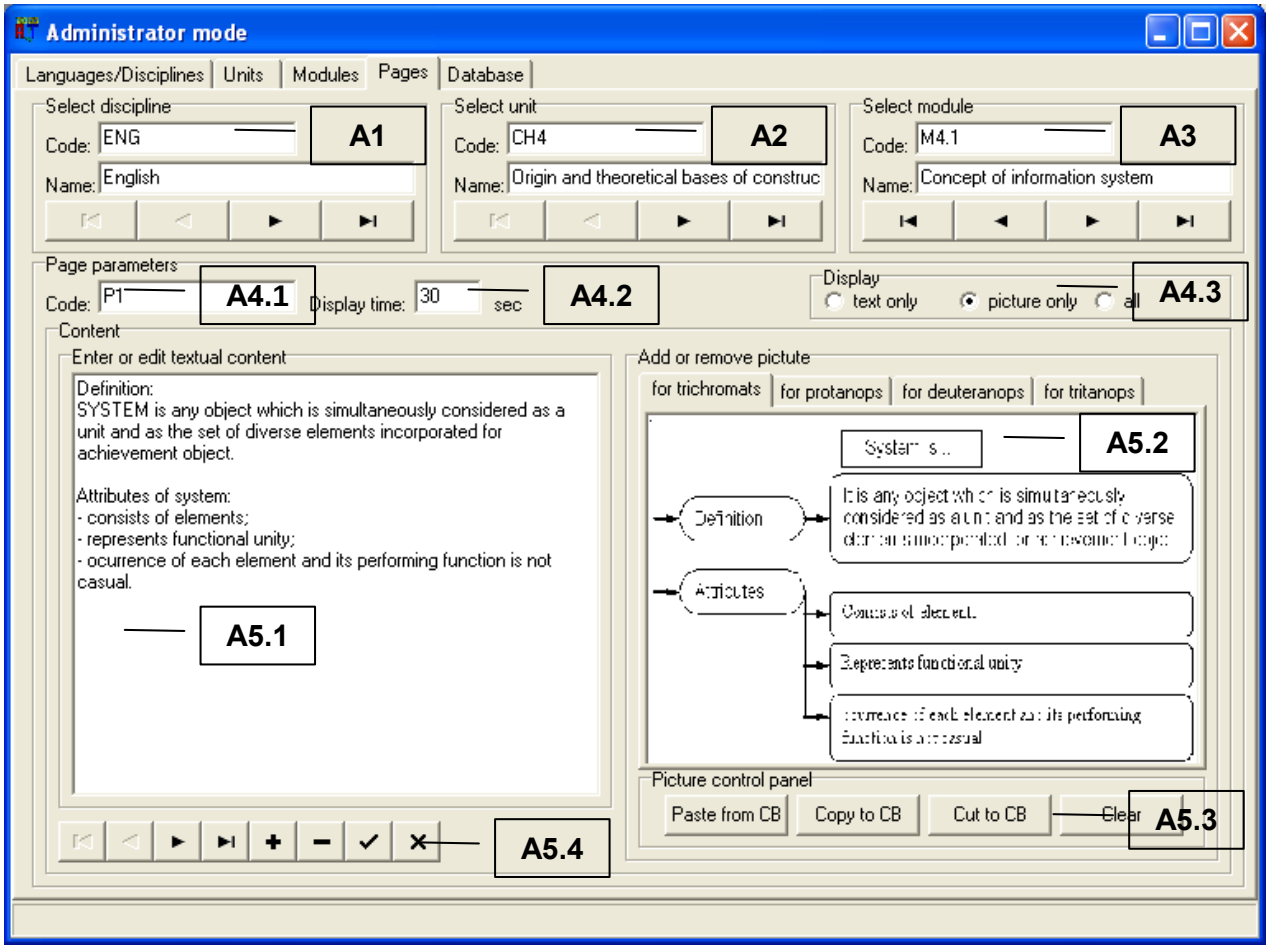
Directly after the choice of the name of a discipline (A1), a section (A2), a module (A3) appears the possibility of switching between pages (pic. 6.10): their addition, removal, and also the saving of modified values in the fields (A4.1-A4.3, A5.1, A5.2) by means of the corresponding the buttons of navigator (A5.3, A5.4).

The addition of a new page initiates the automatic generation of code of a page (A4.1), and then there is the possibility of input of the value of the interval of time of display (A4.2) and the way of display of information fragment (A4.3) used by default if is switched off the adaptive representation of information fragments processor (parameters are calculated by the adaptive representation of information processor on the basis of PCMB).

The removal of current page causes the removal of a corresponding set of information fields in DB with filling on subjects of the means of training (ET).

Further the parameters of elementary page (pic. 6.10) are saved: textual content (A5.1), graphic content (A5.2) of information fragment for the normal trichromats and dichromats (protanopes, deuteranopes and tritanopes).

For the control of graphic image it is used the special panel consisting of a set of buttons (A5.3), allowing to insert the image from the clipboard, to copy or to cut out the content of graphic field into the clipboard.



Pic. 6.10. The form of interface of the adaptive means of training in the mode of administrating of the parameters of page

Each graphic image, entering into the method of research is previously prepared in the graphic editor (Adobe Photoshop, AutoCAD, ArhiCAD and others) and represents inside as the picture or a set of pigmentary spots of various size, perception of which allows to take into account (to diagnose) the degree of severity of the certain pathology of color perception: normal trichromat – without anomalies; abnormal dichromate – expressed partial or full pathology of color perception of red (protanopia), green (deuteranopia) and violet (tritanopia) colors of a polychromatic range of photon radiation (see the correction of the scale of white).

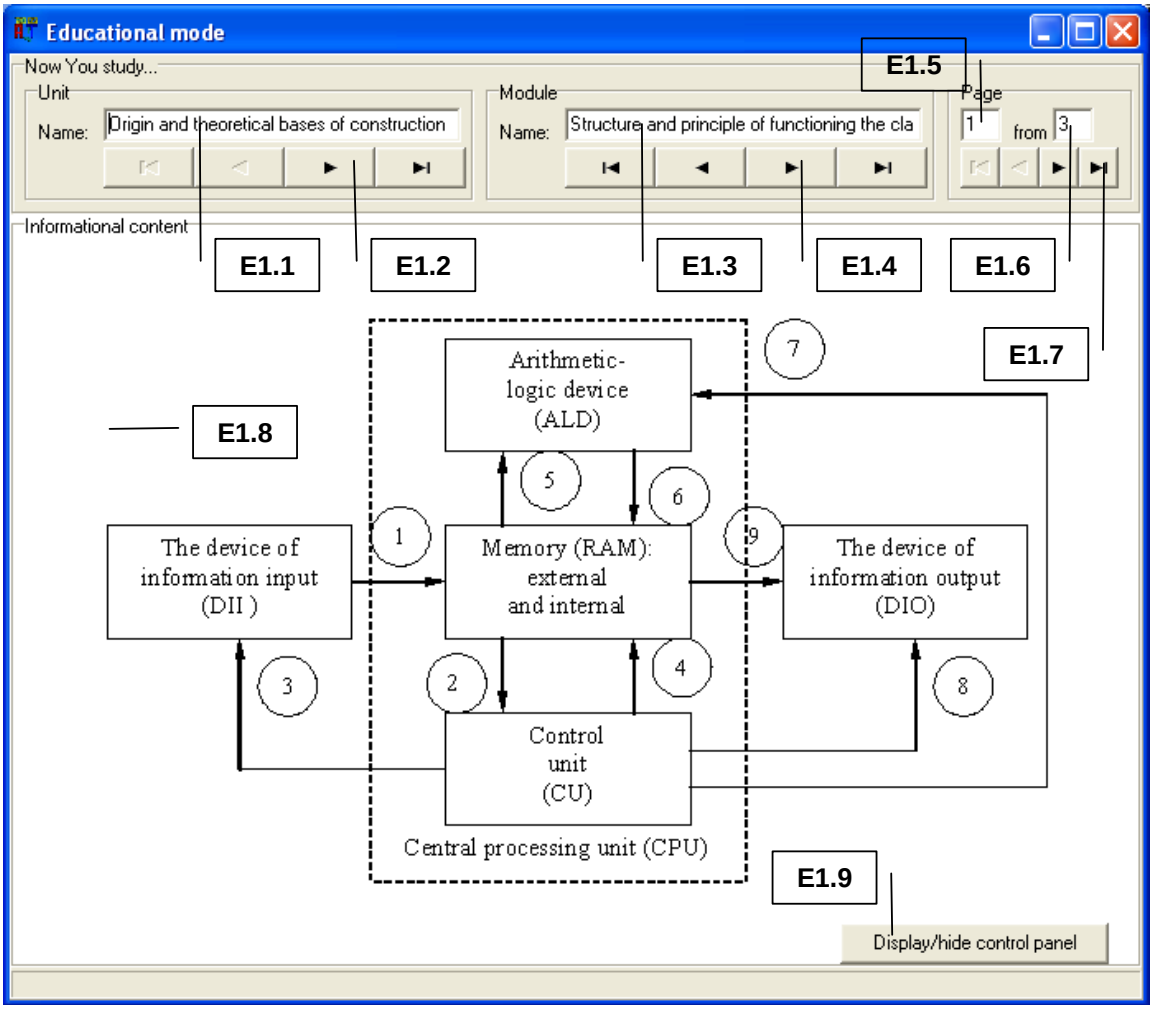
The display of information fragments is carried out by two ways:

- automatically – the fixed interval of display of information in dependence from the previously established nominal value;
- manually – switching of pages is carried out by means of the panels of navigation, allowing to provide the switching between pages (fragments).

The control panel of navigation of the first type is the hierarchical tree, which realizes the switching between the displayed pages and is constructed on the basis of the structural (semantic) model, reflecting the content of the subject of studying.

The control panel of navigation of the second type is presented in pic. 6.11, allows consistently to choose the name of a section (E1.1), a module (E1.3) and a page (E1.5).

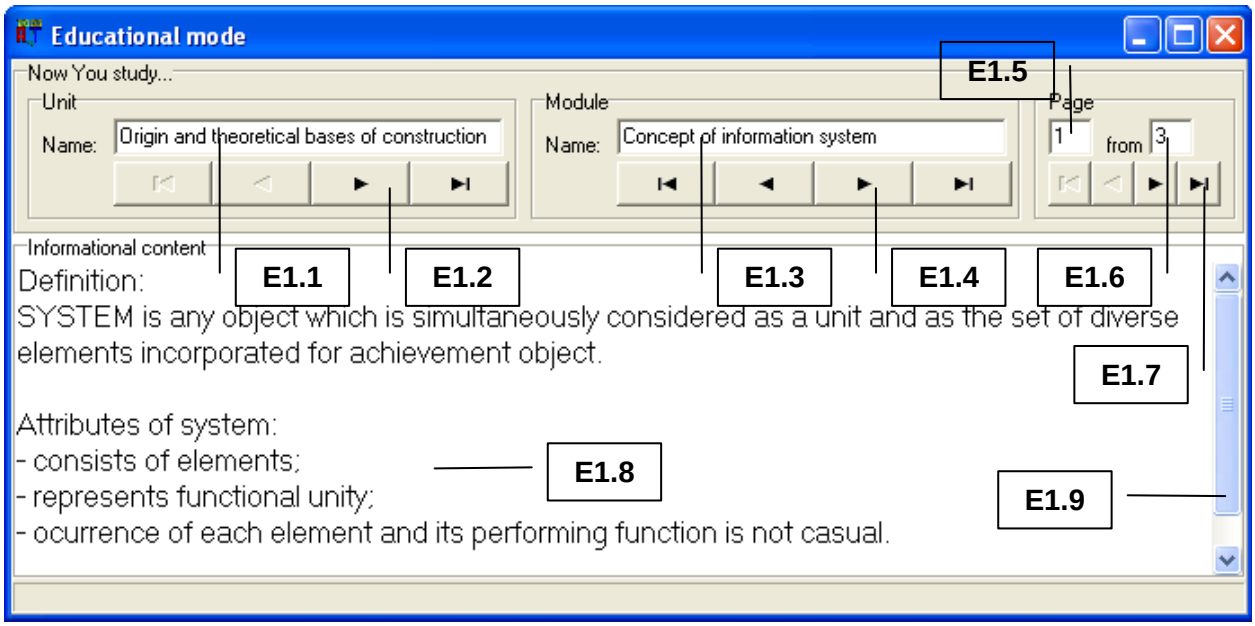
At display of information fragment in the mode of adaptive training the pressing of the button E1.9 provides the concealment of the control panel (of navigation) (pic. 6.11).



Pic. 6.11. The form of interface of the electronic textbook in the mode of adaptive training at the display of information fragments in the view of the flat scheme

The adaptive representation of information fragments processor realizes the calculation of an optimal combination of the nominal values of parameters of TI (color of background; color, size, set of font; color scheme; a volume, timbre and a sound scheme; level of statement of material, set of terms and definitions, set of elements of interface; speed of presentation of fragments, kind and style of presentation of information) on the basis of PCMB, including CM of the subject of training and CM of the means of training.

In pic. 6.12 is presented the form of interface of the adaptive means of training (ET) in the mode of adaptive training on the basis of the textual kind of representation of information fragments and the manual way of switching of pages displayed to the trainee by means of use of the navigator of the second type.



Pic. 6.12. The form of interface of the electronic textbook in the mode of adaptive training at the display of information fragments in the view of the text

The switching of displayed information fragments (E1.8) is reached by means of the use of the navigator of the second type (pic. 6.12): the name of a section (E1.1) and the selector of a section (E1.2), the name of a module (E1.3) and the selector of a module (E1.4), the number of current page (E1.5), the total quantity of pages in module (E1.6) and the selector of pages (E1.7). If the volume of information fragment exceeds the size of displayed area of the page (E1.8) on the presented form of interface of the program realization of ET, then appears the possibility of the use of the strip of scrolling (E1.9).

The saving and extraction of a content of information fragments is carried out by means of the algorithm of extraction of information on the basis of the semantic model of a discipline irrespective from the values of parameters which are contained in PCMB, defining the features of display of information to the certain trainee.

The start of the mode of adaptive training is possible only in the case of realization:

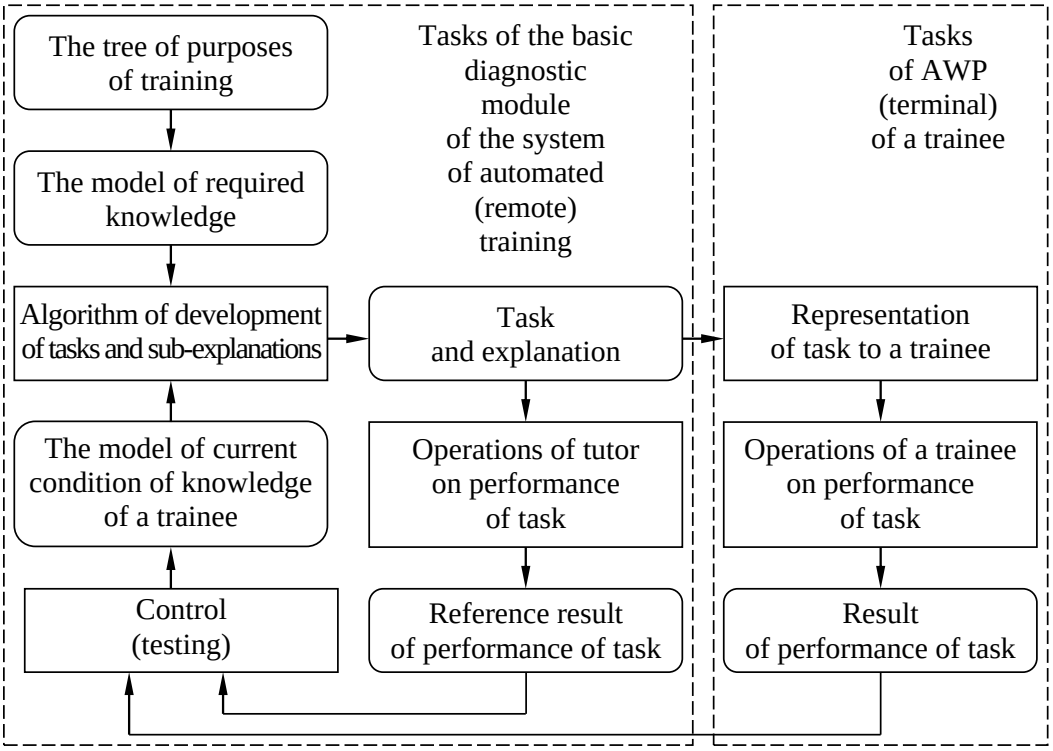
- of the preliminary diagnostics of IFPST and subsequent installation of the values of parameters of CM of the subject of training for the chosen contingent of trainees;
- of installation of the values of parameters of CM of the means of training, defining the list of possible types, kinds and ways of representation of information fragments (adequately to the technical opportunities), and also the parameters of display by default, which are used in the case of impossibility of the choice of optimal combination of the parameters of display for the specific trainee because of the absence of the values of his parameters in CM of the subject of training.

The switching between pages is carried out automatically after the given interval of display of the page or manually by the user. The window of interface of the mode of (adaptive) training is closed automatically after the taken-away of the interval of time or manually by the user.

For the compulsory completion of the session of training to the user it is necessary to close the corresponding window of interface irrespective from the mode of work.

6.3. The basic diagnostic module

The basic DM is intended for the realization of the automated testing of LRKT of the contingent of trainees and operates on the basis of the formed selections of question-answers structures, which are contained in DB of tests on subjects (pic. 6.13).



Pic. 6.13. The scheme, reflecting the principle (algorithm) of functioning of the basic diagnostic module

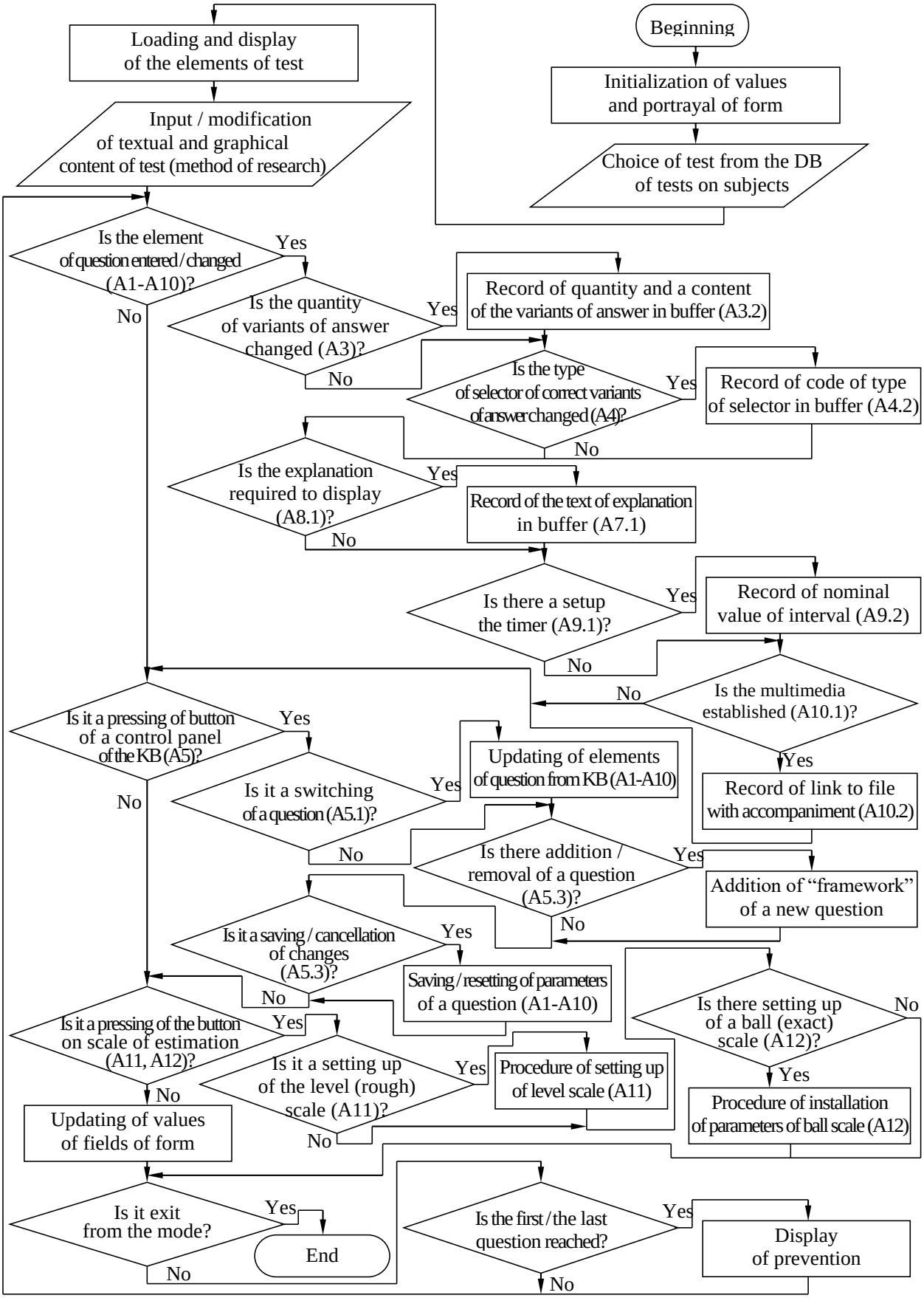
The tree of purposes of training is in the basis of the model of required knowledge and is constructing proceeding from the existing standards, restrictions, preferences and technical capabilities of the means of training, used in IEE for the realization of ART.

According to the formed and filled by the teacher the model of required knowledge, containing the tree of purposes of training, to each information fragment, reflecting the content of a discipline in the certain language of statement (a section, a module and a page) is associated a set of control questions which are contained in DB of tests on subjects, providing the intermediate and total estimation of LRKT.

The algorithm of development of learning tasks and sub-explanations (explanations) provides the generation of sequence of question-answers structures, realizes the comparison of reference (forms the teacher) and experimental (forms the examinee in the process of testing) answers, and in case of the registration of incorrect variant(s) of answer of an examinee in one of the questions displays the explanation, which is installed beforehand by the teacher.

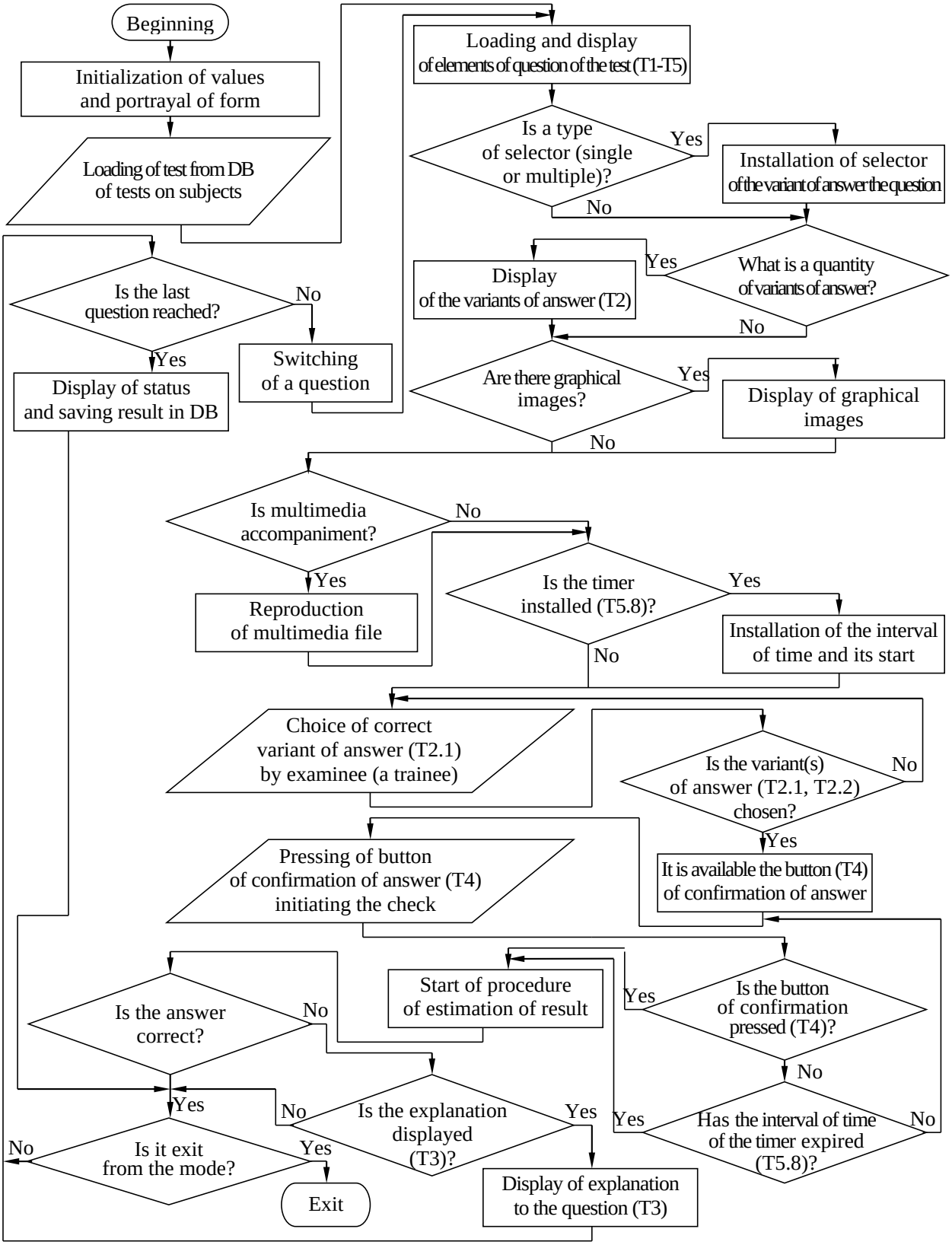
The basic DM operates in the context of a limited set of the modes of functioning:

- administrating – the modification of DB of tests on subjects, account records of users and the viewing of a posteriori results of testing (pic. 6.14);
- diagnostics – the automated estimation of LRKT with the use of a set of tests on a set of disciplines on the basis of adjusted scales (pic. 6.15).



Pic. 6.14. The algorithm of support of functioning of the mode of administrating of the questions of test (method of research)

In pic. 6.15 is presented the algorithm of functioning of the basic DM in the mode of diagnostics, allowing to make the automated estimation of LRKT on the basis of the formed interval scale and the function of estimation.

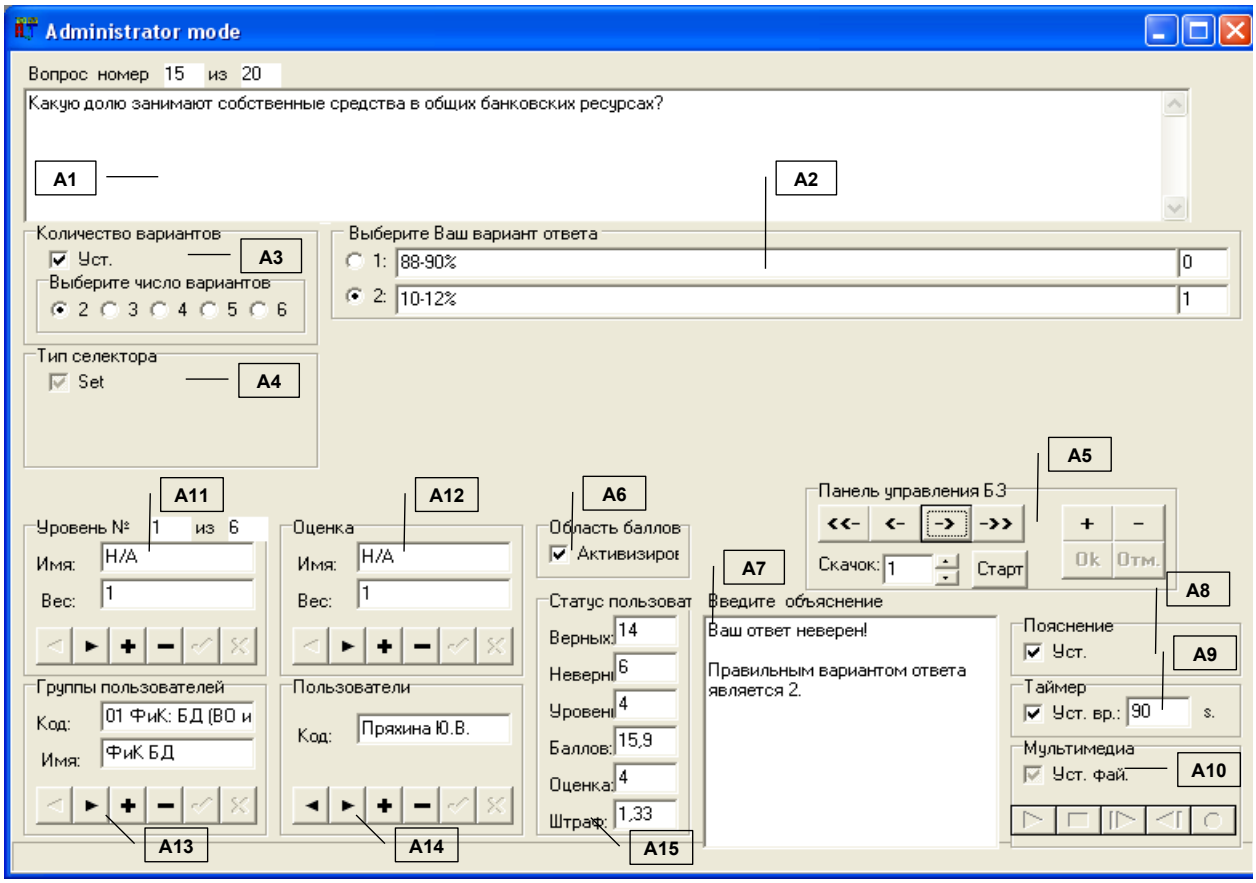


Pic. 6.15. The algorithm of support of functioning of the mode of diagnostics for the estimation of the level of residual knowledge of a trainee

The test represents inside in advance a formed set of questions and answers, shown to the examinee in the certain sequence, which are assumed the choice of the standardly only-correct variant of answer or the several correct variants of answer from a set of offered, and also assumes the input by the examinee of the formulation of correct answer into the special field.

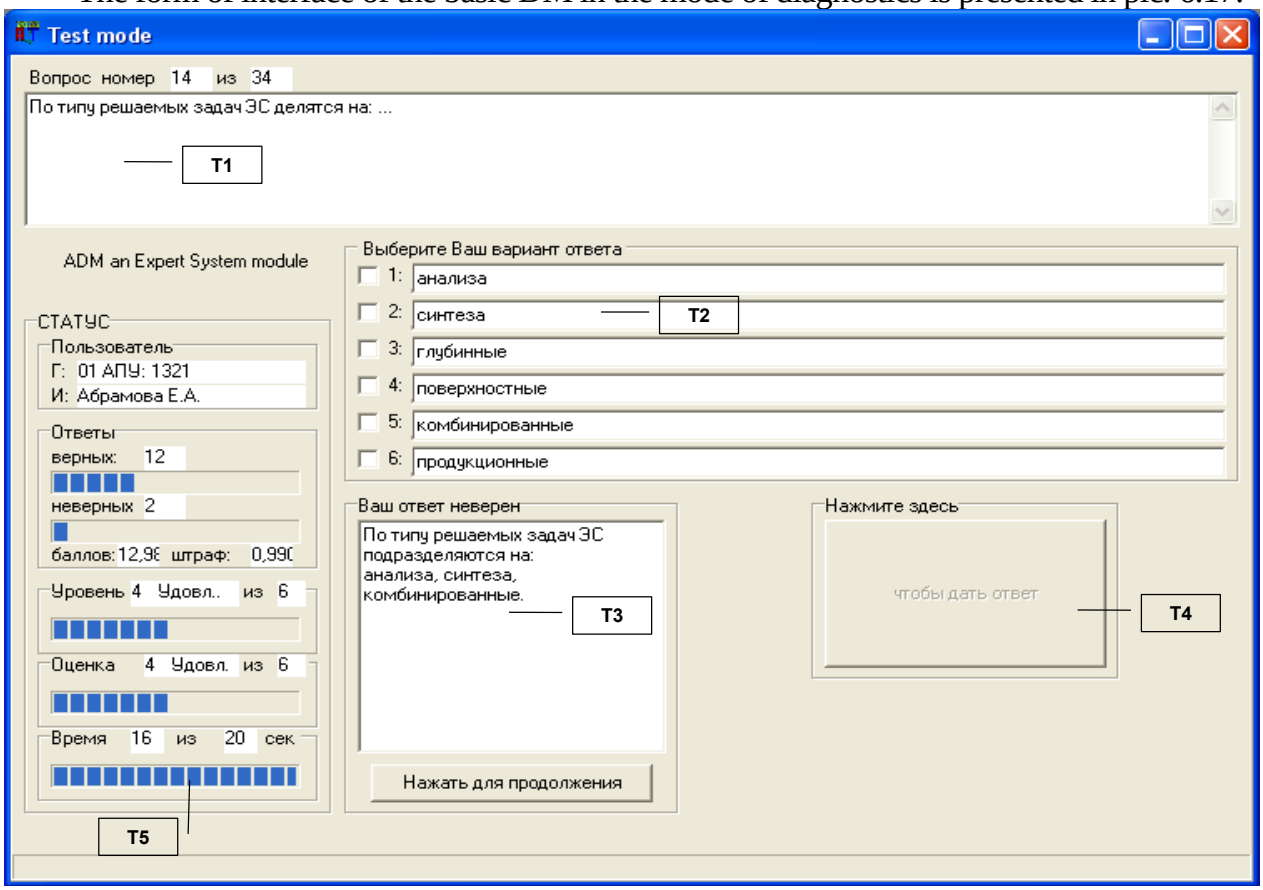
In pic. 6.16 it is presented the interface of the basic DM in the mode of administrating, allowing to modify the parameters of elementary question-answers structure as a part of test task (method of research): the indicator of the text of question (A1) – the textual content of question; the selector of variants of answer (A2) – the textual content of variant of answer and sign(s) of their correctness; the field for installation of the nominal value(s) of weight(s) of the variant(s) of answer a question at the using of the point scale of exact estimation; the selector of quantity of variants (A3) – the quantity of variants of answer the question; the type of selector of variant of answer (A4) – the switch of correct variant(s) of answer the question; the graphic image (option is not activated in this designer); the control panel of KB (A5) – the navigation within the limits of the list of questions with the possibility of addition of a new, removal of existing, saving of modified and cancellation of saving of made changes in one from the parameters of question; the selector of the point scale of exact estimation (A6) – connects the use of the point scale on the basis of weight coefficients (exact scale); the indicator of explanation (A7) – provides the display of a content of explanation in case of incorrectly given answer by the examinees; the selector of explanation (A8) – makes active the possibility of display of explanation (direct display of explanation is realized in the mode of diagnostics); the area of timer (A9) – allows to activate the accounting and to set up the nominal value of the interval of time for the display of a content of certain question; the area of multimedia (A10) – provides the possibility of activization of reproduction of a sound stream from the file with the certain name; the area of the scale of rough estimation (A11) – the interval scale and function of estimation is formed on the basis of the sum of correct answers the questions; the area of the scale of exact estimation (A12) – the interval scale and function of estimation is formed on the basis of the sum of gained points for each correct variant of answer the question; the area of groups of users (A13) – realizes the display and modification of the list of codifiers and the names of the groups of examinees; the area of users (A14) – provides the possibility of display and modification of the list of examinees for the subsequent registration in the system and saving of a posteriori data of testing; the field of status of an examinee (A15) – aggregates a set of the values of parameters, reflecting: the quantity of (in)correct answers the questions, the sum of gained (penalty) points, the (estimation) of LRKT on the rough (exact) scale on the basis of the sum of correct answers the questions (the sum of gained points for each correct variant of answer the question) of method of research (test).

The form of interface of the basic DM in the mode of diagnostics is presented in pic. 6.16, provides the passing by the examinee of a cycle of the automated testing of LRKT by means of the delivery of variants of answers on a set of questions of various type displayed in the certain sequence by the algorithm of diagnostics. The program realization supports the change of scale and function of estimation.



Pic. 6.16. The mode of administrating of the basic diagnostic module

The form of interface of the basic DM in the mode of diagnostics is presented in pic. 6.17.



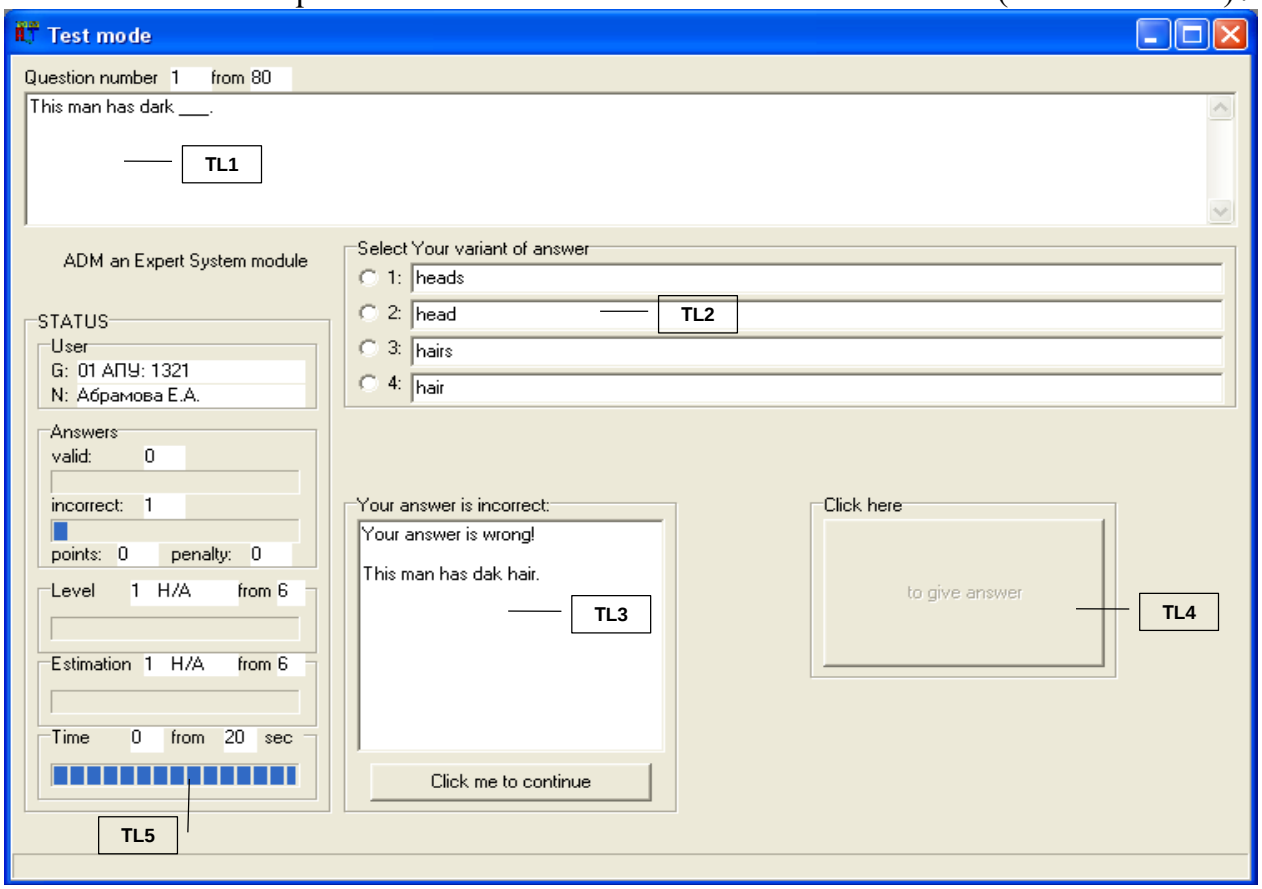
Pic. 6.17. The interface of a user in the mode of diagnostics

Directly after the display of the task (pic. 6.17), including the textual contents of question (T1), variants of answer (T2), explanation (T3) to the examinee it is necessary to study with the content of listed elements, to choose the correct variant(s) of answer the question of the method of research (test), to confirm the choice and to initiate the start of the procedure of check by means of pressing on the button (T4). If the examinee has given the correct answer the posed question of the method of research (test), then by the algorithm of the analysis provides the transition on the following question. If the answer of an examinee is incorrect, then it is displayed the area, containing the explanation (T3). The status of an examinee (T5) includes a set of the values of parameters formed in the real scale of time directly in the mode of diagnostics and saves in DB with a posteriori results of testing (research) in fact of the end (compulsory end) of a procedure of testing of LRKT.

There are provided two scales of estimation in the program realization: rough (standard) – is considered the sum of correct answers the questions; exact (point) – it is based on the sum of gained points for each correct variant of answer.

The basic DM duplicates the possibility of diagnostics (testing) of some parameters of CM of the subject of training, in particular allows to research the parameters of linguistic portrait of CM of the subject of training: the level of proficiency in a national or foreign language of statement of material, the level of proficiency in keywords and definitions, the level of proficiency in interface.

The interface of the basic DM in the mode of diagnostics of the level of proficiency in the English language is presented in pic. 6.18: for the realization of the procedure of testing of examinees is used the technique of "The Colchester educational center" (Great Britain).

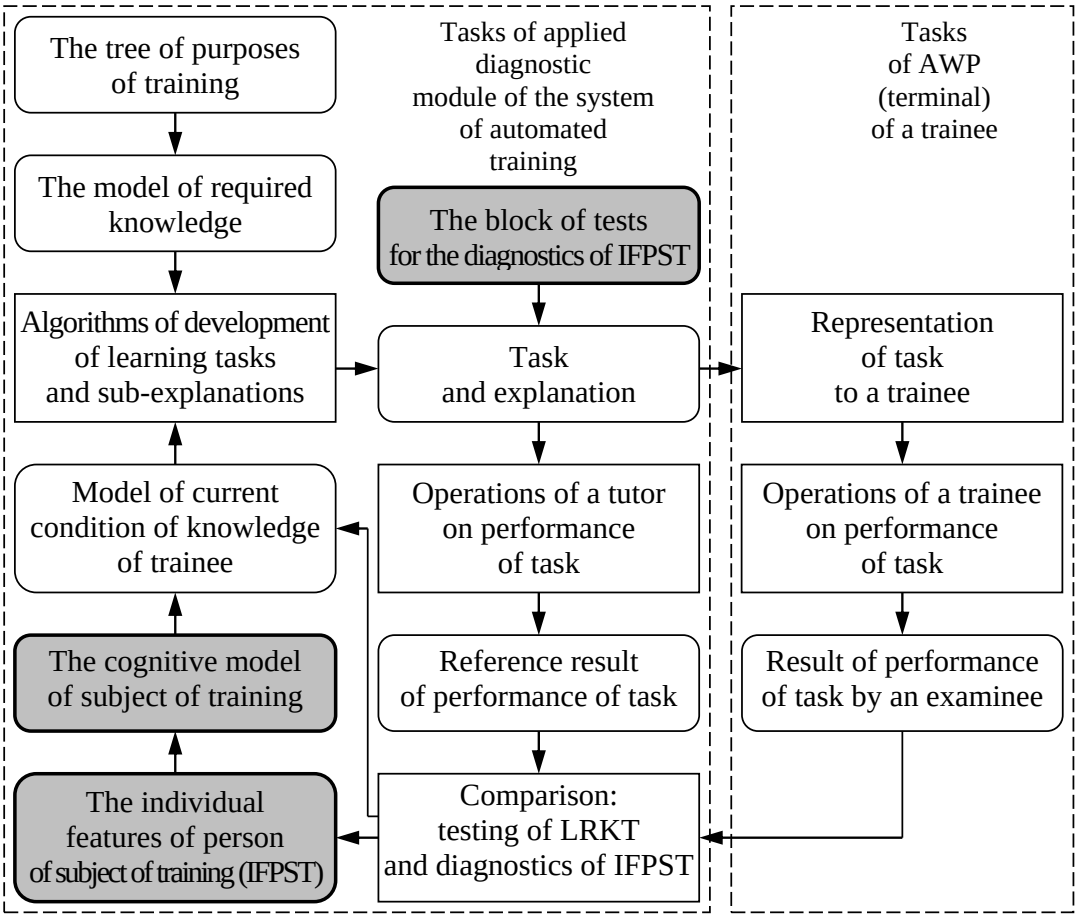


Pic. 6.18. The form of interface in the mode of diagnostics of the level of proficiency in language of statement of material

6.4. The applied diagnostic module

This module is intended for the realization of the procedure of automated diagnostics of the individual features of personality of the contingent of trainees (IFPST) on the basis of the selections of question-answers structures which are contained in DB with tests of IFPST, which allow to estimate the nominal values of parameters, entering into the physiological, psychological and linguistic portraits of CM of the subject of training.

The principle (algorithm) of functioning of the applied DM is reflected in pic. 6.19.



Pic. 6.19. The scheme, reflecting the principle (algorithm) of functioning of the applied diagnostic module

According to the presented schemes the principles (algorithms) of functioning of the basic and applied DM are identical, but in force of the features of the structure of task (question) entering into the basis of the certain method of research (test) and according to the specifics of realization of the designer of tests in the mode of administrating there are the essential differences, which are shown at the algorithmic level, therefore the program realization of the presented modules is executed separately.

The architecture of the applied DM provides the use of several independent designers of test, which are used independently of each other.

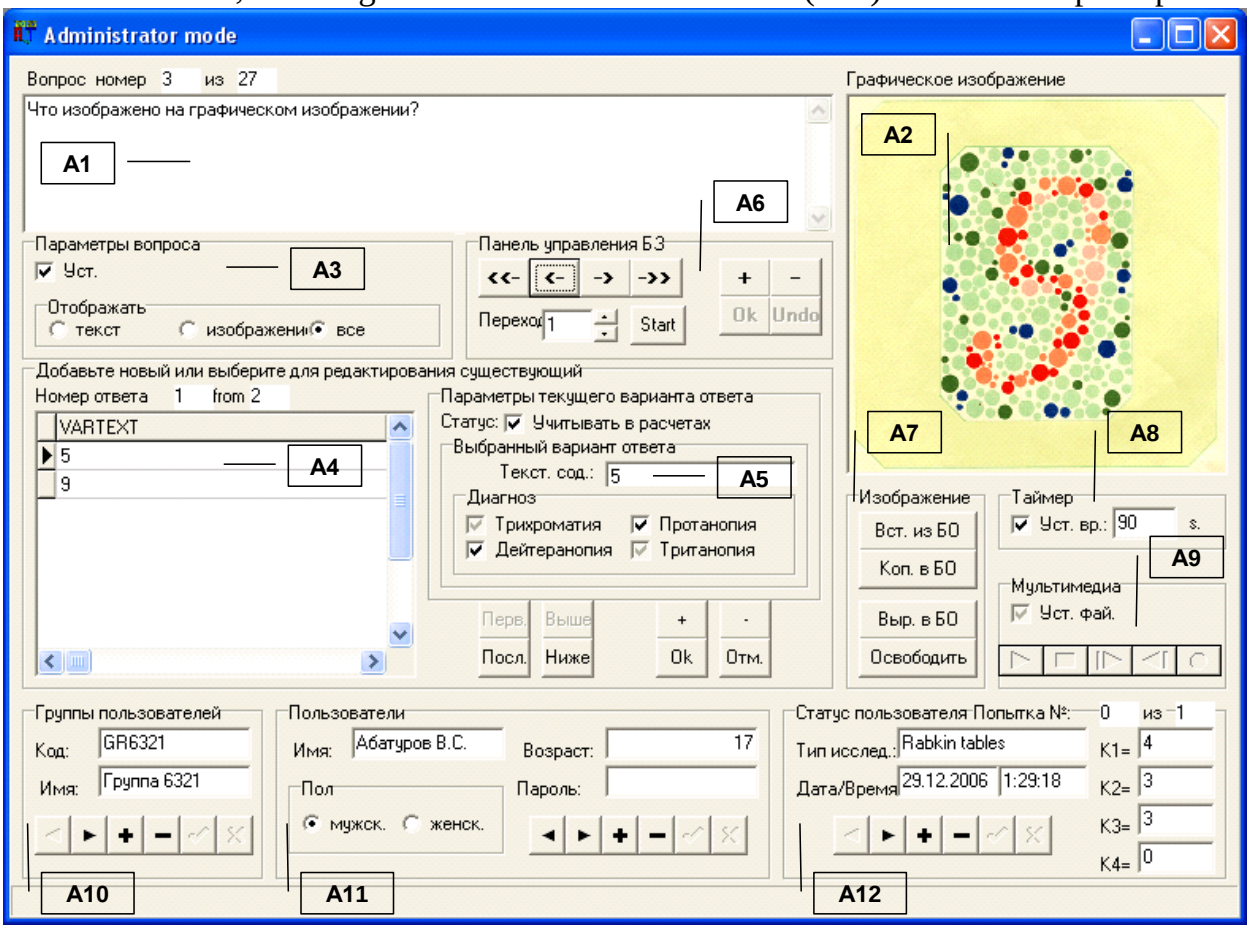
As the applied DM provides the diagnostics of the values of parameters of CM of the subject of training, than for the research of each of its portraits is selected the certain method of diagnostics (the method of research in the form of testing). At the same time the algorithm of development of learning tasks of a method of research (test) and the interface of designer in the mode of administrating have a number of differences.

In particular, the form of interface of the applied DM in the mode of administrating allows to provide the setting up of the parameters of question-answers structures, entering into the methods of research of the color perception of Rabkin E.B. and Yustova E.N. (the physiological portrait of CM of the subject of training), providing a set of polychromatic tables, which are consistently shown to the examinee.

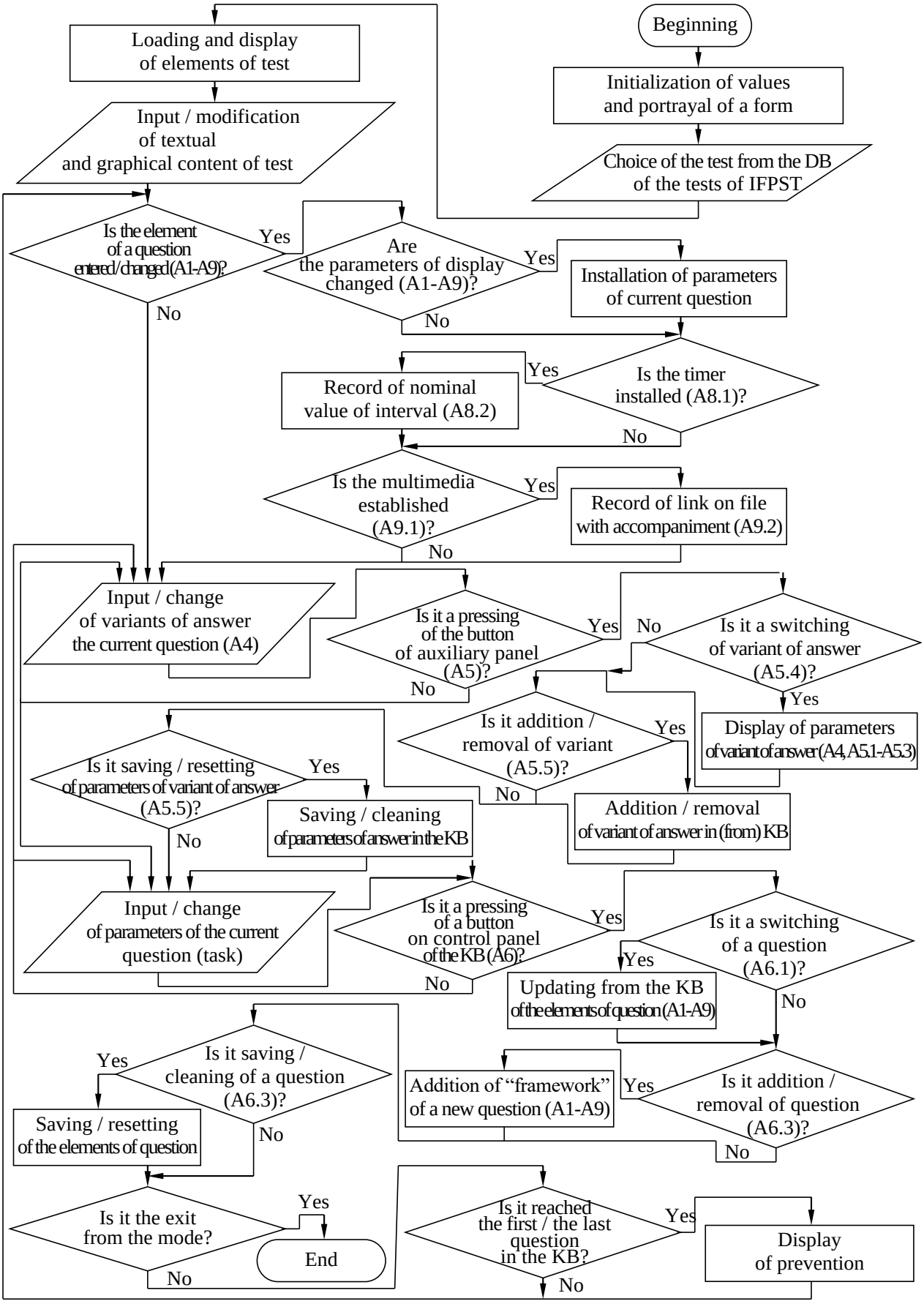
Each graphic image in the polychromatic table is formed by a set of pigmentary spots of various color and diameter, at perception of which the examinee must to identify the certain geometrical figure or digit, that allows in the process of comparison with reference variants of answer to define the degree of expressiveness of the anomaly of a color perception, caused by full or partial dysfunction of one from the components of "coneal" device of a retina of eye:

- normal trichromat – the anomalies of color perception are absent;
- abnormal trichromat – is observed the insignificant expressiveness of the certain anomaly at the perception of colors of a polychromatic range;
- full or partial dichromate – completely or partial is absent the susceptibility on relation to the certain color;
  - protanope – is not capable to distinguish the red and shades of red color (partial pathology);
  - deuteranope – is not capable to register the green and shades of green color;
  - tritanope – instead of the violet and shades of blue sees the shades of gray color.

In pic. 6.20 is presented the interface of the applied DM in the mode of administrating of a set of tasks, entering into the method of research (test) of the color perception.



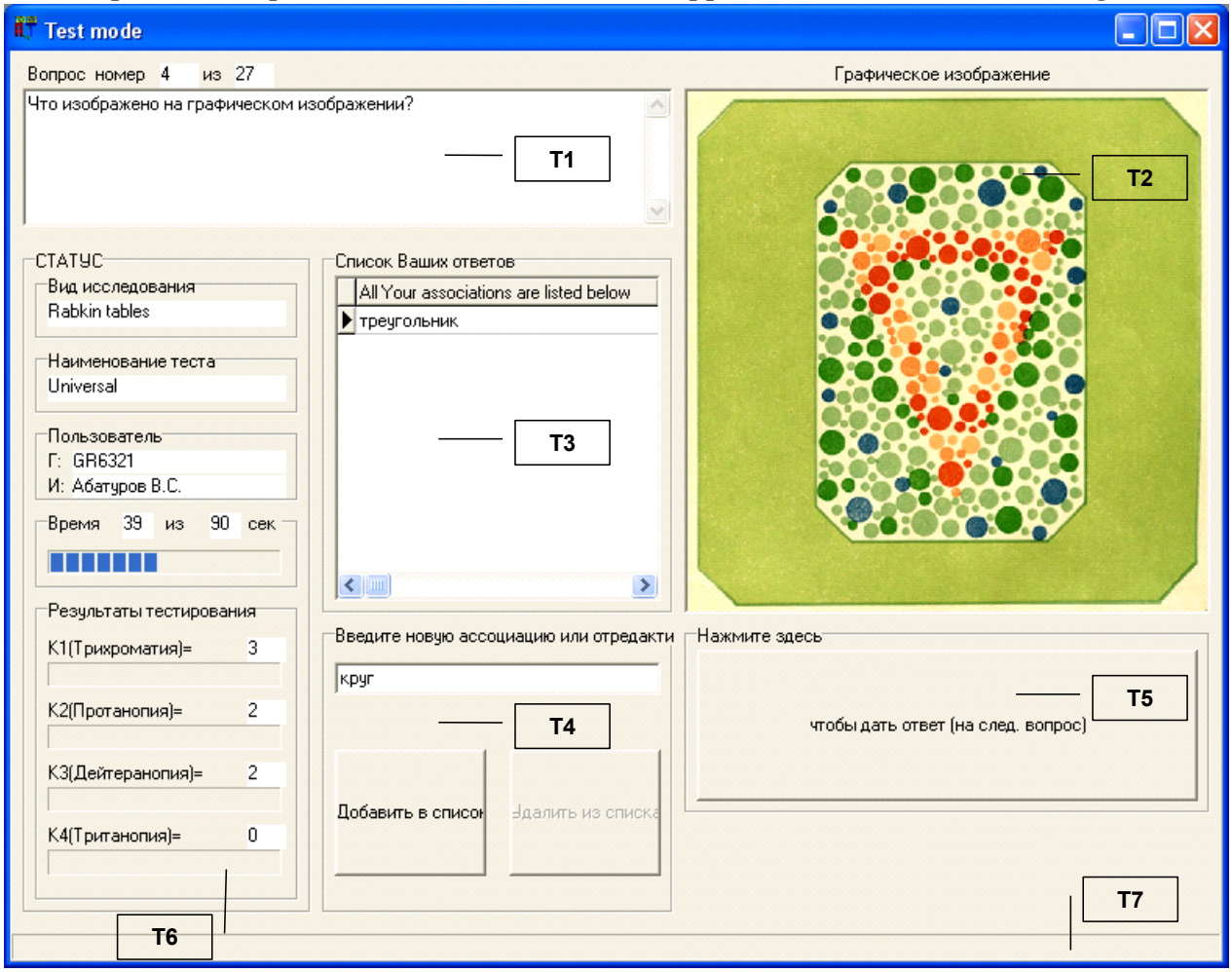
Pic. 6.20. The mode of administrating of the applied diagnostic module



Pic. 6.21. The algorithm, reflecting the principle of functioning of the applied diagnostic module in the mode of administrating of the questions of test

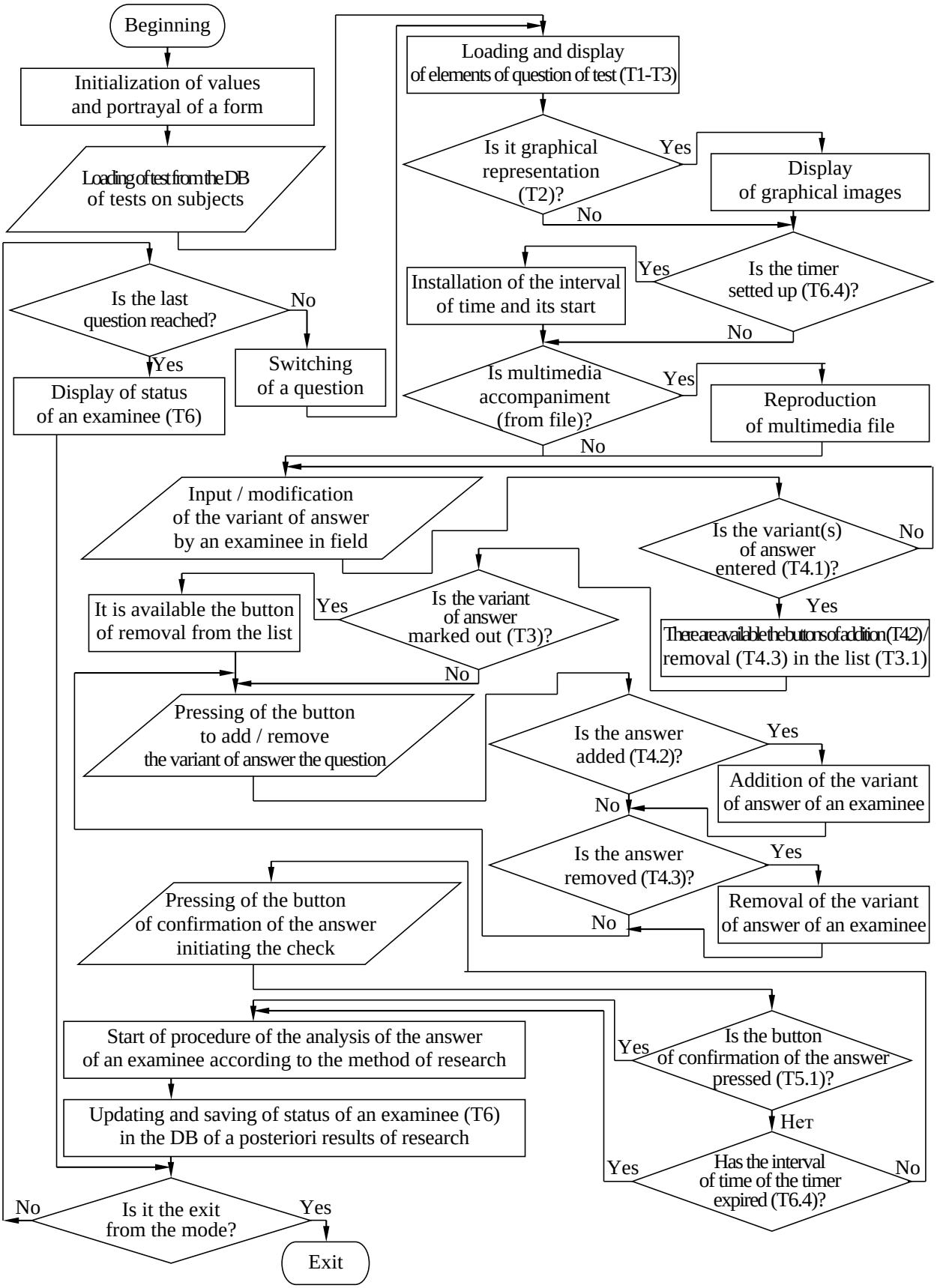
The control of DB of methods of research (tests) is realized in the mode of administrating of the applied DM by means of the designer of test (method of research), allowing to set up and modify the parameters of everyone question-answers structure: the indicator of a question (T1) – the textual content of a question of the method of research; the indicator of graphic image of question (T2) – it is intended for saving of graphic object; the indicator of variants of answer on question (T3) – the textual content of the list of the variants of answer the question of the method of research (test); the control panel of the variants of answer of an examinee a question (T4) – the field of input of the variant of answer of an examinee, being a subject to addition into the list of variants of answer and allowing to delete one from earlier entered variants of answer; the button of registration and verification of answer (T5) – pressing on button initiates the start of procedure of verification of the entered list of the variants of answer of an examinee a question and transition to the next question; the indicator of status of an examinee (T6) – displays the identifier of group, full name of an examinee, remained time, allowed to the examinee for the answer the question, the nominal values of coefficients testifying about the degree of expressiveness at the examinee of the certain (full or partial) anomaly of the color perception (K_1 – trichromatia, K_2 – protanopia, K_3 – deuteranopia and K_4 – tritanopia); the status bar of program (T7) – displays to the examinee the appointment of the allocated certain element of interface of the program realization of the applied DM.

In pic. 6.22 is presented the interface of the applied DM in the mode of diagnostics.



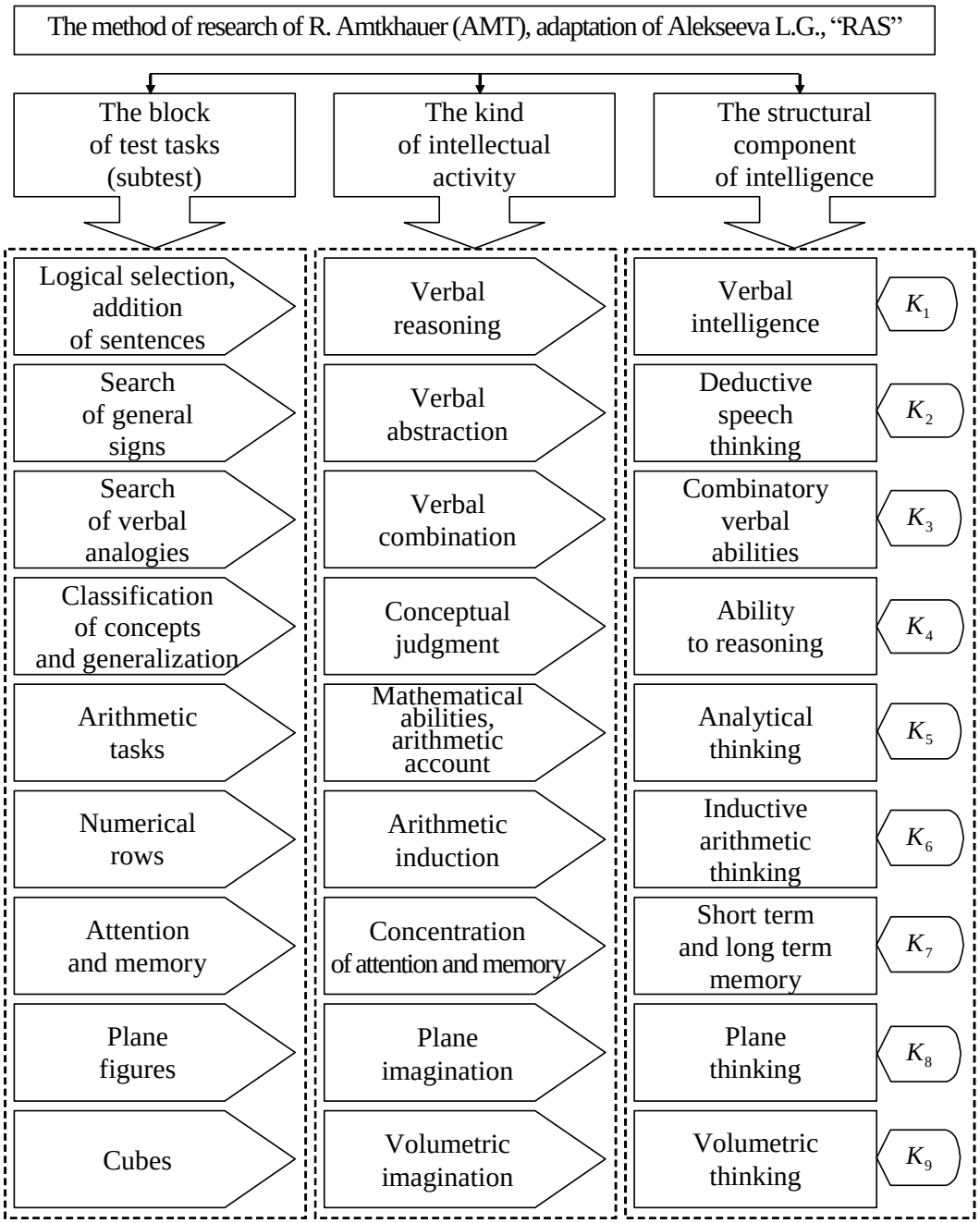
Pic. 6.22. The interface of a user at work in the mode of diagnostics

The algorithm of functioning of the applied DM in the mode of diagnostics in pic. 6.23.



Pic. 6.23. The algorithm, reflecting the principle of functioning of the applied diagnostic module in the mode of diagnostics of IFPST

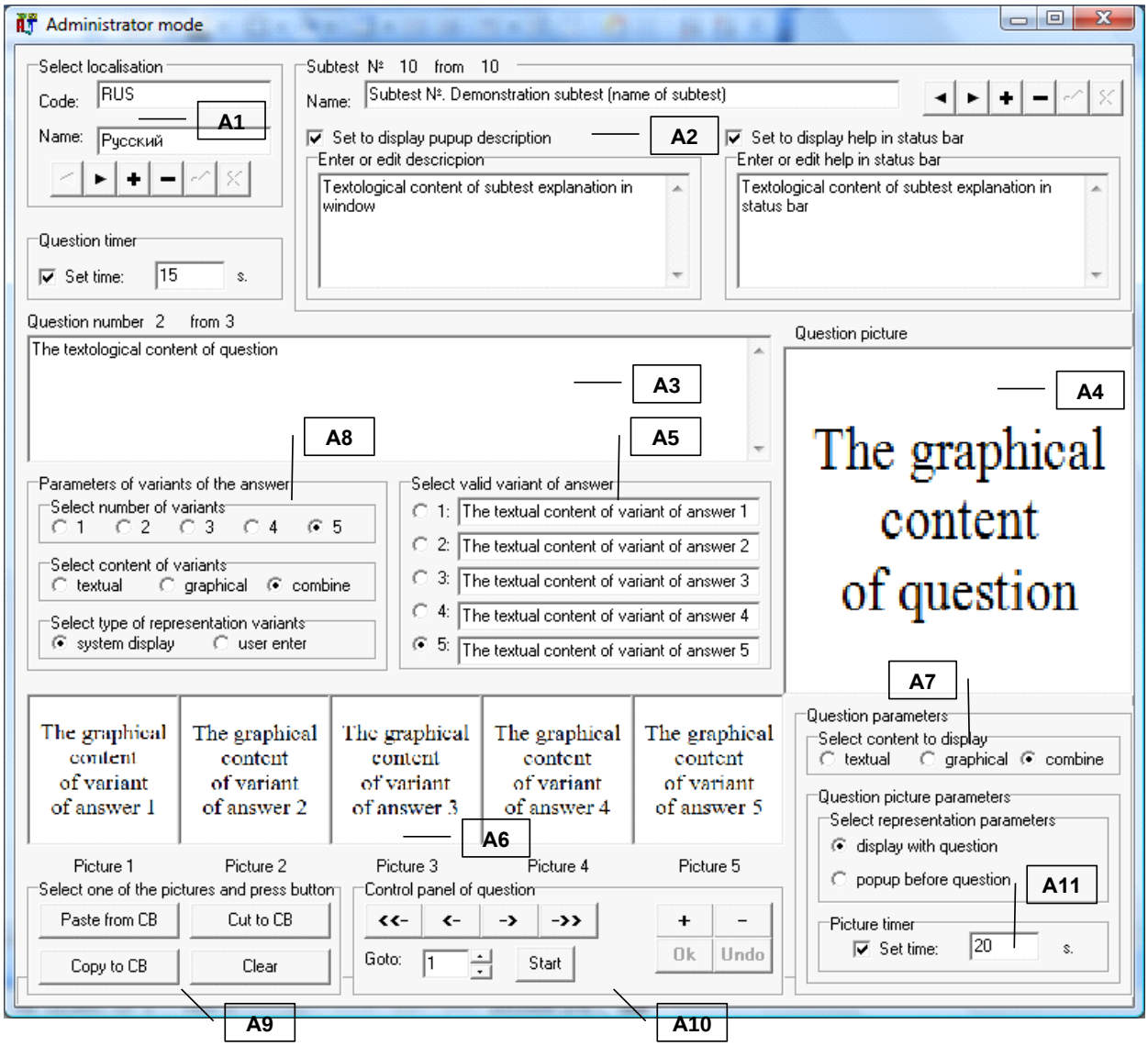
The method of research of R. Amtkhauer (pic. 6.24) provides the consecutive presentation to the examinee of a set of question-answers structures of the test tasks (of the method of research), grouped on the subtests (blocks of questions): "Logical selection, addition of sentences", "Search of general signs, exception of word", "Search of verbal analogies", "Classification of concepts, generalization", "Arithmetic tasks", "Numerical rows", "Attention and memory", "Choice of figures" and "Cubes", which in the process of decision provide the activization of the certain kinds of intellectual activity in the process of the cogitative activity (verbal reasoning, verbal abstraction, verbal combination, conceptual judgment, arithmetic account, arithmetic inductive conclusion, concentration of attention and mnemonic, plane imagination and volumetric thinking).



Pic. 6.24. The structure of the method of research of the convergent intellectual abilities of R. Amtkhauer

In dependence from the quantity of correct answers the question gathered in the separately taken subtest of the method of research is dynamically performed the measurement of the level of development of the various structural components of intelligence as the latent property of psychophysiological construct of a brain of an examinee directly (verbal intelligence, inductive speech thinking, verbal combinatory abilities, ability to reasoning, analytical thinking, inductive arithmetic thinking, short-term and long-term memory, plane thinking and volumetric thinking).

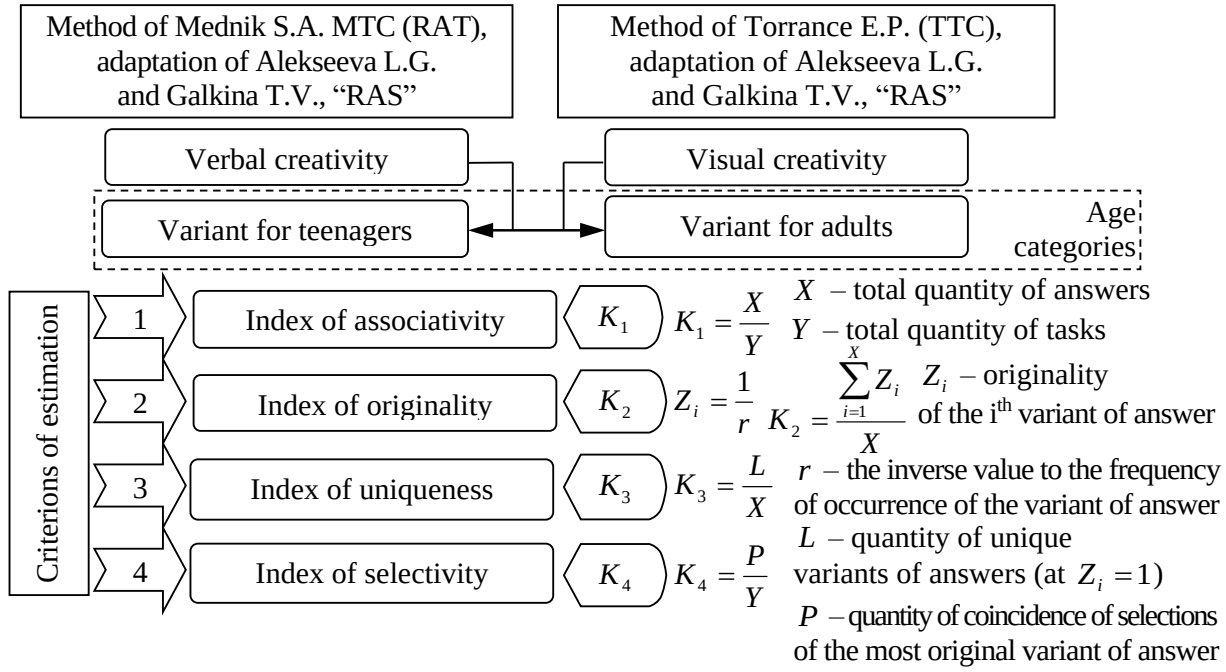
In pic. 6.25 is presented the form of interface of the program realization of the designer of tests of the applied DM in the mode of administrating of the parameters of question-answers structures, entering into the method of research of the convergent intellectual abilities of R. Amthauer (directly the psychological portrait of CM of the subject of training).



Pic. 6.25. The developed structure of the window of interface in the mode of administrating of the applied diagnostic module

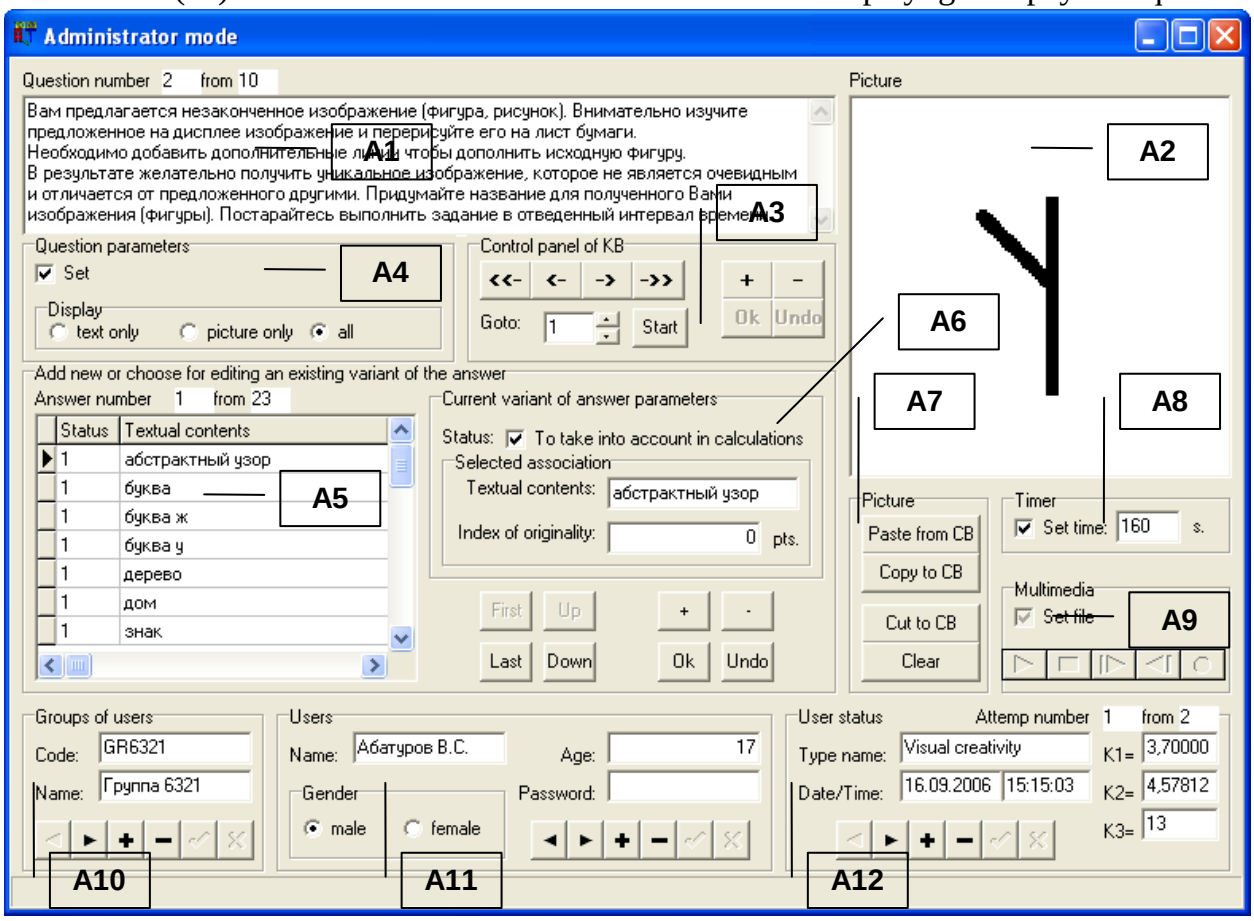
The presented designer in pic. 6.25 provides the input and modification of the various elements entering in the basis of question-answers structure of each task from subtest: the indicator of localization (A1) – allows to change the list of names and codifiers of localizations; the indicator of subtests (A2) – allows to establish the status of display and the textual content of description of the subtest of the method of research (it is displayed in the mode of diagnostics before the beginning of each block of questions) and help (reference) information (it is displayed in the mode of diagnostics in status bar); the indicator of textual content of the question (A3) – the text of question of the method of research; the indicator of graphic content of the question (A4) – displays the picture of the question; the indicator of textual content of the variants of answer (A5) – allows to enter the text of the list of possible variants of answer the question and to set up the sign of their correctness; the indicator of graphic content of the variants of answer (A6) – allows to enter the pictures of the list of the possible variants of answer the question of the method of research (test); the panel of the parameters of question (A7) – allows to set up the parameters of the question, including: the type of a content (a text, graphic image and combined), the way of display of pictures of the question (before the text in separate window, in parallel with the text), interval of display; the panel of parameters of the variants of answer the question (A8) – allows to set up the quantity of the variants of answer the question, type of a content (only text, only graphics and combined) and the way of display of the variants of answer the question (displays the system, enters the user); the control panel of graphic objects (A9) – allows to realize the insert, copying and cutting of picture (A2) on relation to the clipboard, or cleaning of contents of field; the control panel of DB (A10) – realizes directly the transition on the first, previous, following, last and any question, allows to add and delete questions, to keep and cancel the changes made into the fields A3-A8.

The essence of research of the divergent intellectual abilities of the subjects of training (pic. 6.26) comes down to the diagnostics of the verbal and figurative creativity by means of the use of two methods of research (Mednik S.A. and Torrance E.P.), each of which is intended for two age categories: teenagers and adults.



Pic. 6.26. The structure of the methods of research of the vector of the divergent intellectual abilities (two age categories)

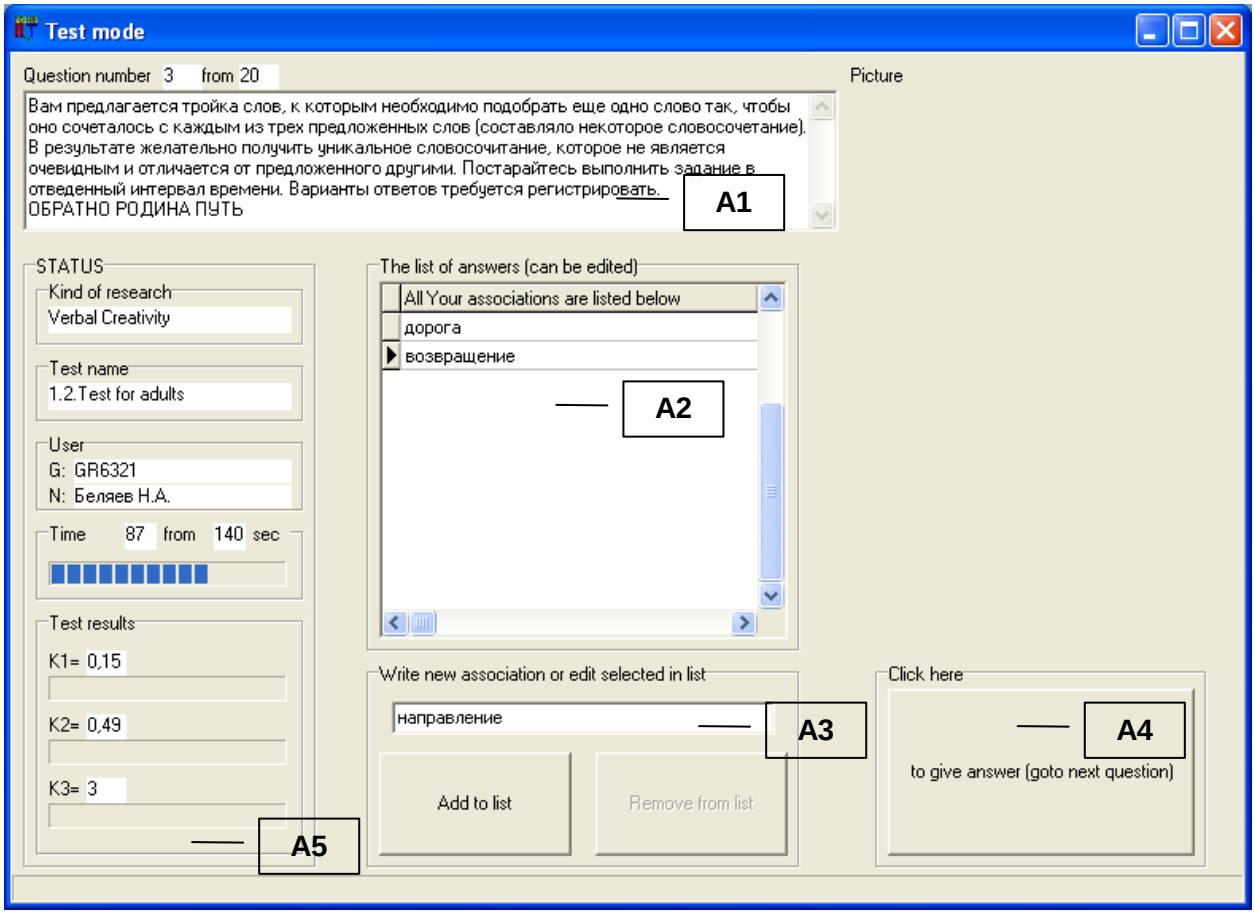
The applied DM (pic. 6.27) in the mode of administrating of the parameters of test, allows to realize the automation of research of the figurative creativity by the method of research of Torrance E.P. and includes a set of elements realizing the display, editing and control at the work of a user, which are designated by the letters with alpha-numerical identifiers: the indicator of the text of the question (A1) – contains the textual content of formulation of the question; the indicator of picture (A2) – displays the graphic content of visual incentive; the control panel of DB (A3) – realizes the transition on the first, previous, following, last and any question, allows to add and delete questions, to save and cancel the changes made into the fields A1, A2, A4, A5, A6, A8, A9; the panel of parameters of display of the question (A4) – allows to specify the elements of the question: textual content (A1), graphic content (image) (A2), all elements; the indicator of the variants of answer (A5) – allows to edit the list of the possible variants of answer the current question and to modify the status (A6) of accounting of the certain variant of answer in the calculations of the values of coefficients; the control panel of graphic object (A7) – allows to realize the inserting, copying and cutting of graphic image (A2) on relation to the clipboard, or the cleaning of a content of field; the timer (A8) – allows to set up the nominal value reflecting the size of the interval of time on the development by an examinee of the answer the question; the multimedia (A9) – allows to enter the name of file with audio-stream accompanying the display of the question.



Pic. 6.27. The interface of the applied diagnostic module
in the mode of administrating of tasks in the basis of the method of research of the figurative creativity

The diagnostics of the verbal creativity is realized on the basis of the method of research of Mednik S.A. in the adaptation of Galkina T.V. (“"IP" of "RAS"”) by means of the applied DM.

In pic. 6.28 is presented the interface of the applied DM in the mode of diagnostics of the verbal creativity of an examinee on the basis of the method of research of Mednik S.A., including several groups of the elements, realizing the control: the indicator of the question (A1) – displays the textual content of the question; the indicator of the variants of answer (A2) – displays the list of remote associations, being as the variants of answer one shown verbal incentive; the panel of the variants of answer (A3) – allows to enter the variant of answer of an examinee, to add it or to remove the previously selected answer in the earlier formed list (A2); the button of confirmation (A4) – pressing initiates the start of the procedure of check of the variants of answer entered earlier by the examinee and realizes the transition to the next question; the indicator of the status of a user (A5) – displays the type of research, the number of group and full name of an examinee, the nominal value of decremented interval of time, allowed to the examinee on the development of the answer the question, and also the nominal values of coefficients, reflecting the parameters of the method of research.



Pic. 6.28. The interface of the applied diagnostic module
in the mode of diagnostics of the verbal creativity

The values of coefficients (received in the course of automated diagnostics) are registered directly in DB and are subject to the further mathematical processing with the use of the various statistical methods of the analysis.

On the basis of carried out research we'll form the conclusions on the sixth chapter.

The advantages of modern software for the automation of research of IEE by means of the various methods of psycho-diagnostics are:

- the automation of the process of planning, organization, statement, conducting of the experimental researches (pilot studies) and processing of a posteriori data by means of the use of modern software means on the basis of ICT;
- the possibility of modeling of the various factors of influence in the course of carrying out of experiment in the determined (in advance a defined set and sequence of TI, which are generated by the algorithms of the means of training) or the stochastic conditions of IEE (TI are selected in a random way, but taking into account the potential capabilities of the used means of training);
- the support of modification of the parameters of algorithm of DM and scales of procedure of estimation, which realize the process of testing of IFPST and LRKT;
- the support of the possibility of (re)designing of the sequence of question-answers structures and parameters of their display, which are located in DB with tests of LRKT and IFPST, which contain the different methods of research;
- the automation of the routine and systematically repeated operations in the process of testing in respect of each examinee (preparation of experiment, preliminary acquaintance with the content of each from tasks as subjects to performance by the examinee, holding the procedure of testing or series of experiments, registration in DB and processing of forms with a posteriori data, formation of selections of data, in particular the dispersive complexes);
- identical for all examinees a set of the values of parameters of the algorithm of automated diagnostics provides the uniformity of conditions of testing, that is sometimes not achievable at the traditional presentation of tasks;
- it is provided the high precision of registration of a set of possible reactions (answers) of each examinee in the course of the procedure of diagnostics;
- there is appearing the possibility of registration and the retrospective analysis of the sequence of actions of each examinee in the course of the development of decision;
- there is appearing the possibility of (re)designing of a content and location of the fields located on the form of individual card of an examinee, intended for the introduction of received answers, intermediate results in the process of the development of decision and resultant values of coefficients characterizing the key indicators which are subject to measurement;
- the recombination of the groups of key indicators and their values with the purpose of support of the possibility of the use of the various methods of the statistical analysis taking into account the available restrictions, recommendations and assumptions;
- extend the possibilities of practical use of the modern mathematical methods of statistical processing and the analysis of a posteriori data, appears the possibility of modernization of the methods of research (tests);

- it is provided the possibility of creation of localizations for the certain geographical region and adaptations of the initial methods of research taking into account the stratification of a contingent of examinees caused by their heterogeneity (professional, sexual, age and other differentiation of the social subjects), that allows to broaden the sphere of the use of the initial and modified methods of research by means of their replication for the realization of the automated diagnostics on the basis of achievements in the field of IT;
- it is realized the possibility of providing of the high degree of confidentiality of the results received in the course of the procedure of testing of LRKT and IFPST;
- significantly decreases the prime cost of inspection of the contingent of examinees, becomes simpler the realization of storage, processing and search of a posteriori data which are saved up in the course of the procedure of automated diagnostics;
- there are created the optimal conditions for the application of the various express methods of diagnostics, allowing to receive the approximate values of key indicators with the minimal temporary expenses;
- the automated means of the realization of diagnostics allow partially to solve the problem of communicative barrier sometimes arising in the process of communication between the experimenter and an examinee (it is observed the decrease of influence of protective mechanisms at the examinee), but sometimes takes place the essential decrease of the values of indicators (the absence of predisposition at some examinees to the holding of control actions in the form of tests), that causes the need of the preliminary analysis of the contingent of examinees and ensuring of motivation in the course of diagnostics;
- the possibility of activization of the "game" motivation at the examinee (execution of test in the view of game) appears, that significantly increases the interest of examinees, the attractiveness of the test and the reliability of the received results;
- the automated means of diagnostics allow to solve the problem of comparability of a posteriori data obtained by means of the use of the various methods of research, and also to provide the interpretation of the values of indicators and revealed tendencies, dependences and regularities;
- it becomes possible of the carrying out of the retrospective analysis of behavior of an examinee (a set of his actions and reactions of the system) directly in the course of the procedure of automated diagnostics taking into account many parameters characterizing the conditions of carrying out of inspection at the organization of virtual remote dialogue in the communication environment "Ethernet" / "Internet";
- the means of animation and computer graphics allow to provide the visualization of the process of diagnostics by means of the use of static and dynamic, and also flat and volumetric graphic schemes and images;
- testing allows to estimate LRKT, developed abilities and skills.

7. The statistical substantiation of the practical use of the received results

The technology of the adaptive formation of knowledge promotes the creation of optimal conditions for the support of increase in efficiency (resultativity) of information interaction between the means of training and the subjects of training taking into account their individual features and abilities (physiological, psychological, linguistic and others), in particular, it will allow to the trainee to increase of the resultativity of training (LRKT), and to the teacher or a consultant – the flexible monitoring and control of learning process (at distance) by means of SW of the different appointment.

The offered CMT allows to carry out the system analysis of IEE, to construct CM, to provide the realization of the contour of adaptation on the basis of PCMB, and also to estimate the efficiency of the individually-oriented formation of knowledge of trainees.

In this chapter it is supposed to provide the statement and carrying out of the series of experiments directed on the justification of efficiency of the use of CMT in IEE and to prove the reliability of the received scientific (theoretical and practical) results, received in the course of parallel work on the dissertation.

The results of the experiment will allow to make the qualitative conclusion about the reasons of the difficulties of trainees, of the structural elements of TMC, which are formed in compliance with the accepted organizational model of training, and also to estimate the efficiency of functioning of the computer means of training realized with the use of the achievements of a new IT in the basis of the automated IEE.

The approbation of innovative algorithms in the basis of the adaptive means of training and IEE causes the accounting of MRK, formed by the teacher (the subject of pedagogics) and initiates the need of structuring of a content of the subject of studying on a set of connected among themselves information fragments (modules) presented to the trainees by the various ways in the certain sequence with the purpose of subsequent filling of DB of the automated means of training (ET). At the same time each module of ET in addition contains the structured sequence of reference question-answers structures for the realization of current, intermediate and total control of the testing of LRKT.

The analysis of the results of experiment will allow to allocate the ways of further improvement of the technologies of training and to modernize the techniques of estimation of LRKT. In the basis of the modern technologies of the automated training and testing it is put the splitting of material and test tasks relating to the module of the subject of studying by the principle of gradual accretion of the level of difficulty, that allows to each trainee effectively to realize the gradual (iterative) studying of information fragments of discipline and objectively to estimate LRKT.

The emergence of the various objective and subjective difficulties in the process of the formation of knowledge of a trainee leads to the decrease in efficiency (resultativity) of training and essential increase of the temporary expenses at all its technological stages.

The offered approach assumes the modifications in the organization of IEE of ART system, allows to realize the individually-oriented model of training assuming the account of IFPST and potential opportunities of the means of training.

At the consideration of the question of improvement of quality and estimation of efficiency of functioning of IEE of ART system use the various criterions of estimation, based on a large quantity of indicators, among which it is possible to mark out:

- the potential diversity of passing of an educational trajectory by the trainee – is caused by the technical capabilities of correction of the sequence of display of information (information fragments) and by the elements of navigation;
- the informativity of TI – is defined by the quantity of information contained in the information fragments and by the level of difficulty of statement of content;
- the possibility of regulation of the parameters of a visual representation of information fragments (background, font and scheme of display) and realization of accounting of anomalies of a sensory perception by the visual analyzer;
- the possibility of regulation of the parameters of a sound representation of information (volume, timbre and scheme of reproduction of a sound stream);
- the choice of the kind of display of information fragments (a text, a table, a flat scheme, a volumetric scheme and a sound stream);
- the style and features of representation of information (complete or detailed representation, automatic or manual switching, constant or variable type of TI, deep specification or abstract statement, cognitive simplicity or complexity of statement, wide or narrow set of keywords and definitions, set of the elements of interface);
- the setting up of the speed of representation of information (high and low);
- the choice of the technique and technology of carrying out of testing of LRKT;
- the support of friendliness of a virtual dialogue and a language of communication (algorithm of representation of material, a set of elements of interface of the automated means of training and the level of a statement of material);
- the flexibility of a virtual dialogue (degree of compliance to a natural dialogue, a way of input and output of information, display of errors and explanations).

The specifics of information interaction of the subjects and means of training of IEE of ART system and the level of development of the educational IT cause the need of consideration of a row of the scientific areas: psychophysiology – the features of perception of information signals by the visual and acoustic sensory systems of the organic individual (person); cognitive psychology – the specifics of information processing by the psychological construct of a head brain of the organic individual (person), applied (cognitive) linguistics – understanding of the content of information fragments reflecting the content of a discipline.

7.1. The factors influencing on the efficiency of the formation of knowledge of a trainee in the automated educational environment

The specifics and plan of organization of the experiment come down to the providing of estimation of influence of the values of parameters of CM on the resultativity (efficiency) of formation of knowledge of a trainee in IEE of ART system, and also to the confirmation of validity and operability of principles, methods and algorithms, developed in parallel in the dissertation.

It is of interest the estimation of mutual and separate influence of the factors on the resultativity (efficiency) of the process of the formation of knowledge of a trainee.

At using of CMT in IEE the estimation of LRKT (Y_i) can be considered as the criterion of resultativity (efficiency) of training (at distance) and is the result of complex influence of various factors, which can be differentiated on relation to the subject of training and the means of training:

1. The group of factors, caused by IFPST at the perception, processing and understanding of information fragments:
   - physiological factors – the influence of features of the perception of information by the visual and acoustic sensory systems: *existence / absence of anomalies of refraction* (astigmatism – K_1, myopia – K_2 and hypermetropia – K_3); *existence / absence of anomalies of perception* (acuity of vision – K_4, field of vision – K_5 and estimation of distance – K_6); *existence / absence of anomalies of color perception* (achromasia – K_7, protanopia – K_8, deuteranopia – K_9 and tritanopia – K_{10}); *violations of the functions of external, middle or inner ear* (absolute sensitivity of acoustic sensory system – K_{11}, thresholds of sensitivity – K_{12} and maximal sensitivity – K_{13});
   - psychological factors – the influence of specifics of information processing: *level of development of the convergent intellectual abilities* (verbal intelligence – K_{14}, deductive thinking – K_{15}, combinatory abilities – K_{16}, ability to reasoning – K_{17}, analytical thinking – K_{18}, inductive thinking – K_{19}, mnemonic and memory – K_{20}, plane thinking – K_{21} and volumetric thinking – K_{22}); *level of development of verbal creativity* (index of associativity – K_{23}, index of originality – K_{24}, index of uniqueness – K_{25} and index of selectivity – K_{26}); *level of development of figurative creativity* (index of associativity – K_{27}, index of originality – K_{28}, index of uniqueness – K_{29} and index of selectivity – K_{30}); the *bipolar cognitive styles* (field-dependence – K_{31} or field-independence – K_{32}, impulsiveness – K_{33} or reflexivity – K_{34}, rigidity – K_{35} or flexibility – K_{36}, specification – K_{37} or abstraction – K_{38}, the cognitive simplicity – K_{39} or the cognitive difficulty – K_{40}, categorial narrowness – K_{41} or categorial width – K_{42}); *learning ability* (implicit – K_{43} and explicit – K_{44});
   - linguistic factors – the influence of features of understanding of the content of information: *existence / absence of language problems* (level of proficiency in language of statement of material – K_{45}, level of proficiency in dictionary of terms – K_{46} and level of proficiency in elements of interface – K_{47}).

2. The group of factors, caused by the technical capabilities of the means of training at the generation of information-educational influences:
   - physiological factors – the influence of features of representation of visual and sound information by the means of training: *parameters of background* (type of pattern – L_1, color of background – L_2 and combination of colors – L_3); *parameters of font* (set of font – L_4, size of symbol pointtype – L_5 and color of symbol – L_6); *color schemes* (at achromasia – L_7, at protanopia – L_8, at deuteranopia – L_9 and at tritanopia – L_{10}); *parameters of reproduction of a sound stream* (volume – L_{11}, timbre – L_{12}, type of stream – L_{13} and a sound scheme – L_{14});
   - psychological factors – the influence of features of way and the style of representation of information fragments: *kind of information* (textual – L_{14}, tabular – L_{15}, schematic plane – L_{16}, schematic volumetric – L_{17}, sound as main – L_{18}, sound as accompaniment – L_{19}, combined – L_{20} and special scheme – L_{21}); *inclusion of additional capabilities* (correction of sequence of statement – L_{22}, navigation on course – L_{23}, addition of modules – L_{24}, choice of kind of information – L_{25}, choice of style of representation – L_{26}, choice of speed of representation – L_{27}, creative tasks – L_{28}, additional modules – L_{29} and additional literature – L_{30}); *style of representation of information* (complete representation – L_{31} or detailed representation – L_{32}, automatic – L_{33} or manual switching – L_{34}, constant – L_{35} or variable type of information – L_{36}, deep specification – L_{37} or abstract statement – L_{38}, simplicity of statement – L_{39} or difficulty of statement – L_{40}, wide – L_{41} or narrow set of terms – L_{42}); *speed of representation of information fragments* (high speed – L_{43} and low speed – L_{44});
   - linguistic factors – the influence of features of statement of material: level of statement of material – L_{45}; set of keywords and definitions – L_{46}; set of elements in the basis of interface of interaction – L_{47}.
3. The factors of unknown and casual origin (stochastic influences), influence of which on the resultativity of training is rely insignificant, therefore they are not considered in the course of (automated) experiment.

7.2. The features of organization and the plan of carrying out of the experiment

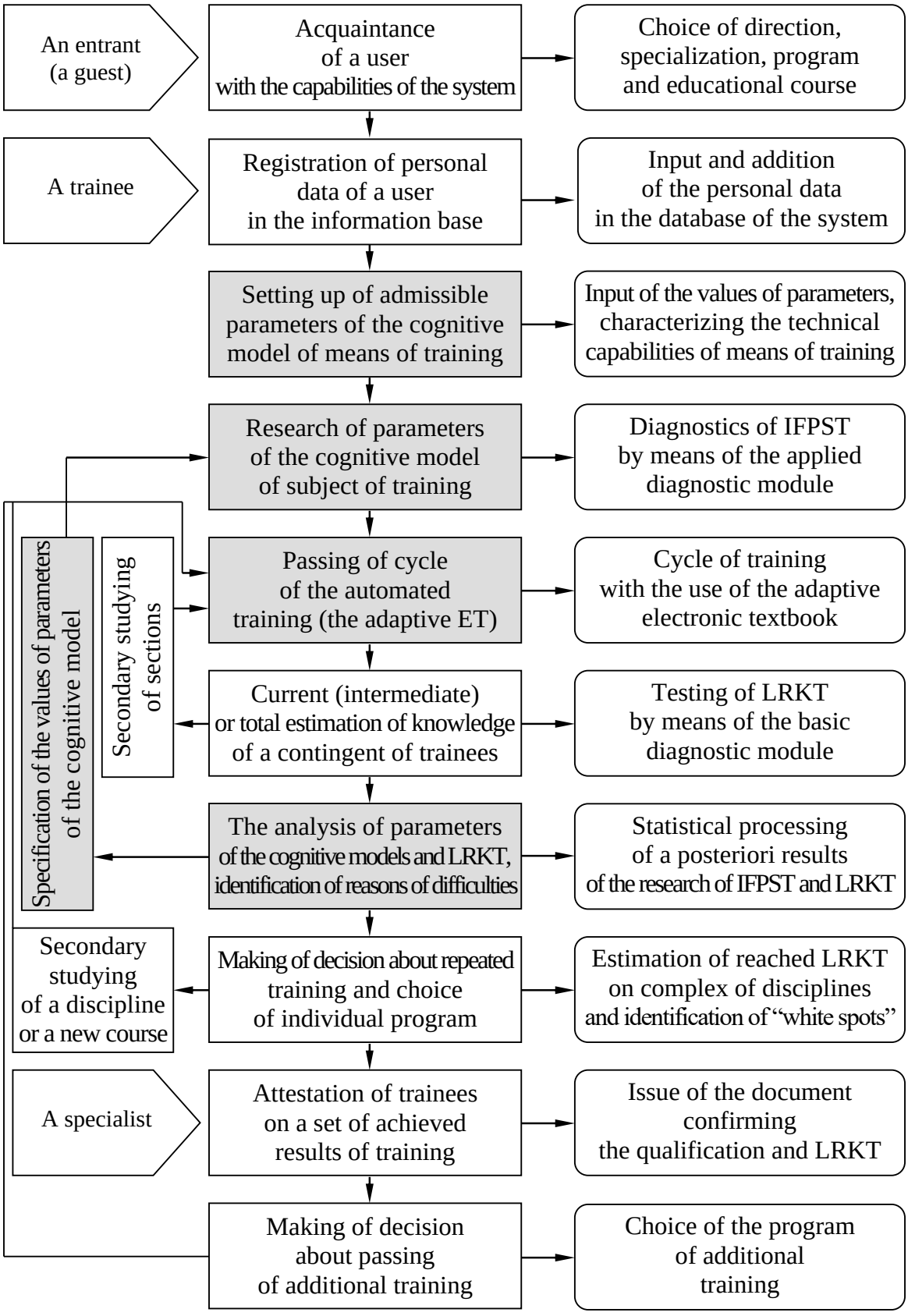
The features of organization and carrying out of the automated experiments depend on the purposes, tasks of research of IEE, a chosen actual set of parameters of CM of the subject of training and the means of training, and also the used software.

The organization and carrying out of series of experiments on the basis of CMT comes down to:

- the choice, addition and removal of the scientific aspects of consideration of the object of research (there are used the first stages of CMT);
- the studying of the content of the stages, presented in the iterative cycle of CMT and technique of its use for the analysis of IEE of ART system;
- the choice of one from the offered models of representation of the structure of CM: oriented graph (formal) or structural scheme (block diagram) (informal);
- the formation of structure of CM of the subject of training and CM of the means of training by means of the algorithm of formation of the structure of CM in the basis of IEE of ART systems;
- the analysis of the initial (theoretical) CM of the subject of training and CM of the means of training, the choice of sets of parameters, which should be researched and diagnosed in the course of forthcoming (automated) experiment;
- the application of technique of research of the parameters of CM and setting up of applied DM for the automated diagnostics of the values of parameters of CM of the subject of training with the use of a set of special methods;
- the primary inspection of a contingent of trainees (examinees), identification by means of the automated diagnostics of the physiological, psychological and linguistic parameters of perception, processing and understanding of information, and then the entering of them into CM of the subject of training;
- the formation of CM of the means of training on the basis of the analysis of technical capabilities of the automated means of training – its ability to generate a various sets of TI taking into account the parameters of CM of the subject of training;
- the use of the formed CM in the basis of the automated IEE;
- the individually-oriented presentation to the contingent of trainees the studied material in the view of a set of information fragments by means of the adaptive means of training (ET), operating on the basis of PCMB (the parameters of CM of the subject of training are set up by the results of diagnostics, and the parameters of CM of the means of training – are set up according to the description of product);
- the automated diagnostics of LRKT with the use of the basic DM and application of the algorithm of processing of a posteriori data of testing;
- the application of mathematical methods of the statistical analysis for the primary processing (preprocessing) of a posteriori data, the identification of dependences, regularities, degree of influence of an actual set of signs.

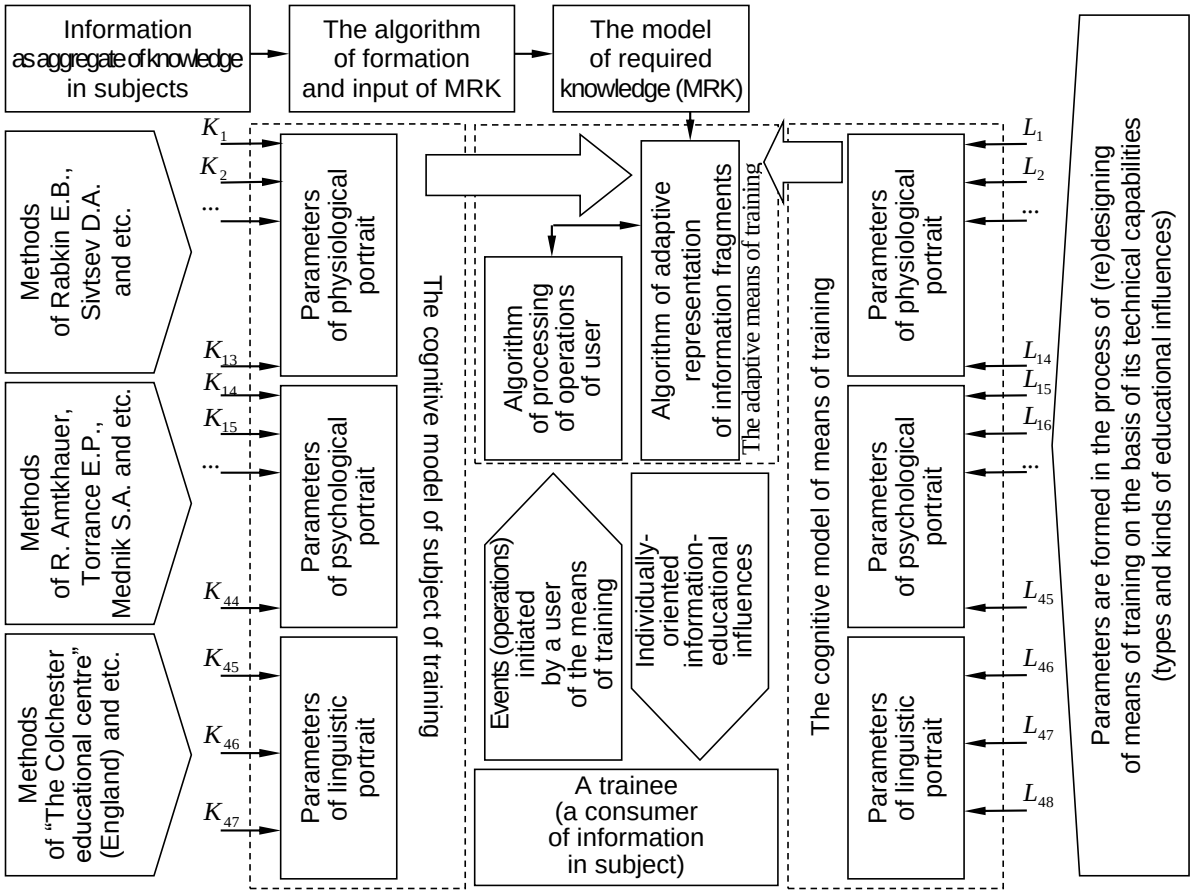
The realization of cycle of the adaptive training demands the preliminary preparation of software, allowing to automate the process of research.

The cycle of ART in IEE with the properties of adaptation based on the parametrical CM has a row of essential features and represents inside the sequence of stages (pic. 7.1).



Pic. 7.1. The scheme, reflecting the sequence of actions for the support of researches of the cycle of the adaptive automated training

In the course of primary research of parameters of CM of the subjects of training it is necessary to consider the specifics of carrying out of series of the experimental researches (pilot studies), which can be characterized by the following structural scheme (block diagram) (pic. 7.2).



Pic. 7.2. The specifics of carrying out of the research for the increase in efficiency of the formation of knowledge of a trainee on the basis of the cognitive models

After the analysis of initial (theoretical) CM of the subject of training and the choice of an actual set of parameters for the implementation of researches it is necessary to select a set of methods, providing the automated diagnostics.

For the realization and support of the possibility of addition and research of new parameters of CM of the subject of training are created the new procedures of diagnostics in the basis of applied DM, and outdated procedures are replaced or are removed (pic. 4.9).

If the picked-up method of research of the certain parameter or the vector of parameters is poorly formalized (it is impossible to pick up model of representation) and it is practically not structured, and in the process of its algorithmization comes to light the impossibility of the use of the available designer of tests for the saving of elements of question-answers structures in the mode of administrating of the applied DM, then it is necessary to make changes into the algorithm or to improve the program, supporting the functioning of available designer of tests.

The switching between the methods of research of parameters of CM of the subject of training is provided due to the connection (switching) of DB with the tests of IFPST.

DB is formed previously on the basis of complex of the methods of research.

7.3. The features of research of the parameters of the physiological portrait of the cognitive models of the subject and means of training

The psychophysiology of perception allows to research the subject of IEE, which is the trainee and (or) the teacher acting as the unique as regards to the perception of TI containing the visual and the sound information.

The process of perception of information messages by the visual (up to 90% of information) and acoustic sensory systems has the hierarchical structure – transformation of polychromatic range of photonew radiation of different wavelength (the range seen by the normal trichromat) and fluctuations of a sound wave into a set of nervous impulses, processed at the level of a head brain.

The question is, how the visual sensory system singles out and measures the signs of visual signal, is studied insufficiently deeply. There is a row of scientific data, demonstrating, that on a retina of eye, which performs the function of a visual analyzer, there is a definition of contours of image, allocation of discrete elements, their identification and other. Then the entrance message is coded, transferred into the brain, where come into action the other mechanisms and there is actually the recognition of visual image. It will be coordinated with the fact, that the full blindness comes not only from the injury of retina or nervous ways (tissues), but also from the violations of the functions of a certain sites of the cerebral cortex of a head brain. The damage of a certain sites of the cerebral cortex of a head brain leads to the violation of processing of visual messages and is directly connected with the disorder of visual perception (visual dignosia). The visual message can be perceived at many distortions and even at the absence of some components of its information elements. The data of the experimental researches demonstrate, that at the perception of incomplete or distorted message is written down the conceptual information, which is recorded and it is stored in the respective sites of bark of a head brain. The process of perception of graphic message assumes the analysis of the structure and optical-graphic characteristics of the elements making its, being the actual task.

The modeling of the process of visual perception consists in the consecutive solution of a complex of tasks, connected with interpretation and understanding by the subject of training of the content of a set of messages in the view of text and schemes on the certain language.

At the realization of interactive interaction of the subjects and means of training in IEE of ART systems are solved the practical and applied tasks, connected with the automation of input and saving in DB of the text, graphic (static scheme) and multimedia (audio- and video-stream) data presented in the view of the structured information fragments on the certain national or foreign language.

There is the need of accounting of difficulty, kind, type and volume of information processed by the components of ART system and displayed to the final user, causes the need of development of the algorithms of its representation.

7.3.1. The specifics of research of the parameters of the physiological portrait of the cognitive model of the subject of training

The fragment of the text in a natural language or a structure of graphic image acts as a set of hierarchically sub-coordinated elementary levels, including a set of various lexical units, considered as the information fragments (portions of the training information – TI).

The information structure of ET is similar used in the traditional textbook, but:

- it is provided the possibility of change of the sequence of the following information fragments;
- it is realized the use of the additional means of visualization.

The process of formation of portions of training information assumes the accounting of specifics of subject, the possibility of formalization of be available information by means of the use of one from the models of representation of structured data (existing: frame model and semantic network or offered: oriented graph combining theory of sets and multilevel scheme) taking into account the optimization of storage and extraction of information, the formation of standard sequence of its presentation, the selection of various ways of its display and the improvement of algorithms of training.

The information is differentiated on the form, availability, perception and other. One from the characteristic properties of its perception is the apperception, i.e. the dependence of perception of a subject from its mental properties. At the organization of process of training it is necessary to consider the features of sensory perception of trainees.

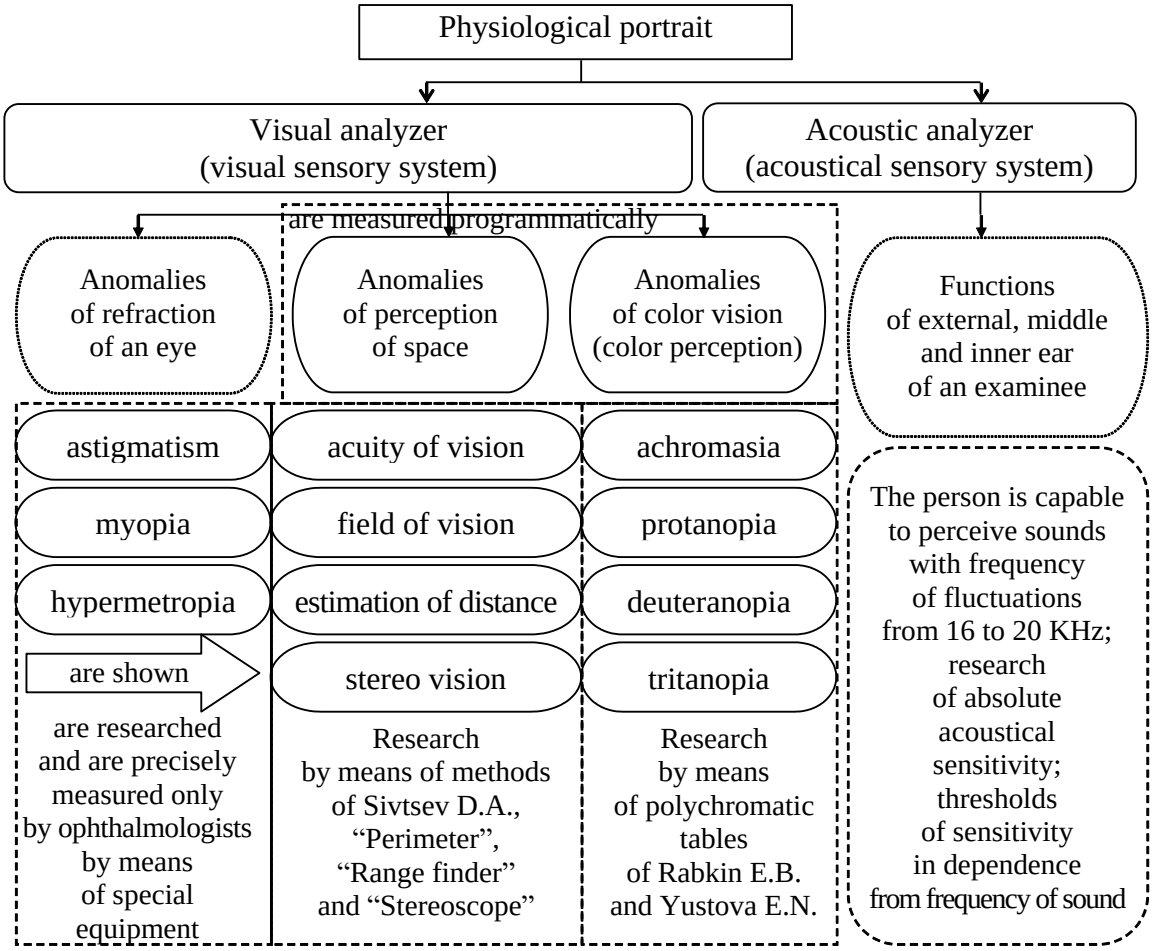
At present time a row of ways of representation of information-educational influences are singled out: the use of paper carrier (paper information resource) or electronic carrier (electronic information resource); direct communication in (not) real scale of time (active form, communicative simplex and duplex channel of information exchange); mediated communication in (not) a real scale of time (passive form, communicative simplex and duplex channel of information exchange), and also a kind of representation of information: unstructured (the text) and structured verbal (the enumerated and not enumerated list or the table); static and dynamically reconstructed graphic scheme (flat scheme and volumetric scheme); static and dynamic graphic image (pigmentary spot, picture and video-stream); static and dynamic sound stream (a sound, a system of sounds and audio-stream).

The psychophysiological aspect of perception of information by the visual sensory system is based on the model of reduced eye taking into account the tasks of classification and identification of content of this or that information fragment.

At the research of IEE is received the physiological portrait of CM of the subject of training, formed on the scientific base of private physiology of analyzers and concentrating the individual features of visual and acoustic sensory systems of person.

The research of physiological portrait of CM of the subject of training (pic. 7.3) initiates the use of method of interviewing and a row of applied methods, realized in the basis of the applied DM, allowing to reveal existence / absence of anomalies of visual and acoustic sensory systems.

The algorithms and procedures, corresponding to the various methods of research of parameters of CM of the subject of training are realized in the basis of the applied DM. If in actual for the analysis a set of parameters is added one more elementary parameter or vector of parameters, then there is the need of the use of the method of research of parameters of CM of the subject of training (pic. 4.9).

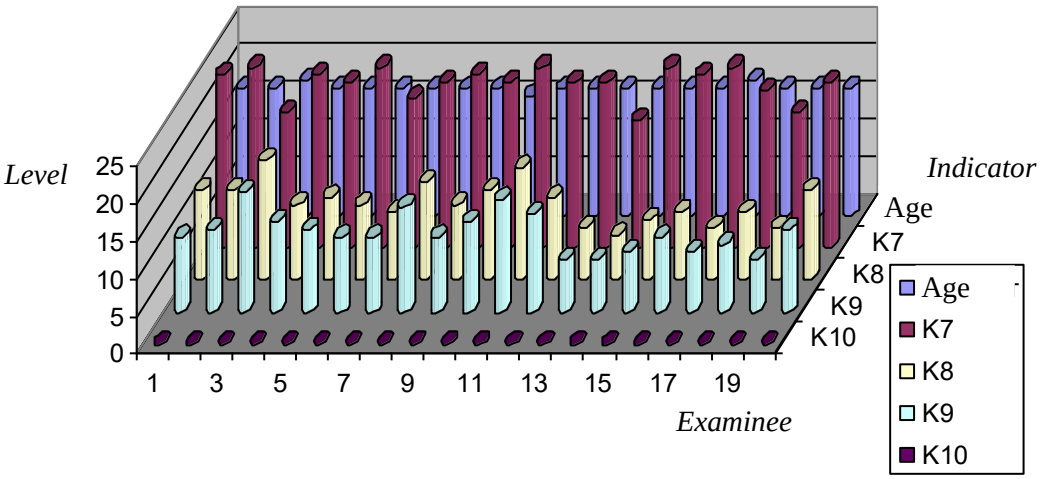


Pic. 7.3. The structure of physiological portrait of the cognitive model of the subject of training

The automation of research of the parameters of physiological portrait of CM of the subject of training is reached by means of the use of the applied DM, containing in DB of tests of IFPST a set of the special methods of diagnostics.

In particular, in pic. 7.4 are presented the results of research of the color perception of examinees of 1st-4th groups by the method of Rabkin E.B. (there are no essential not uniformities).

For order that "to filter" the abnormal values ("emissions") of researched parameters it should be necessary to mark out the characteristic feature of normal distribution: 95,44% of values are located in the interval $\bar{x} \pm 2\sigma$, that allows to calculate the lower and upper threshold values for the analysis of each selection of data. For the evident representation of deviation of nominal values in selections from their average was used z-transformation on the basis $z_i = \frac{x_i - \bar{x}}{\sigma_x}$. The procedure of standardization (linear normalization) has allowed to transform the initial values and to choose the optimal scale of measurement.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Examinee
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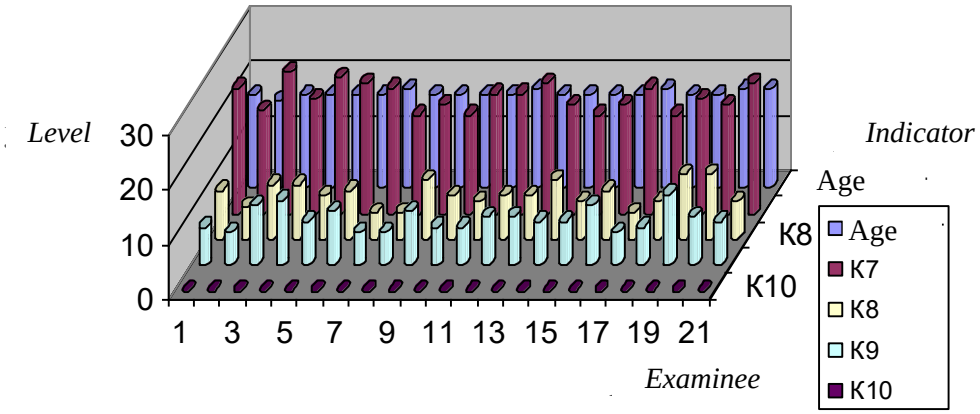
a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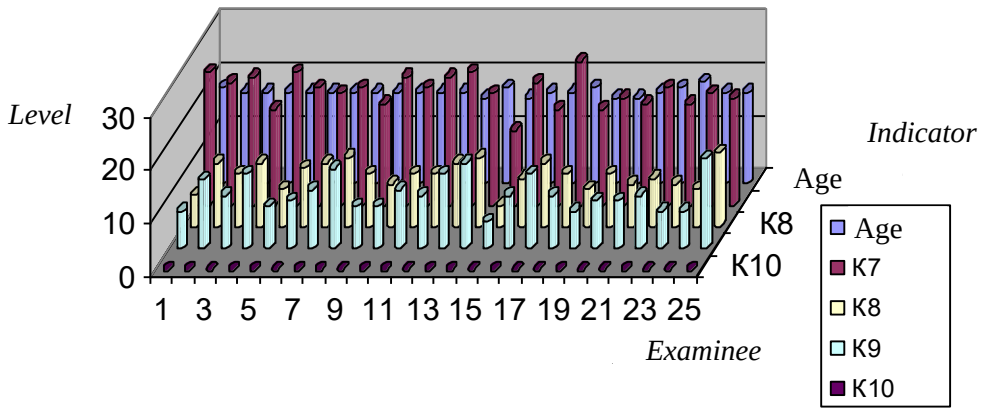
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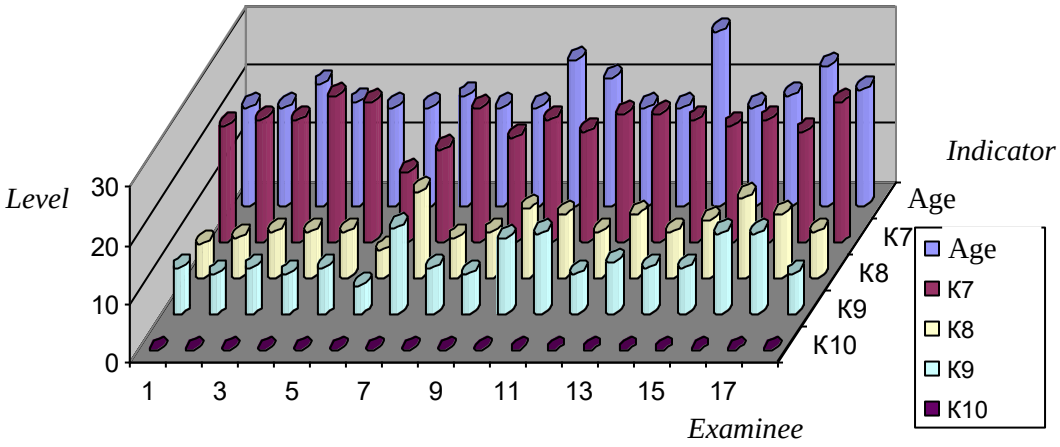


d

Pic. 7.4. The parameters of physiological portrait: color perception according to Rabkin E.B.

The descriptive statistics of formed selections with a posteriori data of diagnostics of color perception by the method of Rabkin E.B. in the 1st-4th groups are brought in the tab. 7.1. In the course of primary statistical processing of the formed selections of a posteriori data the essential not uniformities in the measures of central tendency and indicators of variation of the values of observed signs are not revealed.

For the automation of mathematical processing of a posteriori data by means of a set of statistical methods was used the package of programs SPSS 15.

The choice of a set of statistical methods of the analysis of a posteriori data initiates the accounting of restrictions on their use and requirements to the initial data: absence of emissions and artifacts (will displace the central tendency) and compliance of the values of indicators to the normal law of distribution of numbers.

Table 7.1

The descriptive statistics of a posteriori data of the research of color perception in the first group

Coefficient / Indicator	*Age*	K_7	K_8	K_9	K_{10}
Average	17,2	21,75	10,5	10,85	0
Standard error	0,156	0,619	0,698	0,737	0
Median	17	22,5	10	10	0
Mode	17	22	12	10	0
Standard deviation	0,696	2,77	3,12	3,297	0
Dispersion of selection	0,484	7,671	9,737	10,871	0
Excess	3,703	1,866	0,974	2,188	-
Asymmetry	1,791	-1,71	0,924	1,331	-
Interval	3	9	12	13	0
Minimum	16	15	6	7	0
Maximum	19	24	18	20	0
Sum	344	435	210	217	0
Account	20	20	20	20	20
Reliability (95,0%)	0,326	1,296	1,46	1,543	0

Table 7.2

The descriptive statistics of a posteriori data of the research of color perception in the second group

Coefficient / Indicator	*Age*	K_7	K_8	K_9	K_{10}
Average	17,191	21,191	8,381	8,619	0
Standard error	0,112	0,604	0,519	0,537	0
Median	17	21	8	8	0
Mode	17	20	8	7	0
Standard deviation	0,512	2,768	2,377	2,459	0
Dispersion of selection	0,262	7,662	5,648	6,048	0
Excess	0,603	-0,841	0,124	2,745	-
Asymmetry	0,355	-0,171	0,534	1,425	-
Interval	2	10	9	10	0
Minimum	16	16	5	6	0
Maximum	18	26	14	16	0
Sum	361	445	176	181	0
Account	21	21	21	21	20
Reliability (95,0%)	0,233	1,26	1,082	1,119	0

Table 7.3

The descriptive statistics of a posteriori data of the research of color perception in the third group

Coefficient / Indicator	*Age*	K_7	K_8	K_9	K_{10}
Average	17,08	21,36	10,08	10,36	0
Standard error	0,141	0,635	0,594	0,635	0
Median	17	22	10	10	0
Mode	17	22	10	10	0
Standard deviation	0,702	3,174	2,971	3,174	0
Dispersion of selection	0,493	10,073	8,827	10,073	0
Excess	1,401	1,784	-0,211	-0,549	-
Asymmetry	0,673	-0,835	0,216	0,542	-
Interval	3	15	12	12	0
Minimum	16	12	4	5	0
Maximum	19	27	16	17	0
Sum	427	534	252	259	0
Account	25	25	25	25	25
Reliability (95,0%)	0,29	1,31	1,226	1,31	0

The presented descriptive statistics are calculated on the basis of available selections with a posteriori data and allow to speak about high degree of coincidence of the values of average arithmetic, median and mode of the corresponding numerical rows, the dispersion between the minimal and maximal values is in admissible limits and it is theoretically reasonable, the values of asymmetry and excess characterize the existence of insignificant pointedness and two-topity.

The need of the use of the parametrical methods of the statistical analysis has caused the analysis of compliance to the normal law of distribution of values.

Table 7.4

The descriptive statistics of a posteriori data of the research of color perception in the fourth group

Coefficient / Indicator	*Age*	K_7	K_8	K_9	K_{10}
Average	21,111	19,444	8,778	8,889	0
Standard error	2,309	1,158	0,778	0,87	0
Median	17,5	21	8	8	0
Mode	17	21	8	8	0
Standard deviation	9,797	4,914	3,3	3,692	0
Dispersion of selection	95,987	24,144	10,889	13,634	0
Excess	15,164	2,656	0,891	-0,052	-
Asymmetry	3,786	-1,664	-0,2	0,146	-
Interval	42	19	14	14	0
Minimum	17	6	1	1	0
Maximum	59	25	15	15	0
Sum	380	350	158	160	0
Account	18	18	18	18	18
Reliability (95,0%)	4,872	2,444	1,641	1,836	0

In the formed selections of a posteriori data are excluded the emissions, and also it is realized the check on compliance to the normal law of distribution:

- graphic way – the creation of schedules of saved-up frequencies and quartile schedules has shown the high degree of compliance of theoretical and empirical distributions of the values of signs to the normal law;
- analytical way – the values of asymmetry and excess of distributions received in the descriptive statistics correspond to the critical values and are connected with the volume of corresponding selections of data as subjects to the analysis.

At the calculating of critical values for the asymmetry and excess were used the formulas, recommended by Pustylnik E.I.: $A_{cr} = 3\sqrt{\frac{6(n-1)}{(n+1)(n+3)}}$ and $E_{cr} = 5\sqrt{\frac{24n(n-2)(n-3)}{(n+1)^2(n+3)(n+5)}}$, where n – the volume of the analyzed selection of a posteriori data.

The error of representativeness of the indicators of asymmetry and excess is calculated respectively on the formulas $m_A = \sqrt{\frac{6}{n}}$ and $m_E = 2\sqrt{\frac{6}{n}}$.

The comparison of empirical (see descriptive statistics for each selection) and critical values allows with rather high definiteness to speak about compliance of received values of observed indicators to the normal law of distribution of numbers (at the condition $t_A = \frac{|A_{эмп}|}{m_A} \geq 3$ and $t_E = \frac{|E_{эмп}|}{m_E} \geq 3$).

The nominal values of errors of representativeness and critical values of asymmetry and excess for the available selections of data are presented in the tab. 7.5.

Table 7.5

The errors of representativeness and critical values of asymmetry and excess for the primary statistical analysis of a posteriori data

Indicator / group	The experimental group of examinees			
	the first	the second	the third	the forth
The volume of selection	20	21	25	18
The error of representativeness of asymmetry (m_A)	0,548	0,535	0,49	0,577
The critical value of asymmetry ($A_{кр}$)	1,458	1,43	1,334	1,517
The error of representativeness of excess (m_E)	1,095	1,069	0,98	1,155
The critical value of excess ($E_{кр}$)	3,805	3,777	3,656	3,856

7.3.2. The specifics of research of the parameters of the physiological portrait of the cognitive model of the means of training

Similar to the physiological portrait of CM of the subject of training this portrait is formed on the scientific basis of the psychophysiology of perception, at the same time are considered the technical capabilities of the adaptive means of training (ET) – the generation of a set of information fragments is realized taking into account the fine tuning of parameters of background (type of pattern, color and combination of colors), font (a set, a size of pointtype and a color of symbol), and also the use of a formed set of color schemes for normal trichromats (subjects without the expressed anomalies of a color perception) and abnormal dichromats (protanopes, deuteranopes and tritanopes).

The processor of adaptive representation of information fragments includes the module of the control of processing of physiological parameters for the support of individually-oriented generation of educational influences (pic. 6.6), including a set of different procedures and algorithms, which realize the calculation of the values of parameters of display of information. The calculation of optimal combination of the values of parameters of presentation of information of ET is performed automatically taking into account the technical capabilities of the means of training (parameters of CM of the means of training) and IFPST (parameters of CM of the subject of training). If the diagnostics of IFPST was not carried out and it is impossible to calculate some values of parameters of display, then are used the previously established values by default of parameters of CM of the means of training in the mode of administrating of the adaptive ET (pic. 6.7).

7.4. The features of research of the parameters of the psychological portrait of the cognitive models of the subject and means of training

According to the cognitive approach as one of the modern directions in psychology the intelligence is treated as the repertoire of parameters, which independently develops due to the training procedures and is the specific form of organization of the individual mental experience of a person (Holodnaya M.A.), providing the possibility of effective perception, understanding and interpretation of the objects, processes and phenomena occurring in the external environment of functioning.

The higher level of intellectual development of a person, the more difficult on a structure and organization the individual mental experience and operational structures at the analysis of created model of a mental construct of a head brain, and the criterions of intellectual maturity are: width of outlook, flexibility and multi-factority of estimates of events, ability to process the heuristically difficult information and to predict the sequence of events (Druzhinin V.N.).

For the increase in efficiency of the formation of knowledge of a trainee in the traditional and automated IEE it is necessary to provide the adequate sensory perception, processing and understanding of information fragments reflecting the content of a subject of studying, therefore the shown information must satisfy to a row of criterions and technologically consider some possibilities:

- the creation of conditions for the introduction and approbation of a new IT in the sphere of education;
- the accounting of psychophysiological features of personality of the contingent of trainees;
- the saving of information in DB of the complex of programs by means of the use of one from the existing models of representation of previously structured data, allowing to provide the possibility of display of the content of a subject of studying at the several levels and languages of statement;
- the use of various educational programs, algorithms and procedures of training in the basis of the means of the automated IEE, allowing to satisfy the requirements of a wide range of consumers of educational services;
- the modification of the values of parameters of the procedures and algorithms of training in the basis of the components of ART system, allowing to create conditions and practically to use the technologies of individually-oriented training;
- the realization of diagnostics of the various IFPST by means of the use of DM;
- the providing of conditions for the introduction of methods of development and correction of personality;
- the formation of awareness of the subject of training in the various subject areas as regards to the certain objects of research.

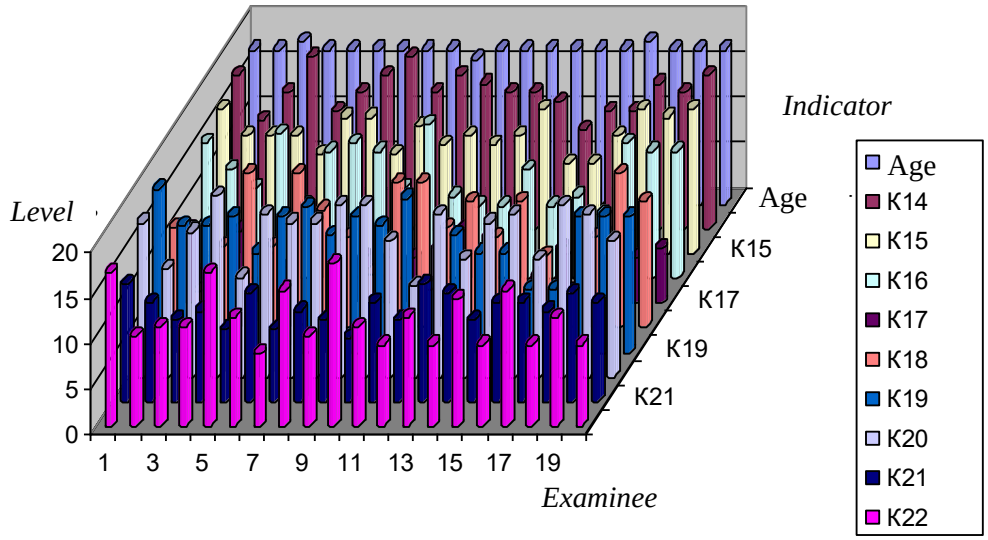
The main line of the cognitive direction in the modern psychology – orientation on the research of mechanisms of the processing of information and formation of knowledge at the level of psychophysiological construct of the head brain of a person from the point of view of information and educational approaches.

7.4.1. The specifics of research of the parameters of the psychological portrait of the cognitive model of the subject of training

The psychological portrait of CM of the subject of training includes a set of the vectors of parameters: the vector of convergent intellectual abilities, the vector of divergent intellectual abilities, learning ability and cognitive styles.

The vector of convergent intellectual abilities is the structural component of psychological portrait of the synthesized CM of the subject of training, acting as one from the manifestations of a psychophysiological construct of a head brain of learning subject (a trainee), defining the individual productivity of deductive thinking, which is connected with the speed of search of the standardly-only correct variant of answer according to the regulation of situation, requirements of tasks or temporary restrictions on the development of decisions.

In pic. 7.5 is presented the graphic interpretation of the results of research of the convergent intellectual abilities of examinees of the 1st-4th groups, at the stage of diagnostics was used the method of research of R. Amtkhauer in the adaptation of Galkina T.V. (""IP" of "RAS"").



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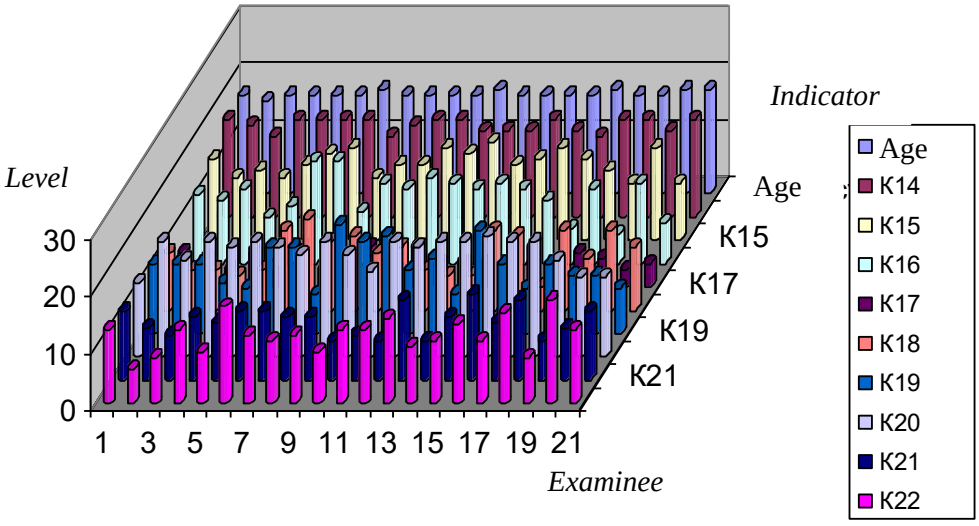

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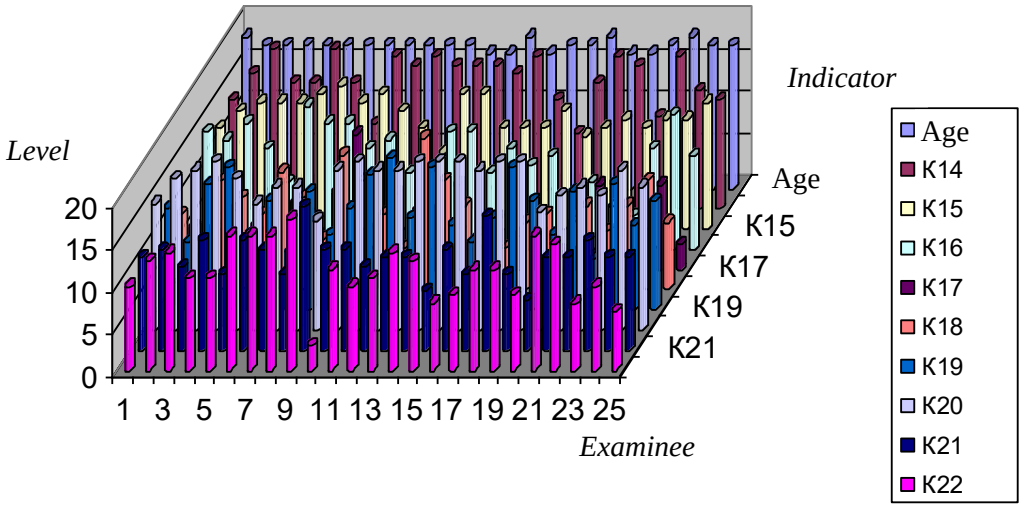

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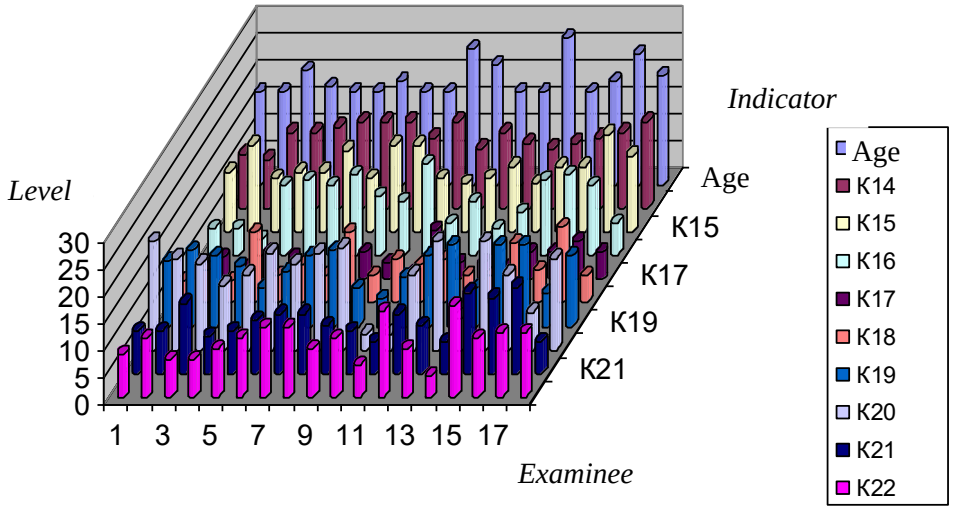

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Pic. 7.5. The convergent intellectual abilities in the 1st-4th groups

The visual analysis of graphic interpretation (in the view of charts) a set of the values of indicators received in the course of diagnostics of the convergent intellectual abilities of the 1st-4th groups of examinees allows to speak about the absence of expressed abnormal emissions and artifacts.

The preliminary statistical analysis of selections with a posteriori data causes the need of calculation of the descriptive statistics allowing to reveal the measures of central tendency and to prove the measure of compliance to the normal law of distribution of the numerical values of researched parameters: verbal intelligence – K_{14}, deductive thinking – K_{15}, combinatory abilities – K_{16}, ability to reasoning – K_{17}, analytical thinking – K_{18}, inductive thinking – K_{19}, mnemonic and memory – K_{20}, plane thinking – K_{21} and volumetric thinking – K_{22}. The descriptive statistics in the tab. 7.5-7.8 are the result of the preliminary statistical processing of the available selections of data.

Table 7.5

The descriptive statistics of a posteriori data of the research of the convergent intellectual abilities of trainees in the first group

Coefficient / Indicator	*Age*	K_{14}	K_{15}	K_{16}	K_{17}	K_{18}	K_{19}	K_{20}	K_{21}	K_{22}
Average	17,1	15,2	13,3	11,75	5,65	11,5	13,1	15,9	10,35	11,95
Standard error	0,124	0,479	0,465	0,721	0,379	0,928	0,743	0,754	0,399	0,713
Median	17	15	13	12	5	11	14	17	10,5	11
Mode	17	15	13	8	5	17	15	17	11	9
Standard deviation	0,553	2,142	2,08	3,226	1,694	4,149	3,323	3,37	1,785	3,187
Dispersion of selection	0,305	4,59	4,326	10,408	2,871	17,211	11,042	11,358	3,187	10,155
Excess	8,208	-0,287	-0,606	-1,568	0,894	-0,814	0,21	1,223	-0,337	-0,306
Asymmetry	2,164	-0,039	-0,328	-0,001	0,903	-0,297	-0,948	-1,252	0,088	0,842
Interval	3,000	8	7	10	7	13	12	13	7	11
Minimum	16	11	9	7	3	4	6	7	7	8
Maximum	19	19	16	17	10	17	18	20	14	19
Sum	342	304	266	235	113	230	262	318	207	239
Account	20	20	20	20	20	20	20	20	20	20
Reliability (95,0%)	0,259	1,00	0,974	1,51	0,793	1,942	1,555	1,577	0,836	1,491

Table 7.6

The descriptive statistics of a posteriori data of the research of the convergent intellectual abilities of trainees in the second group

Coefficient / Indicator	*Age*	K_{14}	K_{15}	K_{16}	K_{17}	K_{18}	K_{19}	K_{20}	K_{21}	K_{22}
Average	17,191	16	13,429	11,952	4,619	10,048	11,952	17,762	10,381	11,905
Standard error	0,112	0,258	0,466	0,761	0,334	0,764	0,788	0,749	0,558	0,717
Median	17	17	13	13	4	10	12	19	11	12
Mode	17	17	13	13	3	7	12	20	12	13
Standard deviation	0,512	1,183	2,135	3,485	1,532	3,5	3,612	3,434	2,559	3,285
Dispersion of selection	0,262	1,4	4,557	12,148	2,348	12,248	13,048	11,791	6,548	10,791
Excess	0,603	-1,303	-1,104	-0,137	-1,142	-1,308	-0,757	0,703	-0,417	0,541
Asymmetry	0,355	-0,601	-0,045	-0,332	0,166	-0,021	0,415	-1,439	0,34	-0,309
Interval	2	3	7	13	5	12	12	11	9	14
Minimum	16	14	10	5	2	4	7	10	7	4
Maximum	18	17	17	18	7	16	19	21	16	18
Sum	361	336	282	251	97	211	251	373	218	250
Account	21	21	21	21	21	21	21	21	21	21
Reliability (95,0%)	0,233	0,539	0,972	1,587	0,698	1,593	1,644	1,563	1,165	1,495

Table 7.7

The descriptive statistics of a posteriori data of the research of the convergent intellectual abilities of trainees in the third group

Coefficient / Indicator	*Age*	K_{14}	K_{15}	K_{16}	K_{17}	K_{18}	K_{19}	K_{20}	K_{21}	K_{22}
Average	16,96	15,36	13,64	11,24	6,4	9,52	12,16	17,88	11,12	11,76
Standard error	0,122	0,624	0,391	0,738	0,712	0,775	0,69	0,418	0,477	0,694
Median	17	16	14	12	5	9	12	19	11	12
Mode	17	18	12	12	5	9	17	20	11	16
Standard deviation	0,611	3,121	1,955	3,689	3,559	3,874	3,448	2,088	2,386	3,468
Dispersion of selection	0,373	9,74	3,823	13,607	12,667	15,01	11,89	4,36	5,693	12,023
Excess	0,012	1,14	-0,369	-0,067	5,551	-0,204	-1,039	-0,291	1,311	0,259
Asymmetry	0,015	-1,232	-0,283	-0,678	1,896	0,163	0,025	-0,812	0,326	-0,367
Interval	2	12	8	14	17	16	12	7	11	15
Minimum	16	7	9	3	2	2	6	13	6	3
Maximum	18	19	17	17	19	18	18	20	17	18
Sum	424	384	341	281	160	238	304	447	278	294
Account	25	25	25	25	25	25	25	25	25	25
Reliability (95,0%)	0,252	1,288	0,807	1,523	1,47	1,599	1,423	0,862	0,985	1,431

Table 7.8

The descriptive statistics of a posteriori data of the research of the convergent intellectual abilities of trainees in the fourth group

Coefficient / Indicator	*Age*	K_{14}	K_{15}	K_{16}	K_{17}	K_{18}	K_{19}	K_{20}	K_{21}	K_{22}
Average	21,111	13,444	12,333	10,167	3,833	7,277	11,056	14,111	9,778	10,333
Standard error	2,309	0,525	0,657	1,02	0,487	0,77	0,802	1,34	0,73	0,788
Median	17,5	14	11,5	10,5	3,5	6	12,5	16	9	11
Mode	17	16	10	5	5	5	13	20	8	11
Standard deviation	9,797	2,229	2,787	4,328	2,065	3,269	3,404	5,687	3,098	3,343
Dispersion of selection	95,987	4,967	7,765	18,735	4,265	10,683	11,585	32,34	9,595	11,177
Excess	15,164	-0,791	-0,823	-1,392	0,937	-0,104	-1,262	-0,231	-0,529	-0,008
Asymmetry	3,786	-0,455	0,677	-0,172	0,837	1,109	-0,497	-0,985	0,648	0,172
Interval	42	7	9	14	8	10	10	17	10	13
Minimum	17	9	9	3	1	4	5	3	6	4
Maximum	59	16	18	17	9	14	15	20	16	17
Sum	380	242	222	183	69	131	199	254	176	186
Account	18	18	18	18	18	18	18	18	18	18
Reliability (95,0%)	4,872	1,108	1,386	2,153	1,027	1,625	1,693	2,828	1,54	1,663

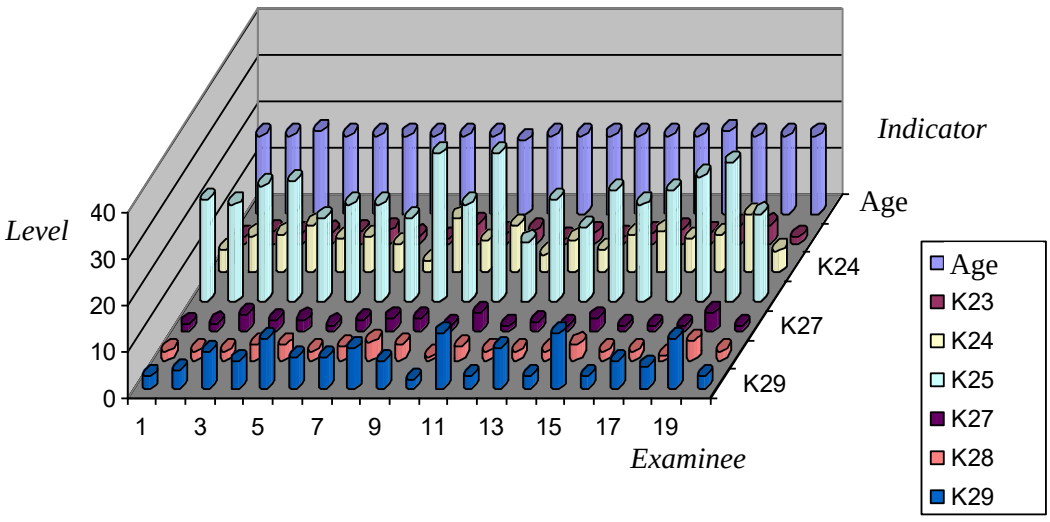
The vector of divergent intellectual abilities is the structural component of psychological portrait of the formed CM of the subject of training, being as one of the manifestations of psychophysiological construct of a head brain of learning subject, defines the individual productivity of the inductive thinking, characterizes the creative potential of personality (creativity).

The creativity or the divergent intellectual abilities causes the potential ability of an examinee to generate a set (a certain quantity) of original ideas (answers) differing from commonly accepted in the regulated situation on the verbal (verbal creativity) or the graphic incentive (figurative creativity), is measured by a set of indexes:

- index of originality – the sum of originalities of all variants of answers of examinees or the sum of inverse values to the frequencies of occurrence of each variant of answer in the received selection of answers of examinee;
- index of productivity – the quantity of answers of an examinee relevant to the shown incentive, which are given by him throughout the session of diagnostics;
- index of associativity – the sum of answers of a user correlated with the sum of shown tasks;
- index of selectivity – the quantity of coincidence of the selections of the most original answers of an examinee and an expert;
- index of uniqueness – the sum of the most original answers of examinee correlated with the total sum of answers generated by him.

For the research are chosen the methods of Mednik S.A. and Torrance E.P. validated for two age groups of examinees in the adaptation of Galkina T.V. and Alekseeva L.G. (“"IP" of "RAS"”).

The graphic interpretation of a posteriori data of research of the divergent intellectual abilities of the 1st-4th groups of examinees by the method of Torrance E.P. and Mednik S.A. are presented in pic. 7.6 (a-d).



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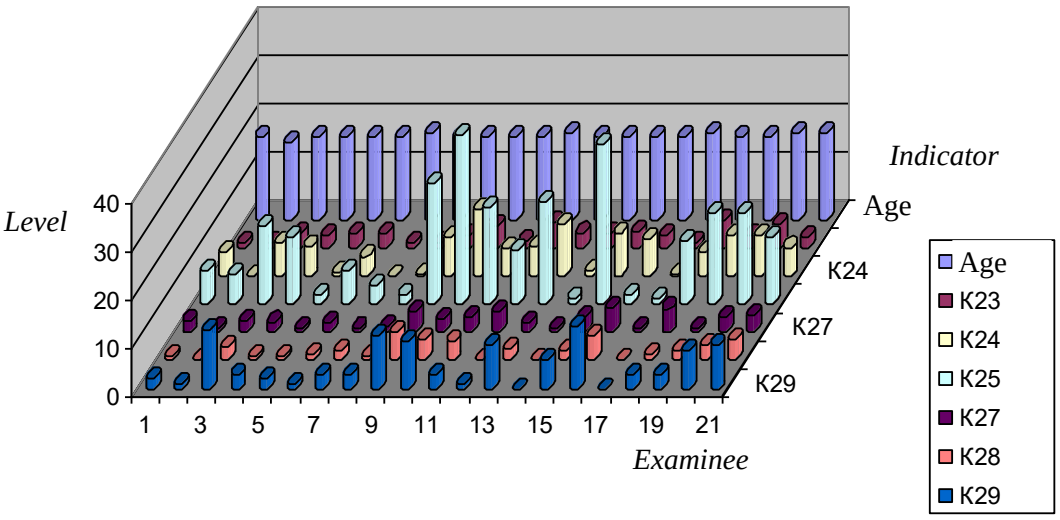

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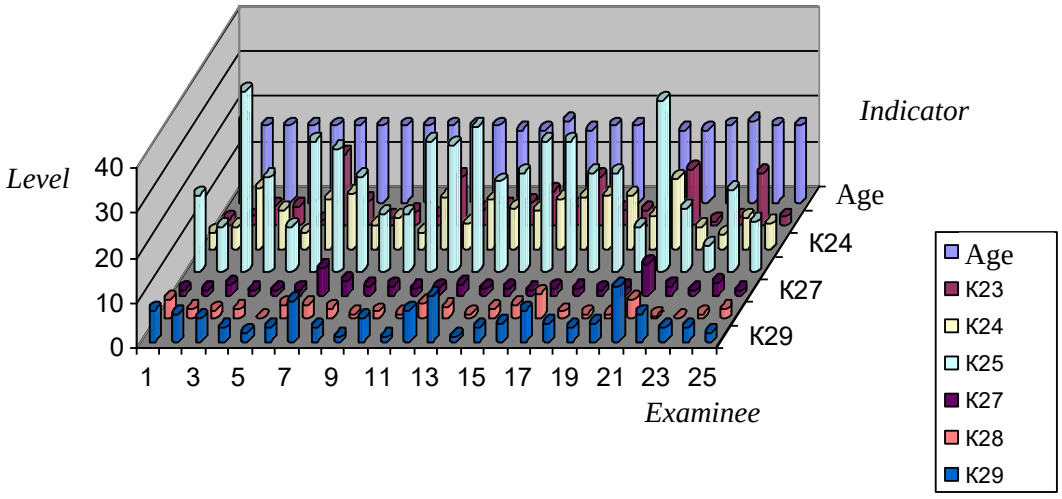

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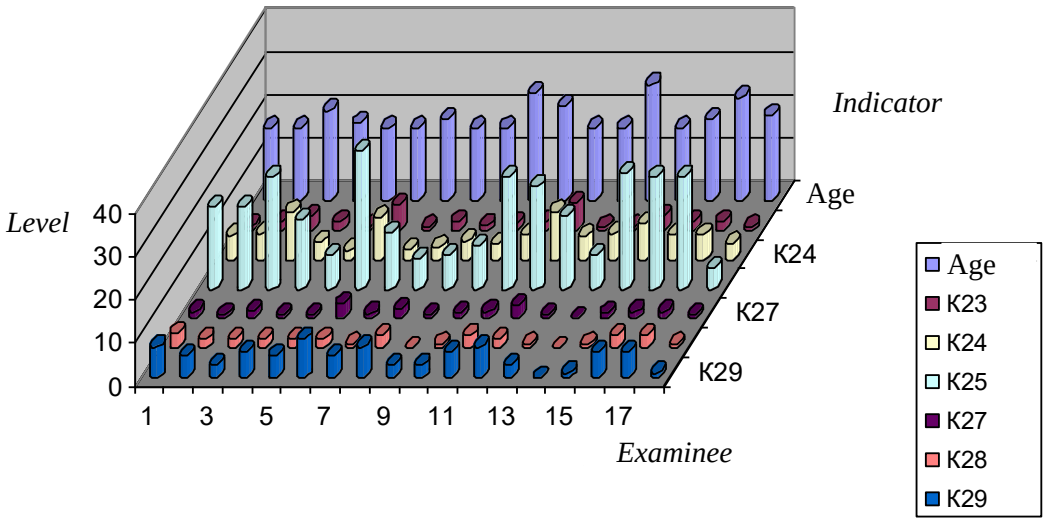


d

Pic. 7.6. The chart, reflecting the age and the level of the divergent intellectual abilities

Table 7.9

The descriptive statistics of a posteriori data of the research of the divergent intellectual abilities of trainees in the first group

Coefficient / Indicator	*Age*	K_{23}	K_{24}	K_{25}	K_{26}	K_{27}	K_{28}	K_{29}	K_{30}
Average	17,100	2,622	7,62	23,55	0	2,025	2,453	6,5	0
Standard error	0,124	0,358	0,622	1,617	0	0,237	0,232	0,738	0
Median	17,000	2,3	7,59	21,5	0	1,8	2	6	0
Mode	17,000	1,4	7,45	21	0	1	2	3	0
Standard deviation	0,553	1,602	2,783	7,229	0	1,059	1,039	3,301	0
Dispersion of selection	0,305	2,567	7,746	52,261	0	1,121	1,08	10,895	0
Excess	8,208	3,837	1,057	4,116	-	-0,279	0,352	-1,142	-
Asymmetry	2,164	1,925	0,568	1,701	-	0,799	-0,232	0,366	-
Interval	3,000	6,29	12,07	33	0	3,3	4,31	10	0
Minimum	16,000	1	2,53	13	0	1	0	2	0
Maximum	19,000	7,29	14,6	46	0	4,3	4,31	12	0
Sum	342	52,44	152,4	471	0	40,5	49,06	130	0
Account	20	20	20	20	20	20	20	20	20
Reliability (95,0%)	0,259	0,75	1,303	3,383	0	0,496	0,486	1,545	0

Table 7.10

The descriptive statistics of a posteriori data of the research of the divergent intellectual abilities of trainees in the second group

Coefficient / Indicator	*Age*	K_{23}	K_{24}	K_{25}	K_{26}	K_{27}	K_{28}	K_{29}	K_{30}
Average	17,191	3,626	5,378	12,952	0	2,555	2,189	5,095	0
Standard error	0,112	0,773	0,832	2,226	0	0,324	0,409	1	0
Median	17	2,7	5,9	13	0	2,3	2	3	0
Mode	17	1	-	2	0	1	1	3	0
Standard deviation	0,512	3,541	3,811	10,2	0	1,482	1,873	4,582	0
Dispersion of selection	0,262	12,535	14,521	104,05	0	2,197	3,51	20,991	0
Excess	0,603	4,071	-0,438	-0,242	-	0,084	0,121	-0,534	-
Asymmetry	0,355	2,158	0,136	0,678	-	0,766	0,812	0,846	-
Interval	2	12,7	13,7	34	0	5,16	6,75	15	0
Minimum	16	1	0	1	0	1	0	0	0
Maximum	18	13,7	13,7	35	0	6,16	6,75	15	0
Sum	361	76,15	112,94	272	0	53,66	45,97	107	
Account	21	21	21	21	21	21	21	21	21
Reliability (95,0%)	0,233	1,612	1,735	4,643	0	0,675	0,853	2,086	0

Table 7.11

The descriptive statistics of a posteriori data of the research of the divergent intellectual abilities of trainees in the third group

Coefficient / Indicator	*Age*	K_{23}	K_{24}	K_{25}	K_{26}	K_{27}	K_{28}	K_{29}	K_{30}
Average	16,96	5,024	8,294	21,48	0	2,028	1,993	4,556	0
Standard error	0,122	0,84	0,71	1,943	0	0,337	0,265	0,573	0
Median	17	3,55	8,46	21	0	1,4	2	4	0
Mode	17	2	11,3	29	0	1,1	1	3	0
Standard deviation	0,611	4,199	3,549	9,713	0	1,684	1,325	2,864	0
Dispersion of selection	0,373	17,629	12,597	94,343	0	2,836	1,756	8,203	0
Excess	0,013	1,239	-1,0403	0,189	-	8,775	0,636	0,625	-
Asymmetry	0,015	1,412	0,1984	0,563	-	2,902	0,777	0,988	-
Interval	2	15,7	12,43	40	0	7,3	5,5	11,1	0
Minimum	16	1	3,27	6	0	1	0	0,9	0
Maximum	18	16,7	15,7	46	0	8,3	5,5	12	0
Sum	424	125,6	207,35	537	0	50,7	49,83	113,9	0
Account	25	25	25	25	25	25	25	25	25
Reliability (95,0%)	0,252	1,733	1,465	4,009	0	0,695	0,547	1,182	0

Table 7.12

The descriptive statistics of a posteriori data of the research of the divergent intellectual abilities of trainees in the fourth group

Coefficient / Indicator	A*ge*	K_{23}	K_{24}	K_{25}	K_{26}	K_{27}	K_{28}	K_{29}	K_{30}
Average	21,111	2,241	5,839	17,611	0	1,506	1,833	4,611	0
Standard error	2,309	0,385	0,649	2,023	0	0,181	0,248	0,578	0
Median	17,5	1,975	5,735	18	0	1,5	2	5	0
Mode	17	1	5,77	26	0	1	1	3	0
Standard deviation	9,797	1,635	2,752	8,583	0	0,766	1,054	2,453	0
Dispersion of selection	95,987	2,672	7,571	73,663	0	0,586	1,11	6,016	0
Excess	15,164	2,568	-0,078	-1,458	-	2,297	-0,878	-0,595	-
Asymmetry	3,786	1,775	0,815	0,003	-	1,247	-0,229	-0,326	-
Interval	42	5,35	8,98	27	0	3,3	3,5	9	0
Minimum	17	1	2,22	5	0	0,2	0	0	0
Maximum	59	6,35	11,2	32	0	3,5	3,5	9	0
Sum	380	40,33	105,11	317	0	27,1	32,99	83	0
Account	18	18	18	18	18	18	18	18	18
Reliability (95,0%)	4,872	0,813	1,368	4,268	0	0,381	0,524	1,22	0

At the present stage of the development of psychology as the science the research of learning ability is new, as there is a small quantity of methods of its diagnostics, some of them are not everywhere used.

Some researchers find it possible to speak about two kinds of a learning ability, which are based on the different neuro-physiological mechanisms of functioning of the mentality of a person and are connected with the different ways of acquisition of knowledge:

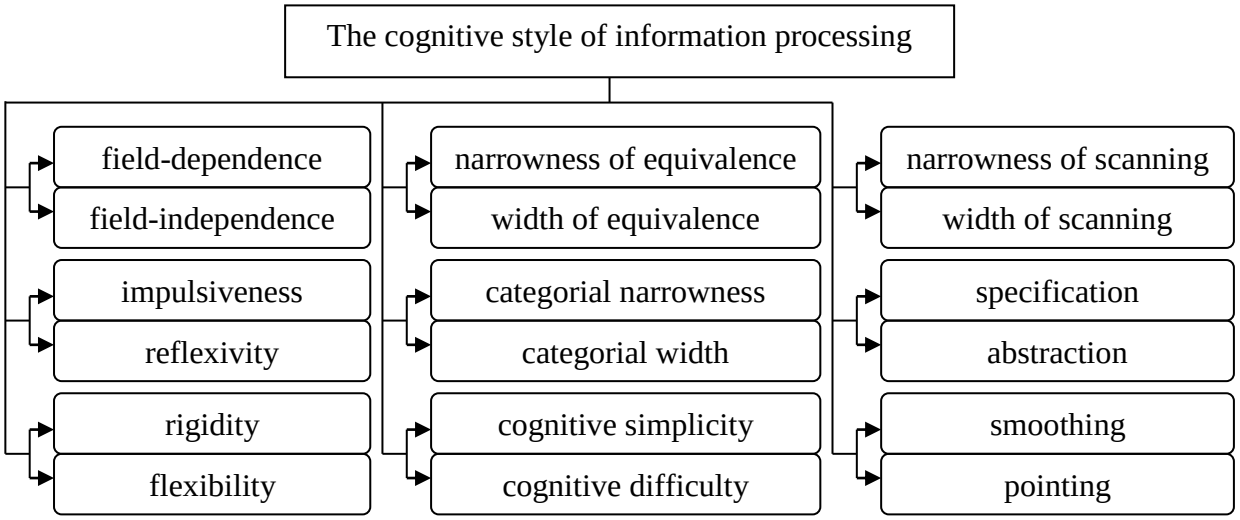
- the explicit learning ability – the training is carried out very quickly with the use of innovative methods, at the same time joins the arbitrariest, deliberate (conscious) control of processes of processing of information;
- the implicit learning ability – the training is carried out slowly in advance on installed algorithm (the program), in the conditions of gradual accumulation of information and the formation of knowledge and skills which is not realized by the person.

For IEE of ART the practical interest has the identification of a contingent of trainees having the characteristic signs of the explicit learning ability.

The diagnostics of the learning ability is realized by two main ways:

- by means of the special method "Diagnostic program" (U. Gutke and U. Volrab) – the express test of the learning ability, takes 45 minutes;
- by means of the formation of psychological portrait corresponding to the certain kind of the learning ability (comes down to the identification of predisposition of an examinee to the certain kind of the learning ability and it is carried out on the basis of a posteriori data of the diagnostics of the values of parameters of the convergent and the divergent abilities of intelligence and the cognitive styles).

The cognitive style represents inside a set of bipolar properties of personality, measured by means of the various methods of research (diagnostics) in the serial scales, formed and gaining stability directly in the early ontogenesis, which characterize the individual features, approaches and the ways of processing of information by the specific (certain) person (pic. 7.7).



Pic. 7.7. A set of bipolar properties, entering into the cognitive style

The cognitive styles come to light by means of the presentation to the examinee of the sequence of questions entering into the certain method of research, the analysis of correctness of his answers (the resultativity of performance of the offered tasks), therefore it is necessary to speak about the possibility of diagnostics (in the form of testing) only the degrees of expressiveness of one of the parameters of marked-out bipolar style on the basis of the nominal value of the received estimation (of parameter).

The methods of research of the cognitive styles are significantly differentiated as on the contents of formulations of tasks, so on the procedure of realization of research, and also on a required set of operations as subjects to performance to the examinee, and some of them have an uncharacteristic basis for the classical testing – poorly give in algorithmization and therefore practically have no program realization, demand a considerable labor costs at the processing of a posteriori data.

Considering the degree of expressiveness of the separate bipolar properties, revealed at the examinee, it is possible to draw a parallel between some parameters of CM of the subject of training and CM of the means of training (individual features of processing of information cause the need of the adaptive generation of TI):

- field-dependence / field-independence (**) – the presentation of information fragments only on one discipline without division in time, but with the restriction of duration of studying (rigid or arbitrariest sequence of statement) / the presentation of TI on several disciplines with division in time and with the restriction of duration of the studying of information (the sequence of studying of information is defined by the algorithm of training in the basis of the automated means of training);
- impulsiveness / reflexivity – the decrease / increase of interval of the display of information fragment (or question in the mode of diagnostics) in dependence from the volume of contained information;
- rigidity / flexibility (**) – the statement of information fragments with the fixed kind and the type of presented information (rigorous or arbitrariest sequence) / the statement of information fragments of the various kind and type (arbitrariest or rigorous sequence);
- specification / abstraction – the choice of template with the concrete / abstract style of statement of the material of a discipline (the template on the basis of the depth of specification at the statement of a content of a subject of studying);
- the cognitive simplicity / the cognitive difficulty (*) – the choice of the level of s statement of the material of a discipline and a set of elements in the basis of interface (the additional means of navigation on the information fragments);
- categorial narrowness / width (*) – the choice of a set of concepts and definitions.

(*) – it is at the same time connected with the choice of level of statement of the material of a discipline.
(**) – it is at the same time connected with the way of navigation within the limits of a course.

7.4.2. The specifics of research of the parameters of the psychological portrait of the cognitive model of the means of training

The psychological portrait of CM of the means of training characterizes the way of representation of the sequence of information fragments to the contingent of trainees by means of the algorithm located in the basis of the means of training (ET):

- the kind of information – a text, a table, a flat scheme, a volumetric scheme, a sound stream as the main, a sound stream as the accompaniment, a combined scheme, a special scheme of display of information on the subject of studying;
- the style of representation of information – complete / detailed representation, automatic / manual switching providing the installation of interval of time, constant / variable type of information (information fragment), deep specification / abstract statement, simplicity of a statement / difficulty of a statement, wide / narrow set of terms used in the process of a statement;
- the additional capabilities of display – the correction of sequence of studying of the elements of course, navigation on course, addition of modules, choice of kind of information, choice of style of representation and choice of speed of representation;
- the speed of representation of information fragments – fast / slow.

The repertoire of parameters entering into the basis of the psychological portrait of CM of the means of training is corrected by means of the use of the technique of research of parameters of CM of the means of training in the course of the life cycle of the program realization of the used means of training (ET).

The calculation of optimal combination of the values of parameters of display realizes the module of a control of the processing of psychological parameters for the support of individually-oriented generation of TI (pic. 6.6), entering into the structure of adaptive representation of information fragments processor of the means of training.

The adaptive means of training (ET) provides the representation of information by the various way adequately to the potential technical capabilities of the means of training (CM of the means of training) and IFPST (CM of the subject of training), which allow to define the predisposition of the certain person to the perception of the certain information displayed by the various way:

- a text – a textual content, which reflects the essence and description of a concept, an object, a process or a phenomenon, which is the subject to studying;
- a table – the matrix of certain dimension including a set of adjacent cells considered as the several vertical columns (fields) having the certain names and the horizontal lines, each of which contains a set of the values of fields corresponding to each column and forming the certain quantity of records on the line;
- a scheme – a static or dynamic set of connected information elements presented in the two-dimensional or multi-dimensional system of coordinates and reflecting the structure of studied concept, object or process.

7.5. The features of research of the parameters of the linguistic portrait of the cognitive models of the subject and means of training

The researches in the field of the artificial intelligence and linguistics put forward the actual task – the modeling of language mechanisms of the understanding of the text.

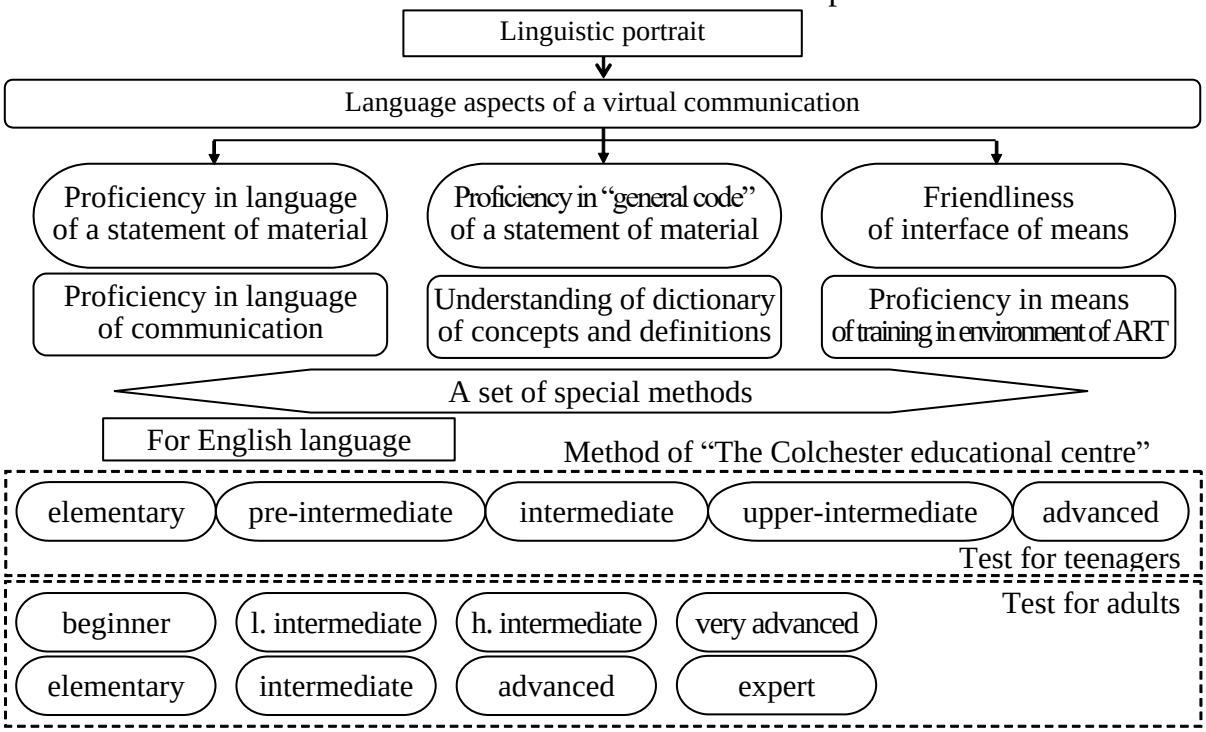
The modeling of the process of understanding of the structure and a content of the text imposes the expanded requirements in the field of the analysis of a dialogue interaction in the certain national or artificial language, or their dialects.

In the modern cognitive linguistics several perspective directions of research of the features of organization and realization of a dialogue are singled out:

- the modeling of a dialogue – they understand the research of the communicative act representing inside the sequence of communicative steps directed on the satisfaction of a set of information requirements between the subjects of communication who are acting as the deficit (scarce) and proficit (surplus) as regards to the actual information, pursuing the definite purposes and carrying out the various tasks in the certain environment of communication;
  - in the natural environment (habitat) – acts in the view of direct (oral speech) or mediated (letter) communication between communicators in the certain conditions of a natural or an artificial (virtual) environment;
  - in the artificial environment – the information exchange of subjects which are located on AWP by means of ICT with division in time (e-mail, a conference in the mode off-line) or a dialogue in the real scale of time (a conference in the mode on-line with the use of equipment of the transfer of audio- and video-stream, allowing to display the condition of all communicators) on the channel of connection of the certain kind (satellite – network "Inmarsat", cable – modem "xDSL" and switched – modem "Dial Up");
  - in the virtual environment – the technology of a virtual reality (helmet "VR");
- the modeling of the process of understanding of the text in the national and foreign language;
  - the identification of semantic, grammatical and lexical features of a formation of the text in the various national and foreign languages;
  - the formation of dictionaries for the translation of words from one language to another;
  - the creation of the systems of the relaying (translation) of a test from one language to another;
  - the allocation of the levels of representation, statement and assimilation of information fragments reflecting the content of the subject of studying;
- the modeling of natural-language interfaces of the understanding of the text;
  - the development of methods of recognition of a natural-language constructs;
  - the creation of algorithms of recognition of a natural speech;
  - the development of the program realization of a procedures which are carrying out the relaying of the text from one national and foreign language to another;
  - the formation of dictionaries allowing to save and to extract a set of words directly for the support of functioning of the systems of translation.

7.5.1. The specifics of research of the parameters of the linguistic portrait of the cognitive model of the subject of training

The research of parameters of the linguistic portrait of CM of the subject of training (pic. 6.4) is based on the use of a row of the special methods of research having the theoretical justification in the context of applied linguistics, allowing to reveal the individual level of proficiency in language and "general code" (knowledge of keywords and definitions) in the course of the statement of material, and also to define the friendliness of elements of the interface of software product at the work of a user.



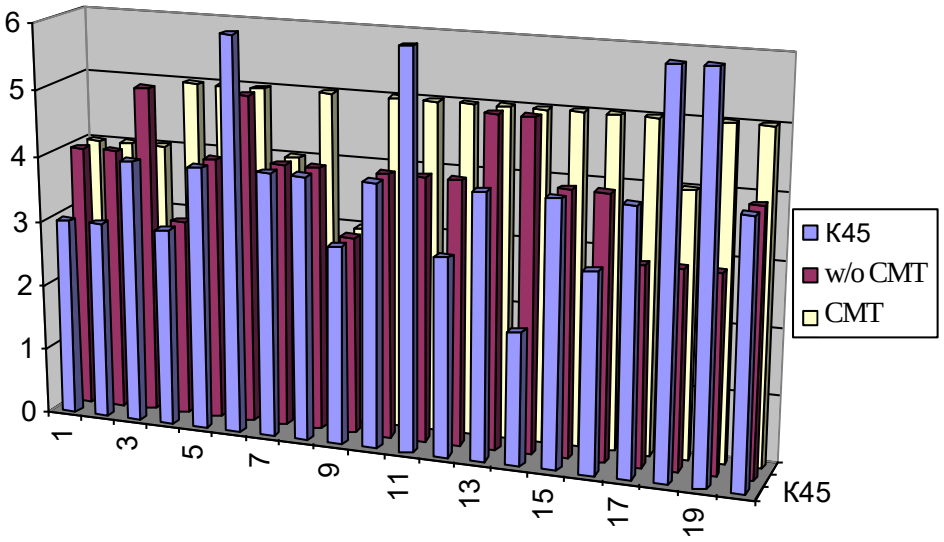
Pic. 7.8. The linguistic portrait of the cognitive model of the subject of training

The diagnostics of the level of proficiency in the language of statement of the content of the subject of studying is performed in the form of tests for the various categories of examinees, which are differentiated on the level of initial preparation in the context of the certain national language. At the carrying out of the experimental researches (pilot studies) the method of "The Colchester educational centre" (The United kingdom of Great Britain and Northern Ireland) was used.

The diagnostics of level of understanding of a set of key terms and definitions, which are used at the statement of a content of the subject of studying or the research of dynamics of functioning of an object, process or phenomenon is provided due to the testing (intermediate and total) on the basis of in advance prepared by the teacher (a tutor and a methodologist) of the selection of the control questions entering into the test on the certain subject of studying.

Just before the use of certain component of ART system it is necessary to acquaint the users of various categories with the content of manual or technical description (specification) to its program realization, and then to reveal the level of knowledge and developed skills at the work of a user with the elements of interface of the means of training, acting as the components of ART system.

The automation of diagnostics of the values of parameters of the linguistic portrait of CM of the subject of training is reached by means of the use of the applied DM (it is possible the realization of diagnostics of some parameters with the use of the basic DM).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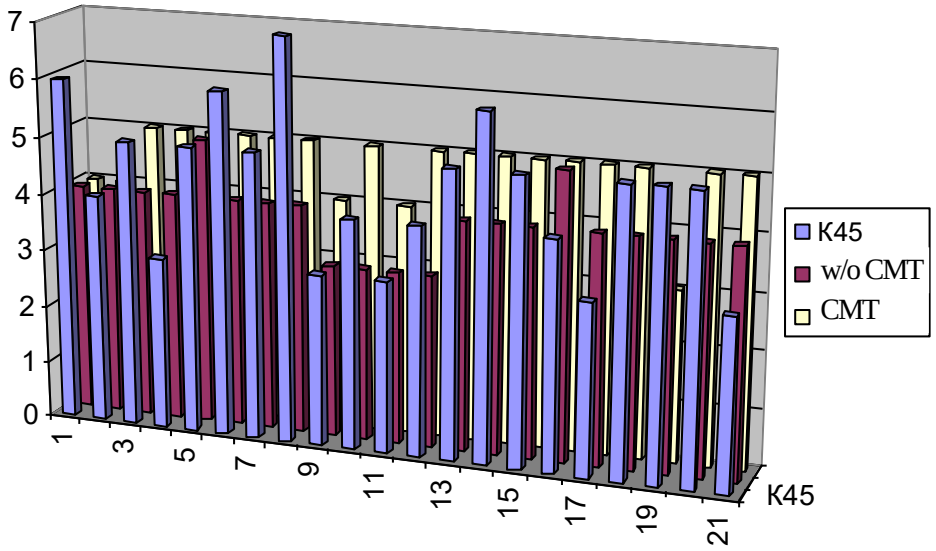
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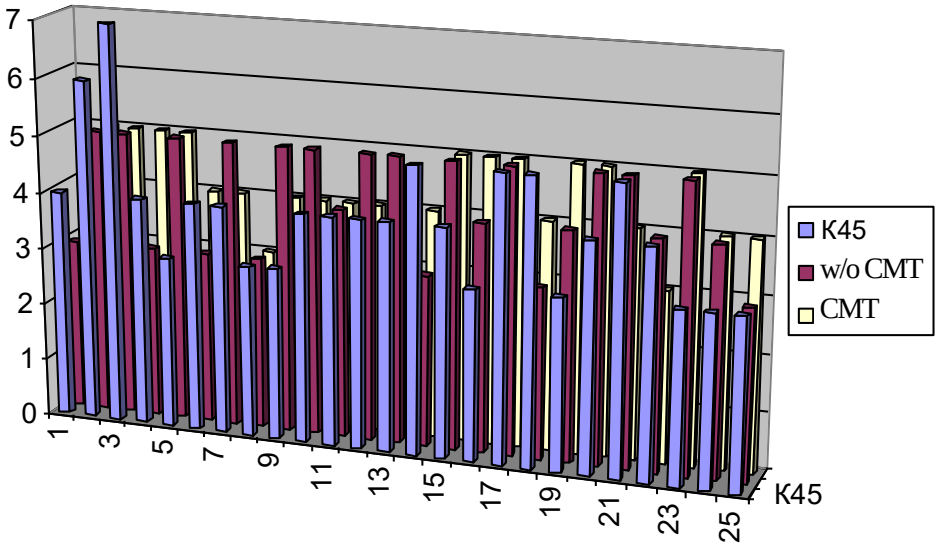
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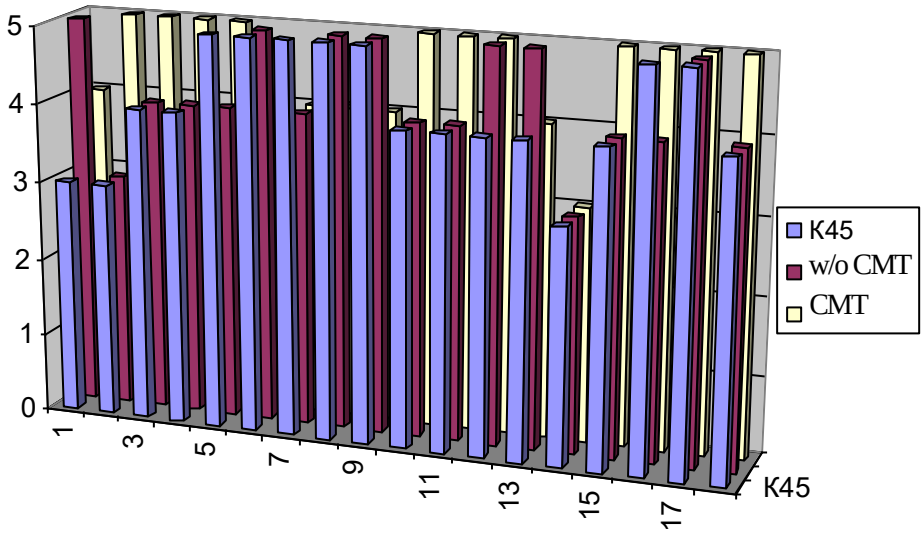

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Pic. 7.9. The chart, reflecting the level of proficiency in language of a statement of material

In the result of preliminary statistical processing of a posteriori data of the diagnostics of the level of proficiency in a language of a statement of information fragments reflecting the content of the subject of studying and LRKT of the 1st-4th groups with application of CMT and without the use of CMT are received the descriptive statistics presented respectively in the tab. 7.13-7.16.

Table 7.13

The descriptive statistics of a posteriori data of the research of the level of proficiency in language and the level of residual knowledge of trainees of the first group without the use of CMT and with the use of CMT

Coefficient / Indicator	*Age*	$K_{45}(corr.)$	$K_{45}(incorr.)$	K_{45}	Y_1, *w/o CMT*	Y_2, *w/o CMT*	Y_3, *with CMT*
Average	17,100	44,7	35,3	4	3,95	4	4,65
Standard error	0,124	2,88	2,88	0,262	0,154	0,145	0,131
Median	17,000	44,5	35,5	4	4	4	5
Mode	17,000	32	48	4	4	4	5
Standard deviation	0,553	12,88	12,88	1,17	0,686	0,649	0,587
Dispersion of selection	0,305	165,905	165,905	1,368	0,471	0,421	0,345
Excess	8,208	-0,546	-0,546	-0,222	-0,63	-0,279	1,636
Asymmetry	2,164	0,357	-0,357	0,658	0,062	0	-1,521
Interval	3,000	45	45	4	2	2	2
Minimum	16,000	22	13	2	3	3	3
Maximum	19,000	67	58	6	5	5	5
Sum	342,000	894	706	80	79	80	93
Account	20	20	20	20	20	20	20
Reliability (95,0%)	0,259	6,028	6,028	0,548	0,321	0,304	0,275

Table 7.14

The descriptive statistics of a posteriori data of the research of the level of proficiency in language and the level of residual knowledge of trainees of the second group without the use of CMT and with the use of CMT

Coefficient / Indicator	*Age*	$K_{45}(corr.)$	$K_{45}(incorr.)$	K_{45}	Y_1, *w/o CMT*	Y_2, *w/o CMT*	Y_3, *with CMT*
Average	17,191	48,714	31,286	4,571	3,905	4	4,714
Standard error	0,112	2,769	2,769	0,254	0,118	0,154	0,122
Median	17	52	28	5	4	4	5
Mode	17	52	28	5	4	4	5
Standard deviation	0,512	12,689	12,689	1,165	0,539	0,707	0,561
Dispersion of selection	0,262	161,014	161,014	1,357	0,291	0,5	0,314
Excess	0,603	-0,633	-0,633	-0,631	0,942	-0,807	3,182
Asymmetry	0,355	-0,399	0,399	0,124	-0,114	0	-1,92
Interval	2	48	48	4	2	2	2
Minimum	16	23	9	3	3	3	3
Maximum	18	71	57	7	5	5	5
Sum	361	1023	657	96	82	84	99
Account	21	21	21	21	21	21	21
Reliability (95,0%)	0,233	5,776	5,776	0,53	0,245	0,322	0,255

Table 7.15

The descriptive statistics of a posteriori data of the research of the level of proficiency in language and the level of residual knowledge of trainees of the third group without the use of CMT and with the use of CMT

Coefficient / Indicator	*Age*	$K_{45}(corr.)$	$K_{45}(incorr.)$	K_{45}	Y_1, *w/o CMT*	Y_2, *w/o CMT*	Y_3, *with CMT*
Average	16,96	44,68	35,32	4,04	4,52	4,08	4,28
Standard error	0,122	2,051	2,051	0,204	0,117	0,152	0,136
Median	17	42	38	4	5	4	4
Mode	17	42	38	4	5	4	4
Standard deviation	0,611	10,254	10,254	1,02	0,586	0,759	0,678
Dispersion of selection	0,373	105,143	105,143	1,04	0,343	0,577	0,46
Excess	0,013	0,196	0,196	1,745	-0,322	-1,179	-0,68
Asymmetry	0,015	0,916	-0,916	1,196	-0,759	-0,138	-0,41
Interval	2	38	38	4	2	2	2
Minimum	16	32	10	3	3	3	3
Maximum	18	70	48	7	5	5	5
Sum	424	1117	883	101	113	102	107
Account	25	25	25	25	25	25	25
Reliability (95,0%)	0,252	4,233	4,233	0,421	0,242	0,314	0,28

Table 7.16

The descriptive statistics of a posteriori data of the research of the level of proficiency in language and the level of residual knowledge of trainees of the fourth group without the use of CMT and with the use of CMT

Coefficient / Indicator	*Age*	$K_{45}(corr.)$	$K_{45}(incorr.)$	K_{45}	Y_1, *w/o CMT*	Y_2, *w/o CMT*	Y_3, *with CMT*
Average	21,111	46,5	34,611	4,222	4,278	4,111	4,556
Standard error	2,309	1,528	1,801	0,173	0,158	0,137	0,145
Median	17,5	46	35	4	4	4	5
Mode	17	45	35	4	4	4	5
Standard deviation	9,797	6,483	7,64	0,732	0,669	0,583	0,616
Dispersion of selection	95,987	42,029	58,369	0,536	0,448	0,34	0,379
Excess	15,164	-1,167	-0,552	-0,906	-0,564	0,413	0,387
Asymmetry	3,786	-0,243	0,451	-0,383	-0,382	0,017	-1,085
Interval	42	20	26	2	2	2	2
Minimum	17	35	25	3	3	3	3
Maximum	59	55	51	5	5	5	5
Sum	380	837	623	76	77	74	82
Account	18	18	18	18	18	18	18
Reliability (95,0%)	4,872	3,224	3,799	0,364	0,333	0,29	0,306

As the result of the mathematical processing of a posteriori data of the diagnostics of the level of proficiency in language and LRKT are received the descriptive statistics, characterizing:

- in the first group of examinees – the received values of median and mode for the presented selections of data coincide with the average arithmetic K_{45} – the level of proficiency in language of a statement of material, Y_3^{CMT} – LRKT;
- in the second group of examinees – there are observed the insignificant deviations of calculated values of median and mode of a numerical row concerning the value of average arithmetic on the selections of indicators K_{45}, Y_3^{CMT};
- in the third group of examinees – there is the insignificant deviation of calculated values of median and mode of a numerical row concerning the value of average arithmetic on the selections of indicators K_{45}, $Y_1^{w/oCMT}$, Y_3^{CMT};
- in the fourth group of examinees – there are the deviations of calculated values of median and mode of a numerical row concerning the value of average arithmetic on the selections of indicators K_{45}, Y_3^{CMT}.

The exception makes the indicator, reflecting the age of examinees which in the 1st-3rd groups causes the increase of pointedness of a distribution of values, and in the 4th group is observed the right asymmetry, caused by the presence of a trainee at the age of 59 years, that is the insignificant artifact as regards to the other parameters, considered at the research of the linguistic portrait of CM of the subject of training characterizing some IFPST.

7.5.2. The specifics of research of the parameters of the linguistic portrait of the cognitive model of the means of training

The linguistic portrait of CM of the means of training characterizes the technical capabilities of the means of training at the display of information fragments, reflecting the content of the subject of studying on the various levels of a statement with the use of a various sets of keywords and definitions, and also using a various sets of elements in the basis of the interface of program.

The module of control of the processing of linguistic parameters (pic. 6.6) is located in the basis of the adaptive representation of information fragments processor, provides the calculation of an optimal combination of the values of parameters of the presentation of information, which reflects the content of the subject of studying:

- the level of a statement of material – defines the difficulty of representation of the content of the subject of studying to the contingent of trainees on the basis of their IFPST;
- a set of concepts and definitions – characterizes a set of terms and definitions, which are used at the statement of a content of the subject of studying, and also are presented in the list of key terms and definitions;
- a set of the elements of interface – determines the difficulty and saturation of interface of the program realization of the means of training (ET) by the various elements, which are used for the realization of control and navigation.

The calculation of an optimal combination of the values of parameters of the presentation of information of ET is realized automatically on the basis of the parameters of CM of the means of training reflecting the technical capabilities of the means of training and parameters of CM of the subject of training characterizing IFPST, in particular the linguistic features (parameters).

If it is impossible to calculate some values of the parameters of a statement of the content of the subject of studying because of the absence of the values of the parameters of CM of the subject of training (previously were not diagnosed), then there are used the values by default of the parameters of CM of the means of training, which are previously installed by the final user in the mode of administrating of ET for all disciplines (the subjects of studying).

The developed architecture of the adaptive means of training assumes the existence of semantic model of a representation of data, allowing to extract and to save a set of information fragments of the certain structure in DB of the complex of programs, each of which reflects the content of the subject of studying on the various levels of difficulty of a representation of material.

The switching between the different levels of a statement of material is carried out automatically or in advance is installed manually in the mode of administrating.

The transactional and temporary expenses at the practical use of this way of the organization of storage and extraction of information, assuming the several levels of representation of the content of a discipline, pay off at a large quantity of consumers of educational services and uniform IEE, including the several EEs specializing on the certain group of disciplines.

7.6. The specifics of preliminary processing of a posteriori results of the diagnostics

As in the course of experimental researches (pilot studies) were used the various methods for the automated diagnostics of the parameters of CM of the subject of training from the essentially various subject areas (physiology of sensory systems, cognitive psychology and applied linguistics), than the registration of a posteriori data was carried out on the specially developed personal cards of examinees and into the summary sheet of the results of the testing of LRKT and IFPST.

The research of the parameters of the physiological, psychological and linguistic portraits of CM of the subject of training, and also LRKT on the studied disciplines were carried out in the several technological approaches (stages). At the fact of completion of a diagnostic cycle with the use of the certain method of research a posteriori results, calculated by the applied and basic DM, were saved in the relevant DB and parallel were brought by the examinees into the personal cards.

In pic. 7.10 is presented the developed form of the personal card of the examinee, which allows to register a posteriori data of the automated diagnostics of the convergent intellectual abilities.

Личная карточка испытуемого для регистрации апостериорных данных автоматизированного тестирования

Группа № 6321 Дата: 28.09.2006

Фамилия: Абдигуров

Имя: Василий

Отчество: Сергеевич

Возраст: 18

Оценки по дисциплинам базового цикла

Наименование дисциплины	Оценка	Наименование дисциплины	Оценка
Русский язык	4	Алгебра	5
Литература	4	Геометрия	5
Иностранный ( )	4	Физика	5
История	4	Химия	4
География	4	Черчение	5
Биология	4	Астрономия	5

Апостериорные результаты тестирования

K1	17	K4	0	K7	16
K2	13	K5	4	K8	11
K3	13	K6	10	K9	12

Личная карточка испытуемого для регистрации апостериорных данных автоматизированного тестирования

Группа № 6321 Дата: 28.09.2006

Фамилия: Артамонов

Имя: Александр

Отчество: Алексеевич

Возраст: 17

Оценки по дисциплинам базового цикла

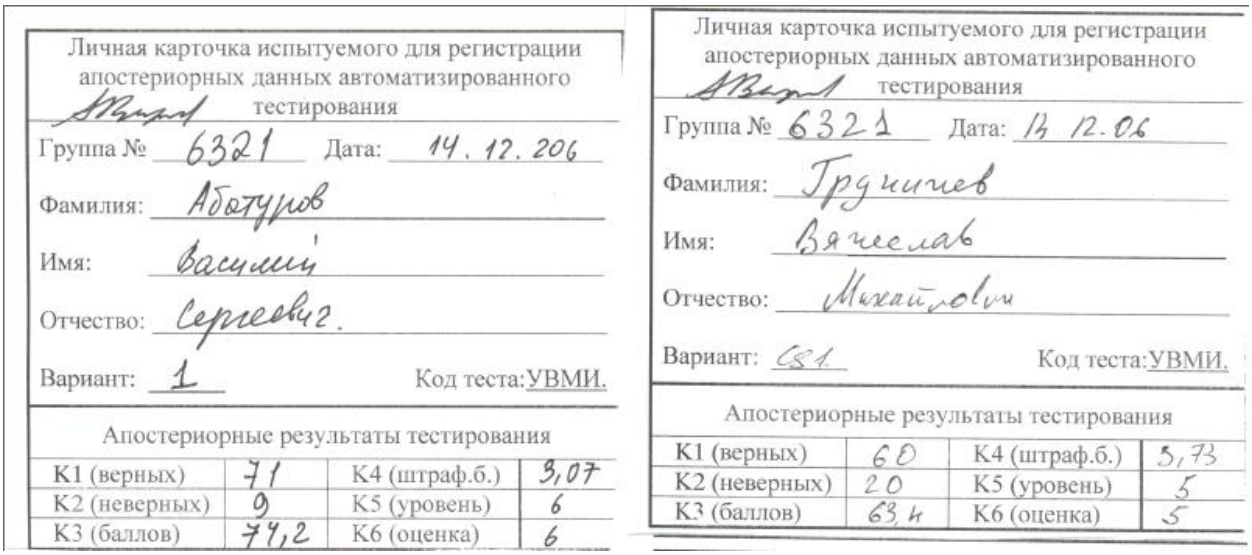
Наименование дисциплины	Оценка	Наименование дисциплины	Оценка
Русский язык	4	Алгебра	5
Литература	4	Геометрия	5
Иностранный (Англ.)	5	Физика	5
История	4	Химия	4
География	4	Черчение	4
Биология	5	Астрономия	5

Апостериорные результаты тестирования

K1	17	K4	8	K7	17
K2	16	K5	11	K8	14
K3	15	K6	15	K9	17

Pic. 7.10. The personal card for the registration of a posteriori data of the research of the convergent intellectual abilities of examinees

In pic. 7.11 is presented the form of the personal card of the examinee allowing to realize the registration of the results of diagnostics of the level of proficiency in language of a statement of the information fragments reflecting the content of the subject of studying.



Личная карточка испытуемого для регистрации апостериорных данных автоматизированного тестирования

Группа № 6321 Дата: 14.12.206

Фамилия: Абатуров

Имя: Василий

Отчество: Сергеевич.

Вариант: 1 Код теста: УВМИ.

Апостериорные результаты тестирования

К1 (верных)	71	К4 (штраф.б.)	3,07
К2 (неверных)	9	К5 (уровень)	6
К3 (баллов)	74,2	К6 (оценка)	6

Личная карточка испытуемого для регистрации апостериорных данных автоматизированного тестирования

Группа № 6321 Дата: 14.12.06

Фамилия: Грудинев

Имя: Вячеслав

Отчество: Михайлович

Вариант: 651 Код теста: УВМИ.

Апостериорные результаты тестирования

К1 (верных)	60	К4 (штраф.б.)	5,73
К2 (неверных)	20	К5 (уровень)	5
К3 (баллов)	63,4	К6 (оценка)	5

Pic. 7.11. The personal card for the registration of a posteriori data of the diagnostics of the level of residual knowledge of the contingent of trainees

Subsequently to each group of examinees there was associated the separate selection of a posteriori data, being subject to the further processing. For the research of dynamics and a tendency of change of the average point (LRKT) and its average square deviation (ASD) for 3 years (2004-2006 y.) were used 8 groups of examinees of a day and evening departments, studying the discipline "Computer science".

For the solution of the tasks of a primary processing of the formed selections were carried out: the search of abnormal emissions (artifacts) in the values of measured signs, the check of compliance to the certain (normal) law of distribution of the values of measured sign, to the calculation of descriptive statistics (measures of a central tendency) for the received selections of a posteriori data.

As the most important stage of the preliminary statistical analysis acts the compliance to the normal law of distribution of the values of signs and:

- the calculation of critical values of asymmetry and excess, the creation of schedules of saved-up frequencies and quantile schedules – the degree of compliance to the normal law of distribution of the values of signs is defined by the relative location of theoretical and empirical curves;
- the calculation of value of the criterion of Kolmogorov-Smirnov and probability of compliance to the normal law of distribution – if the value of admissible probability $\leq 0,05$, then there is no the essential difference from the normal distribution.

The results of a primary statistical processing of the formed selections with a posteriori data allow to speak about the absence of essential not uniformity, which are not allowing to carry out the further researches of statistical regularities, according to the submitted plan of the mathematical processing.

The analysis of compliance to the normal law of distribution of numbers is realized:

- analytically – the degree of the variation of asymmetry and excess from the critical values;
- graphically – the quartile schedules and schedules of saved-up frequencies.

7.7. The features of choice of the methods of the statistical analysis of the created selections

The modern procedures of the mathematical processing of a posteriori data by means of the use of different statistical methods are algorithmically difficult and cause the need of the use of the certain means of automation:

- the packages of mathematical programs – Mathcad 12, MathLab 13 and Mathematica 5.0;
- the packages of statistical programs – SPSS 15, Statistica 6.0 and SYSTAT 10.2.

The degree of compliance to the normal law of distribution of values in the received selections and the values of calculated descriptive statistics allow to limit a set of expedient and acceptable for the use of methods of the statistical analysis taking into account the requirements and restrictions of each of them.

The calculation of descriptive statistics, acting as the measures of a central tendency of a distribution of values on the selections with a posteriori data allows to choose the scale of measured sign taking into account the specifics of a source data.

The dispersive analysis of variability of a resultativity of training under the influence of various factors demands the compliance to the normal law of distribution of the values of measured parameters and homogeneity of dispersions in the received dispersive complexes, that is actually partially satisfied, therefore at this moment the expediency of application of this method does not cause.

The factorial analysis allows to single out an uncorrelated set of factors in the context of preliminary preparation to the regression and discriminant analysis, acts as the means of reduction of an initial set of the researched parameters, each of which causes the influence on the resultativity of training.

The method of the factorial analysis in a complex was not used as the period of the carrying out of the experimental researches (pilot studies) is short and the received results at the using of this method are difficult for the subsequent interpretation, and also it is not observed the essential increase of the values of CMC and CMD in the course of the subsequent regression analysis of a new space of factors.

As the resultativity of training as the dependent size (value) can be measured quantitatively (the nominal value of estimation of LRKT) and nominatively (the name of estimation of LRKT or a group of trainees, formed by the value of estimation of LRKT), therefore for the identification of dependences is justified the use of the multiple regression analysis, or the discriminant analysis.

The multiple regression analysis is intended for the research of interrelation and forecasting of a resultativity of training in dependence on the values of the set of various factors, acting as the analog of the dispersive analysis. There are given the results of its application with the use of return step-by-step method.

The discriminant analysis acts as the alternative of the multiple regression analysis, if the resultativity of the training is presented nominatively – LRKT allows to predict the groups of excellent, good, mediocre and poor-pupils.

7.8. The analysis of the dynamics of resultativity of training for several years

The collecting of results of the automated testing of LRKT and diagnostics of IFPST was carried out by means of respectively the basic and applied DM, providing the registration of a posteriori data into the specialized DB.

For the verification of the used algorithms in the basis of the components of complex of programs, in particular for the subsequent identification and correction of the possible mistakes are developed the special cards (forms) for the parallel registration of answers of the contingent of examinees and the total values of target indicators (coefficients), calculated by the automated way of calculation. The results of the statistical processing of a posteriori data are given in the tab. 7.17.

Table 7.17

The results of the statistical processing of a posteriori data of the experiment

The name of indicator	The number of the experimental group of examinees							
The quantity of examinees in group	1	2	3	4	5	6	7	8
	26	28	22	25	27	23	21	24
The experiment №1 (without the use of CMT)								
Average point Y_1	3,850	3,414	3,224	3,678	4,036	3,643	3,790	3,645
AQD 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, personal adaptation)								
Average point Y_2	4,041	3,674	3,357	3,786	4,157	3,853	3,821	3,743
AQD of average point	0,723	0,127	1,743	0,743	0,446	0,654	1,538	0,986
Total results of the research								
Comparative indicator $k_1 = Y_2 - Y_1$	0,191	0,26	0,133	0,108	0,121	0,21	0,031	0,098
Relative indicator $k_2 = Y_2 / Y_1$	1,049	1,076	1,041	1,029	1,029	1,057	1,008	1,026
Absolute indicator $k_3 = \frac{Y_2 - Y_1}{Y_1} \cdot 100\%$	4,96	7,62	4,13	2,94	3,0	5,77	0,82	2,69
Change of AQD of average point	-0,144	-0,051	-0,215	-0,136	-0,131	-0,129	-0,141	-0,061

The values of comparative, relative and absolute indicators in the tab. 7.17 demonstrate the increase of the average point in 0,82-7,62% and the decrease of AQD of the average point after the use of CMT.

For the exception of the factor of coincidence there was the need of additional researches, including the analysis of dynamics of change of the indicator of resultativity of the training for the several years, and also the statement and carrying out of the series of experiments with the purpose of estimation of influence of the various factors (parameters) on the efficiency of the formation of knowledge of a trainee.

Previously there was carried out the analysis of the dynamics of a change of the indicator of resultativity of training (LRKT) for the last three years and there was estimated the efficiency of the use of CMT in the educational process (2006 y., groups 1, 2 and 3), the results of which are presented in the tab. 7.18.

Table 7.18

The results of the preliminary statistical analysis of resultativity of the (adaptive) training

Name of indicator	Number of group of examinees							
	1	2	3	4	5	6	7	8
The indicators of resultativity of the training for 2004 year								
Quantity of trainees	20	21	25	18	18	15	0	0
Average point Y_1	4,05	4,286	4,24	4,611	4,056	4,4	-	-
AQD of average point	0,686	0,845	0,779	0,502	0,802	0,507	-	-
The indicators of resultativity of the training for 2005 year								
Quantity of trainees	24	22	24	25	24	22	23	21
Average point Y_2	4,333	4,046	4,375	4,16	4,042	4,091	4,696	4
AQD of average point	0,817	0,785	0,824	0,8	0,859	0,811	0,559	0,894
The indicators of resultativity of the training for 2006 year (with the use of CMT in three groups)								
Quantity of trainees	26	23	29	24	25	22	22	22
Average point Y_3	4,5	4,609	4,379	3,708	3,92	3,773	4,455	3,818
AQD of average point	0,707	0,656	0,775	0,751	0,572	0,612	0,858	0,853
Total results of the statistical analysis								
The indicators, reflecting the change of the efficiency of the 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	-	-
Change of AQD	0,13	-0,06	0,045	0,298	0,056	0,304		
The indicators, reflecting the change of the efficiency of the 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
Change of AQD	-0,109	-0,129	-0,049	-0,0494	-0,287	-0,199	0,299	-0,042

In the tab. 7.18 is reflected the resultativity of the training for 2004, 2005 and 2006 years, characterized LRKT of day (groups 1st-6th) and evening departments (groups 7th-8th). The values of indicators for 2004-2005 y. in the table demonstrate both the increase in 3-7% (groups 1st-3rd) and the decrease in 5-10% (groups 2nd, 4th, 5th and 6th) of resultativity of the (adaptive) training without the use of CMT in IEE.

In 2006 year at the statement of the content of the discipline "Computer science" CMT was used, on the basis of which there was carried out the series of experiments, and also the statistical processing of a posteriori results.

The experimental researches (pilot studies) were carried out in the context of the separate sections of the discipline "Computer science", the information fragments on which were presented to the contingent of trainees by means of the adaptive means of training (ET).

For the increase of presentation of the change of indicators of the efficiency of training at the using of CMT in 2006 year (groups 1^{st}, 2^{nd} and 3^{rd}) is provided the increase of the level of difficulty at the statement of studied material. The obtained data (2005-2006 y.) confirm about the sharp decrease of the resultativity of the training in 3-10% (groups 4^{th}-8^{th}) and its essential increase in 3-14% (groups 1^{st}-3^{rd}).

According to the offered technique of the research of parameters of CM of the subject of training (pic. 4.9) at the stage of testing of IFPST were diagnosed the vectors of parameters of the physiological (acuity of vision, field of vision and color perception), psychological (the convergent and the divergent intellectual abilities of a trainee) and linguistic portraits (the level of proficiency in language) by means of the applied DM with the use of applied methods, presented in pic. 6.1.

At the stage of the analysis of parameters of the physiological portrait of CM of the subject of training among the contingent of examinees are not revealed subjects with the various anomalies of perception of information of a visual and an acoustic sensory system.

The diagnostics of the values of parameters of the psychological portrait of CM of the subject of training has allowed to reveal the level of development of the convergent and the divergent intellectual abilities, the predisposition of subject to the certain kind of learning ability, perception and processing of information of the certain kind and type.

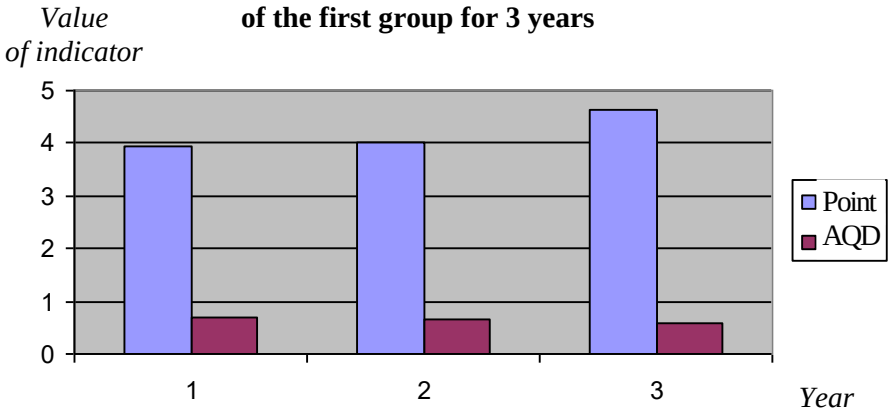
The research of the linguistic portrait of CM is directed on the detection of compliance between the level of a statement of material by the means and the level of proficiency in language of a subject. The statement of information reflecting the content of the subject of studying was carried out in the international foreign English language to the native speakers of the Russian language.

At the stage of the adaptive training was carried out the automated representation of information fragments by means of the adaptive ET, allowing to take into account the parameters of IFPST (CM of the subject of training) and the technical capabilities of the means of training (CM of the means of training). At the representation of the learning material as the main there were used the information-educational influences of several kinds: verbal, tabular and schematic (a plane), at the same time it is admissible the use of audio- and video-streams.

At the final stage there was performed the automated diagnostics of LRKT by means of the basic DM, containing in the own basis two scales of estimation:

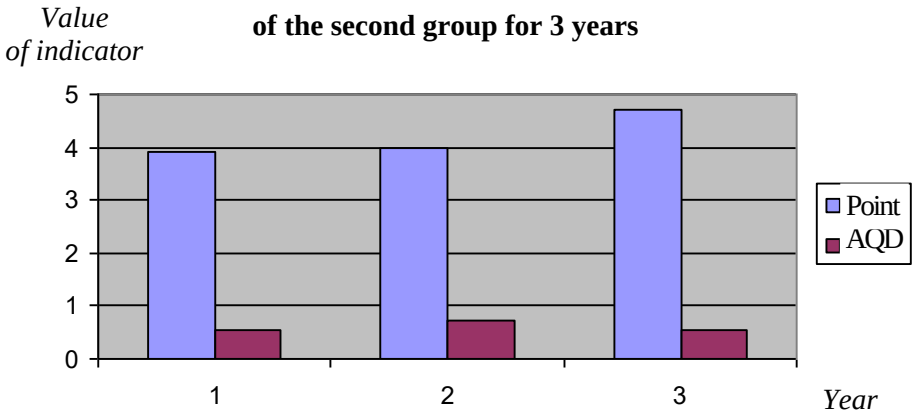
- a standard scale (rough) – allows to define the nominal value of estimation of LRKT on the basis of the sum of correct answers the questions by the examinee;
- a point scale (exact) – allows to determine LRKT on the basis of the sum of the gained points for each correct variant of the answer a question of the method of research (test) by the examinee.

The dynamics of the indicators of resultativity of the training of the first group for 3 years



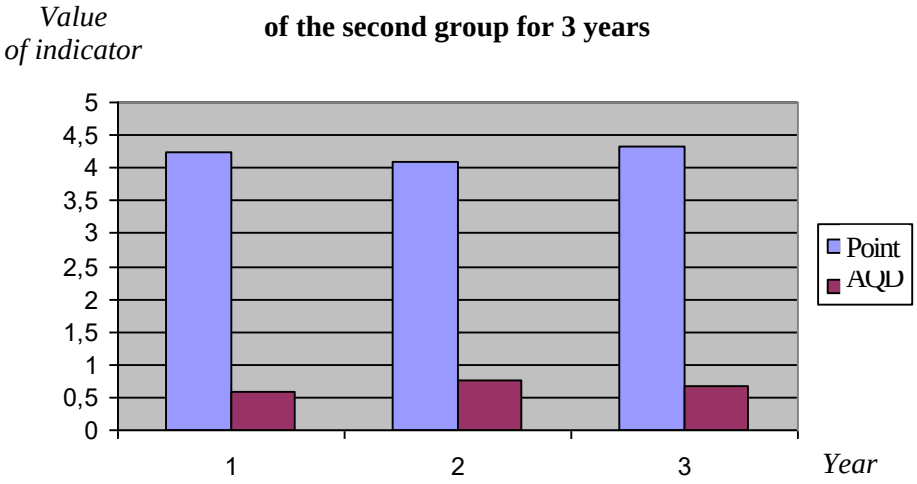
a

The dynamics of the indicators of resultativity of the training of the second group for 3 years

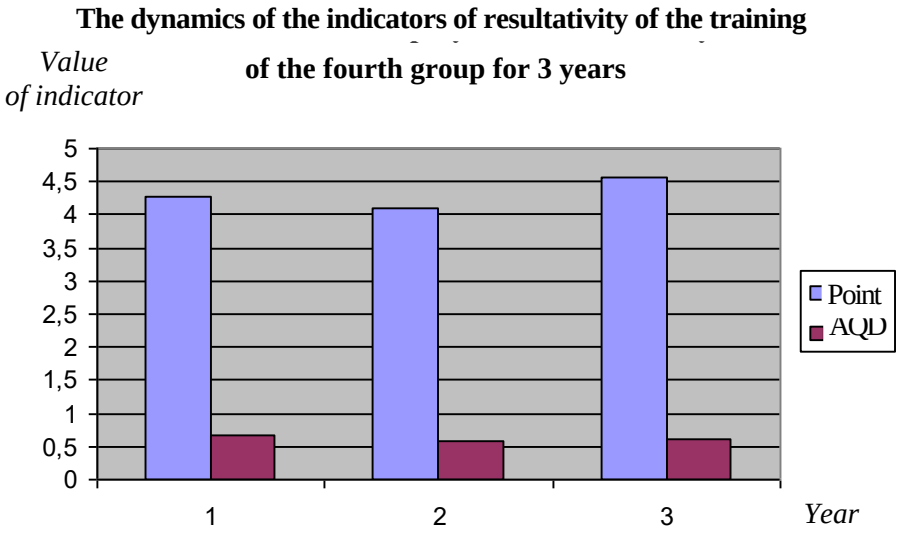


b

The dynamics of the indicators of resultativity of the training of the second group for 3 years



c



d

Pic. 7.12. The dynamics of change of resultativity of the training for 3 years

The received graphic interpretation of the dynamics of LRKT and its average quadratic deviation in the 1st-4th groups of examinees demonstrates about the essential increase of the first indicator and decrease of the second.

The information structure of the subject of studying includes a set of information fragments reflecting the content of sections, modules and pages entering into the description of the subject of training. To each information fragment it is entered in compliance a set of control questions for the realization of procedure of current, intermediate and total testing.

The analysis of answers of the contingent of examinees is realized by means of a set of algorithms and procedures of the analysis of correctness, which are put in the basis of the basic and applied DM. The algorithms and procedures form a procedural basis in the process of the functioning of DM and realization of the automated diagnostics.

The testing of LRKT assumes the use of one from the formed tests on the certain subject of studying, to which are imposed the requirements of validity (substantial), reliability (retest) and consistency.

The existence of the automated class of training, equipped by a necessary set of hardware, software and brainware is the necessary and sufficient condition of the possibility of realization of testing.

The application of various mathematical methods, procedures and algorithms allows to realize the processing of a posteriori data obtained in the course of the automated testing of LRKT by means of the use of the basic DM and diagnostics of IFPST by means of application of the applied DM.

Further the results of the deep statistical analysis of data are presented.

7.9. The results of the regression analysis

The regression analysis of generalized selection of a posteriori data of examinees in all experimental groups was carried out for the purpose of realization:

- for the identification of measure and the importance of connection of the dependent variable with a set of independent variables – the calculation of coefficient of multiple correlation (CMC);
- for the determination of the importance of a contribution of each independent variable to the estimation of dependent variable, and also the elimination of insignificant for prediction independent variables – the calculation of regression non-standard coefficients β;
- for the analysis of accuracy of prediction of LRKT and the probable errors of estimation of dependent variable – the calculation of coefficient of multiple determination (CMD), which allows to explain the share of dispersion of the dependent variable, explained by the variation of a set of independent variables;
- for the estimate (prediction) of unknown values of the dependent variable in advance on known values of independent variables – the record of regression equation taking into account the substitution of the values of independent variables.

As the result of the carried-out regression analysis the received values of coefficient of multiple correlation (CMC=0,558) and coefficient of multiple determination (CMD=0,312) demonstrate, that 31,2% of dispersion of dependent variable Y (estimation of the level of residual knowledge) is defined by the variation of the values of predictors (K_1-K_{45}) of the linear regression model $Y(K_1, \ldots, K_{45})$.

The results of the calculation of the initial (β) and standardized (β') coefficients of the linear regression model *Y* are presented in the tab. 7.19.

Table 7.19

The nominal values of initial β and standardized β' coefficients

Indicator (predictor)	*VOZR*	K_7	K_8	K_9	K_{14}	K_{15}	K_{16}	K_{17}	K_{18}	K_{19}
Initial β-coefficient	-0,006	-0,002	-0,156	0,121	0,064	-0,029	0,006	-0,074	0,025	-0,009
Standardized β'-coefficient	-0,017	-0,010	-0,714	0,611	0,247	-0,104	0,034	-0,262	0,159	-0,052

Table 7.20

The nominal values of initial β and standardized β' coefficients

Indicator (predictor)	K_{20}	K_{21}	K_{22}	K_{23}	K_{24}	K_{25}	K_{27}	K_{28}	K_{29}	K_{45}
Initial β-coefficient	-0,026	0,001	0,035	0,013	0,009	-0,008	-0,111	-0,008	0,032	0,022
Standardized β'-coefficient	-0,147	0,002	0,182	0,052	0,052	-0,113	-0,226	-0,018	0,172	0,037

The nominal value of a constant of the linear regression model is 4,653.

Then it is offered to form the linear regression equation allowing to realize the forecasting of estimates of LRKT proceeding from the combination of the values of parameters of CM of the subject of training, reflecting IFPST.

For the realization of the analysis it is necessary to provide the compliance to the normal law of distribution of the analyzed signs.

The variation of the nominal values of various independent variables exerts the impact on the nominal value of resultant (dependent) variable.

The predictors in the received linear multiple regression model: $VOZR = Age$, $K_7 = P_7^1$ – achromasia, $K_8 = P_8^1$ – protanopia, $K_9 = P_9^1$ – deuteranopia, $K_{14} = P_{14}^1$ – verbal intelligence, $K_{15} = P_{15}^1$ – verbal deductive thinking, $K_{16} = P_{16}^1$ – verbal combinatory abilities, $K_{17} = P_{17}^1$ – ability to reasoning, $K_{18} = P_{18}^1$ – analytical thinking, $K_{19} = P_{19}^1$ – inductive thinking, $K_{20} = P_{20}^1$ – mnemonic abilities, $K_{21} = P_{21}^1$ – plane thinking, $K_{22} = P_{22}^1$ – volumetric thinking, $K_{23} = P_{23}^1$ – associativity, $K_{24} = P_{24}^1$ – originality, $K_{25} = P_{25}^1$ – uniqueness, $K_{27} = P_{27}^1$ – associativity, $K_{28} = P_{28}^1$ – originality, $K_{29} = P_{29}^1$ – uniqueness, $K_{45} = P_{45}^1$ – level of proficiency in national or foreign language of a statement, and as the factor (dependent variable) acts the efficiency (resultativity) of training Y.

Then the linear equation of multiple regression takes the view:

$$Y = 4{,}653 - 0{,}006VOZR - 0{,}002K_7 - 0{,}156K_8 + 0{,}121K_9 + 0{,}064K_{14} - 0{,}029K_{15} + 0{,}006K_{16} - 0{,}074K_{17} + 0{,}025K_{18} - 0{,}009K_{19} - 0{,}026K_{20} + 0{,}001K_{21} + 0{,}035K_{22} + 0{,}013K_{23} + 0{,}009K_{24} - 0{,}008K_{25} - 0{,}111K_{27} - 0{,}008K_{28} + 0{,}032K_{29} + 0{,}022K_{45}$$

or

$$Y = 4{,}653 - 0{,}006VOZR - 0{,}156K_8 + 0{,}121K_9 + 0{,}064K_{14} - 0{,}029K_{15} + 0{,}006K_{16} - 0{,}074K_{17} + 0{,}025K_{18} - 0{,}009K_{19} - 0{,}026K_{20} + 0{,}035K_{22} + 0{,}013K_{23} + 0{,}009K_{24} - 0{,}008K_{25} - 0{,}111K_{27} - 0{,}008K_{28} + 0{,}032K_{29} + 0{,}022K_{45}.$$

7.10. The results of the discriminant analysis

The discriminant analysis of the generalized selection of a posteriori data of examinees in all experimental groups is carried out with the purpose of realization:

- of the determination of statistical importance of allocation of the classes on LRKT;
- of the clarifications of contribution of each variable in the course of the discriminant analysis;
- of the calculation of the distances between the centroids of the allocated classes;
- of the evident interpretation of the differences between the classes of excellent, good, mediocre and poor pupils on the basis of a set of the values of parameters of CM of the subject of training and CM of the means of training essential for the analysis;
- of the solution of the task of classification with the use of the discriminant functions on the basis of a set of received values of CM of the subject of training.

The carried-out discriminant analysis allows to receive the own values of canonical discriminant functions (tab. 7.21) and the chart of relative arrangement of the centroids of the classes (pic. 7.13), selected on the indicator of resultativity of the training, allowing to provide the evident interpretation of the differences between the classes of excellent, good, mediocre and poor pupils on the basis of a set of the nominal values of parameters of CM of the subject of training and CM of the means of training essential for the analysis of efficiency of a formation of knowledge of trainees in IEE of ART.

The received canonical discriminant functions are presented in the tab. 7.21.

Table 7.21

The own values for the canonical discriminant functions (Eigenvalues)

Function	Own value	Share of dispersion	Saved-up dispersion	Correlation
1	0,493	52,8	52,8	0,575
2	0,441	47,2	100,0	0,553

The informativity of the presented canonical functions is approximately equal.

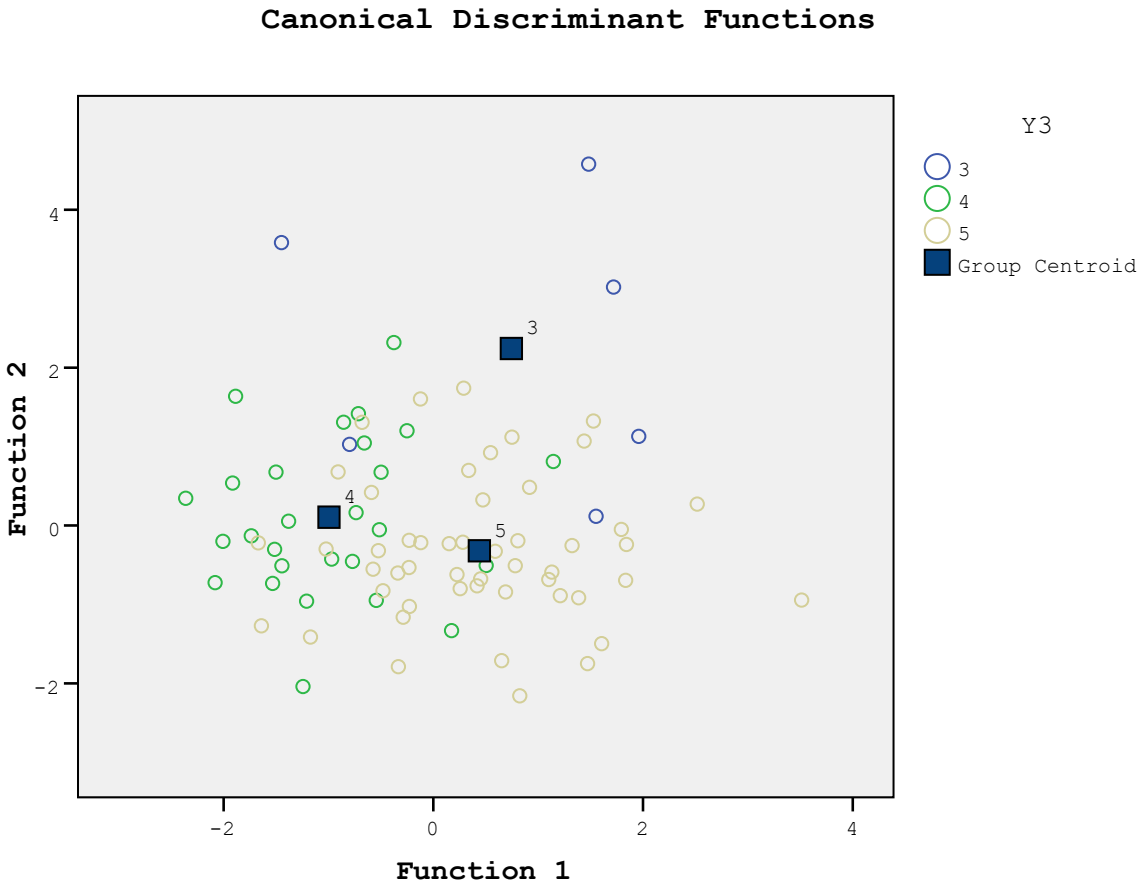
The standardized coefficients of the canonical functions (tab. 7.22) allow to define the ratio of the deposits of variables into each of the canonical functions.

Table 7.22

The standardized coefficients of the canonical discriminant functions

Indicator		*VOZR*	K_7	K_8	K_9	K_{14}	K_{15}	K_{16}	K_{17}	K_{18}	K_{19}	K_{20}	K_{21}	K_{22}	K_{23}	K_{24}	K_{25}	K_{27}	K_{28}	K_{29}	K_{45}
Function	1	0,435	0,321	0,938	0,996	-0,225	-0,371	-0,091	-0,600	0,505	-0,305	0,137	-0,213	0,517	-0,106	0,710	-0,408	-0,259	0,177	-0,276	0,145
	2	0,295	0,211	1,195	-0,942	-0,695	0,038	-0,136	0,273	-0,097	-0,052	0,445	-0,129	-0,152	-0,191	0,284	0,043	0,409	0,147	-0,588	-0,008

The graphic interpretation allows to analyze the received canonical discriminant functions and visually to estimate the quality of classification by the density of the distribution of the objects inside each class and by the conditional border between them.



Pic. 7.13. The chart of distribution of the centroids of classes in the space of canonical discriminant functions

The statistical analysis of a posteriori data received in the course of practical use of the results of the research in the learning process of “SPbSETU "LETI"” and “IBI” allow to make the following conclusions:

- the effective use of CMT in the automated IEE assumes the modification of IEE of ART and the modernization of electronic means of training and TMM;
- the degree of influence of the parameters of CM on the efficiency of training depends on the contingent of trainees and has the individual character;
- the increase in efficiency of the formation of knowledge of trainees with the use of CMT containing the algorithms and techniques is defined by the capabilities of means of IEE, the content of ET containing the structured information on the cycle of disciplines is adequately to the purposes of training, varied according to the algorithms in the basis of the various components, techniques, learning plans and working programs.

In detail the results of the mathematical processing of a posteriori data by means of the use of the admissible various statistical methods are presented in the report on the individual initiative SRW of the author.

Conclusion

As the result of the carried out scientific research there was carried out the analysis of the theoretical provisions of creation and principles of functioning of the adaptive and intellectual means of training in the basis of the automated information environments of EEs, and also the problematics of their introduction, practical use and support.

There was developed the structure of environment of the automated training with the properties of adaptation based on the parametrical CM of the subject of training and CM of the means of training.

There were presented the modifications which are subject to the implementation on the relation to the organization of IEE and the technology of formation of knowledge of the contingent of trainees for the subsequent realization of a contour of adaptation in ART system based on PCMB allowing to take into account LRKT and directly the row of IFPST.

There were presented the physiological, psychological and linguistic aspects of information interaction between the subjects and the means of IEE of ART system.

There were revealed the factors (parameters of CM), having the significant effect on the efficiency of the formation of knowledge of trainees in IEE of ART system.

There were developed the principles (algorithms) of functioning of the main components of IEE of ART system (ET and DM), and also the adaptive representation of information fragments processor, allowing to realize the automated individually-oriented training of the contingent of trainees.

Among from the received scientific and practical results are distinguished: CMT, including a set of techniques and algorithms; PCMB, including the structures of CM of the subject of training and CM of the means of training; the complex of programs, containing the adaptive means of training (ET), the basic DM and the applied DM, which were developed in the course of my dissertation research.

There was developed the methodical support of the discipline “Computer science”, including the textbook, course of lectures, examination cards, practical tasks and three methodical instructions to the laboratory works. There was carried out the practical use of the scientific and practical results in the learning process of “IBI” and “SPbSETU "LETI"”.

As the practice has shown, the point scale of estimation in the basis of the basic DM significantly increases the accuracy of diagnostics of LRKT, which increases with the increase of a quantity of questions with a set of correct variants of answer. At the same time it is considered the choice of incorrect variant of answer by the examinee (there is formed the sum of penalty points) and it is provided the display of explanation.

There were published and presented the works in the materials of the conferences of the various level, scientific articles and monographies, which have formed the basis of a doctoral work.

There was carried out the statistical analysis of a posteriori data, confirming about the degree of the influence of some factors on the efficiency of the formation of knowledge. There was revealed the dynamics of resultativity of the training of the contingent of trainees for 3 years.

There was formed the equation of regression, allowing to provide the forecasting of resultativity of training taking into account the parameters of CM of the subject of training and CM of the means of training.

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“The environment of automated training with the properties of adaptation
based on the cognitive models”

The specialty 05.13.01 – “The system analysis, control and information processing”
(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)

The dissertation

on the competition of scientific degree
of the candidate of technical sciences

Editors: Kvitko A.N. and Egorov N.V. Translator: Vetrova E.I.

Accepted to printing __.__.__ Format 60×84 1/16.
Paper offset. Printing digital. 17 pr. sh.
Type of font “Times New Roman”. Circulation ____ copies. Order №____.

It is printed from the ready original-model (dummy) of the customer
in “The publishing house of "SPbSU"”
RF, 199034, Saint-Petersburg city, Universitetskaya emb., h. 7-9.