Classification of Information Technology in Education

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Abstract— The purpose of information society is creating of a hybrid integrated intelligence of all civilization able to anticipate and manage the development of mankind. The educational system in such a society should also be anticipatory. Transition from conservative to anticipatory training and education should be based on the preliminary formation of the information space with the wide use of information technologies in education. The success of creation of the global information society strongly depends on the readiness of the educational system to implement the reforms necessary for the specialists' adaptation to the knowledge-based activity in the short time. As subject teachers are usually not experts in Computer Sciences, classification of Information Technology will help them navigate this complex and rapidly developing world which has become an integral part of modern education. The article is just a small part of the research in the field the use of IT in education and their classification.

Index Terms— computer-based program, computer-based training system, E-Learning, expert system, multimedia, systems approach, types of information technology, user interface, Web 2.0.

1 Introduction

Before classifying information technologies used in education, it would be appropriate to consider the basic definitions first.

The International Foundation for Information Technology (IF4IT) defines information technology as one "used for the study, understanding, planning, design, construction, testing, distribution, support and operations of software, computers and computer related systems that exist for the purpose of Data, Information and Knowledge processing" (as cited in IF4IT, 2012). Use of information technologies in education provides:

- a great variety of educational resources;
- fast access to authentic and relevant information;
- opportunity to use the resources of the world libraries;
- opportunity to study at any convenient for the user time in any place;
- access to education for disabled people or those who are unable to attend traditional schools for some reason;
- individual approach to learning; taking into account the level of knowledge of the trainee;
- opportunity to join students from different countries for collaborative learning;
- multimedia approach to education;
- unlimited opportunities for increasing motivation for learning;
- education data storage;
- a variety of communication channels like e-mail, forum, blog, chat, etc.;
- access to the free computer and IT training software;
- ease of complicated tasks;
- saving time;
- significant improvement of task performance.

2 Classifications of Information Technology According to the Type of Equipment

There exist a lot of classifications of information technologies. One of them, according to the type of equipment used, is provided in table 1.

TABLE 1
CLASSIFICATIONS OF INFORMATION TECHNOLOGY ACCORDING TO THE TYPE OF EQUIPMENT

STAGE OF DEVELOPMENT	TYPE OF IT	TYPE OF EQUIPMENT	FEATURES OF THE STAGE
I until the second half of the 19th century	**Manual**	pen, ink, book	communication is carried out by rewriting the books, letters and messages; low efficiency of information processing; the goal is to provide information in the right form

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II from the end of the 19th century	**Mechanical**	typewriter, telephone, enhanced mail	the goal is to find more convenient ways to provide information in the right form
III 1940-1960s	**Electrical**	electric typewriter, fax machine, portable recorder	focus of information technology moves from the presentation of information to the formation of its content
IV early 1970s	**Electronic**	large electronic computer, automated control system (ACS), information search engine	increasing attention to the content of the information and analytical research
V from the middle of the 1980s	**Computer**	personal computer with a wide range of standard software products for different purposes	personalization of automatic control system; development of Workplace Automation System; extensive use of global and local area computer networks; increasing uniformity in information processing
VI nowadays	**New Information Technology**	high-performance multiprocessor cluster system; software based on predictive graphical user interface	advanced communication tools

In order to emphasize innovative, rather than evolutionary, nature of the modern changes in information technology, including its significant impact on the content of professional activity, the term has repeatedly been changed by joining the words "new", "computer" or "modern". But the pace of change is so rapid that these definitions became irrelevant. For the same reason it becomes impossible to give a unified classification of information technology. It is advisable to research selectively the characteristics of practical importance for specific application areas. The classification depends on the criteria, which may be a separate indicator or set of attributes.

As for application and use, information technology can be divided into two main interrelated groups: basic (also called providing) and applied (functional). The first group, the mathematical tools, is designed to organize the process of communication, processing and transmission of data (information or knowledge). As a basic component on which applied information technology is projected, they are meant not for direct implementation of specific information processes but to ensure maximum effectiveness of information processes through the use of recent advances of basic science.

3 Multimedia & Telecommunications Technology

Basic information technology includes multimedia and telecommunications technology; technology of artificial intelligence and expert systems; CASE-technology; database technology; information security; software engineering; image processing; speech recognition; modeling of technological and other processes; network engineering; technology of storage and processing of very large volumes of information, etc. Multimedia becomes of particular importance in education. It provides:

- association of multidimensional information environment (text, audio, graphics, photos, and video) in a uniform digital representation;
- reliable (with no distortions in the process of copying) and durable (warranty period is ten years) storage of large amounts of information;
- ease of information processing (from routine to creative operations).

Functional information technology, which is a modification of the base technology for a particular subject area, includes systems of process control in real time, quality control technology, machine translation technology, etc.

The major areas of multimedia technology in education are:

- electronic editions;
- information superhighway as a global network of high speed transmission of digital data, voice and video through satellite, cable and fiber-optic communication lines (telecommunications);
- multimedia information systems that give visual information at the request of the user.

Multi-media environment is divided into three groups:

- sound: speech, music, noises;
- graphics:
- static graphics: pictures, photos and scanned images;
- dynamic graphics (videos and animations);
- text: writing.

Multimedia applications include:

- presentation (linear, interactive, slide, production);
- animation (frame by frame or programmable);
- educational games;

- videos and video players;
- Multimedia Gallery (change of images frame by frame, panorama, interactive gallery);
- audio files players (digital sound);
- Web programs (banner, transfer data application).

4 Classifications of Information Technology by the Type of Information Processed

Types of Information Processed	Types of Information Technology	
Data	System database management (DMS) Paradox, Access, FoxPro, Clipper, Oracle, Firebird	→
Text	Word processors W&D, Foton, Lexicon, Word, EditPad Lite, Notepad	→
Test	Word processors LaTeX, Microsoft Word, WordPad; hypertext systems Flexis	→
Table	Tabular processors Lotus, Excel, SuperCalc, Abacus	→
Knowledge	Expert systems CLIPS, OpenCyc, WolframAlpha Educational systems EduPRO	→
Real world objects	Multimedia, hypertext HyperWave, Microcosm, Intermedia, Storyspace, WebThing World Wide Web, HTML	→
Workplace Automation System Database	Workplace Automation System	→
Animation, video, sound	Multimedia applications Microsoft Power Point, Corel Draw, Adobe Illustrator, 3D Studio Max, Camtasia Studio, AutoCAD, Autodesk Inventor	→
Graphics	Graphics processors Corel Draw, Adobe Photoshop	→

Integrated packages: Framework, Works (integration of various interfaces)

Fig. 1. Classifications of Information Technology by Type of Information Processed

This classification (table 1) is quite relative because most of the information technologies can support different types of information (such as simple calculations are available in word processors; and tabular processors provide graphs generation).

5 Types of User Interface

The fundamental factor in the effective use of information technology is a user interface as the rules of interaction between the operating system and the user (Fig. 2).

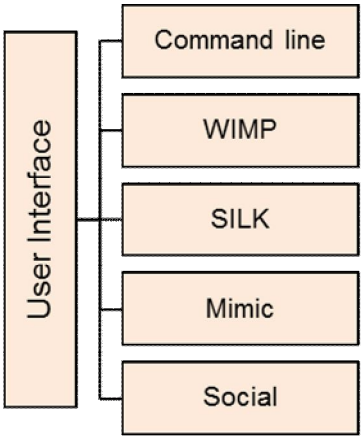

Fig. 2. Types of User Interface

The command interface is implemented as a packet technology, which historically occurred first in 1937; and command-line technology, which appeared with the advent of alphanumeric displays. Today's standard is man-machine WIMP interface coined by Merzouga Wilberts in 1980. It stands for Windows, Icon, Menu, and Pointer. This technology significantly reduces the cognitive load on the user. It can be easily transferred from one program to another due to the high consistency between interfaces. WIMP technology is used in Microsoft Windows operating system. This type of interface is implemented at two levels: a simple graphical interface and full WINP-interface.

Another user interface, which has broad prospects in education, is SILK (stands for Speech, Image, Language, and Knowledge). It is an audio compression format and audio codec used by Skype. Working on technology-based recognition of sounds, SILK-interface ("language technology") is the closest one to our usual form of communication; it's a Computer to Person conversation. Analyzing human speech, a computer will recognize a key phrase in the command, and transform the results into a readable form. To recognize voice commands properly, this interface needs to be adjusted for each user.

Another new types of user interface have recently attracted significant attention:

- biometric (physiological and behavioral) interface, which identifiers are the distinctive, measurable characteristics used to label and describe individuals. Identification is particularly carried out by the iris and fingerprints. The images are read from a digital camera, and then the commands are issued with the help of special recognition programs.

- semantic interface as "a natural ways to handle the increasing complexity of information structures". It is a combination of the best features of WIMP and SILK interfaces, in which menu will be replaced by screen images. Moves from one search pattern to the other will be made by semantic links.

Though anticipation is one of the most important tasks of higher education, these inventions are, unfortunately, implemented very slowly.

According to the user participation in the information process, technologies can be divided into package, dialogue and networking technologies. Tasks, which are performed in the batch mode, are characterized by the following:

- formal decision algorithm;
- the process does not require human intervention;
- large volume of incoming and outgoing data, much of which is stored on magnetic media;
- long time needed to perform a task (due to the large volume of data);
- time limit (defined recurrence of the task performance).

Development of a batch mode, rather than its alternative, is the conversational mode of User to Computer interaction that provides an opportunity to human intervene in the information processing. In the conversational mode, data processing can be carried out and information retrieval system and computer programs can work. In practice, it is possible to get benefit from both batch and conversational mode. The collective dialogue with the computer system in the automated process of solving educational problems is characterized by a large set of poorly formalized factors. Especially it relates to expert systems. Dialogue is a conversational exchange between two or more people; it is getting, processing and delivering of information notes in real time. It can be:

1) a question-and-answer dialogue;
2) a flexible dialogue when a lot of the options are submitted to the user in the form of a menu, usually of hierarchical structure; and the user can select the task solution;
3) a free dialogue, which allows participants to exchange information freely.

Educational dialog systems should provide:

- relatively simple but reliable syntactic, logical and numerical control of output;
- adjustment of information stored in the computer memory;
- interruption of the algorithmic process with the possibility to return to the nearest point and see the restored files.

Effective integration of information and teaching technologies allows shifting the emphasis in teaching from the traditional approach to the active learning, in which a computer is a means of thinking, developing cognitive abilities and communication skills.

6 Other Classifications of IT

Classification of information technology according to some other characteristics is presented in Figure 3.

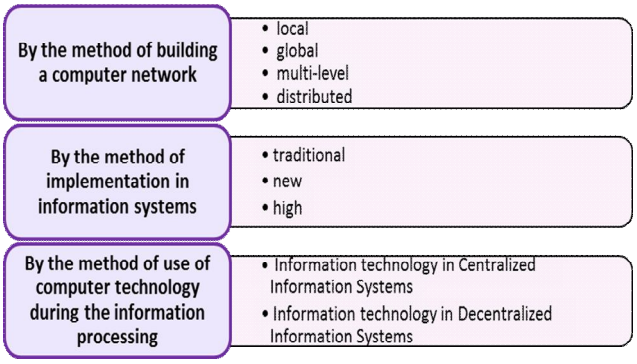

Fig. 3. Types of Information Technology

7 Computer-based Programs and Training Systems

Computer programs and training systems are widely used in education (Fig. 4):

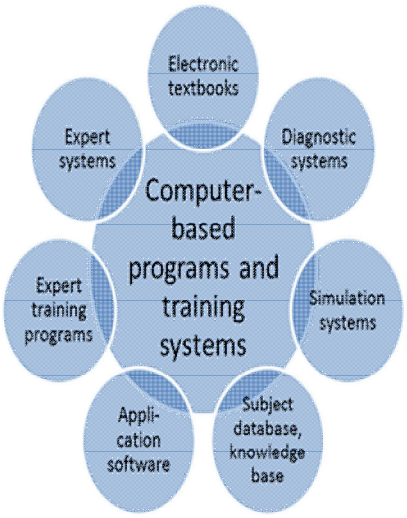

Fig. 4. Computer-based programs and training systems

8 Hypertext and Hypermedia

It is impossible to imagine modern education without technologies like hypertext and hypermedia. Hypertext pioneers are Vannevar Bush (the concept of the memex, 1930s), Douglas Engelbart (development of hypertext), Theodor Holm Nelson (terms "hypertext" and "hypermedia", 1965). TheFreeDictionary cites a quotation: "Let me introduce the word hypertext to mean a body of written or pictorial material interconnected in such a complex way that it could not conveniently be presented or represented on paper" (Ted Nelson). Hypertext technol-

ogy is a creation, maintenance, extension and revision of the text presented in a network. Programs that support this technology are based on four features of hypertext:

- replacement (while viewing the text, you can replace any part of the information by an image or any other piece of the text);
- links (you can use links of information network);
- notes (like standard notes in the margin, but by expressive means of video, color, graphics or sound);
- requests (text analysis from the specific position).

The invention of hypertext was caused by difficulties with information perception and assimilation in polytypic simultaneous streams of information, which had become difficult to structure. Hypertext enabled the authors to create links and users to decide, which link to follow and in what order. Text became nonlinear.

Similarly, hypermedia is an extension of hypertext, which allows graphics, images, movies, and Flash animations to be linked to other content.

There exist a lot of systems to create and store hypermedia resources: HyperWave, an information system similar to a database (hierarchical structuring; all hyperlinks from the document are separated and stored as individual objects; link control, both full text search and search by attribute options, interactive editing of links and documents, etc.), Microcosm (development of online multimedia textbooks, reference books and documentation; dynamic and automatic links, thematic search and navigation), Intermedia and Storyspace (creating hypermedia works, working with large and complex hypertext), WebThing (joint authors work in telecommunication networks), World Wide Web (based on client-server architecture and runs on the Internet), Information Processing – Text and Office Systems – Standard Generalized Markup Language, SGML – abbreviated name of the international standard ISO / IEC 8879:1986 (method of document creation and markup; forms the basis of a number of standards); HTML – HyperText Markup Language, the main markup language for displaying web pages, an application of SGML for hypertext document presentations (creating interactive forms; embedding images, objects, and scripts in languages such as JavaScrip; creating structured documents by denoting headings, paragraphs, lists, links, quotes, etc.), HyTime – Hypermedia/Time-based Structuring Language – also an application of SGML and the international standard ISO/IEC 10744:1992 (provides the technical basis for integrated open hypermedia technology, including SDML; Extensible Markup Language (XML) that defines a set of rules for encoding documents in a human-readable and machine-readable format; etc.

An important factor affecting students' use of information and improving their long-term memory is not the amount of educational multimedia resources, but their brevity due to the necessity. As software designers usually are not teachers, they do not always adhere to this. At the same time, educationalists long remained aloof from the new trend in education. As a result, there is a lack of commonly accepted psychological theory of computer-aided teaching. Computer training programs are still created and applied without regard to principles and laws of learning.

9 WEB 2.0

An important step in applying information technology in education was the introduction of Web 2.0, enabling everyone to create and publish content online, including: video on YouTube, photos on Flickr, blog posts, social networking, wiki projects and more. The key components for Web 2.0 is easy to use tools and social interaction with expected results. An important result of Web 2.0 is the so-called "collective mind" – the ability to search and sharing knowledge with users and experts from around the world. With the advent of Web 2.0, there appeared a new term E-Learning 2.0 proposed by a Canadian researcher Stephen Downes as a derivative for aggregate trends in e-learning, which arose from a combination with the means of Web 2.0.

Tony Karrer identifies the most relevant aspects of Web 2.0 E-learning:

- software service;
- harnessing collective intelligence;
- everyone as publisher;
- aggregation and tagging.

Web becomes a computer platform that provides software as a service (Cloud Technology or Cloud Computing). National Institute of Standards and Technology (NIST) defines cloud computing as a "model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model is composed of five essential characteristics (on-demand self-service, broad network access, resource pooling, rapid elasticity, measured service), three service models (SaaS, PaaS, IaaS) and four deployment models (private, community, public and hybrid clouds)". The other models are DaaS (Data as a Service), HaaS (Hardware as a Service), WaaS (Workplace as a Service), SaaS (Security as a Service), AaaS (All as a Service).

10 CLOUD COMPUTING

Cloud computing is a paradigm, in which information is permanently stored in servers on the Internet and cached temporarily on the client side, such as personal computers, game consoles, laptops, smartphones, etc. The main advantages of cloud IT infrastructure are:

- scalability;
- use of common standards;
- significant simplification of the system as a whole;
- high level of reliability;
- flexibility and mobility;
- security of data and information security, including virus protection;

- lack of capital costs for the use of software, purchase servers, powerful personal computers.

Nowadays there are over 70 companies that provide the use of cloud infrastructure. Ukraine's first provider of cloud infrastructure is the virtual software environment Tucha, deployed in the cloud-based computing facilities located in European data centers.

Modern education can be called network education. To ensure its global and outpacing nature, the enormous possibilities of computer networks able to combine information resources of mankind by providing instant communication with anyone around the world are used. Members of the educational process are able to use online tutorials and world libraries materials; participate in teleconferences to study in virtual classrooms; use email; exchange graphic materials; etc.

11 Technologies Based on the Use of the Internet Service

Let us consider technologies based on the use of the Internet service.

Multi-user Object Oriented (MOO) is an environment that provides us with communication in real time, possibility to create virtual objects, use virtual boards and record everything which happens in the virtual room.

Multi User Domain (MUD) for individual and group meetings, and creation of situational models. It provides MUD-mail in the form of small messages and bulletins for public debate.

Interactive Relay Chat (IRC) Technology is software that allows you to communicate in real time through short text messages. You can create the University environment for consultations, tests and exams.

Large files such as high definition videos, audio files, images, some text documents (usually in PDF) are placed on the File Transfer Protocol server (FTP).

The World Wide Web (WWW), invented by Sir Tim Berners-Lee, is the most developed and perspective service that runs on the Internet. The main components of the World Wide Web technology are Hypertext Transfer Protocol (HTTP), Universal Resource Locator (URL), HyperText Markup Language (HTML) and Common Gateway Interface (CGI). In the training process they are used in conjunction with Java, Java Script, Active X languages; Macromedia Technologies; Real Audio, Real Video systems and MPEG to transmit sound in real time.

12 Intelligent Information System

Another kind of technology is *Intelligent Information System (IIS)* that can be defined as the next generation of *Information System* (IS) developed as a result of integration of artificial intelligence (AI) and database (DB) technologies. IIS are effectively used for poorly structured problems without strict formalization. Heuristic procedures, which cannot be described by any algorithm, are used to solve such problems.

The International Research and Training Center for Information Technologies and Systems conducts research into the following classes of intelligent information technologies:

- visual information technology, intended for the perception and image recognition;
- speech information technologies for the perception, recognition and synthesis of natural human speech;
- knowledge oriented information technologies for analyzing, understanding, interpretation and generation of text information, and digital content processing of text information;
- information neuronet technologies for efficient processing of knowledge .

Expert systems (or knowledge based systems as a narrower concept) are a subclass of intelligent systems. There exist many definitions of the term “expert system”. We can say that it is an intelligent computer software system, which behavior, knowledge, and skills can be compared with the behavior, knowledge and skills of specialists in a certain narrow field of applied knowledge. The main structural elements of an expert system are the knowledge base and inferential mechanism. Such a program can make logical conclusions and solve specific problems independently.

Expert system emulates the decision-making ability of a human expert. It has a universal component, which contains only the mechanisms of reasoning and the “shell” of knowledge base, which users fill with practically limited information. Knowledge of great number of experts is compiled and generalized during training while the system is receiving input tasks, analyzing them and building a plan to solve a problem. In contrast to the limited stock of human knowledge, which is lost when it is not used, knowledge put into an expert system is stored permanently; system is capable of self-learning.

Sometimes expert system is compared with Master Wizard. But Master is just a set of forms that is filled out by a user whose actions are programmed, while the expert system’s problem-solving algorithm is unknown.

Application of expert systems in education provides intellectualization of educational activities; training specialists able to work effectively in a modern information society; developing the personality whose level of intelligence will always exceeds the level of artificial intelligence.

Expert systems in education:

- increase the probability, frequency, and consistency of making good decisions;
- help distribute human expertise;
- facilitate real-time, low-cost expert-level decisions by the no expert;
- enhance the utilization of most of the available data;
- permit objectivity by weighing evidence without bias and without regard for the user’s personal and emotional reactions;
- permit dynamism through modularity of structure;
- free up the mind and time of the human expert to enable him or her to concentrate on more creative activities;
- encourage investigations into the subtle areas of a problem;

- give emphasis on individual student by keeping record of his or her learning ability and speed;
- provide convenient environment to ask queries and find out their solutions;
- give a congenial way to find out errors and fix them.

The global role of expert systems in education consists of two interconnected problems:

- to assist students in solving particular educational problems using scientific methods and techniques;
- provide students with methodically competent assistance in solving particular educational problems taking into account their mental development and level of training.

Research has shown that the implementation of educational expert systems makes possible new kinds of learning activities such as interactive dialogue, control of real objects and displayed models of various objects, phenomena and processes. Computer-aided control, self-control and correction of the results allows to create methodology focused on the development of thinking, assists in developing of communication skills and ability to make optimal decision and offer options in difficult situations.

All expert systems are applications of *artificial intelligence*. The term intelligence (from Latin *intellectus* – mind, mental capacity) means "the ability to solve problems, using limited resources". Accordingly, artificial intelligence (AI) is a feature of automatic systems that can engage on behaviors that humans consider intelligent, for example, select, and make better decisions based on prior experience, and rational analysis of external influences. In other words, it is the ability of application process to identify properties associated with reasonable human behavior. Challenges associated with finding a solution algorithm of some type problems are called intelligent. Intelligent system structure includes three main categories: knowledge base, solver and intelligent interface.

Artificial intelligence is developed by using specially designed languages: LISP (functional programming) and PROLOG (logic programming), Smalltalk (object-oriented language with dynamic typing), FRL, InterLisp, etc. Programming languages like Assembler, BASIC, C, Fortran, Pascal can also be used to creating expert systems.

Important steps towards development of artificial intelligence algorithm were Aristotle planning algorithm (circa 400 BC); the René Descartes mechanical theory based on the assumption that the animal is a complex mechanism (17th century); Ramon Lulliya logical machine (13th century); Wilhelm Schickard (1623), Pascal (1643), Gottfried Leibniz (1671) mechanical computers, Charles Babbage and Ada Lovelace mechanical general-purpose computer, Konrad Zuse program-controlled Turing-complete computer (1941); Bertrand Russell and Alfred Whitehead's "Principles of Mathematics" (1903), which was revolutionary in the development of formal logic; Lewis Carroll logic research (19th century); Warren McCulloch and Walter Pitts's neural activity, brain theories and cybernetics research, which gave rise to the creation of neural networks; Alan Turing formalisation of the concepts of "algorithm" and "computation" and the Turing machine, which is considered a model of a general purpose computer (20th century); the first general-purpose mobile Shakey the Robot able to reason about its own actions (20th century) et al.

Now intelligent information systems are under research of A. Bashmakov and I. Bashmakov (intelligent information technology); S. Korsakov (intelligent machines), T. Gavrilova, V. Khoroshevsky (the knowledge base of intelligent systems); C. Manning, P. Raghavan, H. Schutze; S. Russell, P. Norvig (artificial intelligence), E. Yudkovsky, S. Omohundro (artificial intelligence as a positive and a negative factor in global risk); T. Leibfried, P. Jackson (expert systems), M. Antonchenko, L. Dobrovsky, N. Esenina, I. Iwaskiw, B. Petrushin, K. Slovak, N. Tverezovska (creation and use of educational expertise systems), F. Winds (design of artificial intelligence); J. Giarratano, G. Riley (CLIPS language); E. Friedman-Hill (JESS language), Ivan Bratko (Prolog language) and many others.

The study of artificial intelligence is carried out in the following areas:

- creation of effective learning systems;
- development of expert systems determined by a set of interrelated rules, which articulate experience in a particular industry; and the mechanism of solution to recognize the situation, diagnose, and make recommendations;
- speech recognition that allows computers to "understand" natural language;
- implementation of technologies in real life, etc.

The main form of manifestation of intelligence is a cognitive human activity, so it should be based on human skills associated with creative mental activity.

Marina Shyshkina enumerates the following types of educational expert systems: academic dialogue, language teaching, translation, classification, problem-oriented systems and expert systems to prove theorems.

13 Intelligent Information System

The author proposes the following classification of educational software, depending on the role of computer in the process of learning:

1) complex functions software:
   - mastering of a certain part of educational content, such as: theme, course section, etc. (electronic textbook, expert learning systems, intelligent training system);
2) special purpose software:
   - ensuring students passing a stage of learning (tutorial, diagnostic, control, testing, simulators);
   - environment for study of objects, processes, phenomena, subjects, etc. (gaming simulation, MicroWorld);
3) supporting software:
   - automation of teacher's and student's routine actions (text and image editors, presentation and special software, tools for creating tutorials, electronic journals, electronic notes, etc.);

- providing information in electronic format (computer-based information retrieval systems: databases, knowledge bases, electronic dictionaries and reference books, electronic educational methodical complex);
- the use of remote access resources (search engines, sites, portals, e-conferences)
- providing indirect connection between the subjects of study (chat, Net Meeting, e-mail, etc.).

The most common communication technologies in computer networks, which provide operational communications, storage and exchange of information messages of any content such as text documents, audio and video files, archives, programs, etc., is the E-mail. It is used for communication between members of the educational process, transfer of teaching materials, etc. The advantage of this technology is an asynchronous exchange of information. Mailing list (LISTSERV) makes it possible to send one email to the list, and then transparently send it on to the addresses of the subscribers to the list.

14 Conclusion

Integration of Education and Science of Ukraine into the global educational environment requires wide use of Information Technology. But analysis showed that Information Technologies and Learning Tools are used spontaneously by both students and teachers because of the lack of systematic approach. The classification given in the article is intended to serve as a part of the basis for developing a systematic approach to the use of modern technologies in teaching and education.

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