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Hypertext technology in teaching: reality and trends

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1 Introduction

A lot of examples on effective application of computers in teaching have been demonstrated during computer development period. Computer flexibility and potential for programming different responses to actions of taught persons provided possibilities for making teaching process active individualized and research-like. At present it is completely obvious that computer is a valuable instrument allowing both to improve present methods of teaching and open new potentials of the field.

Computer-aided teaching is commonly named an "automated teaching", while programmed systems implementing automated teaching are respectively named "automated teaching systems" (ATS). In broad sense, ATS can be defined as a man-machine complex, working in dialogue mode and meant for managing of cognitive activity in teaching process.

An author (teacher) and a taught person (pupil) are the main users of automated teaching systems. Using his experience and knowledge the author compiles so called teaching courses, i.e. dialogue programmes based on principles for teaching a certain discipline and on algorithmic models for automated teaching. In its turn, the pupil uses teaching courses to improve his knowledge: he learns new material, practices in problems solution, analyzes his abilities, etc.

We shall emphasize the field of application and strategy applied for teaching management among many other ATS classifying charac-

teristics. Due to the field of application ATS can be divided into two groups:

a) systems where computers are used directly with the teaching material;

b) systems in which computer is a means for making investigations in teaching purposes.

The first group includes systems using tutorial techniques as well as drill and practice. The second group consists of systems implementing modeling, problems solution, calculations, games, etc.

The strategy applied for teaching control usually distinguishes:

a) control exercized precisely according to the algorithm prepared by the programme author;

b) control exercized by the pupil.

Recently, automated teaching acquired new keywords, i.e. hypertext and hypertext system. They commemorated appearance of principally new mechanisms for storage, search and representation of information which are adequate to assotiative man reasoning [1,2]. Hypertext is getting widely applied in teaching and recent information market has already got dozens of hypertext teaching systems. University courses [3], encyclopedias [4], reference books [5], project documentation [6], etc. are given nowadays as hypertexts. It is worth mentioning that due to the application field, hypertext systems are regarded as systems operating directly with teaching material while due to teaching control strategy, they are considered as systems in which teaching control is exercized by the pupil.

2 Hypertext Definition

Followed by recent popularity of a hypertext many attempts have been made to give its definition. It is possible to state by intuition that the ability to provoke user's feeling of free travel in the information flow

according to his needs is a distinguishing feature of a hypertext. From this point of view "small overheads" are the most suitable characteristics of a hypertext. According to the level of user's experience "small overheads" are regarded as quick response to user's request, ability to orient the user freely in a broad information area as well as many other notions which are hardly to define precisely though are easily revealed by the principle "look and feel".

The simplest way "to feel" what is hypertext is to compare the latter with the traditional text, for instance, the text of the present paper. A traditional text is considered as a consecutive due to sense that there is a unique linear sequence determining text reading order, i.e. we first read page one, then page 2, page 3 and so on. One may not be a great mathematician to determine what page is to be read next.

A hypertext is not consecutive. There is no unique order determining sequence for reading the text. This fact is explained by Figure 1.

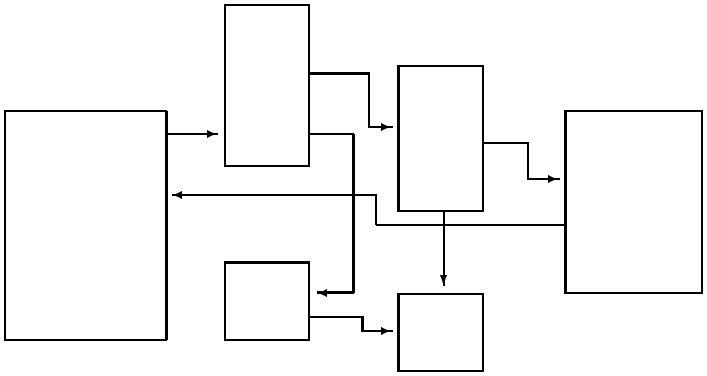

Figure 1

It is supposed that hypertext components correspond relatively to complete sense fragments of the initial text. The Figure shows that there are many different ways connecting two elements of the hypertext.

Following these ways one may read material in different order making various linear texts.

Therefore, hypertext is a form to organize text material where text fragments are presented as a system of indicated possible passages and links between the latter; and where text fragments are not given in linear consequence.

The material being sufficiently voluminous and with many links, there appears a rather complex hypertext space which can be represented as a net. Separate symbols, finished phrases, drawings, diagrams, schemes, etc. can be net peaks. Every peak, independent in size and structure can include references to other peaks. These references are called links in the hypertext. The number of links per every peak is usually not fixed in advance, it depends on peak content. Some peaks are connected with many other peaks and, therefore, have more links; others are final hypertext peaks.

The link connects two hypertext peaks and indicates way from one peak to another. It is associated with some certain place at the initial peak and not with the whole peak. Figure 1 shows that links come from a certain place of the initial peak and point to the peak of destination as a whole.

For instance, when link is coming from some word in the text, a fetch of the net fragment is made by cursor setting on this word and pressing of a corresponding key.

Links play a special role in the hypertext. They represent specially stored and generated information which is important for the user. They can be interpreted as cause and effect, general and particular, function and argument, as well as any other associative link which the user sees, sets and names. Hypertext allows to review and interpret the material in any order and for different purpose. In this case the user actively moves along hypertext net, determining the order for peak passage, and this process is often called examination or navigation, not reading.

Hence as compared to data base, hypertext has no apriori written structure. Practically all limits on structure and links inside the latter are removed. Hypertext is free for adding and changing. The user himself forms his information environment while friendy interface

provides maximum freedom for work with the material. In this context, hypertext can be considered as a pattern which depends more on user's or author's view than on internal properties of its components. The above said demonstrates a new level of relationships when many barriers between computer and user disappear.

3 Hypertext History and Examples of Hypertext Systems

To one's surprise, hypertext has a rich history, though many people have learned about it quite recently. The stages [1] are distinguished in hypertext development. The first stage includes works of "hypertext fathers", i.e. Bush Engelbart and Nelson who were the first to form hypertext concept and lay down a chart for its implementation. The specific feature of the second stage was the emergence of some search projects which demonstrated hypertext application potentials in a broad spectre of applied fields. Finally, the third stage of hypertext development was accompanied by the emergence of many commercial hypertext systems for personal computers and by sharp increase of user's interest to hypertext as a new paradigm in documentation science.

Hypertext history is assumed to begin in 1945 when Vannever Bush firstly described developed by him "device with the help of which people could store books, notes, other useful information and in the design of which provided quick and flexible response to a request" [7]. Bush works described the main features of modern hypertext systems: information storage in the form of a common text by means of associative links between fragments, replenishment of data base with own notes and storage of review sequence by users. Unfortunately, Memex system was developed during before computer age and have never been created. However Bush ideas have not been left unnoticed.

In 1963 when a certain experience on computer usage for research and economic purposes had been accumulated, Douglas Engelbart published his work "A Conceptual Framework for the Augmentation of

Man's Intellect" [8] in which he demonstrated his views on the problem of man's reasoning modelling. Engelbart's ideas were implemented in the first hypertext system NLS (On Line System) [9] aimed at increase of labour efficiency in a group of project designers. Projects, plans, reports and other text materials needed for everyday work could be loaded into NLS. The system provided possibilities for establishing hierarchical and reference links between documents. In the process of NLS development Engelbart made some inventions which constituted an integral part of modern software: text editor, multiwindow interface, "mouse" manipulator and context susceptible support.

The term "hypertext" firstly appeared in 1965 in the works of Teodor Nelson. Working on Hanadu Project in Harward University, Nelson defined hypertext as "nonlinear style for texts writing" [10]. Hanadu System was meant for use as a base for developing big electronic editing system. As Nelson said, the system had to provide storage, search and continuous correction of interrelated electronic documents, to serve thousands of users working simultaneously with text and graphic information, sound records, multiplication, etc. Users of the system have possibility to carry out collective editing, to create their own electronic documents; to make TV conferences. Therefore, Nelson foresaw development of electronic libraries and associated with them new information technologies. However, it is worth mentioning that nowadays the implemented Hanadu version represents the prototype for one user with a relatively small text data base [11].

The second period of hypertext development began in the middle of 60es when works in the field of interactive teaching, electronic documenting and projection automation assuming active use of hypertext had been initiated in some education institutions of the USA. In 1968 T.Nelson and A.Van Dam developed the first Hypertext Editing System [HES] [12] in Broun University which was later used in Hewston Center of Cosmic Space Research while developing technical documentation for the Project "Apollo". In 1969 in Broun University A.Van Dam and his group developed hypertext file search system FRESS (File Retrieval and Editing System). The commercial version of FRESS has been developed later and used for a long time in many universities for

teaching students and for information support of research works [13].

The greatest fame was gained by the latest hypertext project in Broun University, i.e. Intermedia System [14]. The system was developed for the operating stations SUN and Macintosh II and used by University teachers for preparation of teaching courses and by students in the process of teaching and making reports. Though Intermedia has not turned into a commercial product, it became an important stage in hypertext development history. Documents, graphic images and other materials are stored in Intermedia as separate files while relational DBMS was used for links control between and inside files. The system allows to give key names to net blocks and links; these key names can be further used for data search and filtration. The user has got possibility to create and preserve passage routes in the hypertext net.

"Webs" idea was the most interesting one among ideas implemented in Intermedia. Web is a set of links grouped according to a certain principle. By opening one of the Webs the user acquires access to a certain type of links at a certain majority of documents and, therefore, gets possibility to obtain functionally oriented section of a total document majority. Application of Webs provides users with possibility to set their own links for distributed document majority (hypertext peaks).

In 1972 D.MacKraken and R.Akshin from Carnegie-Mellon University created the prototype of ZOG System [15] and later on implemented version of this system fore VAX. The system has been meant for interactive solution of supervision tasks. To provide quick response to request of many users of different levels was the main requirement to this system. In 1983 ZOG was applied in the net of operating stations in the airplane carrier "Carl Winson" for information support in quick solution of different regulating and supervision works in the ship.

ZOG was further developed into the commercial version KMS [15] which firstly appeared in the information market in 1985. KMS had a distinguishing feature, i.e. ability to store both text and graphic information in hypertext peaks called frames. The authors planned this system as "commercially oriented". It was primarily meant for support of computer aided design when many engineers worked simultaneously

on development of the final document in computer net entity. With the time KMS possibilities have been extended and the latest version provides support in preparation of electronic publications, operations electronic control and reference systems; it can be used in systems of project management, financial modelling and accounting as well as for teaching.

Another system, oriented to the solution of computer aided design problems, is Neptune system developed in 1986 by the Tektronix Company [16,17]. Multilayer pattern, powerful user's interface based on Smalltalk and internal hypertext generator allow to create and modify blocks and links, support several "versions" of the same block and to provide quick access to any version. Ability to set descriptive flags and to confer them to blocks and links is an interesting peculiarity of Neptune. As a result, search in hypertext network can be done with the use of logique for the first order predicates and, hence, the process of decision making can be simulated. Ability to make conclusions and easily metamorphize text data base marked a new step in hypertext intellectualizing.

The system NoteCards became the biggest system of the second stage. It was developed in the Laboratory for Artificial Intellect Systems of Xerox Research Center in Palo Alto. System developers defined NoteCards as the medium for ideas processing [18]. The system authors were the first to introduce the metaphor of the "cardfile" which was later on used in HyperCard and Linkway systems. According to this metaphor hypertext peaks in NoteCard system are considered as electronic "cards". Every card may contain information of any volume as texts, graphs, images or their combinations. The users can collect cards and make cardfiles which one may refer to as to usual cards and form hierarchical representation of data base. Links can be of different types. They resemble relationships both between cards in one cardfile and between cards from different cardfiles. Some links are determined by the very system, though commonly it is done by the user. The system provides many protocols and functions to generate new card types and to control network information. NoteCards was planned as an instrument allowing purposeful collection of materials,

their systematizing and compiling of analytical reports. The system has been implemented on Lisp computers of the Xerox Company and used to control projects for juridical documentation processing as well as for technical design [19,20].

The third stage of hypertext development was manifested by appearance of hypertext envelopes for PCs followed by interest "outburst" to hypertext systems. At present HyperCard, Guide and Linkway systems are the most known among hypertext systems implemented for PCs.

Guide system [21] became the first commercial hypertext system for PCs. It was been developed since 1982 by the Owl International Inc. Company and appeared in the software market in 1987. Like all hypertext systems for PCs further developed, Guide did not possess functions characterizing systems introduced for mainframes and operating stations, however it was based on graphic interface. System management is exercised by the "mouse". By pressing electronic keys the user can activate hidden information layers, make passages on crossing references among majority of documents, make notes to appear in temporary windows, start up external programmes. The latest Guide version includes special programming language which provides considerable extension of functional possibilities of the system. Besides the system is supplied with the programme shell Guide Reader allowing multiplication of applied systems. Guide system proved good in teaching, electronic documenting, developing of on line reference systems [22].

Success of Guide predetermined, to some extent, the interest to appearance of HyperCard [23,25] system of the Apple Computers Company. Like in NoteCards, text and graphic information in HyperCard system is stored in cards. Unlike NoteCards, HyperCards system allows to show only one card on display. The card occupies the whole display and may contain text, graphic information and "buttons" allowing to activate programmes in the Hypertalk language. Cards can be united into stacks. Any hyperdocument is regarded as a document representing a pile of cards where the first card is upper and the last is lower. Data base is organized on the base of scope associations and

in accordance with hierarchical subordination. The user can successively move up and down the card pile and change passage sequence by means of special operations like, for instance, sampling. Recent HyperCards is one of the most widespread hypertext systems. It is interesting to note that it is explained by rather low price of the system and by the fact that Apple includes free of charge HyperCard into the standard supply set of Macintosh. HyperCard is most widely applied in not very complex commercial and educational accessories as well as friendly interface to data base [24].

Development of the hypertext shell Linkway by the IBM Company [27] can be regarded as the evidence for growth of hypertext systems popularity. Like in NoteCards and HyperCards the Linkway system uses cardfile metaphor; the cardfile (card index) consists of pages. Every page may contain any number of drawings, text fields and electronic buttons pressing of which results in performance of certain actions. Every button can be associated with the script which describes certain sequence of events. In addition, Linkway set of functions allows to load cardfiles, change user's access level, edit, create, type, remove pages and objects, pass to any cardfile page. The system is meant for use in teaching process and represents seven standard operation modes i.e. lecture plan, calendar plan, audience loading with work, journal of marks, lectures abstracts, hometasks, tasks list.

Therefore we may note constantly growing interest of researchers and potential users to hypertext systems. Nowadays, several dozens of commercial hypertext products have been presented in the information market. New versions of systems which already became a success, such as HyperCard, Guide and Hyperties [26], are regularly appearing. Many articles devoted to hypertext have been published. However, it is worth mentioning that the number of articles on hypertext theory is much less than that devoted to technical implementation of hypertext and commercial hypertext systems. We need to recognize the fact that the problem theory has not been yet developed in spite of considerable practical achievements. Uniform classification of existing hypertext systems, understanding of the present hypertext state, proper evaluation of tendencies and development prospects are important problems

waiting for their solution.

4 Types of Hypertext Systems

The review made by Konklin [28] is still considered as the best review of existing hypertext systems. It gives description and comparative analysis of the majority of up-to-date systems. Due to application Konklin distinguishes four types of hypertext systems i.e. systems for data base scan, library macrosystems, instrumental means to support creative process and systems for broad purposes.

The systems data base scan (browservs) are intended to create reference books. Simplicity in use and compactness are distinguishing features of such systems. The main requirement is easy access to the information. Browsers do not stipulate adding of new information. Data base is made initially before system running and can be changed only by the administrator. The above mentioned systems ZOG and KMS as well as HYPERTIES [26] and AFORISM [29] are typical examples of browsers.

Library macrosystems are intended for storage of big information volumes, for support of links between documents and their different versions as well as for automatic reconstruction of documents. Unlike browsers, library macrosystems allow to modify hypertext network. Support for sharable work of users group to solve common tasks is an important requirement to systems of this class. Library macrosystems are also widely used in teaching, Xanady, Textnet [30], EBook3 [31] and ASKTom [32] systems can serve as examples of library macrosystems.

Instrumental means to support creative process, i.e. authors systems, are useful for work with badly structured and poorly linked with each other materials and can be applied at different stages of author's work. The final task of author's work is to create a document: a book, project, review, report, lecture, teaching technique. Authors systems provide users with convenient means for collection and support of various information in the form of hypertext network, assist in analyzing of big data volumes, in revealing links between their separate fragments at different stages of the hypertext document development process. A

number of interesting authors systems IBIS [33], DIF [34], TRAILS [35], GYPSI [36] has appeared lately.

Within the frame of research in the field of hypertext technology, search is continued for new means which allow to make hypertext more intelligible and convenient for the user. System of wide purpose or so called systems investigating hypertext possibilities are meant to solve such problems. Intermedia, NoteCards and Dedal [37] are the most well known systems of this kind. Undoubtedly the above mentioned systems have all properties of browservs and library macrosystems.

5 Hypertext Technology

Though the idea of nonlinear presentation of text information sprang up even before the appearance of the first computers, teal possibilities of hypertext could be appreciated only with after appearance of computer hypertext systems. Computers provided easy work with hypertext which became a decisive for users attraction and for development of the hypertext technology.

Under hypertext technology we understand generation, support, accumulation and scanning of network-like texts on computer base [27].

The main functions of hypertext technology are the following:

- support of reference links;
- hypertext change, replenishing and updating;
- selection of virtual structures;
- random access and
- quick scanning.

Support of reference links is the most important function of hypertext technology. It allows to work intensively with the information network in the form of which hypertext is presented. Movement along network is made by means of successive performance of enquiry and

replacement operations. Enquiry operation consists in selection of certain types of links from total number of links of this block with the aim of further search and filtration of necessary data. Search can be done on key words, separators, by comparison with the sample, etc. Replacement operation follows that of enquiry. It allows to replace a default block associated with it fragment, drawing, scheme, etc. Therefore, combination of enquiry and replacement functions allows to implement purposeful text structuring. In the physical level it means text scanning according to users requirements.

The function of change, replenishment and updating of the text provides the user with the possibility to modify initial text structure, change links, introduce new and destroy old blocks, edit block content, introduce interlinear notes, leave electronic bookmarks, etc. Presence of this function is an advantage of hypertext as compared to standard data bases not allowing changes in conceptual schemes of information storage. Note operation, which allows to make "marginal notes" using all available text and graphic means, is an important one which is peculiar for hypertext.

The function of separation of virtual structures provides possibility for making and memorizing the path in hypertext network. It is the most important function from the point of view of support of human intellectual activity. The kind of activity may include preliminary grounding of decision making, search for solution of a poorly formalized problem, projecting of various objects, development of some system of ideas, acquisition of a connected text.

The function of quick scanning and random access has been used almost in all hypertext systems. The function of quick scanning allows the user to orient quickly in large scale information environment. Physically it means ability to review data base general structure, i.e. titles, big fragments and information blocks. The function of random access is that of electronic journal which provides access to stations by names. In practice it provides possibility for jump to alphabetic index and continue from it the movement along reference links.

6 Developmental Trends of Hypertext Systems

Development of hypertext technology has been connected with the progress in the field of computerizing. The first generation of hypertext systems worked on the base of a central processor. Set up of operating stations initiated the second stage in the development of the hypertext technology. Contemporary systems work both, in operating stations and personal computers. They are more adjusted to users needs. Hypertext has further developed in two directions [27]: integration of information of various types and intensification of information semantic processing in hypernetwork.

The first trend presupposes development of hypermedia systems. Hypermedia or hyperenvironment is a hypertext which provides work with text types of information, computer graphics, speech and video copy [38]. Constant development of technical possibilities allowed to include into hypertext systems videorollers, sonic and speech illustrations, in addition to static pictures. New technical possibilities bay down tasks related to establishment of links between new forms of information representation, to possibilities for combination of different representation forms, etc. Hyperimage systems have appeared lately for nonlinear work with image arrays [27]. Combination of various types of information with network visualization and use of different computer graphics instruments is a good means to invoke user's reasoning.

The second trend in contemporary hypertext development is associated with the intellectualizing of hypertext systems. It is worth mentioning that movement in this trend is made both from intellectual and hypertext systems. On the one hand in knowledge engineering and in particular in expert systems, the problem of friendly interface and the user has been always important [39]. The use of hypertext technology helps in the solution of this problem. Besides, hypertext can make much easier the labour-consuming process of knowledge base creation. In this case hypertext can be regarded as a preliminary means for knowledge representation. Hypertext system will help expert in knowledge accumulation and check, in understanding of representation formalism and later on in knowledge assembly into selected structures

[40].

On the other hand, elements of artificial intellect are introduced into hypertext systems. Hypertext technology is extended by procedures which traditionally were referred to the artificial intellect. Authors systems turned out to be the most advanced in this direction [6,34,35,41,42]. Authors systems develop hypertext possibilities offering additional functions related to selection of virtual structures in the text for linearizing hypertext the certain stand-point. For example, HYPERLOG [43] system uses algorithms for making nodes successive in accordance with the criteria of "good cohesion" of the next node with the foregoing. In GYPSI [36,41,44] system such succession is formed in accordance with the set characteristics for nodes. The obtained set of text fragments is considered as the fore text and needs further editing.

Integrated system TOPIC [27], containing subsystems for text understanding and search can also be of interest. The subsystem for text understanding uses knowledge base of frame structure. Text compression and generalization on frame structures is made interactively in TOPIC. As a result initial file turns into text graph, i.e. generation of knowledge base takes place. Such compression can be used in automatic abstracting, search of factographic information, extraction of informative segments from the initial text.

7 Conclusion

Experience of hypertext usage has shown that it is an indispensable instrument in teaching. This circumstance is conditioned by special distinguishing hypertext properties, i.e.

- ability of hypertext to ease and accelerate every separate aspect and notion which provides easier access to the information array;
- information in hypertext is organized according to purely semantic criteria which results in the effect of the objective information system;
- hypertext not only loads the pupil with the information flow,

it provides a number of alternatives and possibilities to choose scanning order;

- hypertext can be an effective instrument for analysis and forecasting of studied objects structures; it allows the pupil both to look through a group of documents and to study technique of associative links formation;

- hypertext provides possibility to make search in big data bases independent on their volume; in this case it does not need knowledge formalizing; it allows to present them as some information units;

- at last hypertext has practically an unlimited field of application.

Further development of hypertext takes place in two directions: integration of different type information and intensification of processing and semantic information in hypernetwork.

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