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Distance Learning: Modern Approaches to Engineering Education

Boris Kruk and Olga Zhuravleva

*Siberian State University of Telecommunications and Information Sciences
Russia*

1. Introduction

Pedagogy, as the science of education, learning and human development, originates from the ideas of Demokrit (460 BC -370 BC), Socrates (469 BC–399 BC), Platon (427 BC -347 BC) and Aristotle (384 BC - 322 BC). Erasmus Rotterdamus (1465 - 1536) is considered the first educator and John Amos Comenius (1592 - 1670) is the founder of didactics. Until recently classical pedagogy has dominated in education. Classical pedagogy based on didactic of John Comenius when a teacher being the bearer of a great volume of systematized information conveys this information to a student and the student has to master this considerable volume of knowledge.

In recent years due to globalization of the world labor market and increased competition in all fields of economics and business, the development of a new system of education has become a very important issue. This new system must respond to challenges of the present and rely on modern pedagogic technologies, up-to-date means of learning process informatization and network models of learning. Starting from the end of the 20th century to the beginning of the 21st century classical pedagogy has been replaced by pedagogy implementing a new paradigm of education, which is oriented on an individual and meets ideas of humanization in education (Savery & Duffy, 1995; Jacobson et al, 2006)

Rapid development of the Internet and multimedia has given a strong incentive to the creation of a new pedagogy and new pedagogic technologies. Today one can have the Internet access from anywhere in the world. The use of the Internet and multimedia technologies in education is becoming more and more popular among the majority of population. The advantages of computer- or web-based education over traditional classroom education include the ability to: study while at work, remain in one location with no need to travel; plan own training, attend courses across physical, political, and economic boundaries. In turn, higher education institutions obtain modern educational tools at their disposal. Distance-learning, e-learning and m-learning provide individualized learning, individual oriented approach and humanization of learning.

The modern educational paradigm provides the following important aspects. It requires the establishment of new subject-object relations between students and teachers who are involved in learning process provided that self-directed, personal-oriented and student-centered teaching methods are used. It becomes necessary to consider pedagogic value and

pedagogical usefulness of electronic educational environment. It also requires alterations in information interaction between students and teachers in new educational environment.

This chapter presents some important aspects of modern approaches to engineering education. The Section 2 describes the model of the network educational system, based on the Internet technologies, and learning process maintenance system with its support by automated subsystems. The Sections 3.1 and 3.2 describe issues of management of students' learning-cognitive activity by means of introduction of self-directed learning (SDL), specify the cognition process as an iterative process of obtaining new knowledge and introduce dynamic training elements (DTE) designed on the principle of the cybernetic model of cognitive process. The Sections 3.3 and 3.4 demonstrate the usage of remote access laboratories and analyze issues of pedagogic value and pedagogical usefulness of electronic educational environment. The Section 3.5 discusses issues of information interaction between students and teachers in new educational environment. The section 4 suggests the new method of quality evaluation of distance learning process. The section 5 contains conclusions and discussions. In the Appendix the best practice of applications of modern approaches to engineering education is described.

2. Distance learning technologies and maintaining process

2.1 Model of educational system based on the Internet

The principal participants of distance learning process are students, teachers-tutors and managers of an educational process. Using the Internet-technologies students can be in any corner of the Earth and have access to information resources of the university via a global network. Also teachers are not obliged to work with students, being in the university building. Nowadays one may have an access to the Internet from one's home, a car, while on board a plane etc. The necessary condition for organization of the Internet-training is availability of a Web-server, a database and a management system of training at university. In order to organize the network training activity via the Internet three conditions should be met: creation of information-educational environment, organization of feedback between students and teachers and management of training process (Day & Foley, 2006; Sakkopoulos et al., 2006; Spoelder, 1999).

Fig. 1 shows the model of the network educational system in the form of a cube with network technologies, based on the Internet channels, incorporated into its foundation. The second layer of this cubic model presents information technologies implemented in the Internet. At last, the third layer of the cube and its top presents to the educational technologies incorporated in the triune educational system that includes electronic educational environment, means for information interaction and means for management of training process.

Internet channels and such tools of information technologies as hypertext, multimedia, Web-servers; transmission facilities in the form of e-mail, teleconferences, file transfers; software for PCs stand for basic elements of a distance educational system in the cubic model on fig. 1. Basic elements of the educational system such as electronic teaching materials forming the educational environment; communication means used for contact and control of knowledge; management facilities of training process including database management system, automated workplace of the teacher, electronic dean's office are created on the basis of didactic properties and functions of initial elements.

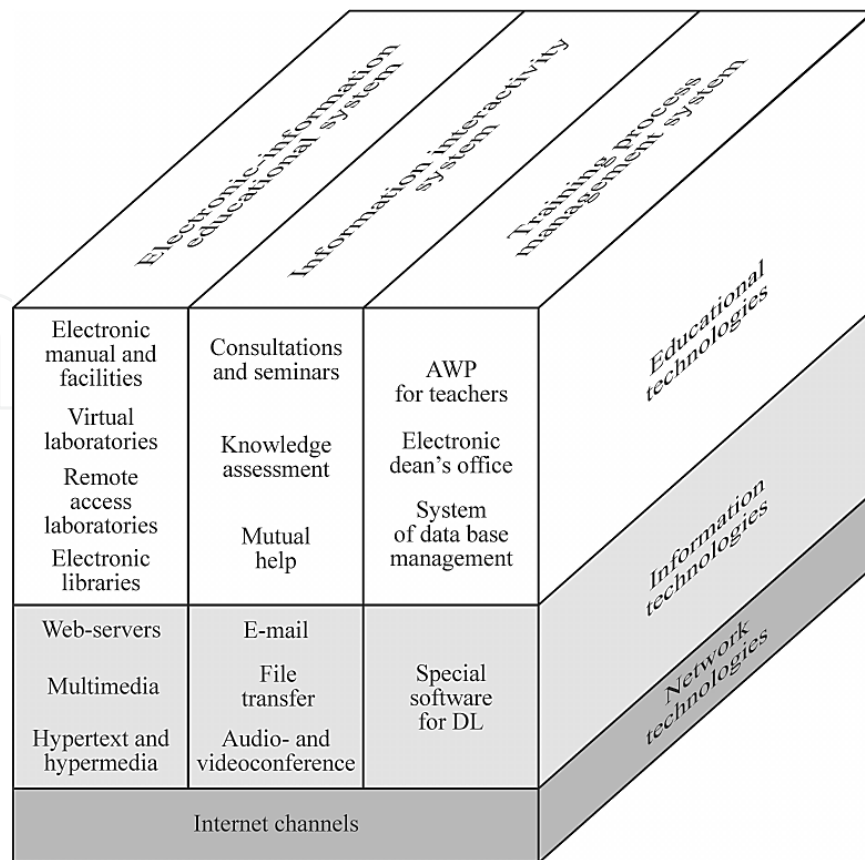


Fig. 1. The model of the network educational system based on network information technologies.

2.2 Learning process maintenance

To provide of the Internet-training process organization and its management, a corresponding environment should be created: organizational-administrative maintenance; technical maintenance; methodical maintenance; marketing maintenance; legal maintenance; financial-accounting and economic maintenance (fig. 2).

The important elements of training process organization are preparation and constant updating of an educational material on a Web-site. It should meet the requirements of self-sufficiency (i.e. to contain all necessary for independent studying), interactivities (i.e. to provide the maximal information interaction between a trainee and an educational institution), availability (i.e. to give an opportunity of access to any available resources), motivation (i.e. to interest a trainee to work with a material), multimedia (i.e. to use the text, figures, sound, animation, video, etc.). All this demands greater time inputs for performing functions of the control over preparation and updating of an educational material.

Development and administrative support of a database plays a significant role because the number of trainees can reach several thousand persons, the number of disciplines can change from several tens up to several hundreds. The duty of the personnel, engaged in training process planning, includes drawing up curricula of courses, schedules of study, timetables of tests and examinations, i.e. preparation of all planning documentation without which a training process is impossible. Preparation of curricula, schedules, timetables can be

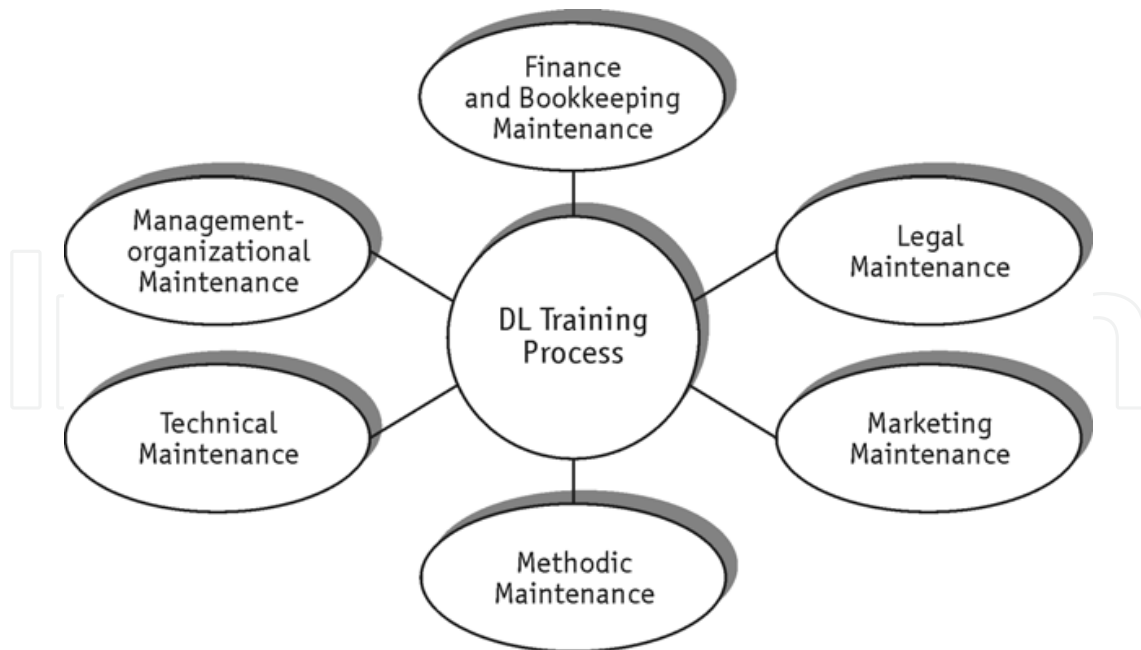


Fig. 2. Organization of the Internet-training process.

done manually by the personnel or by means of various automated tools. In any case all necessary documents should be placed on a Web-server available to various categories of users.

The primary means of public communication is a forum. Unlike the electronic bulletin board, which is an unidirectional means of communications, a forum, as well as an e-mail, make it possible to organize public communication. A trainee can ask any question and receive appropriate explanations. Distance learning based on telecommunication and information technologies needs serious technical support. Availability of a local network and several servers in leads to the necessity to administrate of a network and servers. It means that it is necessary to exercise the complex of technical and organizational activities on support of viability of a network and servers and maintenance of their normal operation. It is well known that the main carrier of the educational information is the Web-server. Web-pages containing a teaching material and information needed to organize a training process should be created and function on the Web-server. Lest the information become outdated on the Web-pages, it should to be updated constantly.

To organize an electronic testing, it is necessary to develop the program shell which would make possible to enter and change the contents of tests easily must be developed, in which it is possible to put. Such program shell make it possible to check tests by means of automated supervising programs located on a server, and handled without participation of teachers in this process. The main concern of teaches is to follow up-to-date information technologies. However, in real life the situation is warring: a great number of teachers has never used the e-mail and never or very seldom worked in the Internet. Some of the teachers do not know how to use a computer. It is a rather serious program and it can be solved only by teachers' practical training. The keystone to success in the organization the Internet-training is a constant methodical support of training process, permanent training of teachers' and exchange of experience between teachers.

Educational services in the Internet-training system are chargeable, as a rule. Thereby educational institutions put their production on the market of educational services. These are the basic steps of marketing activity aimed at a the final goal: to admit students, course participants, named afterwards trainees, to the educational institution and sign study contracts with them.

The educational institutions with a wide network of branches, and as result, a great number of students, faced serious problems at early stages of distance learning introduction. It was necessary to cope with processing of plenty of documents by limited staff effort. It was not easy to monitor the training process on a regular basis and to track the fulfillment tasks done by each student who followed individual schedules of training. Thus, the process of distance learning administrating required automation. The characteristic of a program complex "the electronic dean's office" is availability of various subsystems.

Subsystem of user authorization identifies the process of the users work with the Internet-training system. It checks the entered name and the password of a user and allows viewing the information. The block of authorization forms only that information which is needed for a particular user (administrator, student, teacher). It is aimed at facilitating user's work.

Subsystem of user access rights' assignment is meant for the system administrator. It allows the administrator to adjust the level of access to information resources for each particular user. Access to the given block is provided only for the exclusive users having the rights of the administrator. To get an access to the closed parts of the Web-site the passwords are needed. They are assigned automatically by means of *the subsystem of users' passwords assignment*. To create passwords special algorithms similar to encoding ones are used. It is done to get reliable means of the information protection.

Subsystem of input and editing information about students has the name "Student". Using this system, the administrator can enter and edit all necessary information about students: personal data (First, middle and last names, date of a birth, address, phone, E-mail), education background (the name of the educational institution one graduated from), place of employment (name of an enterprise, address, contacts).

Subsystem of input and editing of teachers' data has the name "Teacher". Besides a surname, the first name and patronymics of a teacher, his/her contact data (phone, E-mail, etc.), the list of the disciplines supervised by the teacher and codes of student's groups are placed in the database. The administrator is the user of this subsystem.

Using the subsystem of the students' progress' record, the administrator can enter and edit the data: about current and final progress of students; deadlines for submitting the tasks to the teacher to be check; timetables of tests and examination; examination and tests results, and also terms and results of final tests and examinations. This subsystem has the name "Progress".

Subsystem of teaching load's record is used to count the amount of tasks done by students the teacher has checked , their the group code, names and disciplines. A similar subsystem demands storage of files with students' works and files with teachers' reviews. It is worth mentioning, that not all institutes of higher education dare adopt the automated teaching load account. The administrator and the teachers are the users of this subsystem.

Subsystem of curricula's revision gives an opportunity to edit the list of disciplines studied in every semester on all specialties of distance learning, to establish all kinds of studies on each discipline, to connect each studied discipline with certain teachers. For users' convenience the search engines and filtrations of the information are built in the subsystem. The administrator is the user of this subsystem.

Subsystem of reports' generation serve to get such reports as: lists of students in groups, the information showing progress of each student in group and in subject and etc. This subsystem include a search engine and filtrations of the information which help to find and filter an information about particular student progress easily and quickly. The administrator and the teachers are the users of this subsystem.

3. Modern approaches to engineering education

3.1 Management of students' learning-cognitive activity

Human need to explore the surrounding world makes an individual to learn lifelong. Educational need includes two components: need to receive information and need to explore the surrounding world, which are not one and the same. Satisfaction of information need relates to obtaining and use of information, but satisfaction of cognitive need relates to obtaining and use of knowledge. Analysis of the information - knowledge correlation allows one to understand that information activity of an individual relates to his/her perception and use of this information in the process of communication, while cognitive activity means creative activity, which is aimed at obtaining new knowledge. The formation of the subject's or the student's thesaurus results from the activity aimed at meeting the information and cognitive needs. An individual has to direct his/her learning-cognitive activity.

A self-direction of student's learning-cognitive activity has become important since internet-education, distance-learning, e-learning and m-learning came up. In these models of education a student is to become a true subject of a learning activity and at the same time a student is to remain an object of a teacher's control. A student, as the subject, should form his/her learning-cognitive activity, but this activity is to be realized within the framework of a model developed by a teacher. The key role of the modern learning process is assigned to a student personality, which in the process of learning-cognitive activity is considered on one hand as the object of the teacher's control and on the other hand, as the subject capable of self-direction. Initially a teacher is a directing subsystem while a student is a directed one.

The goal of Self-Directed Learning (SDL) is to develop a student personality when he/she acquires knowledge in the particular subject field. Personal development means step-by-step action from learning under the teacher's control to self-directed learning and from SDL to self-learning. As a result abilities for self-education, self-discipline and self-developments are formed. The essence of SDL is that a teacher should direct the process of a student's self-learning activity formation (Ellis, H.J., 2007; Splitt, F.G., 2003).

The concept of SDL is based on subject-object relations in the process of training-informative interaction. When distributing subject and object roles a criterion of subject - object information interaction should be taken into account. Activity analysis implies ascertainment of activity source, its direction and who it is aimed at. To whatever extent the

student's initiative is demonstrated, the student's need in obtaining learning information will not be satisfied, if there is no source of information or no bearer of information, i.e. the teacher. Since the organizer of a learning process is a teacher, the teacher may be considered as the subject of a learning process. In this case the student acts as the object of a learning process, for his/her sake the subject starts producing information.

The term "interaction" implies counter activity: actions like "object-subject". The moment of interaction happens when the subject, who conveys information, receives information about the object's state via feedback channels and, what is most important, the subject learns of the changes, which occur in the object at the end of interaction. The feedback allows the teacher to improve methods and means of teaching.

Learning and education mean control of human knowledge. Mechanism of learning and education is subject-object relations in info-interaction. The goal of learning and education is to teach an individual to solve nonstandard problems, which require unconventional approach. In turn, students are supposed to have high level of intelligence and abilities to think independently. The main objective of any learning is to form student's intelligence and prepare the student to a certain intellectual (professional) activity. Intelligence cannot develop out of info-interaction. The analysis of subject-object relations shows that this activity is based on the following circumstances. Cognition process occurs due to specific mechanism which is termed information interaction. Info-interaction rests on subject-object relations established between the subject (teacher) and the object (student). An object's activity depends on a subject's activity: a teacher may reduce student's cognitive interest or on the contrary, develop a student's interest to the level on which high intellectual abilities are formed. If there is a feedback channel from an object to a subject, the subject can improve the object's learning-cognitive activity and create conditions for SDL.

When the conditions needed for SDL are created, the most essential thing for an object is his/her ability for self-direction, self-control, self-education and self-development. In this case, the student is transformed into a true subject of learning-cognitive activity; furthermore activity of the student's information interaction is considerably increasing. Only an active person proving to be an individual in learning and influencing the whole learning process and progress in learning may act as the subject of learning-cognitive activity.

One of the major problems for teachers is to create an educational environment that allows students to direct their own learning-cognitive activity (Garofalakis et.al., 2002; Gick & Holyoak, 1987; Glaserfeld, 1989). Self-directed learning assumed particular importance at the time when on-line learning came into existence (Evans & Sabry, 2003; Dearholf et al., 2004). According to the theory of self-directed learning, a student builds his/her own learning and cognitive activity within the framework of the model developed by the instructor (Petridis et al., 2003; Spoelder, 1999).

3.2 A cybernetic approach to cognitive evolution: the DTE model

As an example one of facilities to implement the self-directed learning process in the on-line course using dynamic training elements (DTE) have been designed on the principle of the cybernetic model of cognitive process management (Bannan-Ritland, 2002; Krouk & Zhuravleva 2009). With DTE introduced into the learning process students can direct their

own learning process. Used in on-line learning, students learn to solve practical problems faster, to understand the theory much better, than they do when they solve the standard problems and do the usual exercises offered in the standard circuit theory course. The use of DTE as a supplement to the regular classroom setting may improve this situation by creating a self-directed learning environment and achieving the goal of adaptive learning (Bannan-Ritland, 2002; Hsiung, 2006). Self-directed learning with DTE is a person-oriented and student-centered teaching method. Heidi J.C. Ellis points out (Ellis, 2007) that SDL allows students to determine their learning requirements and goals, to select resources to achieve these goals and to assess the results of the learning process.

Some terms should be defined before proceeding further. Imagine that a student performs multiple actions aimed at changing certain qualities of the object or environment of interest, and every time receives an external correction of his or her actions. Consequently the student reacts to this information coming to his or her brain. The process of formation of the student's reaction based upon his/her own multiple actions and the external corrections can be named the *learning process*. The external correction can be made by the instructor (or the program) who knows what the desired reaction from the student should be. Thus in the learning process the student is provided with additional information as to whether the reaction is right or wrong. If there is no external correction of the student's action, i.e., if the student is not provided with additional information whether the reaction to the change of the object or environment qualities is right or wrong, then this cognition process can be termed *self-learning* (or learning without an instructor). The formation of the student's knowledge by cognitive evolution is considered to be the primary goal of the self-learning process.

The process of a student's cognitive evolution based on the accumulation of incoming information to the low initial level of a student's knowledge is called the process of a student's adaptation to a studied course-material (Gick & Holyoak, 1987). Thus, the most typical feature of adaptation consists of accumulation and immediate use of incoming information aimed at increasing a student's current level of knowledge. When information is continuously delivered to a person, a certain reaction is developed to incoming signals. This is a way of the person's cognition of the environment formation. The method of cognition is based on the method of trial and error. Multiple trials and external correction of these reactions results in evolution of cognition. This evolution is the process of the student's adaptation to the environment.

The cognition process is an iterative process of obtaining new knowledge. In the initial cognition stage the student has to estimate unknown parameters of the process or the environment. For this purpose the information received in the previous supervision should be generalized. The induction is a creative stage of scientific cognition. Various hypotheses are forming in the student's head. When a certain hypothesis is chosen the transition to the next stage of scientific cognition - hypothesis checking - occurs. It is the next iteration. Each iteration brings benefit. When the number of iterations is increased it becomes possible to create the best hypothesis. As the information about the process or environment increases, the probability, that each subsequent estimation or hypothesis would be confirmed, grows. Essentially, the sequences of hypotheses, which have already been confirmed by experience, can promote generation of a new hypothesis. Each successful hypothesis repeatedly succeeds the research. Iterative processes are inherently evolutionary and make possible to

reach consecutive movement to the purpose. The combination an inductive conclusion and method of trial with the subsequent check of hypotheses leads to the increasing conformity of hypotheses to the logic of process and provides better "understanding" of environment.

If the logic of scientific cognition described above is put in the cybernetic model, it becomes possible to realize all private and global aims of training sequentially - formation of a trainee's thesaurus and his/her intelligence. While training it is more preferable to study processes or environment by means of simple models. The easier studied models the higher their value for training. It means that, when forming dynamic frames in the cybernetic model of training, it is needed to represent processes or environment being studied in the form of set of simple models as far as possible. Such rule is justified by the fact that for simple models require the smaller number of iterations to draw an inductive conclusion, in comparison with complex models. Due to this fact the probability of search of the proved hypotheses raises. This principle known under the name «Occam edge» originated in XIV century and passed the test of time. It should be emphasized, that the inductive cognition demands addition of new information. This new information must distort the previous one about the process or environment minimally. It is important when managing a trainee's self-learning process by means of cybernetic model.

The definitions cited above agree with psychology-pedagogical researches of the human cognitive process. In order to clarify how the DTE written in this chapter differs from many other training programs, let us observe behavior of a child taking their first steps. How does this child form his/her knowledge of his/her environment? As information from the external environment repeatedly influences the child's brain, an intelligent reaction is developed to incoming signals. In the case of the child, the "trial and error" method is the method of cognition. Multiple trials done by the child, and the constant correction of his/her reaction, lead to the goal - the child's cognition has evolved. This training approach and the ensuing cognitive evolution is natural for a human. The highest phase of this process is when a person based on current observations, forecasts the behavior of the object of interest for a future, not yet happened moment. This point can be called the phase of knowledge formation.

Teenagers playing videogames learn extremely rapidly as they play. At a heuristic level, teenagers deduce the logic of game and its rules by using only a single method of cognition - the method of trial and error. Within several minutes they can easily predict the behavior of any object on the screen; this process is an example of the evolution of cognition as the result of self-directed learning.

The principle of DTE stimulating the above processes of *self-learning* and *adaptation* can be presented by the cybernetic model of interaction between a student and a computer program shown in Fig. 3. The central link of the learning element is a dynamic self-learning frame, being created on the monitor display. The frame displays the properties of an object designed on the basis of the mathematical model of the object or on real properties of an object, connected to a user's PC via the Internet.

A student, considered in this case as a subject of management of his/her learning-cognitive activity, has an opportunity to change the parameters of the object or environment at each iteration and thus to operate the dynamics of the learning frame. As mentioned above, the basis of the cybernetic model of the DTE is a dynamic self-learning frame, the dynamic state

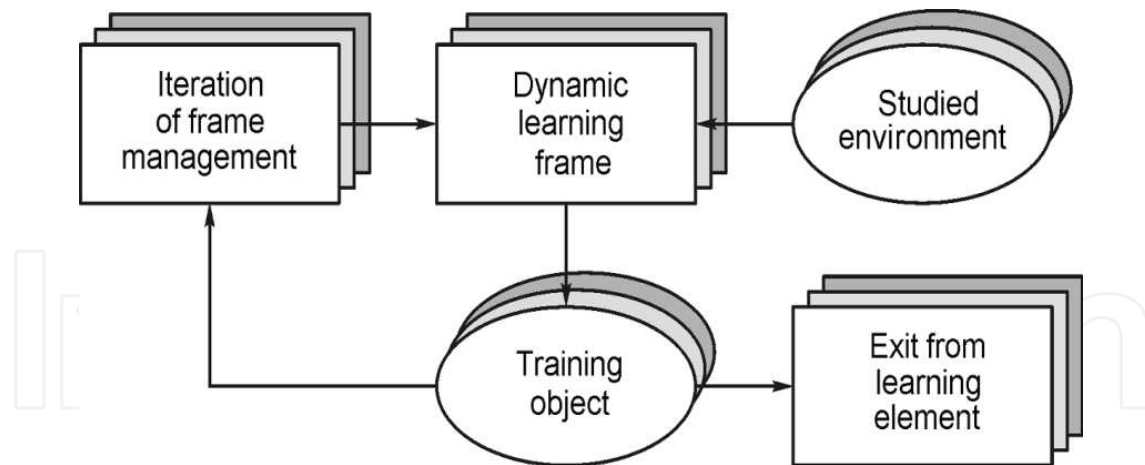


Fig. 3. A cybernetic model of self-directed cognitive process in the dynamic training element with a self-learning dynamic frame.

of which is changed by a student as he or she iterates the parameters that control dynamics of the frame. The major feature of this model is feedback between the subject of management (the object of the training) and the dynamic self-learning frame. When using such a model, the basic process of self-learning takes place by accelerated evolution of the student's cognition. Availability of feedback in the model provides easy application of the method of trial and error, which results in a transition to the top stage of cognition - to the prediction of the dynamics of the object being investigated for the next iteration of the operating parameters. This process leads to the student's heuristic awareness of laws, concepts, and the like, being incorporated into their structured, formal knowledge. It should be pointed out, that the process of self-learning with a cybernetic model is very individual and does not fit set time frameworks. As seen from Fig. 3, the student operates the process of cognition independently, choosing parameters of management that are convenient only to him/her, and spending as much time, as he/she needs to complete self-learning.

The dynamic training element with the self-learning frame, created on the basis of the cybernetic model of self-learning, qualifies the same didactic requirements as other training elements. A training element should reflect an independent and completed portion of the material and should have its own menu. This element should contain some fields in the dialogue window which would make it possible to keep up a dialogue with the student. The dialogue should be an option available to the student. The form in which the self-learning dialogue is conducted should imply that the student has the priority in decision-making. A learning element with a self-evaluation dynamic frame to evaluate progress in training is shown in Fig.4. To do this the self-learning frame is replaced by the self-evaluation dynamic frame.

The idea behind the new element is the following. The student has to examine the object or environment and enter the results of his/her research into the computer. Then the achieved level of cognition of the object is displayed on the dynamic frame, giving the student the opportunity to evaluate his/her self-learning process, and to correct the input. It might seem that this dynamic element of self-evaluation is the same as existing knowledge control programs, which point out any error in the answer, and suggest trying again (Dearholf et.al., 2004; Petridis et.al., 2003). The crucial difference, however, is that in this learning

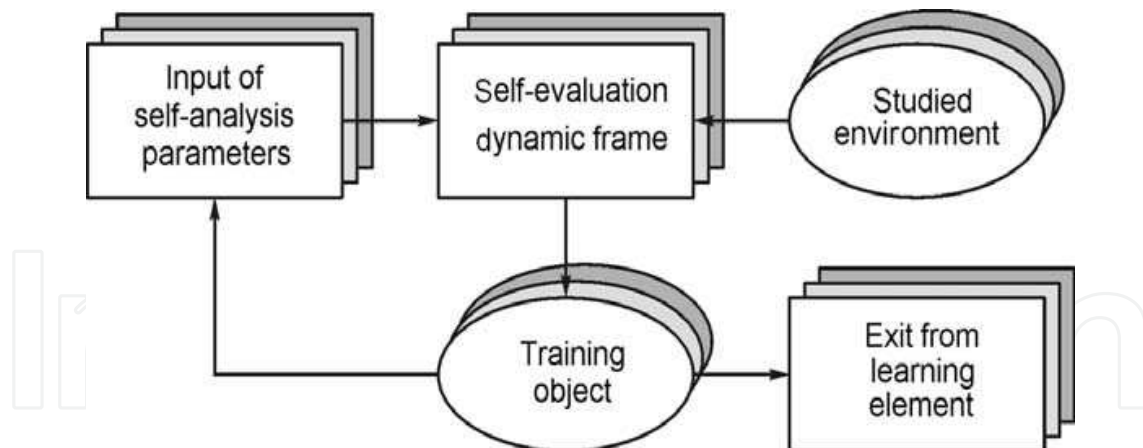


Fig. 4. A cybernetic model of the self-analysis process management in the dynamic training element with a self-evaluation dynamic frame.

element there is no such program which judges whether the object, its properties and the behavior have been correctly described. There is no "teacher". The student's actions are evaluated not by the program, but by the student himself/herself. The student can see the results of his/her actions and the reaction of the object (or the environment) to the student's actions simultaneously. If the student is not satisfied with the reaction of the object (or environment), he or she corrects the actions, i.e., enters new parameters until the desired state of the object (or environment) would be achieved. The student's evaluation of the accuracy of his/her actions is a continuation of the self-learning process.

3.3 Remote access laboratory

At present time real experiments in a laboratory for an analog and digital electronic course are very often replaced by computer simulation by using special software for training. However, to train qualified engineers a skill for real physical process investigating with real equipment is needed. Computer simulation can only expand the experiment, but cannot replace it. In the distance form of education additional difficulties of organizing carrying on laboratory works on real equipment arise. In this case the installation for carrying on laboratory works fundamentally differs from traditional one – a student has to have a laboratory in domestic conditions. One of new guidelines creates an automated laboratory with remote access (Bohne et al., 2002). In this case, device controls and indicators are located on the screen of the student's personal computer, which is connected to the Internet. To provide executing of laboratory works with a remote access the test bench must be available, i.e. supplied by modern equipment and controlled by computer via the Internet (Borisov et al., 2006). This test bench can be located at a campus research laboratory, or at a research institute, or at an enterprise. It allows studying modern devices, systems and networks, which are difficult of access even in the internal form of education. Another advantage of this technology is the possibility of multiple students work with one test bench simultaneously. Installation flowchart for a laboratory is represented on Fig. 5.

Installation consists of a server connected to the Internet, DAQ device, multiplexer, and studied circuits. The server is connected to the NI-6008 module which is an inexpensive DAQ system produced by National Instruments. The module is connected via USB interface.

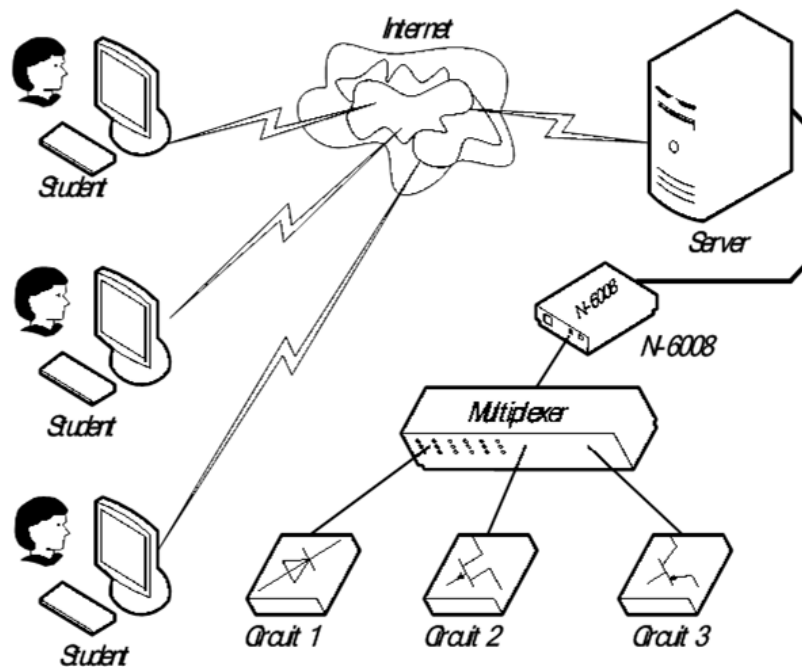


Fig. 5. Laboratory installation flowchart.

It is represented by 8-channel 12-bit ADCs, 2 DACs, and 12 I/O lines. The research circuit assembling is done by a multi channel switchboard (analog multiplexer) which is controlled by DAQ's digital I/O lines. When the student chooses certain laboratory work to execute, commutation of corresponding ADC inputs and DAC outputs occurs giving a possibility to research circuit. DAC is used as software controlled power supply, and ADC measures voltages and currents at necessary circuit points. Let's take a look at the laboratory installation elements interaction by the example of measuring semiconductor diode characteristics. The student runs special client software on his computer.

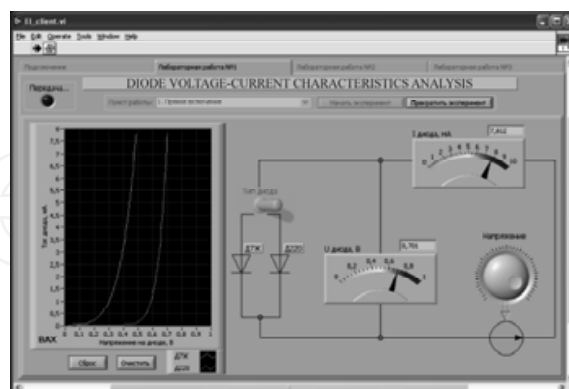


Fig. 6. Diode voltage-current characteristics analysis window.

In this menu the student types the server's name (www.leso.sibsutis.ru) which test bench is connected to, his name, last name, and group number. Then he chooses laboratory work no. 1. As a result a window with diode voltage-current characteristics analysis appears (Fig. 6). By means of the switch one of diodes (siliceous or germanium) is connected to the measuring circuit. In this case, to the remote test bench the real corresponding diode is

connected. Then the student turns a power supply regulator knob and observes voltmeter. At the same time the voltage-current characteristic graph is plotted automatically. To compare the characteristics of two different diodes it is possible to plot both their graphs on one screen. Then the student copies of the experiment result to his report.

Fig.7 represents the laboratory work window to analyze bipolar transistor characteristics. In this circuit two adjustable power supplies are used. Supply E_b sets constant base current. When supply E_c changes, one characteristic graph is plotted. To measure the family of characteristics several constant base currents should be set in series.

One of the important advantages of the suggested technology is ability to research temperature influence on transistor output characteristics. In this laboratory installation an ability of circuit analysis on alternating current in real time is provided. Examples of such laboratory works are represented on Fig. 8 and 9. Fig.8 represents the window of FET amplifier analysis. This circuit allows visually analyze gate bias voltage influence on amplifier's nonlinear distortions. Fig. 9 represents the window of half-wave diode rectifier analysis in time domain.

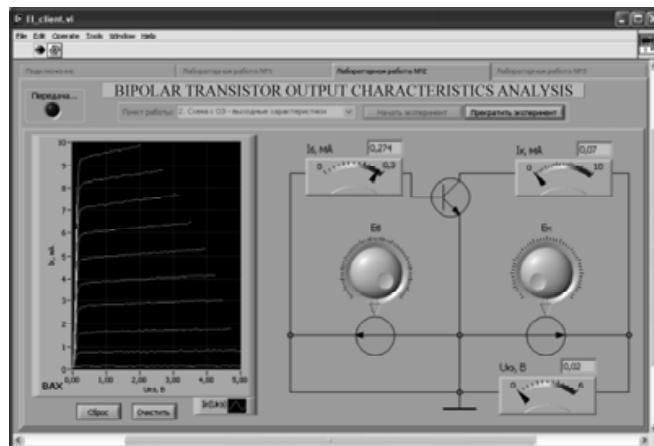


Fig. 7. Bipolar transistor output characteristics analysis window.

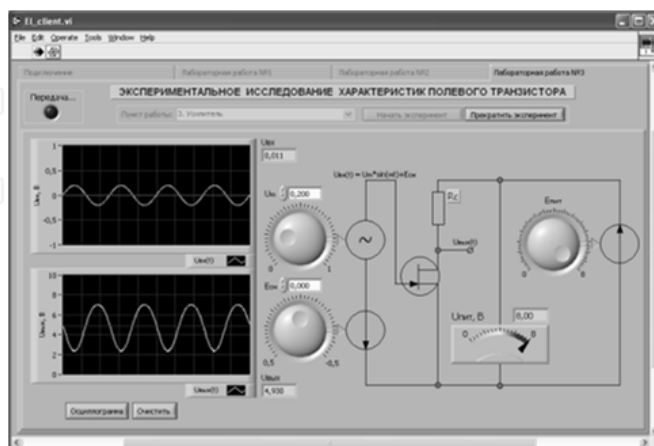


Fig. 8. FET amplifier analysis window.

The software consists of two parts – a client software and a server one. As a basis of network interaction it was decided to choose protocol TCP/IP well-provided for delivery.

The server part is Win32 executable that has been developed in Delphi 7 environment. The server accepts clients on TCP port, controls multiplexer which switches research circuit; it also controls ADC and DAC of DAQ device NI-6008. Communication with the device is conducted by means of a software layer which is distributed with NI-DAQmx drivers from National Instruments. According to the developed protocol of data transmission between the server and the client, at first the client sends some request to the server and waits for the answer. Meanwhile the server processes the request and sends the response (including measured data). The data received by the client are visualized on the student's screen. Much attention has been paid to minimize traffic through the Internet while developing client-server protocol since many students still connect to Internet via slow modem lines. To minimize latency between sending request and receiving measured data the Nagle algorithm on established TCP/IP connection is disabled.

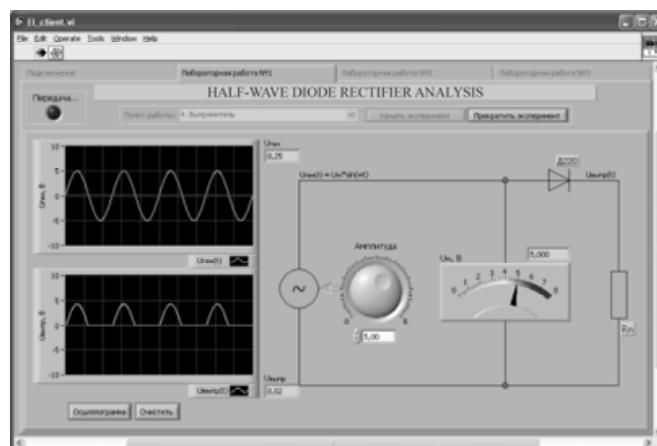


Fig. 9. Half-wave diode rectifier analysis window.

One of problems of laboratory installation was realization of ability for several students to work simultaneously with different laboratory works. The solution consists in temporal distribution of clients' requests, for example, by means of using unblocked TCP socket on the server application. In this case, requests query is controlled by operating system. Due to that more than 10 students can work with the laboratory installation simultaneously with no problems. To accommodate quality control of the executed laboratory work by the student, server stores in special database an information about who and when has been connected, and how many laboratory works the student done during the session, and how much time it took for the student to do it. This information is available for an instructor via the web interface.

The client part of the software was developed in Lab View 7.1 environment (Travis, 2004). Lab View was chosen because it has a large base of different well-visualized devices which make it possible to measure a student's work intuitively. Also Lab View has a native support for TCP/IP protocol. Let's take a look at a small part of application source which was designed for the semiconductor diode analysis in direct inclusion laboratory work (window appearance look at Fig.9). The network benchmark results show that the network load utilization does not exceed 3 kilobytes per second in most cases, even while executing the most intensive laboratory work like "rectifier". Time between sending request and receiving response practically is completely defined by network latency. It helps a student to

do a laboratory work easily via slow modem communication lines and even via mobile internet technology GPRS.

The laboratory set (Fig. 10) is a printed circuit board with a single-chip microprocessor ADuC842 located on it with light diodes, semi-segment displays, a temperature sensor and a keyboard connected to the microprocessor. Special software running on the server is able to record the necessary downloading file in the microprocessor's internal memory from any computer located in any part of the world and connected to the Internet. This special software was developed with PHP, dojo Ajax library, and Delphi 7. The advantage of this laboratory set is a possibility to observe the operation of an experimental set in real time via the Internet. For this reason a web camera is directed at the set and a special software uninterruptedly broadcasts image received from the camera to the Internet. Another advantage is that a student doesn't need any special software to use this laboratory except Kiel-C IDE for firmware building. The firmware can be downloaded into the microcontroller in the window of any Internet browser and the image can be watched in the same window.

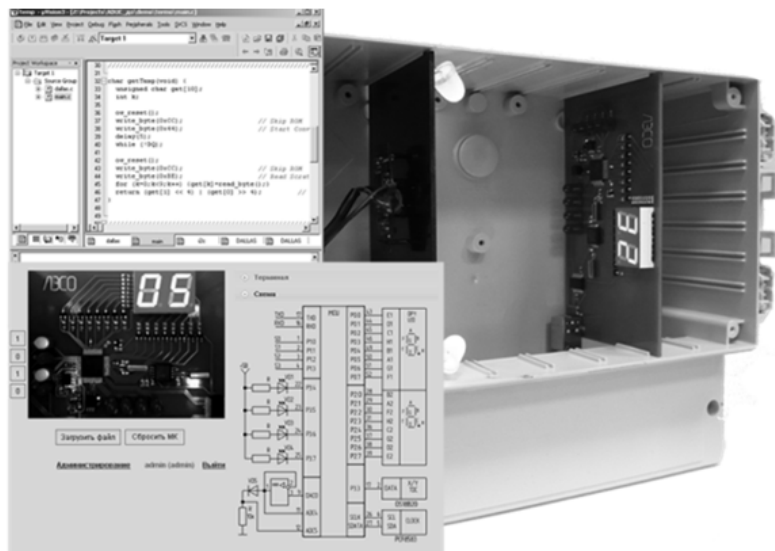


Fig. 10. Remote access laboratory to research microprocessors.

Programmable logic device PLD is one of the most prospective devices of digital circuit technology. PLD does not require any sophisticated technological manufacture. PLD is configured on a programmer's desk with the help of a PC. That is why sometimes this technology is called "manufacture on the desk". For this reason PLD is most optimal when learning digital circuit technology. In order to design a digital device of any complexity a student just draws its circuit on the PC display by the instrumentality of the Aletra's Quartos II software. The hardware part of the laboratory (Fig.11) is a printed circuit board with PLD and a web camera directed to the laboratory. The printed circuit board and the web camera are connected to the server with the Internet access. To identify logic states on the PLD's outputs light diodes are used. Control signals are transferred to PLD's inputs by a special microcontroller.

Digital electronic remote access laboratory can be used to teach design fundamentals of digital devices and carry out research on the basis of programmable logic devices.

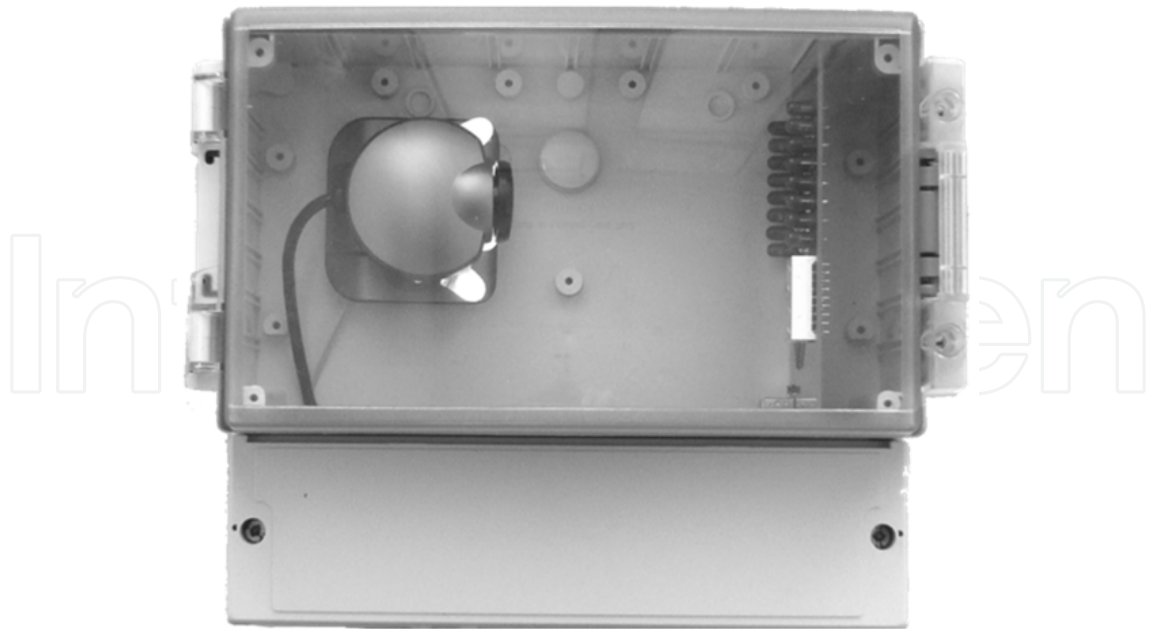


Fig. 11. Remote access laboratory based on PLD.

To access the laboratory an Internet browser is used. A configuration file of any complexity designed in a Quartus II computer-aided design environment. On the uploading page a student can specify the path to the configuration file of PLD, he can upload the file into the remote stand and observe functioning through the web camera. Thus a student located at any distance from the laboratory can design real digital devices and watch their functioning by means of the web camera.

3.4 New requirements to e-learning environment

An e-learning information-educational environment acts as a tool of subject-object information interaction to form student's fund of knowledge - thesaurus, which accumulates enriched during the life span and becomes a basis of any kind of activity. An individual's ability to use accumulated knowledge in order to achieve a certain objective testifies to his/her intelligence. The student's information interaction with training material underlies form of intelligence and knowledge, i.e. the student's thesaurus. Therefore it is very important to investigate axiological characteristics of an e-learning environment.

In traditional interpretation the value means ability of an object and a thing to satisfy some requirements of an individual. The more the individual is satisfied, the higher the value is. Similar to this, the characteristics of the information-educational environment which allows students to use this environment to achieve their set objectives act as a pedagogical value. It should be noticed that one and the same information-educational block can have different pedagogical value from the point of its use for various learning objectives. The use of a "student-centered" teaching model instead of a traditional "teacher-centered" model and applying methods stimulating student's cognitive activity immensely raises the pedagogical value of information-educational environment. Also multimedia demonstrations and simulators make an outstanding contribution to the pedagogical value of the information-educational environment. These tools help students who do not studying in the class to

learn correct pronunciation of foreign words, be involved in a live work platforms right from their PC desktops, to see historic events and handle complex mechanisms and processes.

Another axiological category, namely, pedagogical usefulness of a teaching material is closely associated with the category of pedagogical value. The pedagogical value is a more general characteristic than the pedagogical usefulness. For example, the student, who downloads an archived file to his/her PC, can be aware of how valuable the information on that file is. However, through the lack of the software, which unarchives files, this information becomes absolutely useless for the student. There are two categories of value: potential and actual. It is possible to notice that the pedagogical usefulness is an actual pedagogical value. In other words, the information, which is useful to achieve a learning objective, is of actual value. It is necessary to understand clearly that the degree of actualization of pedagogical value depends on a number of factors and personal characteristics of a student, i.e. the object of the information interaction. The larger fund of knowledge and the more sophisticated thesaurus a student possesses, the more successfully the student uses the information received in order to achieve a learning objective or, in other words, the more useful this information is for the student.

The pedagogic value of the information-educational environment is not an invariant axiological category. Horizontal and vertical alterations are typical of the information-educational environment. Horizontal alterations mean that pedagogical value of the information-educational environment is acknowledged not only by individuals or small social groups, who benefit a lot from the teaching material, but by the general pedagogic community and many students. Vertical alterations of this category lead to increase or decrease of pedagogic value of information materials. Upward motion has a subjunctive meaning and relates to the information updated by the doer while downward motion has an imperative meaning and relates to the process when the information becomes outdated and when the most destructive factor is time. The decrease of the pedagogical value does not happen at once, as a rule. This is a rather long process stipulated by new information appearance in a concrete subject field. For example, the replacement of analog telecommunication technologies by digital ones has resulted in the drastic decrease of pedagogical value of many textbooks, which had been used widely in Telecommunications before. The same happened to many Russian textbooks in Economics and Management, since Russia had shifted to Market Economy. In many cases the process when the information becomes outdated is inevitable, therefore the producers of electronic teaching materials should evaluate and measure pedagogic value of their e-teaching materials in order to improve them and make them pedagogically valuable.

In the system of distance learning and e-learning the pedagogical value of teaching material is influenced by the character and means of a subject-object information interaction, such as the interaction between the teacher (tutor) and the student, between separate students and student classes. It also involves the interaction with e-teaching material. For this, e-teaching material should be "tuned" to an uninterrupted "dialogue" with the student. The more opportunities the student has to direct his/her process of cognition by interactive means, the higher the actualization degree of pedagogical value of teaching material is. In other words, the pedagogical value of teaching material acquires great importance. There are two types of interaction. They are: direct interaction when the teacher conveys information to the

student, and indirect interaction when information is conveyed and apprehended without the teacher. In any type of interaction the main factor is to establish the feedback. The feedback checks the student's reaction to provided information and ability to use it in order to improve a learning process. The feedback makes the process of information interaction among the subject and the object synchronous. The delay in feedback results in asynchronous interaction. Participation in chats and videoconferences are good examples of synchronous direct interaction and instant evaluation of students' answers by teaching program is an example of synchronous indirect interaction. Asynchronous information interaction occurs, for example, in the form of participation in Web-forums, disputes in discussion rooms. Introduction of feedback, that supports student's ability to learn efficiently, considerably increases the potential value of the electronic teaching material.

Whatever high pedagogical value the e-teaching material has been provided with, the most important factor in distance learning is to transfer information. When the information flow is reduced during transmission, an information interaction can become worse, therefore, the pedagogical value of a teaching material can be decreased. While a citizen in a big city has an opportunity to use telecommunication channels of good capacity and transmission rate, a citizen of a remote town is sometimes doomed to have very slow channels. Even a high-speed modem does not provide good connection with the Web-server in the Internet. However, despite low transmission rate, an outdated software and the lack of a reliable Internet provider citizens of remote towns can join the distance learning process, but they will not be able to observe a multimedia part of the teaching material on the Web-server and they will not have a full access to all information recourses. Therefore, it will take a lot of time to receive any information that at best will annoy students or at worst, they will quit learning. The actual value of the teaching material will decrease to zero and the teaching material will become absolutely useless. Of course, the information theory suggests the methods against poor information interaction.

Various information barriers or info-barriers impede the travel and comprehension of information flows. In the information theory this term is used to denote the range of objective and subjective factors, which influence the process of information transfer to the object of interaction. It is clear that info-barriers diminish potential value of the teaching material. A short description of some info-barriers is cited below. One can speak of geographical and technical info-barriers, which results in weak interaction and hence decrease of teaching materials' value because of remote location of towns and lack of proper facilities. Thesaurus info-barrier has been also mentioned, when an accumulated fund of knowledge is not enough to understand teaching material. Terminological (language) barrier takes place, if the terms used in a textbook are not clear and unknown to an information user. Some of psychological and communication info-barriers are associated with mistrust to new methods and technologies of training, and with special perception of nonverbal methods of training. There is a whole range of situational info-barriers, which may happen in certain situations, for example, when the amount of information does not correspond to the time that an object of the information interaction has. There is a considerable amount of other information barriers that occur while learning in an electronic environment. The objective of info-barriers analysis and search of ways of how to overcome or eliminate them is very important because it is related to the increase of pedagogical value of the electronic educational environment.

3.5 Alterations in info-communication activity of subjects' of learning

In e-learning, distance learning and m-learning students receive psychological support from their communication activity. Being isolated from an educational institution and lacking constant communication with teachers and students, a student may experience psychological discomfort, and suffer from isolation and neglect in comparison with other students. Therefore, for these types of learning it is very important to set up constant contacts of students who are geographically isolated from the administration of an educational institution, teachers and colleagues. Such communication contacts allow teachers to answer students' questions promptly, to identify difficulties that students face with, and render them assistance by making an impression of constant communication between individuals and geographically isolated groups. For students these communication contacts help students to compare their progress in learning with the progress of other students and to render mutual assistance.

In human communication a personality plays a very important role. For many students the personality of a teacher determines their attitude to the subject they learn. Participants of interpersonal communication influence each other through facial expressions, gestures and voice timbres. Nonverbal communication increases the efficiency of the communication process. When shifting to new types of learning, it is necessary to take measures compensating the lack of interpersonal communication. Educational process should be considered as interpersonal and dialogue interaction in "teacher-student" and "student-student" systems aimed at forming of theoretical and practical thinking and developing the personality of a future specialist. Dialogue lays the foundation of educational process by turning it into a mutual cooperation favoring the mutual development of all participants involved in this process. The lack of communication activity in learning may result in several problems: lack of interpersonal contacts among the participants involved in a learning process; inability to create favorable psychological climate and comfortable conditions for learning; lack of efficient control for students' mastering the material, inability to organize students to work in a team; inadequate perception and interpretation of teaching materials; interest decrease in learning up to a complete vanishing of motivation to learn through new technologies.

A full-fledged communication activity among students is impossible without teaching them the means and characteristics of a text presentation as the main means of verbal communication via the Internet, without teaching students to overcome information barriers in a personal contact with the teacher in the Internet and also without teaching participants of a learning process the Internet communication etiquette. The Internet affords many opportunities to organize communication: e-mail; discussion groups; two-side audio conferencing (NetMeeting, internet Phone, Powwow); two-side video conferencing (NetMeeting); group desktop conference (Intel ProShare), group text chat (NetMeeting, Microsoft Chat); whiteboard (NetMeeting); discussion forum; bulletin board. Via the Internet various kinds of electronic communication can be organized. They are the following: informing of students (bulletin board, student portfolio, visit cards); individual and group consultations for students (e-mail, mailing lists, news group, audio- and video conferences, forums, chats); electronic workshops (mailing lists, group news, chats, e-conferences, forums); teamwork in small groups (forums, whiteboard); student mutual help (e-mail, mailing lists, news group, conferences, forums, chats); monitoring of student's

progress (e-mail, chats). In order to organize efficient distance learning via the Internet one should take into account characteristics of the telecommunication environment and human behavioral features in this environment. New communication environment creates new learning situations and new learning relations (Chou, 2003; Regueras et al., 2009).

4. Quality evaluation of distance learning

The difference between the distance educational technology and traditional in-class one is that a object of teaching (referred to as a student further on) has an access only to the network electronic teaching materials and the network means of communication with an subject of teaching (referred to as a teacher further on) (Dearholf et al., 2004; Evans & Sabry, 2003). The role of the teacher in the given educational system changes considerably as compared to a traditional style of teaching. In the distance pedagogical system the teacher's aim is to create such electronic information-educational environment, which together with the information communication means could provide opportunities for direction and self-direction of a students' learning-cognitive activity. It means that students, being the objects of a training effect, must transform to subjects with developed abilities for self-learning, who are willing to direct the learning process themselves. In other words when using distance technologies the new paradigm of education is used: namely, the teacher does not transfer knowledge, but stimulate students to develop their own learning-cognitive activity (Splitt, 2003)].

In new conditions the teacher acts as a highly qualified manager of the learning process, an organizer and an intermediary between a new educational environment and learners.

Electronic educational environment created by the teacher in the distance pedagogical system provides opportunities for students to direct their own learning-cognitive activity, determines principle of formation and development of students' thesaurus and intellect which in turn, determines a specialist's ability to be in professional activity. There is a fairly close link between professional competence of the teacher, who deals with a distance learning environment, and the process of thesaurus phylogeny (i.e. the process of building cognitive skills, circulating in certain community or its part, for example in a group of students). Indeed, research on the thesaurus in ontogeny (i.e. in a person) makes it possible to determine a learner's individual abilities, while research on the thesaurus in phylogeny (i.e. in a group) demonstrates pedagogical abilities of a teacher: the higher professional competences of a teacher engaged in distance learning, the better indexes of a collective thesaurus formation in a group of students.

In pedagogical publications the majority of authors are unanimous that various tests and assignments can be used as basic tools for evaluation of the collective thesaurus of a group of students. Quantity indicators for evaluation of a group thesaurus and methods of indicators' measurement are offered bellow. Relative frequencies of correct solutions can be used as indices to learners' individual thesauruses:

$$p_{cor} = \frac{m_{cor}}{m_{com}} \cdot 100\% ,$$

Where m_{cor} is the number of correct solutions,
 m_{com} is the total number of assignments.

Calculating the average value of \bar{p}_{cor} of these parameters by the formula:

$$\bar{p}_{cor} = \frac{\sum_{i=1}^N p_{cori}}{N},$$

where \bar{p}_{cori} is the relative frequency of correct solutions of i -th student;

N is the number of students in a group, we obtain the indicator of the state of the collective thesaurus for the learning group.

On the basis of the received data it is possible to build a diagram showing what number of students has reached this or that level of the indicator. Fig. 18 shows the curves built for two groups.

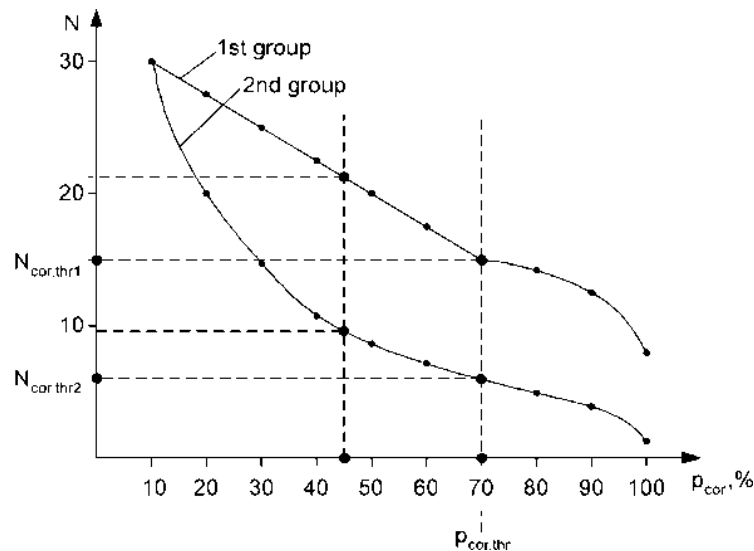


Fig. 12. Curves of the level of group learning.

It would be appropriate to name these curves as the curves of the level of group learning.

It is possible to set a threshold value of the relative frequency of correct solutions, for example, $p_{cor.thr} = 70\%$ as it is demonstrated on fig. 18, and define the number of the students $N_{cor.thr}$ who coped with the assignment at this level. Then one more indicator of the state of the collective thesaurus could be formulated - *coefficient of group learning*

$$K_{ln} = \frac{N_{cor.thr}}{N} \cdot 100\%.$$

The higher the coefficient of group learning, the higher the quality of learning is.

Pedagogical literature distinguishes three basic learning goals. The learning goal of the first, the lowest level, is to give knowledge to students. The learning goal of the second level is to teach students to apply this knowledge, i.e. transform the knowledge gained into abilities. Finally the top step or the learning goal of the third level is to provide students with professional skills. According to this classification it is possible to make evaluation of how efficiently the learning group has achieved learning goals. For this purpose assignments for

evaluation of three specified levels have to be developed. The number of assignments for each level should be sufficient for its estimation.

The following criteria could serve as indicators of goals achievement:

- coefficient of knowledge

$$K_{kn} = \frac{n_1}{n_{com1}} \cdot 100\% ;$$

- coefficient of ability

$$K_{ab} = \frac{n_2}{n_{com2}} \cdot 100\% ;$$

- coefficient of skills

$$K_{sk} = \frac{n_3}{n_{com3}} \cdot 100\% ,$$

Where n_1, n_2, n_3 are the number of assignments solved correctly by a student of the 1st, 2nd and 3rd levels, correspondingly;

$n_{com1}, n_{com2}, n_{com3}$ - total number of assignments of the 1st, 2nd and 3rd levels.

In order to obtain the parameter of a group learning goals achievement one can define the average values

$$\bar{K}_{kn} = \frac{\sum K_{kni}}{N} ; \bar{K}_{ab} = \frac{\sum K_{abi}}{N} ; \bar{K}_{sk} = \frac{\sum K_{ski}}{N} ,$$

Where $K_{kn_i}, K_{ab_i}, K_{sk_i}$ are coefficient of knowledge, abilities and skills of i -th student.

To compare the quality of distance learning of various groups, the diagrams, showing what number of students from the group reached this or that level of knowledge, abilities or skills, can be built. For an example, the diagrams for indicator of K_{kn} for two groups are shown in Fig. 13.

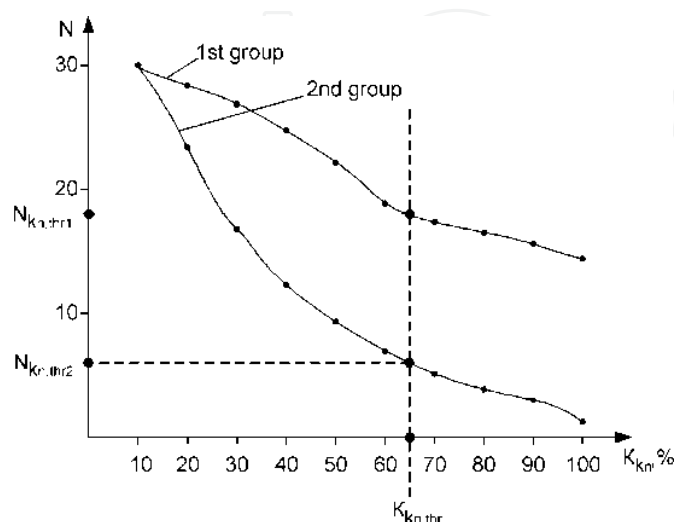


Fig. 13. Curves of the level of group knowledge.

These curves can be named the curves of the level of group knowledge. Similarly the curves of the level of group abilities and curves of the level of group skills can be built.

Following the diagrams it is possible to find out the number of students who reached the threshold levels $K_{kn.thr}$, $K_{ab.thr}$ and $K_{sk.thr}$, and to evaluate the achievement of learning goals by the whole group at any of their three levels by means of the following coefficients:

- coefficient of the level of group knowledge

$$K_{kn.gr} = \frac{N_{kn.thr}}{N} \cdot 100\% ;$$

- coefficient of the level of group ability

$$K_{ab.gr} = \frac{N_{ab.thr}}{N} \cdot 100\% ;$$

- coefficient of the level of group skill

$$K_{sk.gr} = \frac{N_{sk.thr}}{N} \cdot 100\% ,$$

Where $N_{kn.thr}$, $N_{ab.thr}$ and $N_{sk.thr}$ are the number of the students who reached respective threshold levels $N_{kn.thr}$, $N_{ab.thr}$ and $N_{sk.thr}$.

Higher group indicators $K_{kn.gr}$, $K_{ab.gr}$ and $K_{sk.gr}$ testify to a better achievement of learning goals by students of a group.

Thus, the results of this research showed that the measurement of quantity indicators of collective thesaurus in groups, which are taught at a distance by means of electronic teaching materials developed by teachers, make it possible to evaluate the quality course levels.

5. Conclusions and discussions

The authors of this paper explore alterations in subject – object relations between a teacher and a student in a new educational paradigm when students direct their own learning-cognitive activity. Herewith a student is transformed from an object of the teacher's influence to a true subject of a learning-cognitive activity. When implementing new pedagogical technologies such as distance learning, e-learning and m-learning, one of the major problems for teachers is to create educational environment that would allow students to direct their own learning-cognitive activity. As an example, one of facilities to implement the self-directed learning process into the on-line course using dynamic training elements (DTE) have been designed on the principle of the cybernetic model of cognitive process management.

At the Siberian State University of Telecommunications and Information Sciences (SibSUTIS), Novosibirsk, Russia, a range of dynamic training elements have been developed for the course "Fundamentals of Circuit Theory": introduction to harmonic oscillations; vector representation of harmonic oscillations; symbolic representation of harmonic oscillations; vector diagram; series- and parallel oscillating circuits; periodic signal

spectrum; transient response in circuits with linear and resistive elements; nonlinear resistive elements; self-sustained harmonic oscillator (Lin, 2006).

At the Circuit Theory department of the Siberian State University of Telecommunications and Information Sciences the research to obtain a quantity index for evaluation of the DL course quality have been conducted. Electronic teaching materials consisted of an electronic textbook including DTE's, virtual laboratory works, assignments published on the Website of the distance learning server.

Two groups of students have been involved in the research: an experimental group who used dynamic training elements during their practical classes, and a control group, who learnt by using traditional methods aimed at solving typical problems. The primary goal of the research was to measure the quantity indicators of groups' collective thesaurus by means of the DTE's, remote and virtual labs and another above proposed method. The students from both groups were given the same test assignments evaluating two levels of learning goals achievement: knowledge and abilities. Average relative frequencies of correct solutions \bar{p}_{cor} for students from the first group was $\bar{p}_{cor} = 79,8 \%$, at the same time, for students from the second group this value was equal to $\bar{p}_{cor} = 65,3 \%$. Dependences of the number of N students on relative frequencies of correct solutions for two groups have been built (Fig.14).

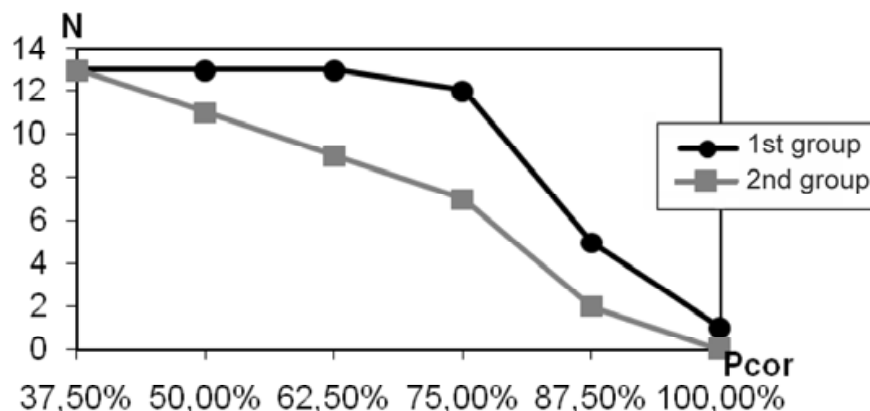


Fig. 14. Distribution of students in groups depending on relative frequencies of correct solutions.

It is possible to set a threshold value of the relative frequency of correct solutions, for example, $p_{cor.thr} = 75 \%$ and to determine the threshold value the number of N students, whose relative frequencies of correct answers were not less than $p_{cor.thr}$, from Fig. 14. In this case one can calculate the value of the group learning coefficient

$$K_{ln} = \frac{N_{cor.thr}}{N} \cdot 100\% ,$$

where N - the total number of students in a group.

For the first group of students the given coefficient was $K_{ln} = 92,3 \%$, and for the second group $K_{ln} = 53,8 \%$.

Therefore, obtained results show that students from the first group showed a higher level of the collective thesaurus.

The further goal of the research was to find out of which of examined groups demonstrated the best knowledge and abilities. For this purpose each group was provided with two types of assignments. One assignment contained the tasks, allowing evaluate knowledge of students, whereas another one contained the tasks, allowing evaluate abilities.

The average value of the gained knowledge coefficient in the first group $\bar{K}_{kn} = 87,5 \%$ was considerably higher than in the second one ($\bar{K}_{kn} = 62,5 \%$). The average coefficient of abilities gained by the first group ($\bar{K}_{ab} = 67,3 \%$) was also higher than in the second group ($\bar{K}_{ab} = 44,2 \%$).

Dependences of the number of students from the coefficient of the gained knowledge have been built (Fig. 15).

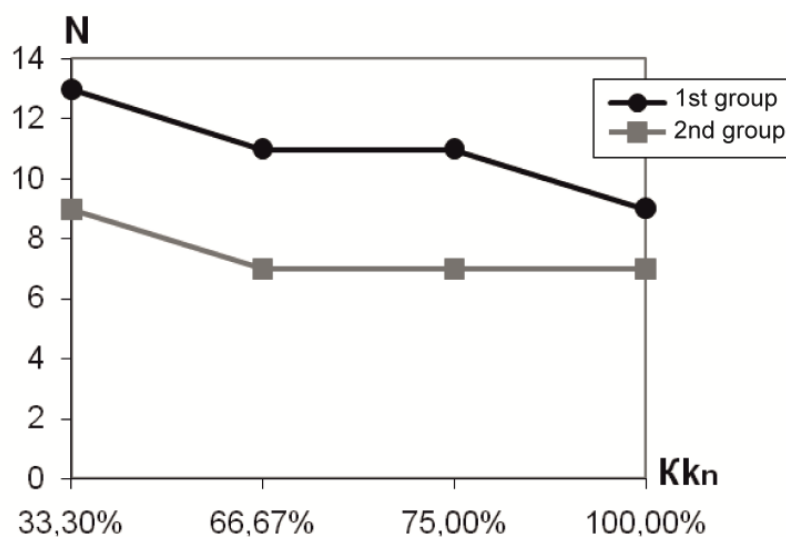


Fig. 15. Distribution of students in groups depending on the coefficient of knowledge.

Taking the threshold value of the coefficient of the gained knowledge $K_{kn.thr}$ for example 75 %, one can determine the number of students $N_{ln.thr}$, whose coefficient of knowledge was not below this threshold value, and calculate the coefficient of learning goals achievement at the level of knowledge

$$K_{kn.gr} = \frac{N_{ln.thr}}{N} \cdot 100\% .$$

For the first group this coefficient was $K_{kn.gr} = 76,9 \%$, and for the second one $K_{kn.gr} = 53,8 \%$. In Fig. 16, distribution of number of students of both groups depending on coefficient of abilities is built. Coefficients of learning goals achievement at the level of knowledge for the threshold value $K_{ab.thr} = 75 \%$ were 53,8 % for the first group and 30,7 % for second one.

It should be noted that the cybernetic approach to the design of dynamic training elements makes the process of self-learning adaptive, i.e., it allows students use the information gained while training to enrich their knowledge base. The use of DTE makes it possible for students to take an active role in their training, and keeps them motivated, which greatly increases the efficiency of training. This is the main pedagogical effect of the DTE application.

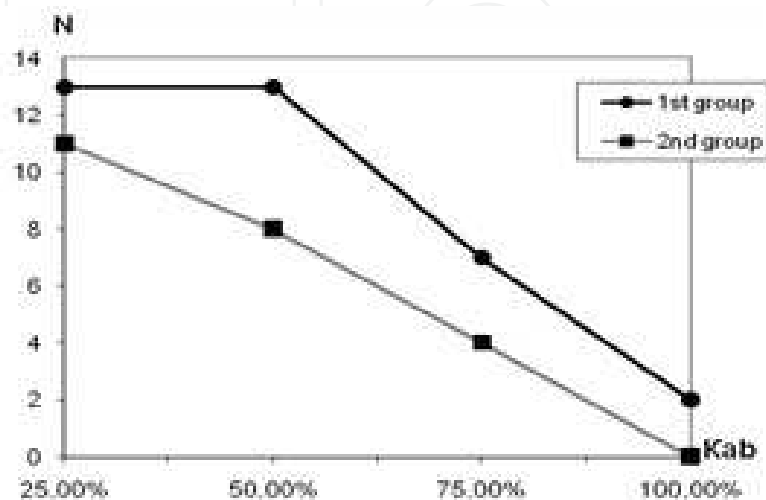


Fig. 16. Distribution of students in groups depending on coefficient of abilities.

In 2009-10 on the department of technical electronics at SibSUTIS statistical researches among students were conducted. Under results of these researches laboratory training on remote access laboratory received many favorable comments. One hundred of students took part in questioning, and 73 of them estimated laboratory training as excellent (Fig. 17).

It is very important to explore axiological characteristics of electronic educational environment, its pedagogical value and pedagogic usefulness. Pedagogical value of electronic learning material is influenced not only by the phase providing information, but by the phase transmitting information. Different information barriers impede travel of information flows and their perception. These barriers reduce potential value of learning material. In new educational technologies (distance-learning, e-learning and m-learning) students receive strong psychological support through their communicative activity. Deficiency of communicative activity in learning results in inability to create favorable psychological climate and comfortable conditions for learning; decrease of interest in learning up to complete vanish of motivation to study through new technologies. The network educational communication is effective as it is based on a subject-subject model, where mutual interaction of subjects takes part. The arrangement of effective education in new educational environment requires considering characteristics of this environment as well as behavior of a person in this environment. New educational environment brings about new learning situations and relations.

The Siberian State University of Telecommunications and Information Sciences (SibSUTIS) has been using the e-learning technologies for higher education services for almost 10 years. The number of students distance studying at the workplace is steadily increasing (fig. 18).

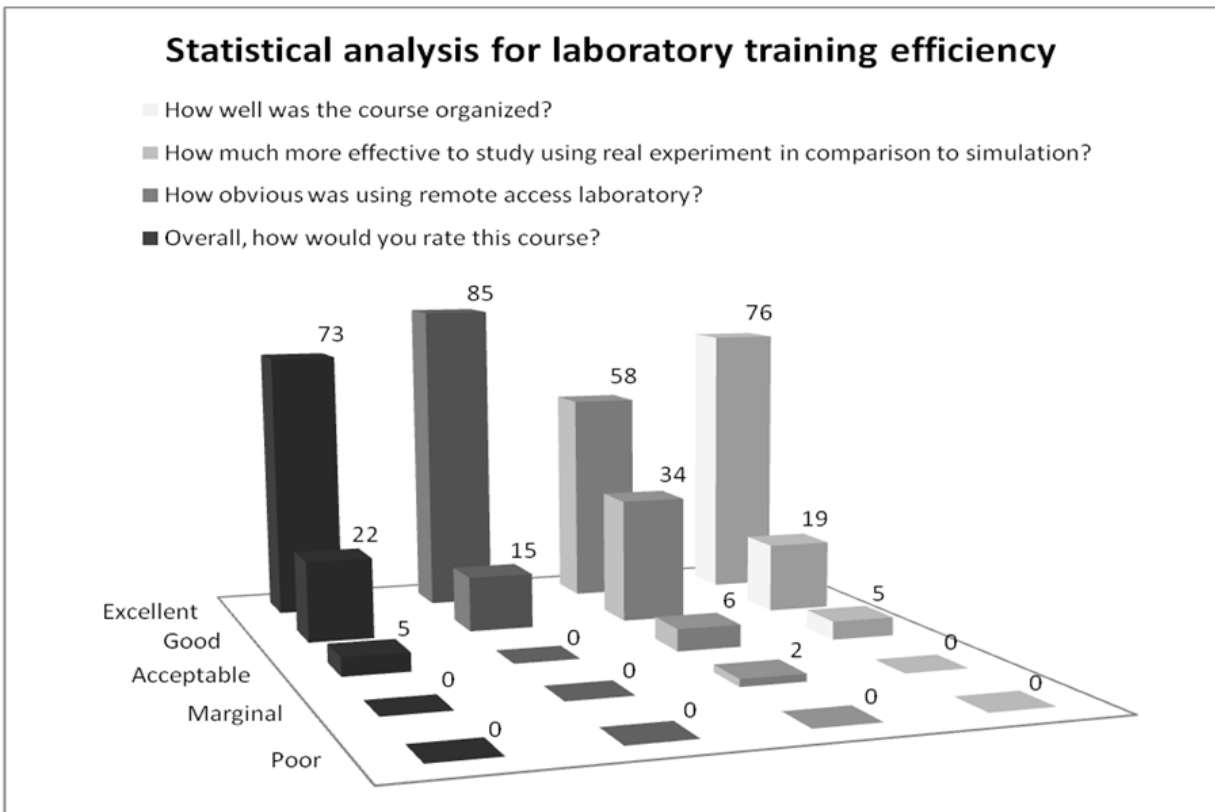


Fig. 17. Statistical analysis for laboratory training efficiency.

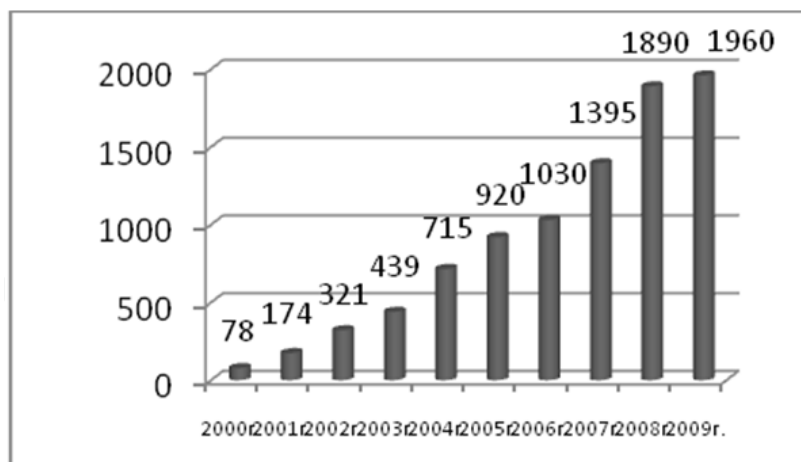


Fig. 18. Dynamics of telecom enterprise employees' enrollment for distance learning.

From the students, who are graduating the corporate distance university, 23% have been fully satisfied; 58% have been mostly satisfied and only 19% have been partially satisfied with the electronic educational environment. It is worth mentioning that there has been no unsatisfied graduated student this year as well as previous years. The articles and notes related to the distance learning in university written by students or those who have completed the distance university are regularly published in corporate editions and publications.

6. Appendix – The best practice of application of modern approaches to engineering education

6.1 DL courses for CIS countries

The liberalization of telecommunications field has resulted in strengthening the competition among alternative telecommunications operators. The development of infocommunication technologies has stimulated internal competition amongst interchangeable services. These changes have brought new approaches, models and instruments of business management into force, required new decision making in the field of policies and regulatory issues, technology and ICT awareness, corporate management and expected professional development of decision-makers as well as senior level officials in the Telecommunications Sector of CIS countries. International Telecommunications Union (ITU) has set up the network of world Centers of Excellence (CoE) with the aim to promote the knowledge accumulated by the international community in the telecommunication sphere among ITU country-participants. Taking into account the successful implementation of Centers of Excellence in five ITU regions (Africa, Asia & Pacific, Americas and Arab region), the decision to implement a sixth Centre of Excellence has been taken for CIS and EUR regions.

This Centre of Excellence plays a unique role in developing telecommunications in the CIS region, by making contributions in keeping the sector at the cutting-edge and giving opportunity to the countries to offer services best-suited for the development of the information society. Accordingly, the CoE strengthens and improves the facilities needed to develop and consolidate high-level competencies related to telecommunications policy development, regulatory issues, telecommunication management, new technologies and services in accordance with requirements and expectations of the region. The CoE must focus on the organization and presentation of excellent training programs designed for government authorities, senior managers, operators and service providers, to facilitate the development of telecommunications in the region. The CoE seeks to bring into operation a network of excellence among potential content providers (e.g. universities, training centers, etc.) and to service providers and technology providers already established in the region to give practical advice and render assistance for program. Within the framework of the Centre of Excellence project for the CIS countries it has been decided to bring into operation a network of excellence amongst potential content providers, like universities and training centers, which could provide on-line solutions. The following telecommunications institutions famous in the CIS countries have been selected as the potential content providers: Moscow Technical University of Communications and Informatics in Moscow (MTUCI, Russia), Siberian State University of Telecommunications and Information Sciences in Novosibirsk (SibSUTIS, Russia), Alma-Ata Energy Institute (AEI, Kazakhstan), Tashkent University of Information Technologies (TUIT, Uzbekistan), Kiev Institute of Communications (KIC, Ukraine), Higher State College of Communications in Minsk (HSCC, Belarus).

One of content providers in "Corporate management" for the CIS countries is the CoE on the basis of the Siberian State University of Telecommunications and Information Sciences, SibSUTIS (Krouk & Sitnikov 2002; Krouk&Zhuravleva,2003). The service of organizing a learning process in this CoE has the following functions: planning the learning process (drawing up a schedule of electronic consultations, examinations, tests and tutorials) and implying functions of an Access Administrator, a Dispatcher of learning process and a

Database Administrator. Most often these functions are performed by the same person. The technical support service in the DL system is the most expensive one because it consists of skillful personnel and exploits expensive equipment. This service consists of: programmers, who provide interactive communication, develop software for DL and elaborate databases; specialists in multimedia; network and web-server specialists whose aim is to provide a regular work of all servers, access to Web-servers over the Internet, video conferences, operation of a local network, protection of information against any fatal errors, and introduce new DL technologies.

The learning material of the course is divided into self-instructional units. This structure allows step-by-step learning, each step pays attention to a particular unit. The learning objectives of the course and each unit are clearly determined. The learning material is self-sufficient and trainees can do all types of training work and achieve stated learning objectives. The material is self-study oriented. Trainees have an opportunity to make calculations, solve different problems, and do practical exercises. The structure of the learning material contributes to the interaction of a trainee, and allows him/her communicate with trainers, tutors, specialists, and other course participants. Every unit has self-assessment questions and tasks, which would make it possible for a trainee to check his/her progress and mastery of the learning material. The learning program provides trainees with tests, which are checked and evaluated by trainers. The learning material is also provided with access devices such as course guides, course curriculum, trainers' email addresses and reference materials. A number of case studies, which require analysis and decisions making by trainees, are included in the learning program. To discuss those problems with other participants, trainees have access to a Web conferencing system offline taking into account different time zones. To manage trainees' study there is a billboard, on which one may put all general information. All materials are issued in HTML, with all necessary hyper references for convenient navigation through a course material. Trainees may see learning materials both online and in an autonomous regime.

The main objective of distance learning is to provide interactive training. For this purpose, dynamic Web pages are elaborated on the Active Server Pages platform. Integrated application of ASP and databases provides trainees with an access to resources of the Web site as well as gives information about grades received in the learning process, possible failures, and current assignments. On the basis of ASP, VBScript, and JavaScript, programs for distance testing of trainees have been developed. The software for group work in virtual class and case study, which help to hold discussions on learning issues with forum and chat technologies, is elaborated in the DL CoE. Communication activity provides such support for trainees who are far from the institution and cannot attend classes as communication with administrative staff, trainers, tutors, and other course participants. It makes possible for trainers to answer trainees' questions quickly, reveal their difficulties as well as render immediate assistance, form a sense of constant community among a dispersed group of trainees, compare their own study progress with that of other course participants, and give mutual assistance. On the developed site one of the main means of communication is the email. By email trainees send their papers to the DL CoE. By email they send questions and receive answers and reviews of accomplished assignments. For the convenience of trainees the email is mounted in a learning module, thereby making it possible to send messages (a question, an accomplished assignment, a draft, a project, etc.) without interrupting the work

in the learning module. The other channels of communication are a debating forum and a billboard.

In 2009 about 250 participants from 10 countries took part in the courses held in DL Centre of Excellence on the basis of SibSUTIS. The quality of training was evaluated by questioning trainees. All course participants were provided with questionnaires to evaluate the quality of training in accordance with ITU requirements. Processing of questionnaire results allowed us to draw the following conclusions: almost all course participants were of a very high opinion of the quality of training; they pointed out that the course was up-to-date and expressed their interest in it; and the course turned out to be very useful for enterprise employees' practical work.

6.2 The corporate DL course for telecom company managers

Another example of modern approaches to engineering education, namely, the corporate e-learning course for top and middle managers of the telecommunication company will be described. The management of "Sibirtelecom" Public Corporation of the Russian Holding Company "Svyazinvest" took a decision to hold retraining of top and middle managers of the company. This large company has its departments in 11 areas of the Siberian federal district and numbers more than 40 000 employees. Siberian State University of Telecommunications and Information sciences (SibSUTIS) - the large branch-wise university located in territory of the Siberian federal district - became an educational institution capable of offering effective programs and methods of training (Krouk & Zhuravleva, 2004).

First of all the e-learning course content has solved corporate queries and has been adapted to the market. Besides, it also focused on the future interests of the corporation and the development of this market. In whole e-learning course consists of 5 modules and is meant for training within 6 months period (600 hours). The teaching time of each module makes 120 hours. Of them 96 hours are set aside on network training which takes about one month (with 4 hours per day), and 24 hours a short internal session. Such a learning containing both distance components and full-time tuition examinations is called blended learning. The e-learning course is based on modular concept on the basis of interdisciplinary approach. The course program is an integral program in which various teachers' activity is completely coordinated. The electronic-educational environment of this e-learning course aims students at self-managing personality-oriented learning, provides an informational interaction between students.

In the e-learning course nonconventional methods of training based on partnership represented by the process of an interactive dialogue in the conversational form, collective discussion of various situations (case-study), team work at joint projects and etc. have been used. The entire teaching material of the e-learning course is mostly connected with direct professional activity of employees. The practical e-learning course component contains special tasks which must be performed during the course by company employees. During the e-learning course the trainees communicate with teachers, the colleagues, the company experts by means of built-in in the module e-mail. Trainees and teachers get acquainted using the "visiting" cards system with photos. Acquaintance between students and formation of virtual class begins with a forum of acquaintance. Each module is provided with a feedback in the form of consultations, checks of practical tasks performance, testing

and control of knowledge, questioning of trainees. As the program is oriented on adult people, it is provided with group discussion of studied problems and tasks performed in modules. At internal sessions methods of work in small groups are used.

To evaluate the training quality and efficiency of educational activity at corporate university the system of an integrated monitoring of an educational process has been implemented. After the students complete studying the material of each distance module they are asked to express their opinion about distance educational process. The questionnaire contains three kinds of questions: evaluation of distance learning organization, evaluation of electronic teaching materials quality and evaluation of trainees' survey. Each trainee should evaluate convenience of work with an educational site, the quality and completeness of communication with colleagues and an administrator of an educational process by five-point scale; to draw the conclusion about completeness and quality of electronic teaching materials, and also to state the degree of distance learning.

The analysis of the results has shown that almost all participants expressed satisfaction with web-site, access to it, service information on the web-site and cooperation with the manager of an training process. Trainees practically had no claims to the quality of teaching material on a distance learning web-site. Gradually in the process of training students completely adapt to a distance learning form, therefore they evaluate efficiency and quality of thee-learning course at the end of training higher than at the beginning. During the e-learning course collective discussion of a particular practical problem with a teacher on a forum is repeatedly organized. It is worth mentioning that students get more satisfied with some problem discussion at a forum by the end of studying (4, 82 points at the end of studying contrary to 3, 29 points at the beginning). Similarly, satisfaction from the dialogue with the colleagues at the end of studying was estimated higher than at the beginning (4, 86 points contrary to 3, 9 points). In process of studying trainees realize that the given training improve their professional work (4, 45 points contrary to 3, 71 points at the beginning). It is obvious that students have coped with electronic discussions and have been able to comprehend better the teaching material and their studying became more effective. On the average, managers have evaluated the e-learning distance course to the 4,86 points and are assured that it would be useful for their colleagues to take a similar e-learning course (4,86 points).

The expert evaluation of the quality and learning efficiency that was given at each grade level by the teachers participating in educational process was the third element of complex monitoring of the educational process system. In their conclusions it is underlined that training materials given in educational modules have caused genuine interest of the learners. It proves that the course is actual and of practical importance for listeners. At the lessons practical estimations have been conducted, special situations (cases) have been studied and investigated, business games have been played. Making task solutions trainees used the data of the "Sibirtelecom" and other enterprises. Students took the most active part in trainings, demonstrated high level of analysis of problems offered to discussion competence.

The fourth and one of the most fundamental monitoring elements has been the score rating evaluation of the student's educational activity results. Not only managers' evaluation of this program is an evidence of the successful work of the network corporate university, but also positive comments by corporate publications. The majority of these managers had career development.

6.3 DL education on communication engineering and computer science

Over the last ten years, perhaps, no sector of Russian national economy has undergone such a revolutionary shock as telecommunications one. In the technical development of this sector there have been five qualitative leaps: the element base of the equipment was replaced (instead of lamps and transistors there were digital very large integrated circuits); principles of the equipment operation have changed (the outmoded analog principle has been replaced by modern digital one) ; principles of communication networking have changed (instead of slow switching of channels superfast switching of packages with speech and video information have come into operation); the transmission medium has changed (instead of electric signals transmitting by metal conductors light beams on optical fibers have been transmitted); automated control systems of networks have been introduced. In this connection ten years ago the problem of mass retraining of the technical and administrative personnel of telecommunications sector came to the fore. There might have been a threat of “a personnel collapse” without solving this problem.

In 2000 the Siberian State University of Telecommunications and Information sciences has launched the corporate distance university. The employees of the telecommunication companies and corporations can graduate in telecommunication, information and economics from the corporate distance university. It aims its educational services at the telecommunication sector of the Russian economy, and also of the CIS countries. The basic consumers of services are such large stock companies, as “Sibirtelekom” and “Uralsvyazinform” (60 %). As for other companies: “Dalsvyaz”, “The Northwest Telecom”, “Vologatelekom”, “Centrtelekom”, “Kazakhtelecom” its a share is about 40% of all consumed educational services.

The main participants of an educational process in a corporate distance university are students, teachers-tutors and managers of educational process. A necessary condition for the Internet-learning organization is availability of a Web-server, database and management system of training process at the university. Introduction of e-learning technology into educational process has demanded introduction of Learning Process Maintenance procedure shown in fig. 2. Support system for e-learning at the workplace fulfills functions which include design of learning courses, teaching of students using the Internet, management of training process, support of e-library. In the process of e-learning organization three categories of users take part. They are students, teachers and administrators of training process. The support system for the e-learning at the workplace provides communication between the users and the administrators of a training process.

Content of e-learning courses developed by teachers get archived and are stored on the server. The database server is used to manage the e-learning database which contains data about students, teachers, managers, curricula, learning specialties, subject, learning progress and teachers’ reviews. The Web-server provides access to the e-learning recourses for all categories of users. The Web-server’s functions include publishing of information, reference and learning materials; access to the database and storage of learning materials. The server of a remote laboratory allows students to work with devices and equipment in the remote access mode. The storage of a student’s works includes all works performed by students and sent by email as archived files. In order to send student works and information teachers and managers use a special mail service. Automated workplaces for students, teachers and e-

learning administrators are workstations where browsers provide the access to the e-learning recourses. The support system for the e-learning at the workplace, which ensures students' training process, starts with a student identification, which is made by entering a login and a password. If identification is done successfully, the student gets authorization to information and learning materials of the current semester.

The support system for the e-learning at the workplace provides students with administrators' and teachers' contact information; allows to send emails; gives recommendations how to work with Microsoft Office and archiving programs, which are used in the e-learning; provides students with the access to the e-learning curricula, tutorials and e-learning forum. The function "copy the learning courses" makes it possible for students to download an archived file with the learning materials of the selected subject into their own PC. Once the file is dearchived, students get a local mini-website, which contains all necessary materials for successful learning. The function "sending the performed tasks" makes it possible for students to send files with the performed learning tasks to the e-learning server in order to get registered in the database and to place their learning tasks into the storage of student's tasks. The student's tasks stored on the server become available to a teacher for checking and to an administrator to control training process. As it is very important for the students to be aware of their learning progress, the system includes "monitoring of student's progress". Functions of the support system for the e-learning at the workplace for teachers are the following: once being identified, the teacher gets the access to the e-dean's office, where the teacher may get the list of student's works assigned for a particular subject. The e-dean's office's page contains filters, which allow a quick search for a certain student's task using such search criteria as student's name, surname, code of his/her group, subject name, category of a student's task (all, checked, unchecked). Every line of the list contains data of one student's tasks including links to a student's email, a file with performed tasks and a student's personal information. The function "check" is used to open the page to make a revision and send the task to a student.

On the ground of the above described structure and functions of the support system for the e-learning at the workplace, one may arrive at a conclusion that application of the e-learning based on the Internet technologies makes it possible to organize a training process within the university education, as well as to administer it thoroughly.

E-learning via the Internet becomes more and more appealing.

6.4 An international project promoting language learning and intercultural communication

Businesses want employees to have international experience, administrations want their civil servants to communicate in a European context and institutions of higher learning encourage their students to study abroad. Yes, we live on a multicultural continent and Europeans have recognized the importance of other cultures. They are no longer a source of conflict but a cornucopia of knowledge and wisdom. Recognizing and accepting this fact is the first and important step on the way to greater European cohesion, but it is not sufficient. Our multicultural world requires extensive intercultural communication. We need more than a side-by-side existence of different cultures. What we want is a fruitful exchange

between cultures and nations. It is the aim of EMA-4-MOODLE, an Erasmus Mundus Project to promote such positive communication.

The aim of this project was to facilitate international mobility for European and non-European students by offering them tools that will help them overcome these difficulties. These tools are specifically adapted on-line language courses and intercultural documents. Project partners are developing four language courses: in French, German, Russian and Slovak. The courses are being implemented on the LMS Moodle (Hörbarth, 2007). The language courses are based on an original film made in each partner country. The film is broken into stages a foreign student at a particular institution has to go through in order to succeed his integration into the new educational system. The film consists of 10 parts lasting for about 10 minutes each and is provided with the subtitles in the original and English languages. The most common situations that foreign students may face when they come to study abroad are shown in the films. The students can see the buildings of the university, accommodation conditions, people actually working and students actually studying there so when they come they would not feel as total strangers; they would have an idea of where to go and what to do. This project has been supported by the European Commission.

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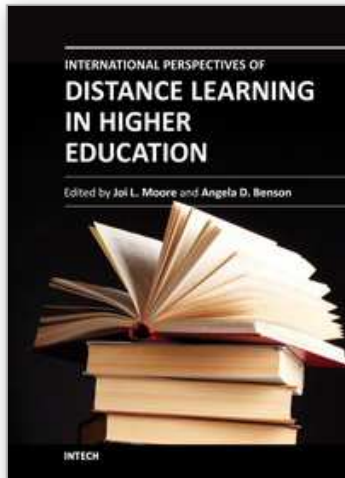
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51000 Rijeka, Croatia
Phone: +385 (51) 770 447
Fax: +385 (51) 686 166
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InTech China

Unit 405, Office Block, Hotel Equatorial Shanghai
No.65, Yan An Road (West), Shanghai, 200040, China
中国上海市延安西路65号上海国际贵都大饭店办公楼405单元
Phone: +86-21-62489820
Fax: +86-21-62489821

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