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## PREFACE

*Intelligo ut credam !*

The **International Journal "Information Technologies and Knowledge"** (IJ ITK) has been established in 2007 as independent scientific printed and electronic media. IJ ITK is edited by the *Institute of Information Theories and Applications FOI ITHEA* in collaboration with the leading researchers from the:

- Institute of Cybernetics "V.M.Glushkov", NASU (Ukraine);
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The main scope of the IJ ITK covers but is not limited to the theoretical research, applications and education in the area of the Information Technologies for:

- Knowledge Collecting and Accumulation
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- Cognitive science
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- Data Mining
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- Information Technologies in Biomedicine
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- Intelligent Robots
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The International Journal "Information Technologies and Knowledge" (IJ ITK) continues the series of international scientific events, which were initiated more than fifteen years ago. It is originated owing to initiative of ADUIS -

Association of Developers and Users of Intelligent Systems (Ukraine) and Institute of Information Theories and Applications FOI ITHEA, (Bulgaria), which have long-term experience of collaboration.

Volume 1/2007 of the IJ ITK contains 68 papers written by 130 authors from 12 countries: Belarus, Bulgaria, Egypt, Finland, France, Germany, India, Jordan, Russia, Spain, Ukraine, and USA; selected from several international conferences, seminars and workshops organized or supported by the Journal. At the first place, the main source for selection were the ITA 2006 Joint International Events on Information Theories and Applications, (June 20-July 07, 2006, Varna, Bulgaria):

- International Conference "Modern (e-) Learning" (MeL 2006);
- IV-th International Conference "Information Research and Applications" (i.TECH 2006);
- XII-th International Conference "Knowledge-Dialogue-Solution" (KDS 2006);
- IV-th International Workshop on Multimedia Semantics (WMS 2006);
- Workshop on Cyber Security (CS 2006).

Several papers were selected from the pool of papers directly submitted to IJ ITK.

Congratulations to *Juan Castelanos* (Spain) and *Georgi Totkov* (Bulgaria) who were awarded by the International Prize "ITHEA" for the year 2006. The "ITHEA" Prize has been established in 1995. It is aimed to mark the achievements in the field of the information theories and applications.



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1996	<i>Sofia</i>	<i>T. Hinova, K. Ivanova, I. Mitov, D. Shishkov, N. Vashchenko</i>
1997	<i>Yalta</i>	<i>Z. Rabinovich, V. Sgurev, A. Timofeev, A. Voloshin</i>
1998	<i>Sofia</i>	<i>V. Jotsov</i>
1999	<i>Sofia</i>	<i>L. Zainutdinova</i>
2000	<i>Varna</i>	<i>I. Arefiev, A. Palagin</i>
2001	<i>St.Peterburg</i>	<i>N. Ivanova, V. Koval</i>
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2003	<i>Varna</i>	<i>T. Gavrilova, A. Eskenazi, V. Lozovskiy, P. Stanchev</i>
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2006	<i>Varna</i>	<i>J. Castelanos, G. Totkov</i>

*Krassimir Markov*  
IJ ITK Founder and Editor in chief

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## ELECTRONIC EDUCATION IN THE FIELD OF ELECTRICAL ENGINEERING DISCIPLINES. COMBINED DIDACTIC INTERACTIVE PROGRAM SYSTEM

**Larisa Zaynutdinova, Maxim Polskiy**

***Abstract:** At present in the educational process of electrical engineering disciplines electronic learning program, providing control over reproductive educational-cognitive activity (the decision of standard problems) and universal modeling program systems, for instance Electronics Workbench, giving a chance of organizing productive, in particular research activity are basically used. However universal modeling program systems can not provide auto control over educational-cognitive activity because of the absence of the feedback with students. The combined didactic interactive program system, providing the closed directed auto control over both the reproductive and productive heuristic educational-cognitive activity of the student is offered.*

***Keywords:** electrical engineering discipline, electronic learning program, universal modeling program systems, combined didactic interactive program system, reproductive and productive heuristic educational-cognitive activity.*

***ACM Classification Keywords:** K.3.1 Computer Uses in Education, J.2 Physical Sciences and Engineering.*

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### Introduction

At present there are two main trends of introduction of the information technologies in the education process of electrical engineering disciplines. The most wide-spread is using universal modeling program systems (UMPS) such as Electronics Workbench, Micro-Cap, Matlab. These systems designed by the leading world companies, possess a broad spectrum of possibilities. On their basis the laboratory practical studies on different educational disciplines: electrical engineering, the principles of circuits theory, electronics, electric measurements etc. can be rather easily realized. The other direction, gradually increasing its positions, is the creation of the author's didactic interactive program systems [Зайнутдинова, 2000]; in particular, electronic learning programs (ELP).

At the electrical engineering department at Astrakhan state technical university (ASTU) both these directions are used. For 15 years the work toward the elaboration of the unique ELP has been under way, since 2001 the virtual laboratory on the basis of Electronics Workbench has been promoted.

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### 1. Electronic learning program «Electrical engineering-ASTU»

This program provides continuity and fullness of the didactic education cycle: gives a theoretical material, provides training educational activity and knowledge level control in realizing interactive feedback. During the elaboration the method of theoretical images, offered by L.H. Zaynutdinova [Зайнутдинова, 1999, а] was used. The High didactic features of the designed ELP were confirmed by the results of the pedagogical experiment and perennial practice of its use in the educational process at ASTU. The motivation of the education has been improved; the students' progress has been increased.

The following points should be referred to the merits of the electronic learning program «Electrical engineering - ASTU»:

- The possibility of the execution by students all the sections of the didactic cycle (the acquaintance with the theoretical information, drilling, control, feedback).
- The possibilities of mastering the basic notions of electrical engineering course and the algorithm of the standard problem solution from the very beginning (the requirements to initial knowledge in the field of electrical engineering is minimum).
- The registration of the user and automatic issue of the individual tasks.
- Visualization of the educational information presentation on the basis of the method of theoretical images.
- A friendly user interface. A person who has no any computer background can work with the program.

- Cyclic (closed) control over the educational-cognitive activity (the operation-by-operation control over student's actions, the multilevel interactive feedback, the furcated system of prompts).
- Saving teacher's time (the reduction of the expenses on routine operations of giving and controlling the educational tasks).

Due to the enumerated merits of the ELP "Electrical engineering - ASTU" and first of all due to the high visualization of the educational information presentation and high level of the control over the educational - cognitive activity (cyclic or closed control system) the high values of the activity assimilation coefficient  $A_c$  are reached.

The rigidly fixed limits of the educational activity should be referred to the demerits of the given ELP. To achieve the formulated aim a student follows the rigidly fixed problem solving algorithm input in the program. Any possibility of choosing any other method of solution is excluded. The student has no chance to fall outside the scope of the educational task block, in consequence of it only the reproductive algorithmic activity level is reached. In this paper we follow the classification of educational-cognitive activity levels and the indicators of its assimilation quality (assimilation coefficient  $A_c$ , in particular), offered by V.P. Vespalko [Беспалько, 2002].

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## **2. Universal modeling program system Electronics Workbench (EWB)**

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The system greatly increases the possibilities of the experimental studies. The main merits of Electronics Workbench are:

1. Electrical circuits modeling. The System EWB is characterized by the simplicity of programming, the availability of the models of habitual measurers and broad set of elements. Such "virtual laboratory" allows to put together a complex experimental mounting and to fulfill a natural consequence of experiment making.
2. A friendly user interface. The program has a standard interface for the system Windows and is easily learned by the students who have a certain level of computer background.
3. Widening the limits of the experiment. If this system has a great set of elements and measurers with any diapason of measurements the possibility of the studied phenomenon increases in comparison of the usual physical experiment.
4. Reducing the material expenses on obtaining expensive laboratory equipment.
5. Saving student's time. The process of computer modeling the studied phenomena from constructing a scheme to processing the obtained data takes less time than in a usual real laboratory.
6. The possibility of formulating an individual educational task, corresponding to the student's preparation including rather a complex task, requiring productive heuristic activity level. The given program proposes student's educational-research activity.

The absence of the possibility of habitual experiment perception should be referred to the demerits of the "virtual laboratory" on the basis of Electronics Workbench. Besides, the student is to possess the initial knowledge in the field of electrical engineering disciplines, to know the main electrical engineering notions, to have the practice of setting up circuits, the experience of working with measurers and also the certain computer background. Thus, UMPS can not train from the very beginning.

From the pedagogical point of view the main demerit of the universal modeling program Electronics Workbench and the similar ones is an absolute absence of the control over student's educational-cognitive activity. The absence of control can prevent the students from acquiring the knowledge on different subjects. At present it is possible to get over this demerit due to the fact that the teacher takes the control function over himself.

The differences in the technique of the control over the educational-cognitive activity with the application of the electronic learning program and universal modeling program systems are shown in table 1.

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## **3. The comparison of the didactic possibilities of the electronic learning program «Electrical engineering-ASTU» and the universal modeling program systems Electronics Workbench**

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The analysis of table 1 shows the undoubted advantage of ELP in the aspect of organizing the auto control over student's educational-cognitive activity; however the frames of this activity are as a rule limited. ELP provides only the reproductive assimilation activity level. In other words, ELP provides a good student's preparation, but only in the field of solving the standard educational tasks. As to UMPS, Electronics Workbench systems in particular,

they, being the most powerful instrument of the scientific study, allow the possibility of formulating and solving problems, requiring productive heuristic level of activity. However because of the absolute absence of the control over students' cognitive activity they can not be directly referred to didactic systems. In virtue of the performed analysis of psychology-pedagogical literature and the materials of scientifically-methodical conferences, devoted to using information technologies in electrical engineering education [Материалы, 1998, 2000, 2003], it is ascertained:

- 1) ELP provide mainly reproductive levels of educational information assimilation, with the possible organization of the auto control over students' educational activity;
- 2) UMPS as the most powerful instruments of the scientific research allow the possibility of formulating and problem solving on productive heuristic level of the activity assimilation;
- 3) UMPS do not provide auto control over cognitive activity and, therefore, can not be directly referred to didactic systems.

In virtue of the statements given above the actual problem of creating a combined didactic interactive program systems possessing the merits of electronic learning programs and universal modeling program systems becomes actual.

Table 1

<b>The stages of laboratory-practical studies, pedagogical conditions</b>	<b>The electronic learning program «Electrical engineering-ASTU»</b>	<b>The universal modeling program systems Electronics Workbench</b>
Giving the theoretical information	Is present	Is absent
Forming the individual educational practical tasks	Is done automatically without teacher's participation	The teacher is to make and give an individual task
Control over performing a task	Is Produced without teacher's participation, automatically	The teacher is to direct the process
Control over the course of performing the task	Step-by-step control, automatic	The teacher realizes the control
Helping, issuing prompts	Help and prompts are given automatically, as the student makes mistakes	The teacher is to help and give prompts
Analysis of an electric circuit, making calculations, drawing graphs, diagrams	Is done by the student (active student's participation)	Is done by the program EWB (the student has the role of an observer)
The estimation task performing level	Is produced automatically with taking into account all the made mistakes	The teacher is to give a mark
The requirements to the student's computer background level	The student who began working with the computer for the first time can work	"Beginning" or "intermediate" user
The requirements to the teacher's computer background level.	"Beginning" user	"Intermediate" or "professional" user
The requirements to the level of the student's initial theoretical background.	Minimum	The student is to have fundamental ideas, to know the basic notions.
Convenience of the conditions of teacher's work at the lesson.	High (the teacher is completely free from the routine work of giving and checking the tasks)	Low (the teacher is very busy)

#### **4. Combined didactic interactive program system**

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In 2004 at the department of electrical engineering at ASTU the first CDIPS to the unit "Quadruples" in "Theoretical principles of electrical engineering" course was designed and tested. The tests showed the working capacity and pedagogical efficiency of the offered CDIPS [Зайнутдинова, Польский, 2005].

According to V.P. Bepalko "a didactic system is a type of the control over student's learning". In the paper [Беспалько, 2002] didactic systems are rated in order of different control methods:

- 1) correcting education on its final result (an open control) or stage-by-stage control (a closed control);
- 2) taking into account the students' individual peculiarities (the directed control) or group averaging (the diffused control);
- 3) the control operations with teacher's help (the manual control) or by means of technical facilities (the auto control).

Traditionally in the field of teaching different disciplines the didactic system, providing the open, diffused and manual control over student's educational-cognitive activity is used more often. Lectures and practical classes can be referred to such didactic systems. A teacher in such a "traditional system", according to V.P. Bepalko, «manually uses the open control in diffused information space. By quality of training the given didactic system is weak» [Беспалько, 2002, p. 181]. Among the perspective directions of the didactic system development V.P. Bepalko distinguishes «the program control system». The foundation of it is a special adaptive program, controlling student's educational-cognitive activity, taking into account his individual peculiarities and correcting training by means of stage-by-stage control. Some analogue of V.P. Bepalko's « program control systems » for the field of general technical disciplines are the didactic interactive program systems analyzed in the paper [Зайнутдинова, 2000], – first of all ELP and intellectual training systems. Herewith ELP have become the most wide spread in the field of electrical engineering disciplines at present. We determined that most of the ELP used in the educational process at technical higher schools, provide the organization and control only over the reproductive educational-cognitive activity of the students. The realization of nonstandard, but herewith automatically stage-by-stage controlled individual training tasks, corresponding to the productive heuristic level of activity, is not provided in them.

Meanwhile the well-known researchers of modern education [Попков, Коржуев, 2004] distinguish the task of mastering technologies of taking the optimum decisions, developing the skill of adapting to different changes, forecasting the course of the development of different situations as the prior. In other words, the student's cognitive activity must have a productive nature.

Turning to the problem of using computer technologies in the educational process of electro engineering disciplines allowed us to draw a conclusion about the presence of the contradiction between the directivity of the modern educational system on the development of productive educational-cognitive activity of the student and the absence of corresponding didactic interactive program systems, providing the organization and auto control over this activity and guaranteeing a sufficient level of its assimilation.

The revealed contradiction has defined the problem of the present study. In the capacity of one of the possible decisions of these problems we are the first to offer creating a new type of the didactic interactive program system on electrical engineering disciplines which can be defined as follows: «A combined didactic interactive program system» (CDIPS) is a training program system of the complex purpose, providing the organization of the reproductive (recognition and reproduction) and productive heuristic educational-cognitive activity of the student under conditions of gradualness and maturity of education under the closed directed auto control.

#### **5. The Structure of the electronic learning program and the combined didactic interactive program system in the aspect of realizing an interactive educational dialogue**

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The questions of organizing the dialogue between the computer training program and a student in one way or another are touched in many papers, devoted to the use of modern information technologies [Роберт, 1994]. To our mind, it is necessary to distinguish two peculiarities:

- an educational dialogue is not a not merely an information exchange; the purpose of the educational dialogue is acquiring by the students the most profound and adequate knowledge of the essence of the material under discussion ;



- providing flexibility and clarity of the student's dialogue with the computer training program is possible if there is a rational organization of the user interface (the realization of the possibilities of quick mastering the rules of the work with the program even for a beginning user).

Meanwhile, many researchers and developers of computer training programs in our opinion do not pay enough attention to the didactic possibilities of the interactive dialogue. Thus, for instance in the paper [Масалитина и другие, 2000] it is said that the analysis of computer training programs, used in the educational process, shows the limited possibilities of most of them in the aspect of forming student's knowledge. Such programs more often give educational information (a theoretical material, tasks) and by means of a testing system check mastering the distinct methods by the student. The insufficiency of controlling influence of the similar programs on the student's cognitive activity is noted.

N.F. Talyzina's research works are devoted to the problems of increasing the efficiency of the control over the process of educational-cognitive activity assimilation. Thus for instance, in the work [Талызина, 1984] it is offered to synthesize the general theory of control (cybernetics) and the adequate to its requirements psychology-pedagogical education theory. The choice of the control type takes into account:

- the rational structure of the person's cognitive activity;
- the complicacy of the educational process, its dependence upon many factors.

N.F. Talyzina draws a conclusion about the unproductiveness of the control over the educational process according to the final results of the assimilation, as there is no unambiguous connection between them and the cognitive activity leading to them. The structure of the cyclic (closed) control is offered : a) the purpose of control is indicated; b) the initial level of the operated process is fixed; c) the program of influences, providing the main transient process conditions is defined; d) obtaining information according to the system of parameters about the condition of the controlled process at each moment of the control (feedback) is provided; d) the information conversion obtained through the feedback channel is produced; correcting influences are worked out and realized.

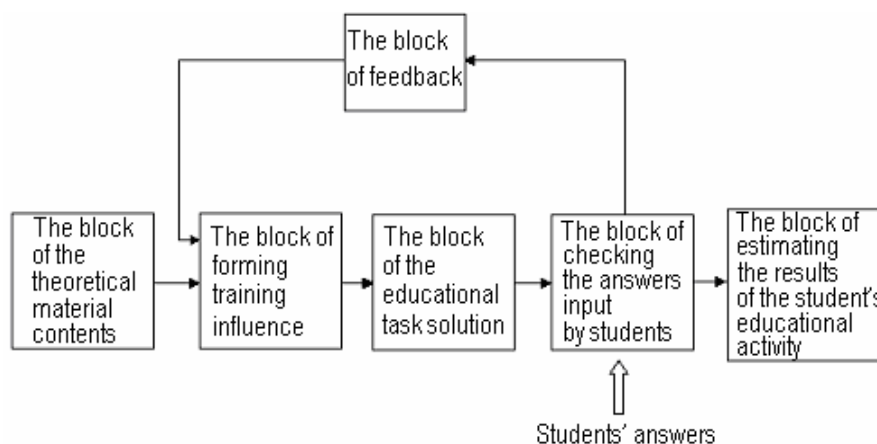


Figure 1. The Structure of the electronic learning program in the aspect of the interactive educational dialogue realization by L.H. Zaynutdinova

The given structure formed the foundation and was developed in the work [Зайнутдинова, 1999, b] as applied to ELP on general technical disciplines (figure 1). It is noted, that the automated control over the educational process is a deep aspect, the essence of the interactive educational dialogue.

The following structure components: the block of the educational discipline contents (the theoretical material), the block of forming training influences, the block of the educational task solution, the block of the control over the students' educational activity, the block of estimating the results of this activity and the block of feedback are represented. The block of forming training influences provides giving the individual tasks to the students with invoking the data from the block of the theoretical material contents. The variety of the individual training tasks is provided by the casual generation of the numerical values of the initial data and casual variety of the individual types of the problems. In the process of solving a problem the student inputs all the intermediate results of his solution in the computer. Then the block of checking answers compares the answers input by the students, with

the answer of standard, worked out by the block of the educational task solution. So the intermediate control over the results of student's educational activity takes place. Relying on this control with the help of the block of estimating the results of student's educational activity a final mark is formed, taking into account the number of the correct and wrong answers, the number of the efforts and other factors. The block of feedback provides the interactivity of the ELP. Such a level of the student's interaction with the program, when watching, control and the correction on the assimilation of the educational-cognitive activity are realized is reached. Thus, for instance, analyzing student's actions, the program issues one or another controlling influence (a prompt, an explanation, a new question or a task etc.). The feedback is the main condition of providing the closed control over student's educational-cognitive activity.

In realizing the feedback the contradiction between the necessity of forming various training influences and increasing because of this difficulty of realizing the control over the educational activity appears. For solving the given problem it is necessary to define properly such a volume of the fragment of the student's educational activity, which will be possible to be put in correspondence with the certain training influence and the results of the execution of which will be possible to be controlled by means of ELP. It was shown by L.H. Zaynutdinova that for the field of general technical disciplines the organization of such an interactive educational dialogue is worth while, when the controlled step of training corresponds to the execution of one operation. In other words, it is necessary to realize an operation-by-operation control over all the student's actions. As a result of such an approach the possibility of the operative formation of the unambiguous correcting training influences appears. This, in turn, allows training the student precisely the solution method. The considered system rigidly fixes the borders of the educational activity with the use of ELP. The student strictly follows the fixed solving problem algorithm installed in the program. Any possibility of choosing any other solution method is excluded. As a result the ELP provides a good preparation of the students only in the field of solving standard training tasks; only reproductive algorithmic level of educational-cognitive activity is reached [Зайнутдинова, Польский, 2005].

Herewith the questions of organizing the control over the process of the assimilation of students' heuristic educational-cognitive activity remain open. The analysis of the materials of the international scientific-methodical conference "New information technologies in electrical engineering education" (NITE) [Материалы, 1998, 2000, 2003] also shows that least developed are those directions of using computer training programs, which are connected with the control over students' productive educational-cognitive activity. Recall that formulating the tasks, requiring the productive heuristic activity level is possible by means of UMPS. For instance, in the work [Прокубовская, 2002] computer modeling is considered as the means of the development of independent cognitive activity of the students in higher schools. However because of the absolute absence of the control over the cognitive activity of the students in higher schools UMPS can not be directly referred to didactic systems.

Reasoning from the merits of ELP (in the aspect of the auto control realization) and UMPS (in the aspect of the possibilities of formulating the tasks of the heuristic level) the present work is the first to offer creating such a didactic interactive program system, which with the closed directed auto control will guarantee the first (b1), the second (b2) and the third (b3) levels of the assimilation of the educational-cognitive activity determined by the certain contingent of students with regard to the gradualness and maturity of the education. We call the new system a combined didactic interactive program system (CDIPS), as it is an interconnected combination of the ELP and UMPS.

The structure of the CDIPS offered in the present study is shown in figure 2.

The control over the students' educational-cognitive activity within the framework of CDIPS in performing the tasks of the first and the second levels is realized in the same way, as in ELP. Watching, control and correction on the assimilation of the educational-cognitive activity is realized by means of the block of feedback. Herewith it is necessary to distinguish the feedback types with the difficulty level of the task. Thus, for instance, in the work [Роберт, 1994] the suggestive feedback (from the English "suggest" – to offer, advise), in general case expecting such a reaction to the student's actions, when the possibility to get the advice proposed by the program, the recommendation about the further actions or commented acknowledgement (demolishing) of the proposed hypothesis or suggestion is provided was considered. In fact the suggestive inverse feedback was considered along with the control by the final result [Роберт, 1994]. In the paper [Талызина, 1984] such an approach corresponds to the control on the principle of "the black box", when the feedback, and consequently, the process regulation are realized only with regard to the "output" process.

Meanwhile, within the framework of ELP feedback messages expect giving the concrete and unambiguous statements (formulae, rules, laws and so on) in performing each operation. So the program reacts to errors and uniquely corrects the course of performing a task. From the point of view of the work [Талызина, 1984] such feedback has the information about the process of obtaining the intermediate results (is realized on the principle of "the white box").

In our view, the feedback, used in the electronic learning program by L.H. Zaynutdinova, should be classified as the declarative feedback. We shall enumerate its main features:

- the realization of operation-by-operation control over all the student's actions;
- the operative formation of the concrete correcting training influences.

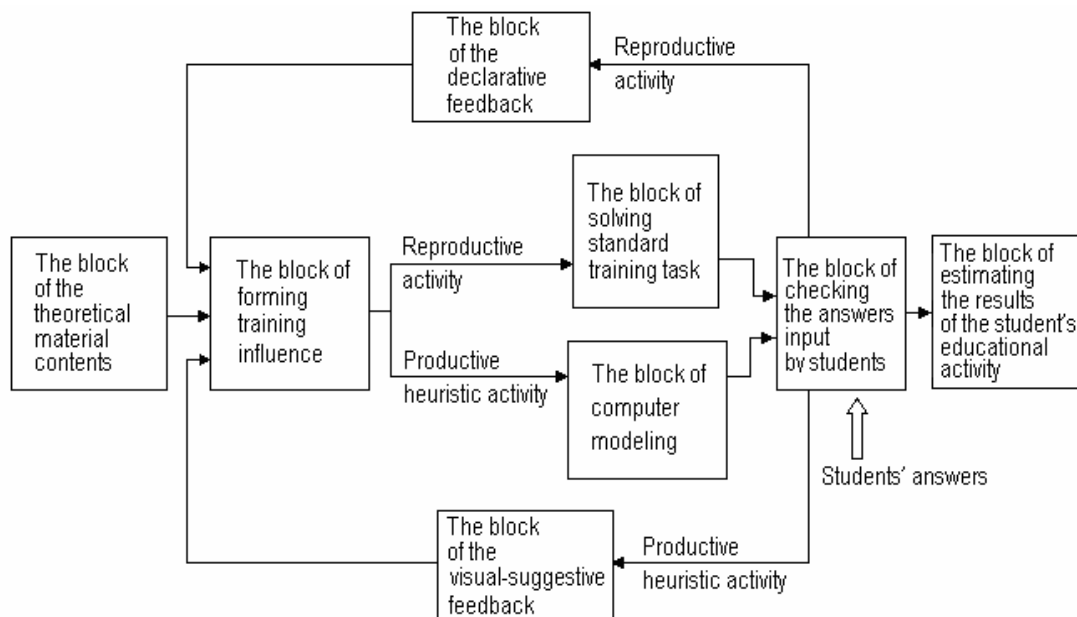


Figure 2. The structure of the combined didactic interactive program system in the aspect of realizing interactive educational dialogue

The given approach, in our view, is justified for the reproductive educational-cognitive activity therefore within the framework of CDIPS the declarative feedback is realized for the tasks of the first and second levels.

The distinctive feature of CDIPS is formulating the tasks of the heuristic (third) level. For this in the structure of CDIPS the block of computer modeling the studied processes (phenomena) is provided. The interactive educational dialogue is based on the correlation of student's solution, obtained by any means (also by means of UMPS), with the solution obtained from the block of computer modeling. Therewith the student may choose any solving method suitable for him, CDIPS does not limit his freedom in choosing - thereby the skills of orientating in non-standard situations in solving nonstandard problems are formed. The control in this case is organized in a more flexible form. The program does not expect the indications of the facts of making certain mistakes of that or this kind. The student is given a possibility to draw conclusions about the correctness of the solution method himself. This possibility is provided by means of visualizing on the screen the discrepancy between the results input by the student and the values of standard obtained by the block of computer modeling. The visualization can be realized with the help of figures, schemes, graphs, video files and so on. We were the first to represent the given feedback type in the present work. This study for the first time offered creating the block of computer modeling in combination with the visual-suggestive feedback for solving the problem of the control over heuristic educational-cognitive activity.

In realizing the tasks of the third heuristic level the contradiction between the necessity of providing the freedom in choosing the solution method by the students and the difficulty of realizing the control over the educational-cognitive activity gains momentum. For solving the given problem in CDIPS it is offered to widen somewhat the volume of the controlled fragment of the student's educational activity (in comparison with the tasks, corresponding to the reproductive level of the educational -cognitive activity). In formulating the tasks of the

heuristic level we offer the organization of such an interactive educational dialogue, where the controlled training step corresponds to the execution of one logically completed stage of work under the program. Each stage is the totality of elementary operations, providing the obtaining of the intermediate result. In other words, it is necessary to realize stage-by-stage control over the student's educational-cognitive activity. In this case the student has freedom in choosing the suitable solution method of nonstandard tasks.

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## Conclusion

**«Combined didactic interactive program system» (CDIPS)**, a training program system of the complex purpose, providing the organization of the reproductive (recognition and reproduction) and productive heuristic student's educational-cognitive activity in conditions of gradualness and maturity of the education under the closed directed auto control **is designed**.

**The designed CDIPS possesses scientific novelty**, namely: it provides the closed directed automatic stage-by-stage control over the productive heuristic student's educational-cognitive activity by means of the block of visual-suggestive feedback in combination with the block of computer modeling.

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## TOWARDS E+LEARNING, OR HOW TO INCREASE THE LEARNING INTO E-LEARNING

Rositsa Doneva, Daniel Denev, George Totkov

*Abstract:* It is discussed some changes in the traditional e-learning notion on the point of view of R. Koper's question 'where is the learning in e-learning?'. We put a focus on the conception of learning as a management process and present the project *Bulgarian Educational Site (BEST)* – a possible answer to Koper's question. The *BEST* is a virtual learning environment, based on the following principles: learning is a goal-directed and didactics-managed process; learners may define their own learning objectives, monitor and regulate the learning process; collaborative e-learning is more effective; etc. The *BEST* is based on two famous e-learning systems (Moodle, LAMS) and Plovdiv e-University (versions 1.0 and 2.0). The paper brings up a matter about the new 'electronic' pedagogy and proposes an approach for pedagogical modeling and interpretation of e-learning applied in the *BEST*.

*Keywords:* e-learning, management of the learning process, didactic methods, Moodle, LAMS

*ACM Classification Keywords:* K.3.1 Computer Uses in Education – Distance learning, K.3.1 Computer Uses in Education Collaborative Learning, H.5.3 Group and Organization Interfaces – Asynchronous interaction, Web-based interaction

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### Introduction

The educational process is based on pedagogy – the methods used for teaching and learning, and the 'teaching objects' in a course, such as assignments, learning activities, objectives, prerequisites, etc. There are three options for any learning technology when it comes to model didactic approaches: *pedagogy-neutral* (supporting no pedagogy at all), *pedagogy-standard* (supporting a single pedagogy) and *pedagogy-driven* (supporting a diversity of pedagogy). A great part of the contemporary software tools and technologies in the e-learning field can be characterized as *subject-dependent* (reorganized for specific fields and users) and *pedagogically neutral* (they don't support or provide any kind of methodical strategies and more specifically they don't specify ways for interpretation of learning content and objectives that are dependent on other conditions). They are 'neutral' especially in relation of the logic of interpreting of the course content while no learning requirements are specified. On the other hand, there are hundreds of different pedagogical models and strategies. As recorded by many authors: learning is different from consuming content learning and the implementation of one pedagogical model/strategy is not the right direction for e-learning researches and standardization. For example, the course may consist entirely of activities without any learning content and thus its implementation in or transfer to a 'pedagogy-neutral' or 'pedagogy-standard' system would be difficult.

On our point of view, the topic of the day for the e-learning researches could be expressed with the concept 'e+learning'. The term '*e+learning*' is used by us to note e-learning principles, technologies, means and tools but with potentialities to be applied in a wide spectrum of subject domains and according to different pedagogical strategies.

In the paper is presented a project for development of a virtual learning environment, named *BEST*<sup>1</sup>. The goal of the project is to implement the e+learning idea.

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### Didactics: from e-Learning to e+Learning

In nowadays, the e-learning educational paradigm gains more and more popularity, both as an alternative or as an integral part of the traditional learning. It is natural that the e-learning educational paradigm has to adequately reflect the well-known didactic principles of the traditional learning, but at the same time it has to implement some

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<sup>1</sup> Bulgarian Educational Site

fully own, specific characteristics that could be showed out by the comparison of the main elements of the learning for the two paradigms (Table 1.).

Element	Type (in respect to the educational paradigm)	
	Traditional	E-learning
<i>Main objective</i>	Preparation for life and work	Providing of an environment for self-determination and self-realization of the personality
<i>Knowledge</i>	From the past ("school of the memory")	From the future ("school of the thinking")
<i>Learning process</i>	Teaching the learners certain knowledge and skills	Creation of own world model with active work of the learners
<i>Learner</i>	Object of the pedagogical activities (effects)	Subject of the cognitive activity
<i>Type of the relation teacher – learner</i>	Monological	Dialogical
<i>Learner activity</i>	Reproductive, "reactive"	Active, creative

**Table 1. Main learning elements for two educational paradigms**

The e-learning essence and characteristics summarized in the above short comparison, together with the fact that the e-learning pedagogical technology is based on virtual learning technologies and wide use of ICT in its implementation and delivering, shows that some additional *didactic principles* should be further formulated for the case of e-learning:

- *communication* (openness of the communication forms and tools);
- *interactivity* (indirect personal interactions student-student, student-teacher, etc.);
- *control* (strict regulation and management of the activities using ICT);
- *suitability* (avoidance of unnecessary and pedagogically ungrounded use of ICT);
- *flexibility* (e.g. choice of time and place for learning);
- *practical orientation* of the content and the activities;
- *case studies* (the interaction during the learning process has dialogical and case oriented nature due to virtual simulators and communication);
- *problem-oriented nature* of the content and dialogical nature of the interaction during the learning process;
- principle of the supporting *motivation*;
- *module-block principle* in the educational programs and the learning activities.

We will go further analyzing the recent changes and challenges affecting the pedagogical aspects of e-learning environments and thus giving the grounds for investigations related to e+learning.

The contemporary e-learning courses are purposed mainly not to present the pure scientific knowledge, but to solve vocational training tasks. The main criterion for the choice of the taught knowledge is its applicability to specific professional tasks. As a result, there is a transition in the process of creation of the course learning content – it is not based on the subject principle. In the same time the requirements to the educational methods and forms are significantly changed as well as to the preparation of the teachers for their new role in the teaching/learning process. For example, various individual and group learning activities (working with learning materials and information) become predominant. The nature of the relationship teacher-learner during the learning process is vastly changed together with their typical behavior.

The importance of universal (methodical) knowledge for assessment and prognosis of the future is increasing. The requirements to educational organization methods and forms and in particular to the preparation of the educators for their new role in this process are changed significantly. Individual and group forms of active work with the learning materials and information become predominant. The type of activities performed by educators and learners is vastly changed together with the nature of the relation between them during the learning process. There is a tendency for the learner to become a full-fledge subject during the process of solving learning and professional tasks – with the support and collaboration of the educator.

The discussed changes in notions related to the personality, as well as the experience gained in the implementation of the new educational forms through e-learning environments allows the formulation of some *specific didactic principles* definitive for the e-learning platforms:

- *organization* (the content of the learning materials and the organization of the learning process should be built on the basis of the major learners' activities);
- *support* (creation of a user-friendly environment for learning process support);
- *effectiveness* (optimal combination between the different management forms of the learning activities of the learners, economical suitability);
- *modularity* (learning courses represent subject fields and for that reason the curriculum may consist of different courses depending on the individual and group educational necessities);
- *individualization* (of the knowledge and grading of specific learners);
- *openness* (participation of learners with different input level, without interruption of the work; with specific educational needs, etc.);
- *personality-oriented* nature of the educational curricula (marketing approach, consideration of the educational necessities of the learners);
- *activeness and independence* of the learners as major subjects in the learning process;
- *reflexivity* (learners' awareness of the content and the ways to participate in the learning activities, and especially – of their own personal development and acquisitions);
- *variety* of the educational curricula – the learning content should reflect multiple viewpoints to the problems and their possible solutions.

The reasoning expressed above is forced by the R. Koper's question 'where is the learning in e-learning?' [Koper, 2001b]. In the following sections, the changes in the traditional e-learning notion are discussed on this point of view. We put a focus on the conception of learning as a management process and present the project Bulgarian Educational Site (BEST) – a possible answer to Koper's question.

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## E+Learning: Concepts and Background

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The proposed approach to development of e-learning platforms means that they should provide:

- *for the teacher* – tools for expressing the above didactic principles according to different pedagogical strategies, appropriate for the regarded subject domain, teacher's preferences, learners' profile, etc.;
- *for the learner* – possibilities for personalized, adaptive and active learning according to its knowledge level, learning results and preferences related with time, way, psychometrics characteristics, etc.;
- *as a whole* (for all players in the e-learning process) – comprehensive and complete support for the e-learning process during the whole life cycle, including portability and reuse of materials and courses.

In the last years a number of projects related to this approach are performed, for example, *EML* [Learning Activities, 2006], *Moodle* [Malikoff, Dougiamas, 2005], *LAMS* [Ghiglione, 2005], *PeU* (Plovdiv electronic University) – ver. 1.0 and 2.0 ([Totkov, Doneva, 1998], [Totkov, Somova, 2002], [Totkov, 2003]), etc.

**EML** (Educational Modelling Language) is a semantic notation of complete *units of study* developed as a mean for expressing various pedagogical models in order to support reuse and interoperability [Koper, 2001a]. The modeling is done with use of the UML [Unified Modeling Language, 2004] and the binding is in an XML schema. A unit of study is the smallest unit providing learning events for learners, satisfying one or more interrelated learning objectives<sup>2</sup>. The unit of study could be a course, a study program, a workshop, a practical, or lesson, that is delivered through online learning, blended learning or hybrid learning.

*Moodle* is an open source course (and content) management system in which activities are at the heart of the system. *Moodle* was designed on base of social constructivism. Constructionism asserts that learning is particularly effective when constructing something for others to experience. The students could be considered as actively engaged in making meaning. Teaching with that approach looks for what students can analyze,

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<sup>2</sup> It can not be broken down to its component parts without loosing its semantic and pragmatic meaning and its effectiveness towards the attainment of learning objectives.

investigate, collaborate, share, build and generate based on what they already know, rather than what facts, skills, and processes they can parrot. Moodle has modular design that makes it easy to create new courses, adding content that will engage learners. This modular object-oriented dynamic learning environment possess intuitive interface that makes it easy for teachers to create courses. Teachers and students require only basic early acquired from Internet browser skills to begin learning, which makes last one very simple and user-friendly platform.

*LAMS* (the Learning Activity Management System) is a software tool for designing, managing, and delivering online collaborative learning activities. The system is based on the concept of Learning Design theory [Dalziel, 2003]. *LAMS* has an intuitive interface with a visual authoring environment that allows users to create sequences of learning activities with very little effort [LAMS, 2004]. *LAMS* offers lecturers a structure on which to build their lessons. The person delivering the lesson does not necessarily need to be a subject expert thus making a case for using *LAMS* for cover lessons.

The *PeU*<sup>3</sup> is a contemporary e-learning platform for cooperative development of learning materials, dynamical generation of courses and automated learning, managed by the previously developed plan of the learning process. The special graph representation of the learning process (plan) allows expressing appropriately the learning process according to different didactic methods. This *PeU* feature shows its key difference from some e-learning systems offering content-centric learning models.

We will omit the detailed comparison of the all existing regarded systems and will point out only functionalities that are realized in *LAMS*, in *PeU*, or in both:

- A. *Both in LAMS and PeU*: models of the learning process, learning management with different interpretations (depending on the user) of one and the same model, etc.;
- B. *In LAMS, but not in PeU*: open source, possibility to include learning activities of communication type (Chat, Forum, etc.) in (linear) order of activities, support of several kinds of weekly schedules; 'simple' design and user friendly interface based on common conceptions and rules, etc.;
- C. *In PeU, but not in LAMS*: not linear structure of a learning course (and of learning materials too) using logical and control structures (*and, or, case, while, join, split*, etc.), and as a result – the system is adaptive to the learners; learning based on concepts (including generation of a learning plan based on a given Concept Map in *PeU* 1.0); powerful test system based on pedagogical requirements; wide user typology (authors, teachers, managers, local and system administrators, guests); administrative subsystem (including learning process management of student groups with different curriculum), etc.

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## The BEST Model of e+Learning

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The crucial moment in realization of the unique characteristics of the e+learning platforms is the possibility for implementation and individualized interpretation of different pedagogical strategies. To deal with this the BEST platform supports two key models – the well-developed *adequate model of the learning process* and the *model of the knowledge in the studied subject domain* (SD).

### Model of the Learning Process

The *necessity* of modeling of the learning process ensues from the following observation: the learning process does not consist only of "absorption" of learning content, learners that are not active in the learning process do not learn well; therefore the adequate modeling of the teaching/learning process, in all its completeness and variety, is essential for the success of the e-learning.

The BEST model/plan of the learning process<sup>4</sup> (MLP) is an explicit *representation* of the learning process logic ('learning flow') depicted visually by a graph structure. The MLP graph *consists* of interlinked learning objects (LO), where an LO could be: a content element (core learning material or additional learning material as dictionaries, useful links to virtual libraries and other electronic resources, software tools for creation and solving problems, writing homework, constructing texts and so on), a learning activity (self-assessment, examination, group activity – consultation, forum, discussion, etc.), a teacher impact (feedback, marking, etc.) or a control (decision-point, sequence, choice, parallel combination etc.).

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<sup>3</sup> Plovdiv Electronic University

<sup>4</sup> Called by some authors "learning design"



Thus, the MLP *allows* the both:

- The *definition* of the 'learning flow' in a e-learning course, i.e. it could be considered as dual specifications, specifying the didactic logic and in the same time the content and active objects (all tools for the educators and the learners accompanying the learning process);

The described BEST 'pedagogical meta-model' allows courses to be created for different didactic methods. This feature expresses the key difference from some e-learning systems offering content-centric learning models and is the merit to call the *BEST* approach 'pedagogically-driven'. The high level of abstraction and flexibility makes the BEST MLP a very powerful tool for expressing very different learning scenarios, including personalized learning.

In addition the MLP include *metadata* elements describing the modeled e-learning course on a meta-level (as the course learning objective, the learning outcomes, author, creation date, etc.).

- The *interpretation* of the e-learning course, i.e. execution (on-line learning), registration and control of the course 'learning flow'.

The process of MLP interpretation allows the learning content (electronic materials which are actually static) to be presented to the learner in a proper manner. But what is more important it provides a complete on-line support of the complex *virtual learning* process, characterized by dynamics and variability, adaptation to specific learners, asynchronous or synchronous participation in the elements of the learning (e.g. in team work), subjective (done by the teacher) and objective (done automatically) assessment and marking, etc.

The interpretation is performed on the basis of the MLP but also using the explicitly supported *model of the learner* (including its profile, preferences, etc.). Thanks to this could be said that BEST supports and individualized and adaptive learning (e.g. the results of the learner's assessment or activities are able to influence the virtual learning process). The learners may define their own learning objectives, monitor and regulate their own learning process and not the last, their learning is embedded in a social context; (collaborative learning).

A significant difference between the BEST approach and the previous works lies in the possibility to interpret the MLP of a given course from the *different viewpoints* (e.g. the viewpoint of a teacher, a learner, a guest and so on) and thus provide necessary services for different types of users. This means that using one and the same MLP for example, the teacher can test and check the course, the learner can learn the course.

Another important application of the MLP interpretation is the quality assurance of the modeled e-learning course – measuring of the educational quality on the basis of the MLP metadata and the learner's results and marks.

### Model of the SD

This model is a representation of the knowledge in a scientific or application SD (e.g. mathematics, cultural science, economics, psychology, electrical engineering, law, etc.) that could be a subject of the teaching/learning. According to the BEST approach this model is developed applying the methods of the *Conceptual Modeling*, therefore it is called Conceptual Model of the SD (CMSD). The BEST CMSD again has a *dual purpose*:

- *Representation* of the knowledge in the subject domain as ontology, structured according to the basic concepts of the SD. The elements of the model are coherent parts of the knowledge content called *reusable learning objects* (RLOs). RLOs are described by corresponding *metadata elements*, characterizing its entity regarding different points of view: informational (author's name; subject; file name, data and time), descriptive (study level, learning hours, etc.) and conceptual (concepts from the SD presented).
- Automatic generation of an e-learning course in the modeled SD using (in addition to the CMSD) a definition of the course subject, the learning objective, the study level etc., all expressed in the terms of the SD concepts.

### Other BEST Ideas and Principles

The BEST platform implements the following *additional important features* that give the merits to classify it as a virtual e-learning system:

- full independence of the supported e-learning from the application field – studied subject field, learning activities, form and mode of learning, educational necessities of the learners, learning and teaching methods, etc.;

- intelligent support to the process of creation of learning materials and assessment tests (including multimedia tools, automated linguistic processing, test generation, etc.);
- web-based on-line learning, teaching, authoring and administration supported by various collaborative and communication tools;
- conversion to standard formats suitable for export to other e-learning systems, including conversion to e-books for autonomous browsing;
- automatized forming of groups of learners (thanks to the models of learners) according to similar educational needs and/or level, for studying the course or for team work, etc.

Finally we could summarize that the BEST environment provide complete support of the virtual e-learning process in all its dimensions, for all players and during the whole life cycle.

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## Conclusions

The *BEST* system is realized on the basis of three of the already mentioned systems (*MOODLE*, *LAMS* and *PeU*) and is fully integrated with *LAMS* (in relation of activity and course format, web-services, database, *LAMS* repository etc.). The experiments with the beta-version of the *BEST*, are encouraging, and confirm the correctness of the project decisions.

The new approach discussed here changes the traditional e-learning notion, in the center of which is the learning object (material) and puts a focus on the conception of learning as a management process. The paper brings up a matter about the new 'electronic' pedagogy in e-learning systems and proposes an approach for pedagogical modeling and interpretation applied in the *BEST* virtual environment.

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## COGNITIVE APPROACH TO E-LEARNING IN SCIENCES AND TECHNOLOGIES

Safwan El Assad, Velina Slavova, Gilles Nachouki

*Abstract:* This article describes the approach adopted and the results obtained by the international team developing WBLST (Web Based Learning in Sciences and Technologies) a Web-based application for e-learning, developed for the students of "UVPL: Université Virtuelle des Pays de la Loire". The developed e-learning system covers three levels of learning activities - content, exercises, and laboratory. The delivery model is designed to operate with domain concepts as relevant providers of semantic links. The aim is to facilitate the overview and to help the establishment of a mental map of the learning material. The implemented system is strongly based on the organization of the instruction in virtual classes. The obtained quality of the system is evaluated on the bases of feedback form students and professors.

*Keywords:* learning assistance through domain concepts, virtual classes.

*ACM Classification Keywords:* K.3.2 Computer and Information Science Education

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### Introduction

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Several factors have led to the widespread adoption of on-line learning, but the Web-accessibility of exposed learning material does not give any guarantee about the efficiency of learning. The added value which educational technologies may bring to education is predetermined by the manner in which the technological tools and resources are used for the objectives of instruction. That requires reinforcing the influence of distance learning theory upon instructional design and delivery and redefining the roles of the participants in education.

The analyses of on-line learning have led to the conclusion that the essential discussion should be: how can a learning process be turned into a model? Several case studies [Altun (2000), Psaromiligkos and Retalis (2003), Weiner (2003)] demonstrate that the delivery model itself is a crucial factor for the effectiveness of the learning system. The delivery model embodies the conceptual part of an e-course, which realizes its teaching strategy. The teaching strategy has to be chosen with respect of the cognitive particularities of e-learning, the specific subject material, the technological possibilities of the used systems etc. After analyzing these factors for years, Barker et al. (2003) came to the conclusion that a fundamental requirement of an electronic performance support system is that it should increase learners' training performance by enabling them to "learn as they do". Naturally, in the context of e-learning systems, that requires the establishment of a corresponding delivery model.

In on-line learning, the learner is left alone with the subject material. This requires an approach matched with the theoretical model of learning, proposed by Min et al. (2000), where the process of learning is considered as a student's activity, and instruction as a relatively static condition. However, in order to take on some of the lecturer's functions, the learning material has to behave actively and to "react" in an intelligible, autonomous way. The creation of an autonomous learning system requires the identification of the mechanisms of acquisition and a presentation of the learning material with respect to its essential cognitive ingredients.

**The Importance of Concepts and Relations.** A well-known theoretical statement is that the acquisition of scientific knowledge strongly relies on the creation of a mental image of the domain's system of concepts and inter-concept relations [Barsalou, 1992]. The acquisition of structural knowledge is typically related to the internal meaningful-interpretation of new concepts, including their incorporation into the edifice of already known concepts. In traditional face-to-face instruction, the exposition of the material is linear; in any case, the lecturer explains it during a given length of time. From the learner's point of view, the process of new concept acquisition demands several "back steps" over the system of new concepts, in other words – it requires some sort of non-linear process of knowledge clarification.

Within an autonomous learning tool, it is the system itself, which has to ensure these functions. The system is supposed to give access to different, semantically consistent teaching sequences, by using static substance "pieces" of textual and schematic explanations, covering different levels of instructing "one and the same thing". That requires a dynamic behavior of the system. In the last few years, a lot of efforts have concentrated on

dynamic learning environment, related to metadata models [Lytras, Pouloudi and Poulymenakou (2002), Alpert (2003)]. Some of the successful attempts associate concepts' issues with the system's components, which technologically ensure dynamic behavior. The generation of learning occurrences has to be based on rules, which guarantee the semantic texture of the result. In the system presented here, it is assumed that consistency of the material might be attained through the links, provided by the concepts and their inter-concepts relations. The appropriate method for the achievement of such a task requires a division of the textual-graphics substance of the subject material into smaller units and, on this basis the generation of learning occurrences by using the organization of concepts and inter-concept relations.

### General Scheme of the Underlying Model

As it is generally done, the course material is organized in a hierarchical tree-like structure. The linear learning material is divided, as usually, into chapters, sub-chapters and so on. That division leads to smaller pieces of linear learning material - the so-called "learning modules". Inside of each learning module, the corresponding learning material (texts and graphics) is sub-divided into smaller units (Figure 1.). Units are the basic atomic substance with which the system operates. From a semantic point of view, a unit represents a more or less autonomous announcement, and from the point of view of the matter – it is a piece of text (often consisting of one or a few paragraphs) or one scheme.

Titles and subtitles are semantic entities. In view of their further use as building material for dynamic generation, they form distinct units. All units are labeled according to their order in the linear course with respect of its hierarchical organization. This labeling makes it possible to reconstruct the learning material in its "teaching" order.

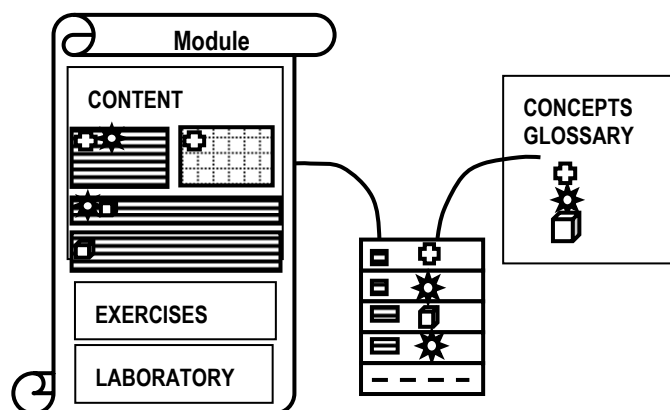


Figure 1. Learning module – units and relationships with the concepts glossary

New concepts and important old concepts are specified, with their definitions, in a concepts glossary. From the point of view of the textual substance used, the concepts glossary also consists of units. Units are stored and organized in a relational database. Data distribution in the database may be presented in two Entity tables – the Units-table and the Concepts-table. The "Concept-to-Unit" table is to express the relationship between the concepts and the units in the learning material. The occurrence of a precise couple of labels expresses the link "this unit deals with this concept". As all units possess attributes for encoding their disposition in the hierarchical structure and their links with the related concepts, the generation has a semantically structured concept-based occurrence of texts and schemes.

### WBLST – a Web-based System for Course Delivery in Sciences and Technologies

WBLST is a Web based system for e-learning, which is an implementation of the described model. Currently it is used in Ecole Polytechnique de l'Universite de Nantes, <http://wblst.presidence.univ-nantes.fr/Cobbalt-v2.0/> managing all the support for telecommunications, signals and high-frequencies course inside virtual classes [ El Assad et al. (2003), (2005)].

As usually in such systems, each student and professor is given an account, enabling to personalize a convenient mode of learning/teaching. The system provides distant tools for organization, management and supervision of the learning material, including the introduction of concept-to-units links.

One central point of the WBLST organisational system is the virtual class. A class gets together a group of students supervised by a professor. WBLST class provides functionalities for training and communication between the professor and the students.

In general, three different functional devices compose the application software:

- the administrative device, which allows the administrator to manage the users.
- the professors' device, which allows each professor to manage his classes, his class activities and his learning materials.
- the students device, which allows each student to manage its class activities.

The professors' device is used to structure the course and its components, to add, delete or modify the units, the incorporated concepts and their relations (figure 2).

The text in the section "Content" (fig. 1) comprises the important for the unit concepts and their definitions. The professor indicates the concepts (keywords and/or key phrases) in each learning unit. That is done in a simple way, by marking the words in the available text. The tool stores all the modifications performed on the server's application. The learning material is imported in WBLST system in HTML format. The files are stored in the database after processing, in order to give to all contents the same look.

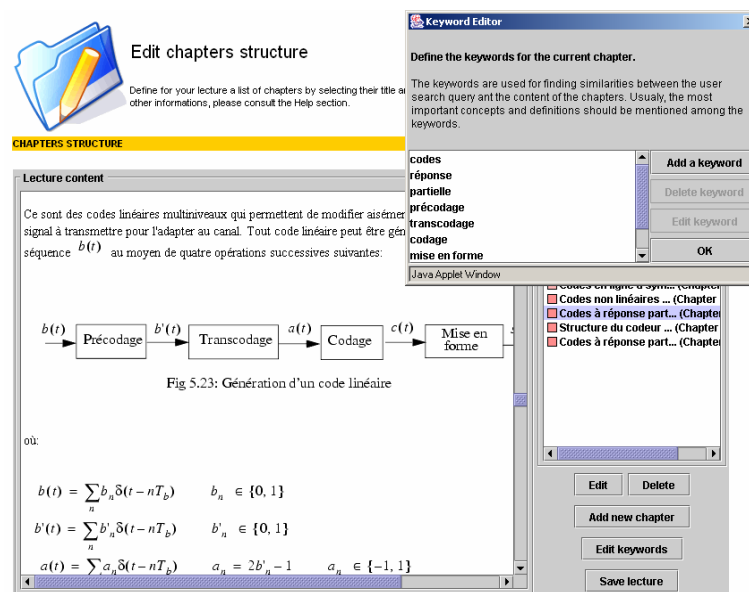


Figure 2. Edit chapters structure (chapter, subs chapter, innerlink, keywords)


The development of an e-course is an extremely time-consuming and heavy task, as has been reported by almost all authors, examining the domain. For example, Ryan et al. (2000) suggest one year's lead time for developing a good web-based course and underline that maintenance by the Course Developer will be needed throughout the life of the course. Mooney and Martin (2003) calculated the preparation of course material task approximately thirty hours for each hour of on-line student time. The approach proposed here cannot eliminate the need for the effort demanded to create the learning material.

Concerning the additional effort that one may suppose is necessary for the concept-based teaching strategy, the developed system includes a simple to use tool, which runs on the Internet and which allows an easy management, structure and maintenance of the course. For example, only two hours is needed to completely structure fifty pages.

The *Exercises Section* offers functionalities for the purposes of tests and exams and includes timing, validation of correct answers, visualization of correct professor solutions or saving partial works.

WBLST provides possibilities to construct an answer-formula by using a virtual keyboard – a special editor, which operates with previously defined graphical objects (figure 3). The technology, used for the implementation, is Macromedia Flash, which has also made it possible to realize the “checking the answer” algorithms by using the incorporated programming language and the XML client-server communication. WBLST uses various technologies currently available. Most of the application is implemented using JSP, CSS, JavaScript. The database server is mySql 4 connected to Apache 2 using Tomcat 5.


**Exercice Problème 3**  
 On considère un canal de transmission d'information de type binaire symétrique sans mémoire: quelle que soit l'information binaire à transmettre, la probabilité d'erreur de transmission est constante égale à  $p$ .



**Question A -** Extension d'ordre  $k$  d'un canal binaire symétrique sans mémoire de probabilité d'erreur  $p$ .

Le canal extension d'ordre  $k$  possède un alphabet d'entrée de  $2^k$  mots binaires de longueur  $k$  et un alphabet de sortie identique à l'alphabet d'entrée. Ce canal est donc représenté par une matrice  $P_k$  carrée de dimension  $(2^k \times 2^k)$  dont l'élément  $p_{ij}$  correspond à la probabilité de recevoir  $y_j$  conditionnellement à avoir transmis  $x_i : p(y_j/x_i)$ .

1°. Si  $d$  est la distance de Hamming entre les deux mots binaires de longueur  $k$  correspondant pour l'un au symbole  $x_i$ , pour l'autre au symbole  $x_j$ , déterminer la probabilité  $p_{ij}$  en fonction des 3 paramètres:  $p, k, d$ .



Extension d'ordre  $k$   
 Le symbole  $x_i$  est formé de  $k$  bits, de même pour le symbole  $y_j$   
 $P_{i,j} = P(Y_j/X_i) = P(y_{j,1}, y_{j,2}, \dots, y_{j,k} / x_{i,1}, x_{i,2}, \dots, x_{i,k})$   
 Le canal est sans mémoire, donc la probabilité d'obtention d'un bit en sortie ne dépend pas du bit émis à l'entrée.  
 D'où:  $P(Y_j/X_i) = P(y_{j,1}/x_{i,1}) \times \dots \times P(y_{j,k}/x_{i,k}) = \prod_{n=1}^k P(y_{j,n}/x_{i,n})$   
 (c.a.d. indépendance entre la source et le canal)

Figure 3. Interface screen of the exercises section (problem and questions)

The device used by the learner provides all the described functionalities merely using the statistical data on the server (databases and statistical folders) and displays the server's generated answer of learning occurrences.

Virtual laboratory is available in the *LabWork Section*. Learner can find the necessary instructions for building simulations, access the instructions and find examples of completed simulations with Simulink under Matlab (figure 4).

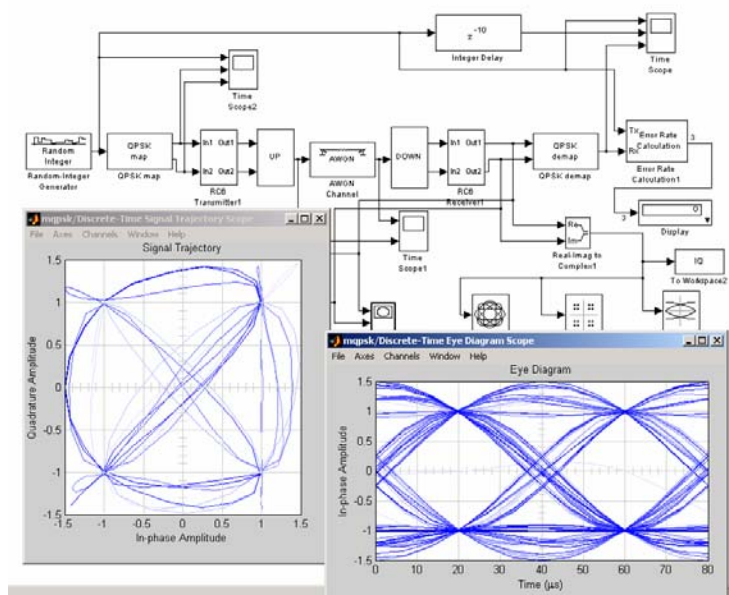


Figure 4. Virtual laboratory interface

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## Realization of the Learning Assistance

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As explained in the previous parts, the learning assistance is provided throughout the organization of the learning material and its relationships with the conceptual glossary. Each concept in the particular domain is stored in the concepts glossary part as a unit containing the "name" of the concept and its formal definition. The "name" of the concept corresponds to the term "keyword" often used in such technologies, but it can also be a term, an entire sentence or a graphical object. By clicking on any of these keywords (e.g: code, coding, etc.), the learner has access to the definition of the corresponding concept, to a hierarchically organized list of "where there is a reference to it", to a list of related concepts and, finally, links to web resources or to a dictionary. Concerning concepts names and definitions, several sources discuss the role of language expression for the conceptualization and suggest that the language processes play their part in helping students to develop abstract content [Rosaen et al (2002), Naeve, A. (2003)].

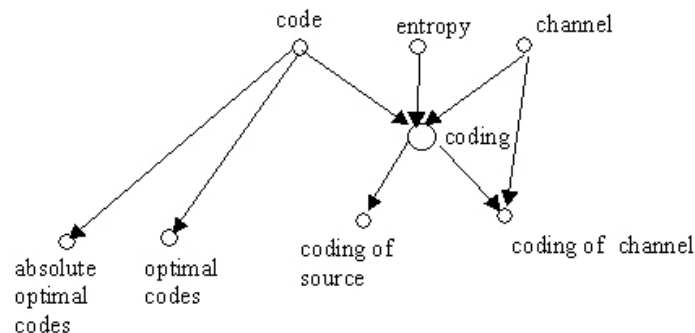


Figure 5. Example of a navigation path through concepts

From the practical point of view, the learner can click on a keyword and, for example, choose to see units from the "content" section, related to the selected concept; to consult the definition; to clarify issues of the related concepts. Consequently, as is illustrated in figure 5, the learner can navigate over the material through a kind of graph of concepts, which covers the learning material, connecting the units in another manner. In this way the navigation becomes flexible between two main modes – following the hierarchy and following the concepts.

The first step of the search gives the learner information about the places in which specific concept is dealt with in the entire learning material. The result is presented on the screen, where the learner can see the titles of volumes (part, chapter, subchapter etc.) within which the concept in question is dealt with, as well as the list of the other concepts, mentioned in the retrieved units together with the concept under consideration.

At the second step of the search the learner has the possibility to clarify the content of a chosen unit by clicking directly on the corresponding title, or to examine concepts, related to the given concept in the context of a unit.

These searching steps provide assistance for the construction of a coherent mental map of the course, corresponding to the concepts edifice and to the semantic links introduced. The aim is to provide a visual support for the creation of a mental scheme of the concepts relations, the size and the ordering of the entire learning material.

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## Evaluation of WBLST

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The WBLST platform has been developed for improving the learning experience in sciences and technologies for the students of "UVPL: Université Virtuelle des Pays de la Loire", by keeping the traditional structure for learning activities, but moving them to the Internet environment using our concept of virtual classes.

During September 2004 until May 2005 twenty professors from different Universities (University of Nantes (France), Politehnica University of Bucharest, Military Technical Academy of Bucharest (Romania), New Bulgarian University of Sofia (Bulgaria), Lebanese University (Lebanon) and different fields of sciences, used the WBLST platform. Fifteen of them have already used WebCT platform. A questionnaire has been administrated to them.

Table 1 Professor's evaluation of the WBLST platform

Question	1	2	3	4	5
1. How easy was it to enter the virtual classrooms (courses, exercises, labworks) without need technical help					100%
2. How helpful was the use of virtual classes to follow distant student activities					100%
3. How easy was the virtual keyboard to enter exercises solution		25%	50%	25%	
4. How relevant was it concerning multimedia aspect		25%	60%	15%	
5. How interesting did you find the WBLST platform?				5%	95%

1 "unacceptable"; 2 "can live with it"; 3 "ok"; 4 "good"; 5 "very good".

The main advantages of the WBLST platform compared with WebCT platform are the properties given by questions 1, 2 and 5. The advantage of WebCT is the multimedia aspect, more developed than in WBLST.

During the same period, one hundred students in the telecommunications field used the system. Their feedback is given in table 2.

Table 2 Student's evaluation of the WBLST platform

Statement	1	2	3	4	5
1. It enhanced my learning experience				10%	90%
2. It was clear and easy to use				15%	85%
3. It increased my freedom degree to learn regarding the space and temporal limitations for traditional classroom					100%
4. It improved my ability for reflective active learning, rather than passive learning			2%	13%	85%

## Conclusions and Future Work

The awareness of some specific features of knowledge acquisition has helped to develop an on-line learning system. Aiming to ameliorate the e-learning environment, we have designed and developed the idea of virtual classes, which integrate all the basic real class activities: lectures, exercises and laboratories.

Considering that the degree of knowledge acquisition is one of the main factors for learning efficiency, one major preoccupation for the development of the system was the teaching strategy. The underlying model is based on the assumption that the teaching strategy has to deal with concepts and has to facilitate the overview. The formalization of this idea is realized in terms of database. It allows concept-dependent access to learning occurrences with respect of their semantic consistency.

The efficiency of the learning assistance has been evaluated for telecommunications courses. The results show that the used approach gives a positive effect, confirming the consistency of the underlying model and the effectiveness of the approach. The technological possibility to apply this approach is provided in the developed system, offering tools for content management which are easy to use.

The international team, which has been working on this approach for three years, realized the need for on-line instruction in sciences and technologies right from the start. The extensive need for new and expensive lab material, due to the rapid evolution of technology and the growing number of students, are current problems faced by most technology schools. That has led to further studies concerning e-learning and to the incorporation of a large number of additional technologies and simulation environments. In conclusion, the self-study characteristics of WBLST appear to be better than they would be without the incorporation of the concept-based learning assistance.

The aim of the further development of WBLST is to build up a more generalized virtual keyboard in the scientific domain and to generalize the virtual classes concept to virtual training school.



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## KNOWLEDGE TESTING IN ALGORITHMS – AN EXPERIMENTAL STUDY

Irina Zheliazkova, Magdalena Andreeva, Rumen Kolev

*Abstract:* With the appearance of INTERNET technologies the developers of algorithm animation systems have shifted to build on-line system with the advantages of platform-independence and open accessibility over earlier ones. As a result, there is ongoing research in the re-design and re-evaluation of AAS in order to transform them in task-oriented environments for design of algorithms in on-line mode. The experimental study reported in the present paper contributes in this research.

*Keywords:* algorithms, experimental study, knowledge testing.

*ACM Classification Keywords:* Computer and Information Science Education, Knowledge Representations of Formalisms and Methods

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### Introduction

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Algorithms are procedural knowledge units, modeling the solution of a given class of problems. Their theory and practice constitute an essential branch of the computer science education. Additionally, an enormous number of special purpose algorithms are used in other domains, such as mathematics, informatics, economics, management, and so on. During two decades the algorithm animation systems (AAS) are the most spread teaching aids developing the learner's logical reasoning in the theory and practice of algorithms [15].

A number of empirical studies have been conducted to evaluate the effectiveness of different kinds of AAS with educational purpose but results vary [4]. Brown used Balsa-II [2] to teach an introductory programming course and an algorithms and data structure course. The system was used as a visualization program in the first course, and as a high-level algorithm animator in the second one. He reported that the use of animation scripts to supplement lectures led to "demonstrable gains in speed of comprehension" over the traditional lecture. Results of using the animator of the XTANGO [10] to teach a computer science algorithms course indicated the following. The students enjoyed the animations and the animations are able to engage students' creativity and expressiveness. Furthermore, students' understandings of the algorithms are enhanced by the animations.

The use of algorithm animation in teaching, however, does not always prove successful. Empirical studies have been conducted by educators and have produced mixed results [6]. Although the results showed that the animated group achieved higher marks than the other group, no significant benefit could be linked specifically to the animation. Similarly, Byrne et al. [3] conducted two experiments in which the results showed that the benefits of animations were not obvious. These mixed results were regarded as disappointing as most educators believe that animation does aid learning.

However, these unfavorable experiment results suggest other important factors regarding the use of algorithm animation. The results indicate that to achieve the full effectiveness of algorithm animation, it is important that the animation is used in conjunction with other factors. Lawrence et al. [7] used the XTANGO and POLKA systems to teach Kruskal's minimum spanning tree algorithm. Amongst the group of students who attended laboratory sessions, performance of students who attended an interactive laboratory session was significantly better than students who attended passive laboratory sessions. Their results have shown that it is important to let students control and interact with animation and that the animation is available to them outside the classroom setting. Better control and interaction were achieved by means of letting students to create their own data sets for the algorithm rather than observing prepared data sets.

Moreover, more recent research by Kehoe et al. [6] does make some possible claims for the use of animation as a pedagogical aid. The experiment was carried out in a different manner from other experiments. The difference in this experiment was that it simulated a homework scenario. Students were given the questions prior to the start of the session. During the test, students could have access to teaching materials and there was no limit on time spent to complete the test. Results of this experiment showed the group was interacted with animation in some aspects, but not all, performed better than the other group. The report demonstrated a more effective way of

using algorithm animation in teaching to achieve higher pedagogical value. It demonstrated that algorithm animation was better used in open and interactive learning situations (such as a homework exercise). As well, algorithm animation can be more useful pedagogically when it is used in coordination with other learning materials or accompanying other instructions that explain how the animation simulates an algorithm's operations. The report also demonstrated that algorithm animation could best facilitate learning of the procedural operations of algorithms. While animation does not always facilitate learning, at least, it can make an algorithm less intimidating by making that algorithm more accessible.

In [10] Stasko et al. concluded from their experiment a number of conditions under which algorithm animation might be most beneficial. One of the conditions is to accompany algorithm animation with comprehensive motivational instructions. When the algorithm animation simulates this instruction, the animation display should be augmented by textual descriptions of the ongoing operations. Another condition is that the AAS should include rewind or replay capabilities to allow users to back up and review important operations. Some form of history showing previous state should also be provided. They also suggested that students' feedback was also valuable in improving the instructional quality of the animation.

Although results drawn from these empirical studies are not always favorable, this does not indicate that algorithm animation is ineffective in teaching. Hansen et al. [5] have developed a system called HalVis and conducted several empirical experiments using it. All experimental results shown, that hypermedia algorithm visualization is significantly more effective than traditional teaching methods.

To prove the practical usefulness of an intelligent system for teaching and learning algorithms (ISTLA) developed by Zheliazkova [11] the standard algorithm for searching the maximal element in an array of numbers has been chosen. The results of the teacher's block scheme and three simulated learners ("best", "better", "average") were compared. The block scheme built by the first learner differs from the teacher's one only topologically (not logically). So the ISTLA estimated the first learner's performance with maximal coefficient of proximity  $C_{prox}=1.00$ . In the block scheme of the second learner an additional unimportant condition block had been inserted within a loop and the system reduced his/her  $C_{prox}$ . The third learner's performance was scored even lower because missing of an important condition block within a loop. The three assessments made by the system are reasonable and had been accepted both by the teacher and learners.

With the appearance of INTERNET technologies the developers have shifted to build on-line AAS, which have the advantage of platform-independence and open accessibility over earlier systems. As a result, there is ongoing research in the re-design and re-evaluation of AAS in order to transform them in task-oriented environments for design of algorithms in on-line mode [8,9,14]. The present paper, which contributes in this research focuses on the following issues of an experimental study: goal, object and methodology of the study, experimental data, test quality evaluation, and correlation analysis. Conclusion outlines the author's team conclusions, current work, and future plans.

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## **Goal and Object of the Study**

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The main goal of the study is to assess the effectiveness of the intelligent computer-based tests in the area of algorithms in comparison with the traditional ways of testing such as multiple-choice tests, and exams. Both intelligent and multiple-choice tests were generated by means of an environment developed and implemented by the authors [12]. Object of the study were students-bachelor (1<sup>st</sup> year, 2<sup>nd</sup> semester), specialties Computer Systems and Technologies (CST) and Communication Technique and Technologies (CTT) at Rousse University. In the framework of the course Programming, part 2 the students learn C++ programming algorithms. The same students during the 1<sup>st</sup> semester were taught course Programming, part 1, including the topic "Algorithms" and several topics on PASCAL programming algorithms. The learning material on algorithms was presented in 2 lectures and applied in 8 practical exercises, where the students worked on computers in teams of 2-4. During the semester the students had to perform two written tests on the learned material and one course work concerning development the block scheme of an algorithm and its implementation in PASCAL. Then an integrated mark was formed on the base of the tests and course work marks. If this mark was 5 or 6, and the student was satisfied with it he/she was relieved of the exam. Otherwise the student was examined during the session with a task similar to the course work.

### Methodology of the Study

Two tests covering the topic “Algorithms” were prepared in the form of WORD-documents. The first one (T1) contains 25 multiple-choice questions and brings 25 scores respectively 1 score per the right answer (Fig.1). The second one (T2) contains 27 different types of questions with 250 total scores (Fig. 2). The questions types of are four, namely: multiple choice, unordered keywords, ordered keywords, and unordered pairs [12]. Both tests were generated in accordance with the technology of using of the authoring environment described in [1]. It can be accepted that both tests have approximately one and same length. At the same time T2 has significant higher degree of covering the taught material.

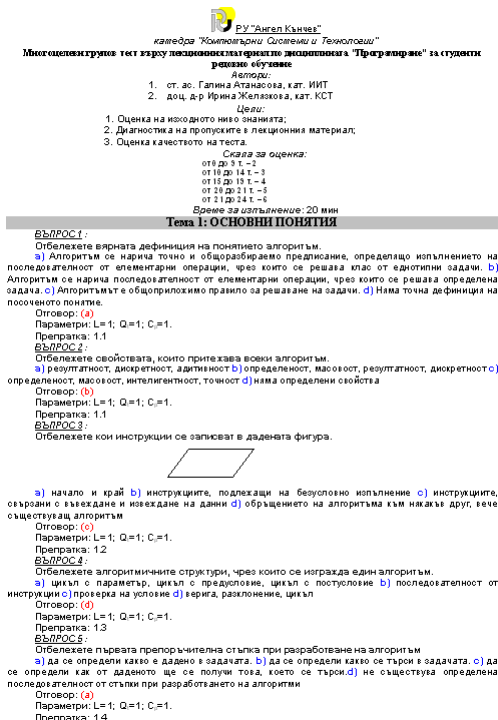


Fig.1. WORD-document of the multiple choice test

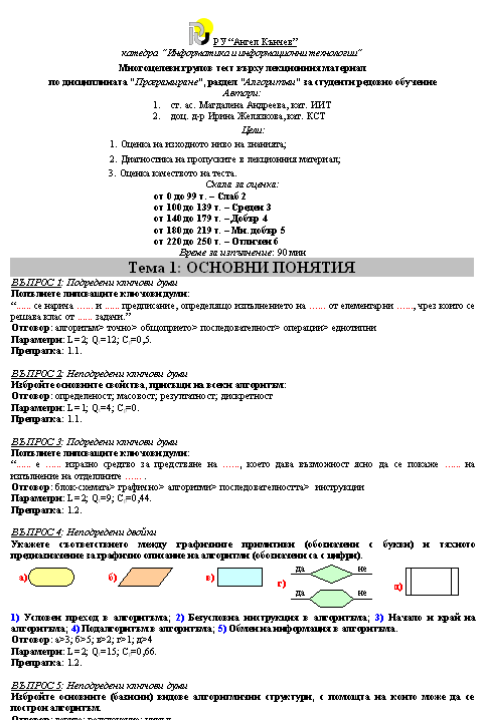


Fig.2. WORD-document of the intelligent test

The announcement about the planned experiment was made at the beginning of the second semester, to ensure students-volunteers, e.g. interested in the experiment. The generated HTML tests were uploaded on the Rousse University server in the same day of the experiment. 12 students took a part in it. At the beginning they were introduced to the study goal, the way of answering to different questions and the way of the system assessment. The students were also told that the planned time is 20 minutes for the T1, and 60 minutes for the T2. However the performance time for the tests was unlimited and was registered by the system.

### The experimental data

The experimental data were brought to two tables (one for each test), containing the following information – the student’s name, the student’s ID, the number of the points for each question, the total scores, the time, the mark and the final mark on Programming, part 1 (Progr.1). The scores, time and mark are parameters automatically computed by the system. The experimental data used for the need of the test analysis are shown in table 1.

Table1. Experimental data

No	Name	ID	Test	Scores	Time	Mark	Progr. 1
1	Nadia Genadieva Mikova	053111	T 1	21	17	5	6
			T 2	159	71	4	
2	Ivailo Angelov Nedelchev	053133	T 1	18	19	3	4
			T 2	176	81	4	

3	Vladislav Atanasov Petkov	053104	T 1	15	15	4	4
			T 2	139	46	3	
4	Nadia Yosifova Antonova	053132	T 1	18	19	4	6
			T 2	195	78	5	
5	Yanica Stoianova Stoianova	053147	T 1	17	24	4	3
			T 2	100	71	3	
6	Nedialko Dochev Nedialkov	053120	T 1	18	21	4	6
			T 2	190	62	5	
7	Ivailo Emilov Ivanov	053109	T 1	17	27	4	6
			T 2	172	77	4	
8	Neshe Nedzhi Ismail	053198	T 1	15	19	4	3
			T 2	143	60	4	
9	Nikolai Georgiev Nikolkov	053211	T 1	13	20	3	3
			T 2	84	60	2	
10	Ana Dimitrova Georgieva	053201	T 1	13	25	3	3
			T 2	81	65	2	
11	Leilia Mehmed Ahmed	053171	T 1	17	21	4	3
			T 2	125	71	3	
12	Fatme Turgai Mehmed	053181	T 1	18	24	4	5
			T 2	150	74	4	

### Test quality evaluation

The student's answers in T2 are partially correct, e.g. the points received for the  $i$ -th question of the  $j$ -th student  $P_{ij}$  could be between 0 and  $P_{max_i}$ , where  $P_{max_i}$  are the maximal scores for the given question. A calculated value  $V_{ij}$  was used, which represents the degree of the student's answer proximity:  $V_{ij} = (P_{ij} / P_{max_i}) \cdot 100, \%$

According to [13] the additional processing the experimental results for T2 become universal meaning that can be used to evaluate the test quality and student's knowledge. In the first case the results are student-independent and describe the questions and test difficulty. According to the average scores of each question they were divided in five groups respectively: very difficult (VD) – from 0 to 30, difficult (D) - 30-40, moderate (AV) - 40-60, easy (E) - 60-70, very easy (VE) - over 70. For each group the average result was calculated and the corresponding graphic was drawn using EXCEL. The resulted chart together with the average approximation is shown on fig. 4. The main graphical characteristic of the question difficulty is the typical S-shape curve: 1) the width of the deviation by X-axis of a curve corresponds to the difficulty of the corresponding question, because too few correct answers are given; 2) the inclination describes the probability of guessing. The lower grade is, the more even is the curve of the distribution of answers. The average curve should be close the diagonal of the chart. It doesn't contain the whole information, that's why it's good to be combined with the number of questions in each group (fig. 4). The first graphic is not suitable for T1 because all the answers have only 2 values: true or false. So, only the second graph type could do the juxtaposition for the both tests. As it is seen from the fig.4 they have similar distribution of the question groups. T1 has no questions in the group VD and more questions in the easiest groups. T2 is more difficult and this is clear seen from fig.6, where the test results of all students are compared. It is obviously that only 3 students have close results for both tests and they are the best ones.

Shortly, the additional processing of the experimental data and their graphical interpretation confirm the expectation that both tests are valid. The main difference is that T2 is more difficult than T1. This can be explained with the availability of questions in T2 with higher level of complexity than the multiple-choice in T1.

The graphical interpretations of the dependences between the marks Progr.1 and T1 (fig.7) and Progr.1 and T2 (fig.8) are presented with dots and the linear approximation with solid line.

The smaller angle of the approximation line with respect to X-axis means lower sensitive regarding to the student's knowledge differences. From the visual comparing both figures follows the expected conclusion that the intelligent T2 is more sensitive than multiple-choice T1.

The study also allows specifying the initial time for performance of both tests defines only by the authors' experience. The actual average time for T1 and T2 was respectively 21 and 68 minutes. This means that the time for T2 could be increased to 70 minutes whereas the time for the T1 can remain 20 minutes.

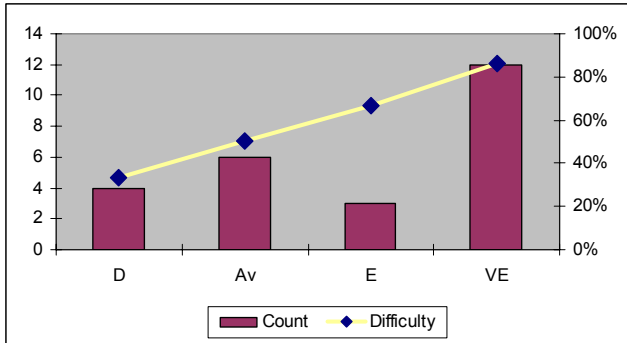


Fig.3. Task groups and their difficulty for T1.

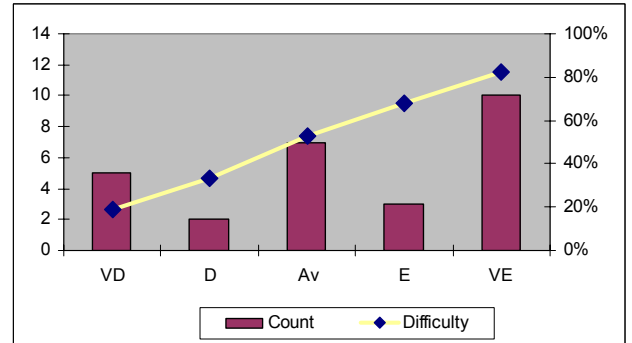


Fig.4: Task groups and their difficulty for T2.

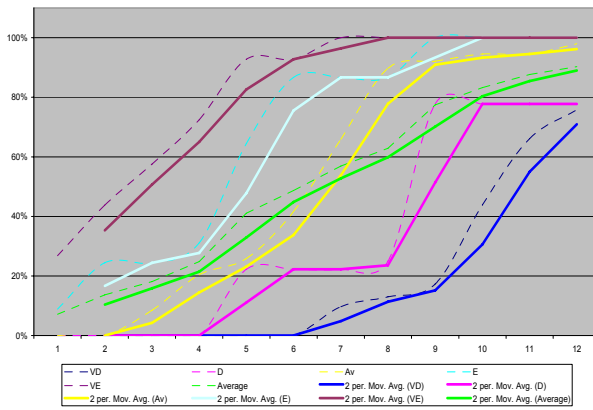


Fig.5. Tasks' difficulty for T2

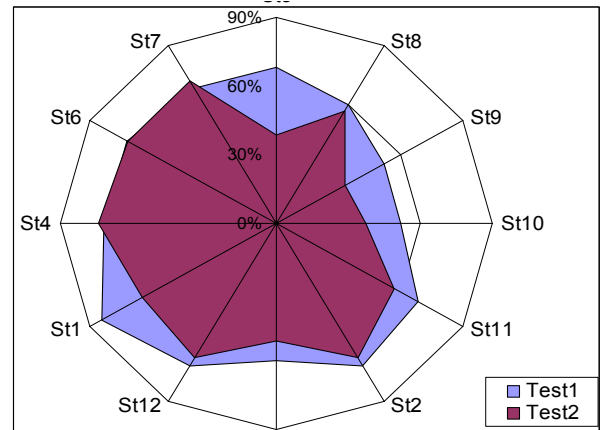


Fig.6. Student's results

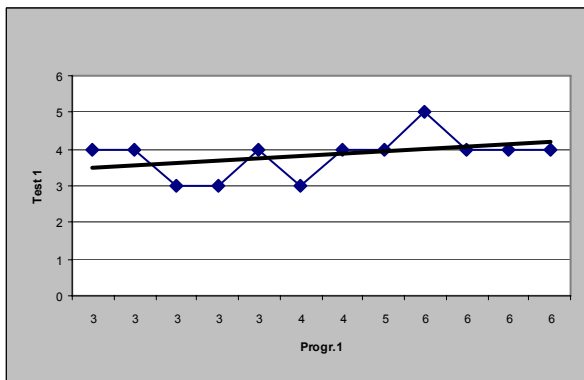


Fig.7. Dependence Prog.1 and Test1

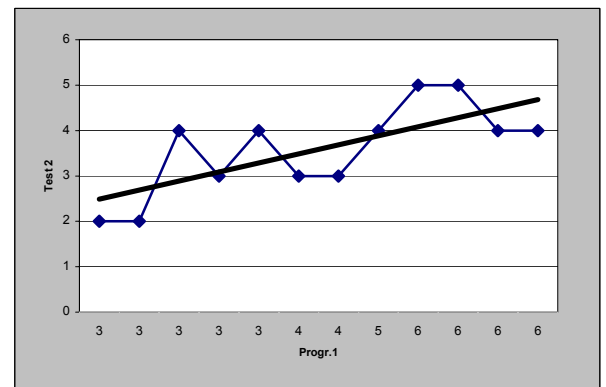


Fig.8. Dependence Prog.1/Test 2

**Correlation analysis**

As a quality indicator for the relationship between two test's parameters can serve the linear correlation coefficient  $r$ , a real number in the range of  $[-1,1]$ . The value of this coefficient shows how strong is the relationship between the parameters. For example, if  $r$  is in the range  $0.0 \div 0.3$  then relationship is low;  $0.3 \div 0.5$  – moderate;  $0.5 \div 0.7$  – significant;  $0.7 \div 0.9$  – high;  $0.9 \div 1.0$  – very high. If the two parameters are moving in the same way  $r = +1.0$  and if in the opposite  $r = -1.0$ . The value 0 means that there is no relationship between parameters.

Table 2. Correlation coefficients

Relationship	Time T1/Mark T1	Mark T1/Progr.1	Time T2/Mark T2	Mark T2/Progr.1	Mark T1/Mark T2
Correlation coefficient	<b>-0.232</b>	<b>0.536</b>	<b>0.389</b>	<b>0.777</b>	<b>0.501</b>

The relationship between the following couples of parameters are of interest for the current study: *Time T1/MarkT1*, *Mark T1/Progr.1*, *Time T2/Mark T2*, *Mark T2/Progr.1* and *Mark T1/Mark T2*. The corresponding correlation coefficients received from the experimental data are given in table 2. It is seen that the highest correlation coefficient is for *Mark T2/Progr.1*. Its value 0.777 means that there is high relationship between these two parameters, the relationship for *Mark T1/Progr.1* and *Mark T1/Mark T2* is moderate, and the one for *Time T1/Mark T1* and *Time T2/Mark T2* is lower.

The experimental data were divided in two tables according to the mark on Programming 1. The first table contains data for the excellent students (mark 5 and 6) and the second one for the mean level student (3 and 4). That was made because the excellent students were assessed at the end of the semester (taking in mind the marks of the course works and the two tests) and were released from exam. The results from the calculation of the same correlation dependences for the two groups of students are presented in table 3.

Table 3. Correlation coefficients for the two groups

Excellent students					
Correlation dependences	Time T1/Mark T1	Mark T1/Progr.1	Time T2/Mark T2	Mark T2/Progr.1	Mark T1/Mark T2
Correlation coefficient	<b>-0.647</b>	<b>0.250</b>	<b>-0.341</b>	<b>0.408</b>	<b>-0.408</b>
Mean level students					
Correlation dependences	Time T1/Mark T1	Mark T1/Progr.1	Time T2/Mark T2	Mark T2/Progr.1	Mark T1/Mark T2
Correlation coefficient	<b>-0.252</b>	<b>-0.091</b>	<b>0.294</b>	<b>0.418</b>	<b>0.382</b>

To analyze the proximity coefficient for each student first we found the relations Scores/Max scores for each question. This coefficient for the questions in T1 is not so interested because it is 1 or 0, meaning correct or incorrect answer. Table 4 contains the calculated coefficients for T2 questions. The column "Total" shows the proximity of the actual student's scores to the maximal scores.

Table 4. Proximity coefficients for T2

ID	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q25	Q26	Q27	Total
053112	1	1	0,2	0,4	1	0,5	1	0,4	1	0	1	1	1	1	1	1	0	0,7	0	0,5	0	0,4	0,3	1	0	0,9	1	0,65
053134	0	0	0,4	1	0	1	1	1	0	1	1	1	1	1	1	1	1	0,4	0	0,4	0	0,5	1	0,6	1	0,9	1	0,68
053105	0,7	1	0,8	1	1	1	0,7	0,4	0	1	1	1	1	1	0	1	1	0,7	1	0,3	0	0,6	1	1	1	0,9	0	0,74
053133	0,7	1	0,8	1	1	1	0,7	0,4	0	1	1	1	1	1	0	1	1	0,7	1	0,3	0	0,6	1	1	1	0,9	0	0,74
053148	0,5	0	0	0,6	0,3	1	0,7	1	0	0	0,4	0	1	0,4	1	1	0	0,7	1	0	0	0	0	0,6	0	0,3	0	0,39
053121	0,7	0,5	0	1	0	1	1	1	0	1	1	1	1	1	1	1	1	0,7	0	0,8	0	0,6	1	1	0	1	1	0,71
053110	0,5	0,3	0,3	0,6	0,3	0,9	1	1	0	1	1	1	1	1	1	1	1	0,9	1	0	0	0,6	1	1	1	0	1	0,72
053199	1	1	0	0,3	1	1	0,8	0,4	0	1	1	1	1	0,5	1	0,3	0	0,7	0	0,5	0	0,6	1	1	0	0,3	0	0,57
053212	0	0	0	0,4	0	1	0,8	1	0	1	1	1	0	0,3	1	0,3	0	0	0	0	0	0	0,3	1	0	0	0	0,33
053202	1	1	0	0,6	0,3	1	0,7	1	0	0	0	1	0,7	0,5	0	1	0	0	0	0	0	0	0,3	1	0	0	0	0,37
053172	0,8	1	0	1	1	1	0,8	0,4	0	1	0,4	1	0	0,5	1	0,3	0	0,4	0	0	0	0	1	1	0	0,7	1	0,53
053182	0,7	1	1	0,6	1	1	1	1	1	1	0,3	1	0,7	1	0	1	0	0,4	0	0,3	0	0,4	1	1	0	0,9	1	0,68

Approximately, the time passed from the of the written test on topic "Algorithms" (TA1) in the middle of first semester to the experiment is 5-6 months. From the cognitive psychology it is well known that each learner has knowledge forgetfulness coefficient. To evaluate it the table 5 had been composed. Its first row contains the TA1 mark for each student, the second one – T2 mark, and the last row - the proportion between these two marks.

It can be interpreted as a coefficient that shows how many percents of the knowledge the students have in the moment of T2 performance.

Table 5. Kept knowledge coefficients

ID	053111	053133	053104	053132	053147	053120	053109	053198	053211	053201	053171	053181
TA1	6	-	6	5	6	6	6	-	4	3	3.5	3
T2	4	4	3	5	3	5	4	4	2	2	3	4
T2/TA1	0.67	-	0.5	1	0.5	0.83	0.67	-	0.5	0.67	0.86	1.33

Value, greater than 1 means that the student has achieved new knowledge (ID 053181). Value, equal to 1 shows that he/she has kept learned knowledge (ID 053132). For all other students the value is less than 1, which means that the student has forgotten some learned knowledge.

### Conclusions, current work and future intention

The experimental data extraction for this study is not enough representative and the intelligent authoring environment used for test generation is on the level of research prototype. Nevertheless the reported results confirms some statements of the author's team earlier studies [16,17,18] and imposes new ones valid for testing not only the algorithms but for other complex learning objects:

The difference between the expected and real results from both multiple-choice and intelligent tests is insignificant, e.g. both tests are valid. This also shows personal interest and respect of the learners to the computer-based knowledge assessment.

In comparison with the multiple-choice test the intelligent one is more effective regarding the level of the tested knowledge, degree of covering the taught material, length of the test, and sensibility of the learner's knowledge assessment.

The relationship between the final mark given by the teacher and the intelligent test mark is very close, while the relationships between the differential marks and multi-choice test vary from moderate to low.

The research prototype of the WINDOWS-based environment for design of algorithm block schemes is in the process of implementation. The hypothesis that will be checked by means of this environment is the evaluation of the design of block scheme by the learner is more pedagogically effective than performing an intelligent test.

### Acknowledgments

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## DEVELOPING COLLECTIVE TEACHING COMPUTER SOFTWARE FOR THE COURSE "DECISION THEORY"

**Konstantin Berezovskiy, Olexy Voloshyn, Igor Drozdov**

*Abstract: Improvement of training students using modern information technologies, like collective developing teaching computer software, is discussed. Organizational, technical, technological advices are given. Experience of using information technologies in educational course "Decision Theory" is described..*

*Keywords: Electronic learning, information technologies, teaching software, collective developing, Decision Theory.*

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### Introduction

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At creation of normative documents for higher educational establishments of Ukraine in 1992-1994, after finding of independence Ukraine on initiative of one of authors, member of scientifically-methodical commission of Department of education of Ukraine on the Applied Mathematics, in the curricula of direction «Applied mathematics», «Decision Theory» course was included. Experience of the best educational establishments of the world such, as Cambridge, Oxford, Californian University (Berkeley), Massachusetts Institute of Technology etc. was taken into account. About importance of similar course testifies a fact, that for the last decade for results got

in the theories of decision-making and its use in many areas of human activity (above all things, in economy), two Nobel awards (1994 - J. Nash, J. Harsanyi, Zelten; 2005 - Aumann) are won.

Adhering to classification of G. Simone and A. Newell [Voloshin, 2006], direction-finding problems behave to the semistructured problems. Then the typical problems of operations research belong to well structured, problems of artificial intelligence to unstructured. Thus, in the view of curriculum of direction «Applied mathematics», a "Decision Theory" is an intermediate between normative courses "Operations Research" («Methods Of Optimizations») and «Artificial Intelligence» («Knowledgebases Planning»).

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### **The methodical providing of the course is «Decision Theory»**

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On the faculty of Cybernetics of the Kyiv Taras Shevchenko National University educational courses "Decision Theory" are on all departments (informatics, social informatics, applied mathematics) on the third year in a volume of 36 hours of lectures and 18 hours of practical or laboratory employments (one semester, one lecture in a week and one practical or laboratory employment in two weeks). During ten years lecturers from a lot of higher educational establishments of Ukraine (which prepare specialists to direction «Applied Mathematics») applied on the faculty of Cybernetics with a request to recommend a list of themes and literature on this course, as school-book (not to mention about textbooks), in which full basic sections would be reflected on the "Decision theory", in world practice are absent. The ten years experience of teaching courses "Decision Theory" on the faculty of the Kyiv Taras Shevchenko National University professor Voloshin A.F. and reader Mashenko S.O. is generalized in an educational textbook «Decision Theory» [Voloshin, 2006] which in the moment of writing of these theses is in a print and it will be presented at conference MeL2006 ("Modern (e-)Learning", on July, 1-5 2006, Bulgaria in Varna). In a textbook on the view of its authors, the basic sections of decision-making theory are presented:

1. Philosophical and mathematical bases.
2. Theory of utility.
3. Expert procedures.
4. Decision-making in the conditions of vagueness and risk.
5. Multicriterion optimization.
6. Decision-making in the conditions of a conflict.
7. Co-operative decision-making.
8. Decision-making in the conditions of unclear information.

First five years teaching the course, professor Voloshin A.F. was accompanied practical employments, where on examples the basic moments of theory were examined, algorithms were illustrated on numeral exercises.

Understanding came later, that in teaching of course «Decision Theory» main things are not concrete algorithms (which mostly have heuristic character), but the basic ideas. Algorithms, and yet better their programmatic realization, serve for an analysis, illustration and understanding of basic principles of decision-making theory.

First two semesters of conducting of laboratory employments, the tasks of students consisted in development of the programmatic modules, realizing concrete algorithms [Voloshin, 2006], without the concordance of programming, language, environment, etc.

Two semesters went away on the attempt of creation of programmatic modules library, incorporated within the themes (for example, multicriterion optimization).

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### **Collective software product**

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In the last 2 semesters, there have been several attempts (that was partially implemented) of the creation of "collective software product that will have methodical and learning features". The goal was to solve common problem, which is shown on the scheme in figure 1.

To create a software product that will fulfill this scheme, there is a need of solving several organizational problems. We need to take into account student's different level of understanding of mathematics and programming, time constrains for the elaboration of the product (18 hours of auditorium lectures and not more than 18 hours of independent work). Generally, in the course of the semester students need to do 3 laboratory works (first week – defining the task, third – consultations for the solving a problem, fifth- completing the

assignment). Two students were selected to create an interface (it would be better if that would be “volunteers”, that are responsible, competent, that also have authority over other students). With them, the preliminary plan was done (this was actually hard to do, since at the beginning of the course students do not know its content).

The system is supplied with inquiry function, that contains description of separate modules and algorithms that allow people to use the product even with minimal knowledge of this course «Theory of decision-making». We think, that the system is most useful in distance learning, and can be used by students of non-mathematical specializations and distance-learning students, that study this course.

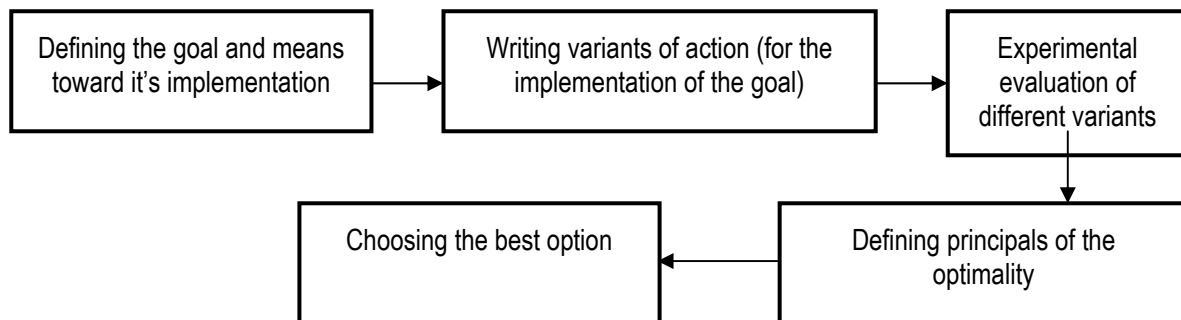


Figure 1

### Some recommendations for the makers of the collective software products

Our experience in making such training products give us the possibility to come up with such recommendations:

1. Choosing means and software product's development environment, due to such reasons as: convenience, platform independent, potential user's software abilities software;
2. There should be installed technique principals of programming with the goal of using the code again and its support by any creator, that is in the team;
3. Structures of software products should be planned in a way that integration of parts, that were created by separate creators or the group, would be max lightened, into one whole;
4. Set a time limit, when each participant would do its part (module);
5. The coordinator of the project and its assistances should periodically familiarize themselves with the results of work, done by separate creators. This from one hand would stimulate working group to complete their assignments on time, and from another, will help to solve problems that will arouse while projecting;
6. Every participant should write technical documentation and information for users in the context of their created module. There should be an opportunity for search inquiries of the needed material in the context of the project as a whole;
7. Modules testing should be organized in a way, that one creator would be checking other creator's work, that should be done up to the integration of separate modules into the whole product;
8. Software product should be tested by all the product creators;
9. There should be a possibility of communication between creators and users, that will help to improve the product, but only in case of its further support and development ;

### Comments to recommendations

The creation of the collective software product can be effectively realized in the context of module-ratings system knowledge evaluation, that assumes time limits for the acceptance and evaluation of intermediate results (program module) and giving penalty points for late handing works. If its possible, some student's software modules development should be duplicated. Authors suggest that while developing a software product, its better to follow a principle "better less, but working" rather than "better more, will complete later" (which is often the case while developing industry related software product; after getting the final grade on the exam – there is no "later").

According to the testimony of one author, first of all “creation of collective software product (even educational) is much harder that it seemed at fist glance”, and secondly “none teaches how to do this in the university department”, although modern software products are 90% done collectively”

Here it needs to be added that the course “Theory of decision-making” is being taught in the 6<sup>th</sup> semester, and the specialization has clearly a software orientation.

Authors want to attach to books several disks that will have 2 training systems:

1. A set of software modules, that will realize separate algorithms;
2. A system of mutually connected software modules that will realize the fulfillment of individual topics.

The second system's fragment is shown on the scheme, shown on figure 2.

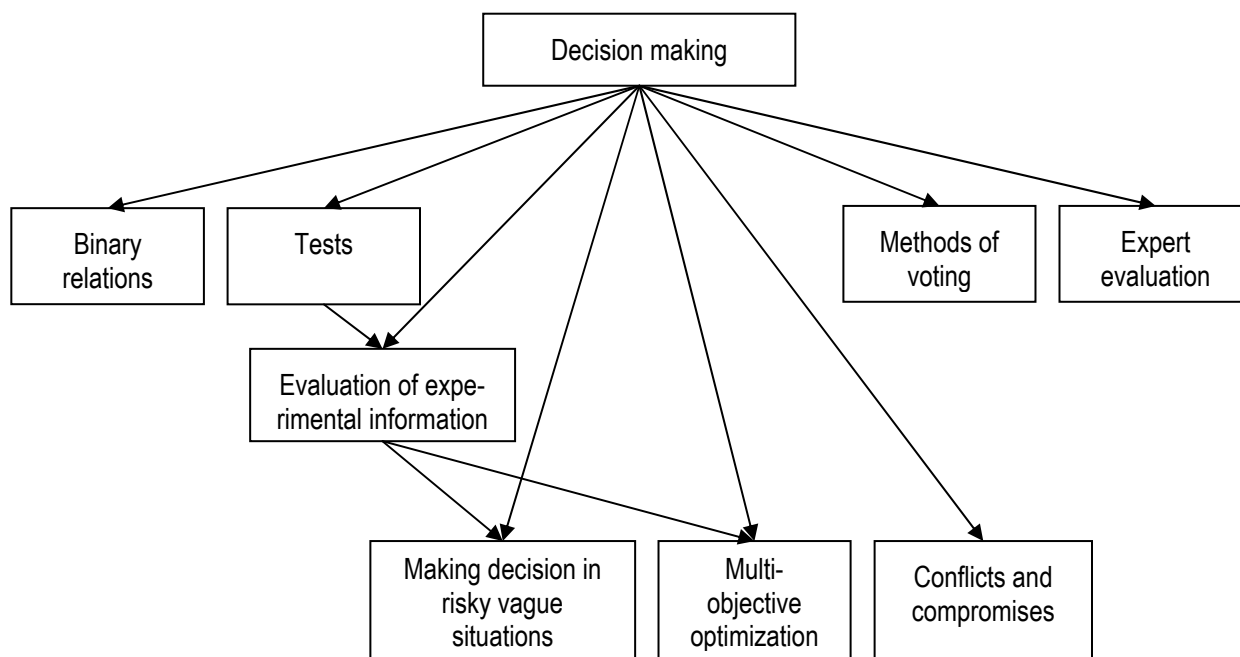


Figure 2

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## Conclusion

The creation of such collective software products that have methodical and learning features, not only improve the quality of computer science students preparation, but also gives an opportunity to create studying systems, that improve the quality of teaching mathematical science courses and to use new IT technologies in the distance learning education.

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## SYSTEMS OF TEACHING ENGINEERING WORK ON BASE OF INTERNET TECHNOLOGIES

Irina Petrova, Viktoriya Zaripova

*Abstract: the presentation graphical information about physical processes in WEB*

*Keywords: physical effect, WEB, dynamic picture*

*ACM Classification Keywords: J.6 Computer-Aided Engineering, Computer-aided design (CAD)*

Rapidly developing Internet technologies are often used now as a basis for building a CAD system and in particular the automated systems for technical solutions searching. Such a system enables the developers to use large and permanently widening databases, to discuss and evaluate job results together. Moreover, these systems are open and accessible for changes and additions

Examples of such systems are as follows: a system for designing the power supply circuits - Webench (<http://webench.national.com>, developed by the National Semiconductor company together with Californian company Transim), a system for automated mechanical modeling – Euler (<http://www.euler.ru/default.asp>) and Comsol Multiphysics ([www.comsol.com](http://www.comsol.com)).

One of methods of searching the new technical solutions is to use a knowledge base of physical and technical effects [1,2,3,4,5,6,7,8,9]. The following principles lay in the basis of this method:

1. Physical principle of action of any device is based on transformation of input quantity into output quantity by means of using some physical-technical effects (PTE). PTE is the smallest indivisible transformation.
2. Transformation of quantities can be made both within a chain of the same physical nature, and between two chains of different physical nature as well.
3. Each PTE has certain geometrical and physical characteristics, as well as performance characteristics, these values are determined by experts or may be calculated by formule.

The article considers conceptual model of a system of new technical solutions searching, the system is realized with the help of Internet technologies. Great attention is paid to graphical visualization of technical solutions searching results, that enables a designer to more effectively analyze the results obtained.

Work of designers and experts requires their independence from hardware-software tools. The environment should have friendly and intuitively understandable interface, to provide high speed of input data processing and correction, to enable work with optimal speed not depending on connection parametres.

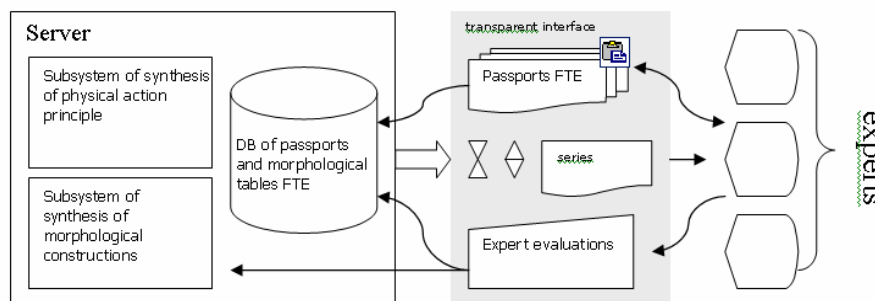


Fig. 1. Scheme of experts' work with automated system of technical solutions on the basis of PTE.

Fig.1 shows a conceptual model of the system of searching the new technical solutions basing on PTE knowledge base.

The knowledge base contains PTE technical logs and morphological matrices of variants of constructive elements of the PTE given. The figure 2 shows an example of such log.

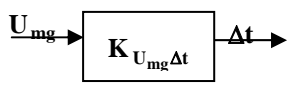
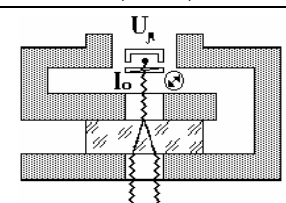
1.	Faraday effect (magneto optic)	
2.	$\Delta t = K_{U_{mg}\Delta t} \cdot U_{mg}$	
3.	Difference in refractive index of rays with left-hand and right-hand polarization leads to phase displacement or time displacement: $\Delta t = \frac{V l H \lambda}{c \pi} = \frac{V \lambda}{c \pi} U_{mg}$	
4.	$K_{u_{mg}\Delta t} = \frac{V \lambda}{c \pi}$	
5.	<b>V</b> – Verde constant [1/A]; <b>H</b> – magnetizing force, [A/m]; <b>l</b> – length of magnetizing lines of force in the sample, [m]; $\lambda$ - light wavelength, [m]; <b>c</b> – light speed in vacuum, [m/c]; <b>U<sub>mg</sub></b> - magnetic voltage [A]	
6.	Verde constant V [1/A]: Glass (0,2 – 0,35) 10 <sup>-4</sup> Gases (2 – 3,2) 10 <sup>-10</sup> Liquids (water, spirit) 0,04 10 <sup>-4</sup> gamete-type ferrite 0,12	sensitivity (calculated by p.4 ) Operating speed: 10 <sup>-9</sup> [s] Reliability: 10 <sup>-6</sup> [1/чac] Error: 0,1 – 1 %
7.	1. U. Sherkliff. Polarized light. - M: "Mir, 1965. – 357 s. 2. V.V.Sizov., Yu. Uhanov. Magneto optical effects of Faraday and Fogt, applied to semiconductors. – Kiev: "Naukova Dumka, 1979, s.26-28..	
8.		Faraday effect means appearance of time delay between rays with left and right circular polarization due to a difference in refractive index of these rays.

Fig. 2. PTE log

PTE log includes text description of the effect action principle, mathematical formulas of transformation of input quantity into output quantity, formula of transformation coefficient, functions of geometrical size of the construction, physical values and constants, formulas for performance data calculation, numerical range of performance data calculated by formulas or defined by experts, graphical imaging of structural scheme of transformation (2d graphic), dynamic graphical picture of action principle (3d graphics).

PTE morphological matrix includes a lot of static sketches (2d graphics) of separate details, sketches of several variants of PTE constructions can be produced of them (Fig.3).

So, a knowledge base should include text information, mathematical formulas in usual for perception view, large amount of graphical information (static - 2d graphics) and dynamic (3d graphics).

A constructor's work with the system may be divided into 2 stages:

1. Synthesis of physical principle of action
2. Morphological synthesis

A sub-system of synthesis of action's physical principle enables to produce variants of series of PTE subsequent transformations for given input and output quantities, to calculate performance data of produced chains, and to carry out multi-criterial selection of the best solutions according to the set of performance characteristics.

A sub-system of morphological synthesis enables to produce various constructive realizations of each PTE in selected variant of technical solution and to evaluate these realizations according to the set of performance characteristics.

Finally a constructor gets several variants of sketches of technical solutions which meet the requirements of the problem put by.



Fig. 3. An example of morphological matrix

Taking into account the large amount and diversity of data to be stored in the knowledge base, the Oracle 8i database management system was selected; it is stable, scalable system for managing the relational databases, it is able to effectively store and process a large amount of data in conditions of multiuser access. The Oracle 8i system makes:

- Support of large and super-large databases in operational transactions mode
- Objective extend of data relational model
- Use of built-in Java-machine for development of server component of the system together with the PL-SQL language.
- Possibility of storing of unstructured information, that meets the principles of development of Internet applications
- Powerful system of users administering

As an additional tool for storing the complicated structure information (for example, information on morphological matrix), the extendable language - XML is used on the server side, definitive features of this language are:

- Flexible structure, which is defined by the developer himself,
- Possibility to lay down the rules of drawing up of XML elements, that facilitates the interface generation
- Built-in support by all the Internet-oriented applications
- A lot of extensions like XQL – extendable language of requests, MathML – mathematical mark-language, etc

To generate graphical images of PTE and constructive elements of morphological matrix on the server side the Macromedia MX editor is used, it has the following advantages:

1. Multi-platformness
2. Small size of created files (less than several dickers of kilobytes)
3. Possibility to create complicated animation
4. Built-in programming language
5. 5 Support of XML format of data representation
6. 6 To process the information coming from the client side and to create user interface the PHP language was used:
  - compatible with such systems and products as Oracle, XML, MSSql, supports many modern Internet protocols
  - Integrated into various WWW-servers: Netscape, IIS, Apache
  - Has efficient productivity
  - Easy to study and use
  - Includes multi-functional tools for data processing

Information on effect may be presented in three view: text view (detailed description of action), in formula view and in graphical one. According to joint opinion of several experts the quality of the last one is very important characteristic of degree of completeness of effect description. (Table 1)

Table 1. Comparative analysis of information type

Characteristics	Positive\negative mark	Text information	Formula	Figure (picture)
Quickness of perception	+	6	4	9
Perception completeness	+	9	7	6
Need in additional knowledge for treatment	-	8	9	5
Wrong treatment (interpretation)	-	5	7	5
Large amount of information are perceived easier	+	3	4	8
Total		5	-1	13

A picture is a good helper for information correct perception and memorization, as well as for instant interpretation.

The task is to elaborate easy and comfortable graphic system for building images of PTE for working in the Internet. This system should have the following characteristics:

1. Understandable interface
2. Quickness and easiness in image elaboration
3. The image elaborated by the system should be understandable for other experts
4. Graphic compatibility of images while building chains
5. Automated support of change of the system version

As the task solution a web-interface was suggested? Which operates with a set of graphic primitives for building PTE images.

To analyze PTE graphic images a control set of PTE was selected, it included 25 PTE. This PTE set consists of electrical, mechanical, magnetic, heat and hydraulic chains. To describe each chain the following set of input and output quantities was used: reaction value (I), actuating quantity (U), charge (Q): they are interrelated as follows:



$$U = I \cdot R \quad \text{or} \quad I = G \cdot U \quad (G = 1/R) \quad (1)$$

$$Q = U \cdot C \quad \text{or} \quad U = Q \cdot W \quad (C = 1/W) \quad (2)$$

$$I = dQ/dT \quad \text{or} \quad Q = \int I/dT \quad (3)$$

Where:

G – conductivity parameter

R – resistance parameter

C – permittance parameter

W – parameter of rigidity for chains of any physical nature

For interrelation of chains of different physical nature the following effects were used: pyroelectric effect, electrocaloric effect, magnetic rigidity change effect, magnetoelectric effect in antiferromagnetics, piezoeffect, reverse piezoeffect, resistive-strain sensor, Hall effect, piezomagnetic effect in antiferromagnetics, magnetostrictive effect, thermobimetallic effect, field effect in MIS-structure, deformation effect of p-n junction.

The following statements were suggested as the basis for elaboration:

1. Any image consists of some set of graphic primitives, which represent arbitrary graphic element with geometrical properties.
2. Any element of an image can be
  - a. Static – information relatively stable concerning its contents, it is used as a background. For example, grid chart, motionless parts of the image, unchangeable parts of the image, and as a rule the contact points
  - b. Dynamic information changeable within certain time interval by the information content or its screen position.
3. Base of graphical data serves for organization of storing the graphical objects which correspond to elements of information models to be formed; the models are selected on request of graphical software.
4. Main functions of graphical software:
  - a. Graphical or geometrical transforming;
  - b. Graphical data base management;
  - c. Realization of interfacing of computer-user dialog;
  - d. Forming of requests to the applied software during the computer-user dialog;
  - e. Control of visual information input-output

To represent graphically a chain nature the following colours were suggested:

1. Gray and black – for mechanical chain
2. Red colours – for electrical chain
3. Green – for magnetic one
4. Yellow – for heat one
5. Blue – for hydraulic one

Analysis of representation of PTE action principle taken from control PTE set gave opportunity to find out 30 graphic primitives.

Examples of primitives are shown on Fig. 4

Increase of dynamic primitives size shows increase of the corresponding value (and verse) .



Fig. 4 Image of primitives

To build images a special 3-d grid chart was elaborated (Fig. 5 a.). This grid's size corresponds with the size of working sheet. The grid consists of four parts: contact points (b), central part of the image (c), inclusions (d). To make the effects' images coincide each other it necessary to place blocks exactly on coincide points, while the lower blocks should be 0.5 cm lower than the grid level; it gives increase in drawing area height up to 6.5 cm. Such approach ensures three-dimension imaging.

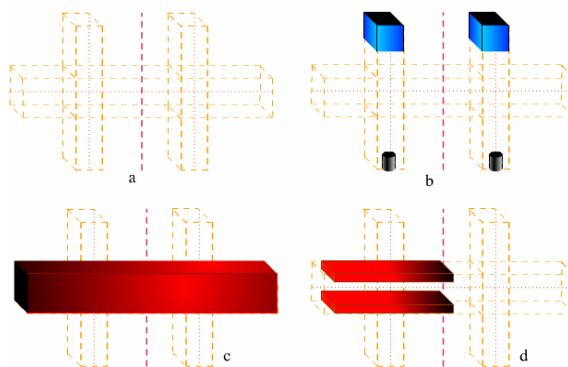


Рис 5. Grid Chart and its application

Apart from primitives of general purposes the primitives of special purposes were developed as well, and they have their own dynamics, they are: spring, condenser, resistor, superstructure block. Their view and dynamics depend on image of a concrete effect. As these images can't be changed in size due to violation of three-dimensionness so they should be restricted by size of their central part of the image or by size of inclusion area (Fig. 5).

All animation in images has a length of 20 or 40 stills, this quantity doesn't depend on picture frequency, it is stipulated by logical dividing of animation into 2, 4 and very rarely into 3 stages, which as a rule are pulsation or figure's place change. While constructing animation the developer has opportunity to change the initial still of each animation insertion thus providing an effect of motion.

Methods of PTE images preparation is elaborated, it consists of following stages:

1. Loading of the page of PTE image editing
2. Automated creation of a working area with the size 10x6.5.
3. The working area has two levels: grid level and a level of image itself
4. With the help of library of primitives to create necessary image, observing the following rules:
  - a. the primitive is automatically snapped to grid lines and to borders of primitives already placed on the sheet
  - b. Central line of the last upper and last lower primitives should coincide with central line of the grid's points of contact

- c. There should be added last lower primitives, which should 0.5 cm go beyond the grid line.
  - d. Animation is placed on primitives "next nearest" to avoid the ripples (flicker).
  - e. A developer can set animation consecution himself having determined the initial still for each animation involved into the effect.
  - f. All primitives not involved (due to any reason) into the library can be drawn by the developer himself, strictly following the size of three-dimension grid.
5. After an image is drawn the system automatically makes a story board (shooting sheet) for 20 stills in order to provide animation effect
  6. The grid level is removed
  7. The file is published and saved with the name of the effect to which it is intended for.

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## Conclusion

1. To build-in a three-dimension graphic image of a PTE into web interface the Macromedia Flash development environment was selected. It provides:
  - a. Minimal volume of finite file
  - b. Being automatically built-in into web interface
  - c. Has its own developed programming language
2. Basing on analysis of control set of effects (25 ones) the rules for building the PTE images were developed, as well as a grid chart which defines the building process.
3. 30 primitives are selected and elaborated: 20 general primitives including animation primitives and 10 applied primitives; as well as 10 pourings - 2 ones for each nature. The set of primitives is enough for elaboration of images of moderately complicated PTE, i.e. PTE with no more than 1 applied primitive with simple animation. The primitives set is open structure.
4. Methods are elaborated for preparation of PTE images

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## ELECTROMAGNETISM: INTERACTION OF SIMULATION AND REAL LAB EXPERIMENT

**Aleksandrija Aleksandrova, Nadezhda Nancheva**

*Abstract: eLearning at universities is taking an increasingly larger part of academic teaching methodologies. In part this is caused by different pedagogical concepts behind interactive learning system, in part it is because of larger numbers of students that can be reached within one given course and, most important, actively integrated into the teaching process. We present here the development of a novel concept of teaching, allowing students to explore theoretical and experimental aspects of act of magnetic field on moving charge through real experiments and simulation. This problem is not only part of the basic education of physics students, but also element of the academic education of almost all engineers.*

*Keywords: Electromagnetism, Physics labwork, Engineering education, Simulation and real experiment, eLearning*

*ACM Classification Keywords: I.6.5 Model Development.*

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### Introduction

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It is extraordinarily difficult to assess the impact of Information and Communication Technologies on education. The critical role of new learning technologies is undisputed. The rapid pace of change, the shift from a training philosophy of "just-in-case" to "just-in-time", and the changing nature of the workforce itself, underpin this development. E-learning raises expectations about the contribution of sophisticated multimedia technologies to meeting training needs. This, in turn, is posing new challenges in developing pedagogy and is leading to new roles for teachers and trainers. The European Commission [1], in their Barcelona declaration of March 2002, declared: "In order to raise the niveau of learning in Europe, the integration of ICT in the educational process is seen as an opportunity to advance the change process and to increase both quality of and accessibility to learning processes."

Early development of the use of ICT for learning focused on technology and on the use of technology to essentially replicate traditional learning environments [2]. More recently there has been a refocus in the discussions on e-learning. Rather than the emphasis on technology, the focus of new thinking on e-learning is increasingly on the learner and on competence [3]. This is seen as more important for the quality of e-learning provision and the success of ICT-supported learning processes.

It is indeed one of the challenges in eLearning and e-Teaching to reproduce adequately the intellectual combination of experiment and theory as found in natural and engineering science labs. Thereby, the purpose of experiments differs between theoretical and practical studies: in theoretical disciplines, experiments in virtual spaces offer a new approach for demonstrating abstract concepts in realistic models. While it is seemingly sufficient – or even necessary – to rely on simulations or purely abstract constructions in the theoretical fields, this does not hold true for the "practical" or applied sciences. Here it is important to include both the presentation of the characteristic features of the basic phenomenon and the experience of the "real" experiment (e.g. how to setup a realistic experiment correctly and how to choose and handle the equipment to measure the desired effects).

The e-learning methods of physics study in Bulgaria are still not popular. Our efforts in the last years have been connected with creation of different Web-based materials for physics education [4-10]. For the purposes of this paper we choose the physics of act of magnetic field on moving charge as an example where abstract and experimental aspects are treated successfully through a combination of demonstration of simulation and real experiments.

### Concept of e-learning

In engineering education the concepts taught are mostly complex concepts, where some links go from of the object/event world to the theory/model world. Tiberghien [11, 12] makes a categorization of knowledge between the object/event world and the theory/model world, which is shown to be very effective when analyzing and developing lab-instructions. She points out that the links between the theory/model world and the object/event world is important to make explicit in education. During labwork students are expected to link observed data, to either theoretical models, or to the real world they are exploring. In order to find these links and to make it possible to highlight them in the labinstructions, there is a need for an extended model that shows all links, and whether these links belong to one of the worlds or link between them. Fig.1 presents our concept about categorization of knowledge based on a modeling activity.

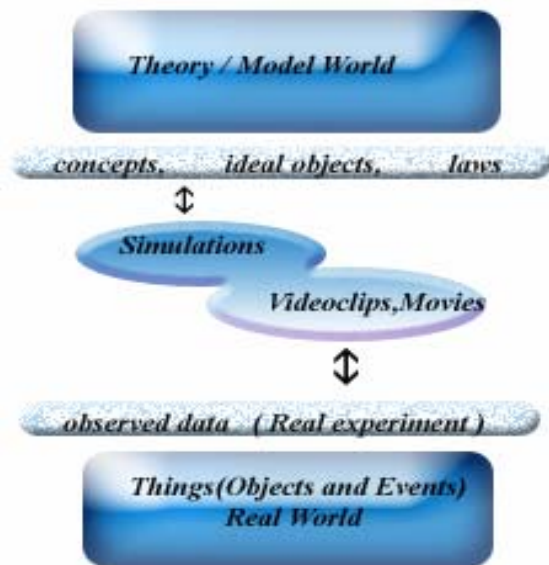


Fig.1. Categorization of knowledge based on a modeling activity

### A Brief Introduction into the Physics of Charge Particle in Magnetic Field

Observations show that a constant magnetic field acts on moving charges (*ideal object*). From experiments have been found that a force (the so-called Lorentz force) acts on a charge  $q$ , which moves (in vacuum) with velocity  $\vec{v}$ , in a constant magnetic field of induction  $\vec{B}$ , equal to  $\vec{F}_m = q(\vec{v} \times \vec{B})$ . The direction of the force  $\vec{F}_m$  depends on the sign of the charge and is perpendicular to the plane containing the vectors  $\vec{v}$  and  $\vec{B}$ , so that the force does no work as the electron moves and so its velocity is constant in magnitude. The force  $\vec{F}_m$  only changes the direction of velocity moving a charge in a curvilinear trajectory. The magnetic field also acts on the electrons inside a conductor, whose motion creates an electric current. Assume that a conductor with current is situated in a magnetic field of induction  $\vec{B}$ . The Lorentz force acts on all the electrons moving with uniform velocity  $\vec{v}$  and it is perpendicular to  $\vec{v}$  and  $\vec{B}$ . Because of this the electrons will describe curved paths. A surplus negative charge appears on upper surface of the conductor, so that a potential difference appears across the upper and lower surfaces (**Hall effect**). In semiconductors with hole conductivity the upper surface becomes positively charged and the lower surface negatively charged (the anomalous Hall effect).

### Charge Particle in Magnetic Field in Simulation Laboratory Experiment

Experiments based on computer simulations have already found widespread use as a supplementary material in the teaching process. The major advantage of computer simulations is an excellent visualization effect that is of special interest in the description of electromagnetic phenomena since the effects of magnetic field on moving charge and Hall effect through action of abstract field that is hard to imagine. A variety of technologies may be used to create computer simulations. We used Web based technology. Web pages were created by Microsoft FrontPage, ArcSoft Photostudio 5.5 and Microsoft Photo Editor. The core of simulation laboratory exercises "Charge particle in magnetic field" [13] and "Hall" effect" [14] are Java applets. These simulation experiments have analog in real laboratory experiments in University of Rousse. Because most standard applets are written with English controls and instructions, students with limited knowledge of the English language might have problems understanding the basic concepts governing the applet behaviour. For our purpose some of the text in the applets has been translated in Bulgarian.

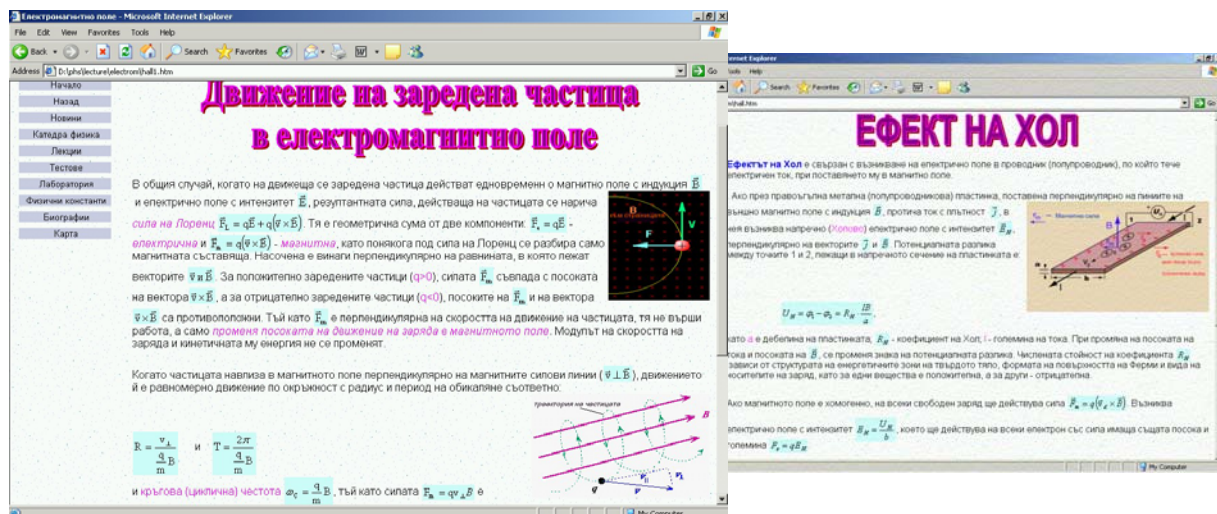


Fig.2. Theoretical part of simulation labs

The simulation lab exercises have:

- Theoretical introduction and analysis of physical phenomenon, which is demonstrated in simulation lab exercise (Fig.2).
- A part where the students may be prompted for the answers to three questions (entry test). The student can only proceed with the exercise after giving the correct answers (Fig.3).
- A part giving the practical instructions describing how to carry out the actual activities and measurements of the lab exercise.
- Detailed measuring process description and the applet used in simulation and measuring process.
- A part giving an overview of the results of the exercise allowing the student to print these results. It is based on these data that the student will prepare a lab report.

Figs. 2, 3 and 4 are examples for theoretical part, entry test, tasks, which students must execute, detailed measuring process description, the applet used in simulation [13,14] and measuring process in the case of simulation exercises "Charge particle in magnetic field" and "Hall' effect", respectively.

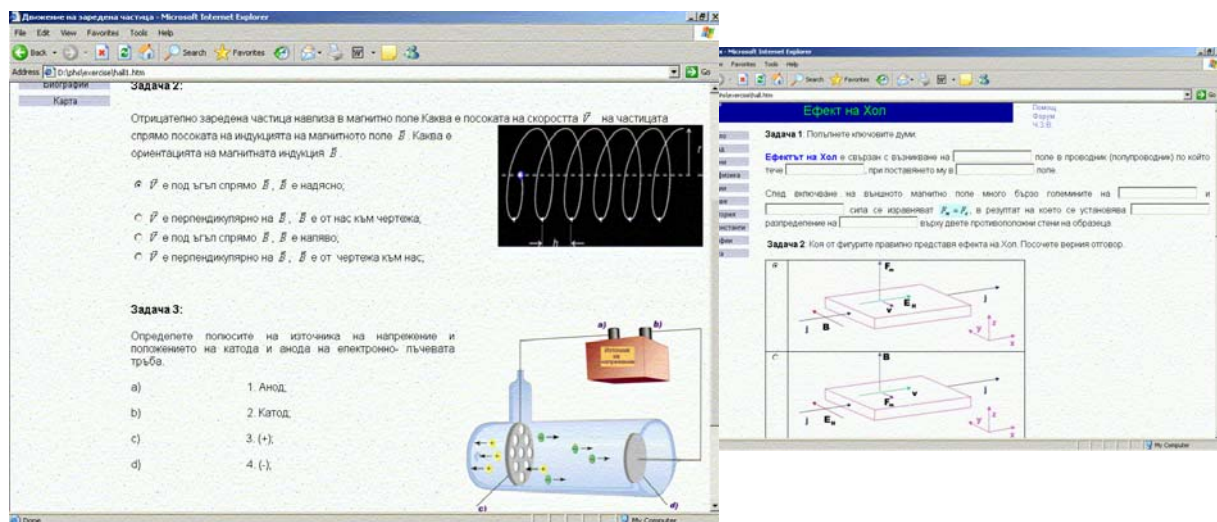


Fig.3. Entry test



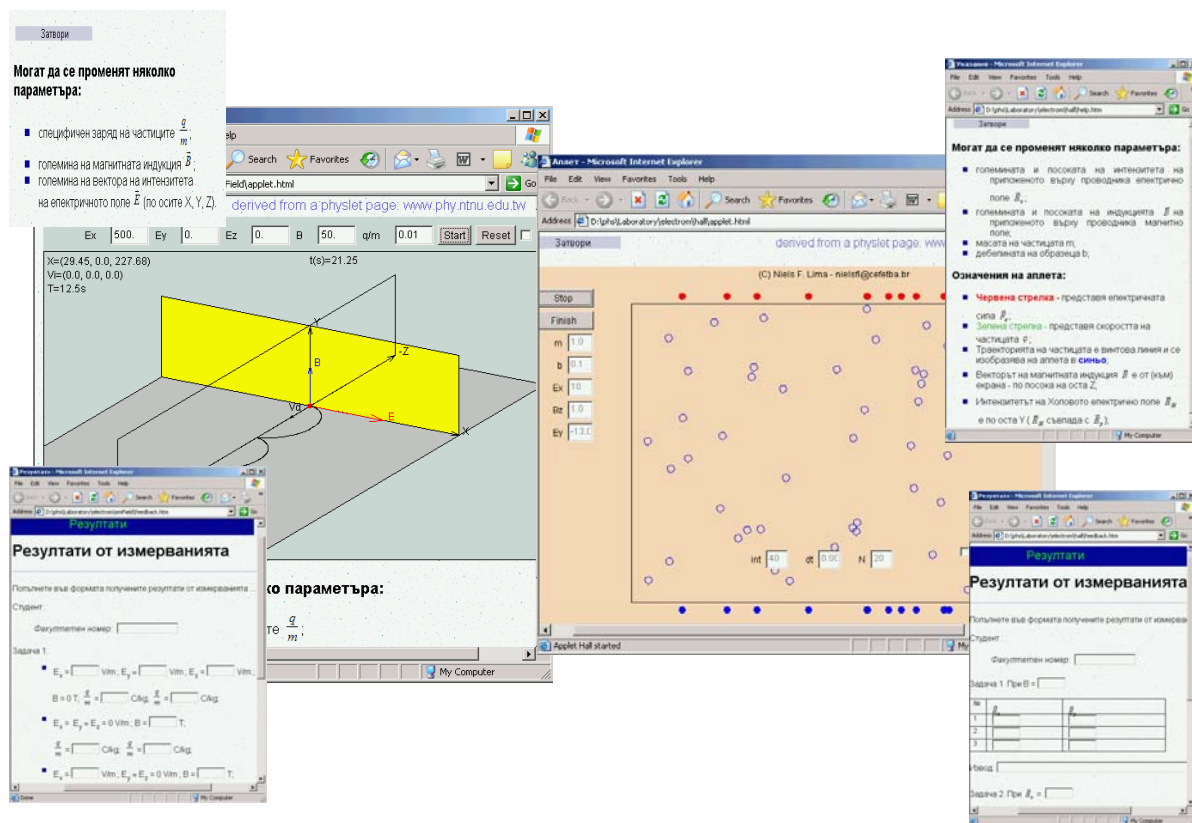


Fig.4. Applets, detailed measuring process description and results

In simulation laboratory experiment “Charge particle in magnetic field” students have possibility to investigate the motion of charge particles with different sign and different specific charge in magnetic field. In the case of “Hall effect” there are possibility for investigation of dependence between intensity of Hall electric field and applied magnetic field.

The presented simulation laboratory experiments are examples from the simulation laboratory [10], created for students from University of Rousse.

### Video Clips and Movies as a Tool for Visualization the Act of Magnetic Field on Moving Charge

Interactive video clips and movies are logical step in the progression of creating useful visualizations for students. According to Kozma [15, 16] “the advantage of any video is in its use of dynamic, visual symbolic systems that allow scientists to view any scientific experiment or discovery from multiple or different perspectives”. In [17, 18] has been shown that:

- The digital video activities and tools can be used by students to make connections between concrete, real-life phenomena and the abstract ideas and models of physics.
- Students can create visual representations of their model and display it directly on the video scene. In this way students can make direct visual comparisons between complex events and simplified scientific models.
- Students can also combine images from different video frames and modify the presentation of motion on the screen.

In the case of lab exercises “Charge particle in magnetic field” and “Hall effect”, we used movies [19, 20] and video clip [21], respectively to demonstrate the motion of positive (in red) and negative (in blue) particles in magnetic field. Fig.5. shows different frames from the experiment.

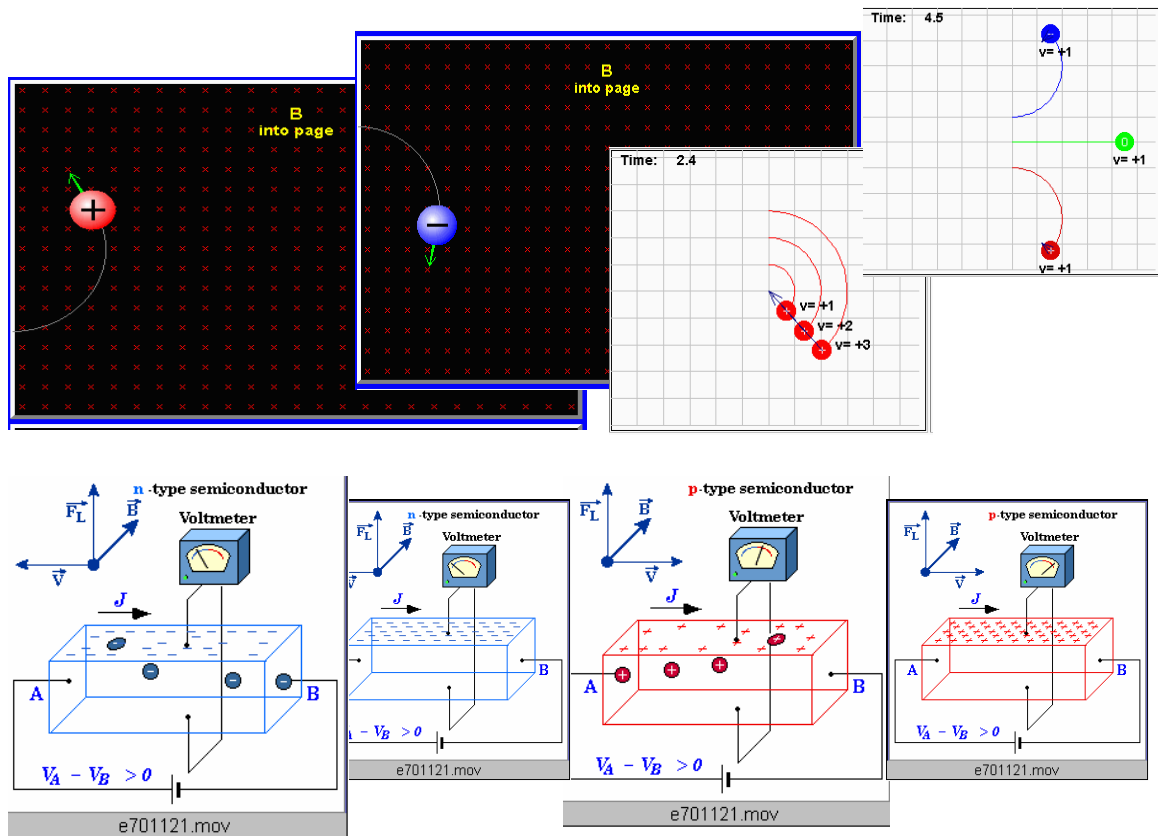


Fig.5. Video clips presented the simulation lab exercises

Video clips and movies can be included in electronic tests for knowledge estimation with the help of appropriate Test Generator [6]. Question examples with integrated multimedia element are presented in Fig.6. This allows creation of more attractive and varied test questions.

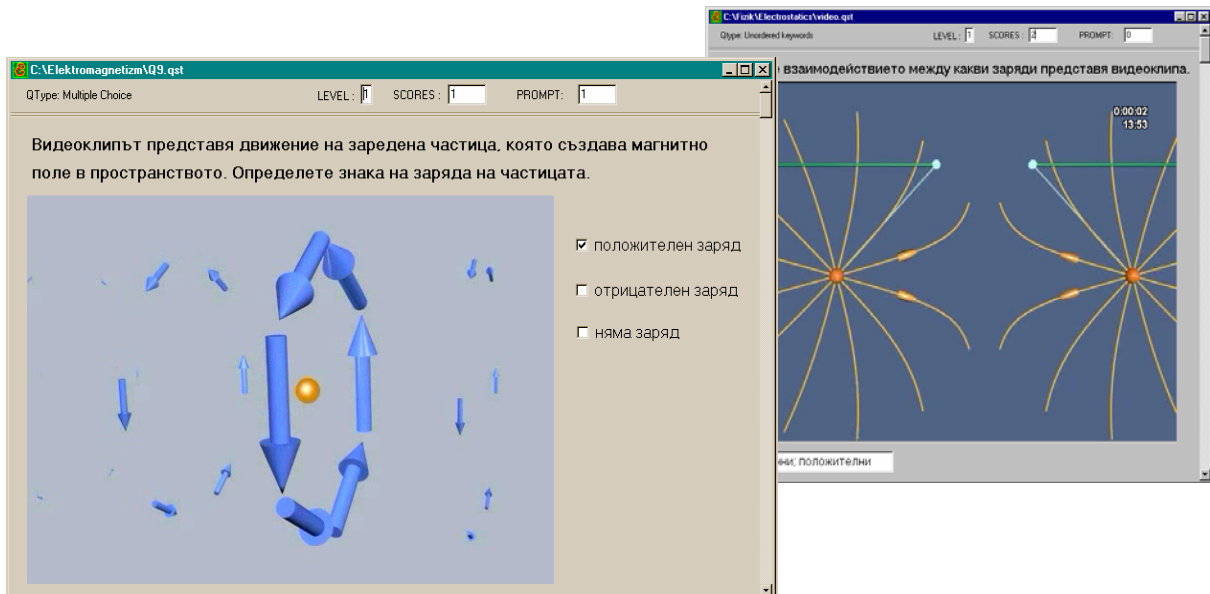


Fig.6. Question examples with integrated movies



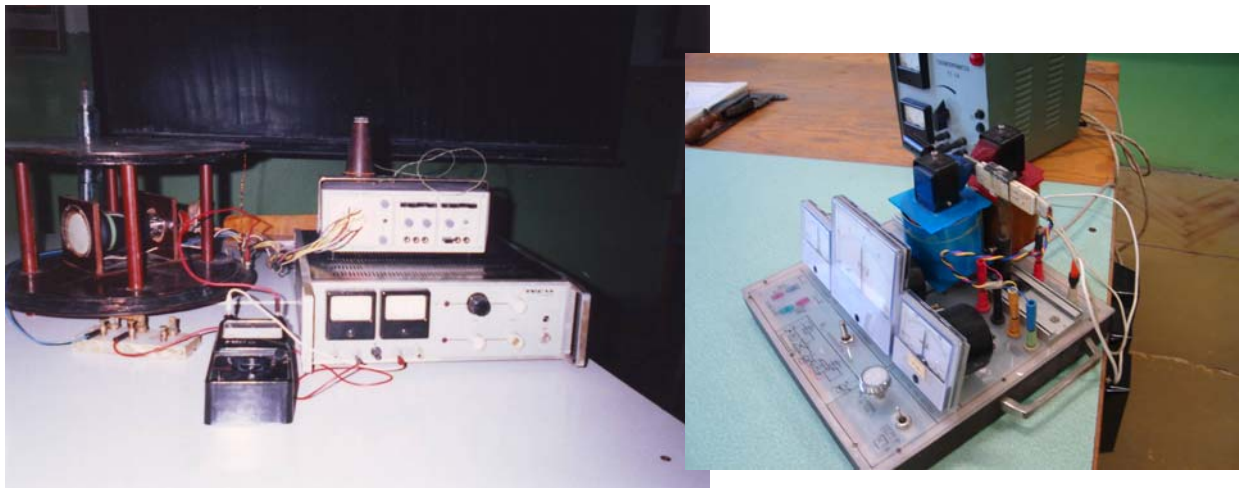
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### Charge Particle in Magnetic Field in Real Laboratory Experiment

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In real experiment "Charge particle in magnetic field" (Fig.7a) the cathode-ray tube, used as source of electrons, is arranged in homogenous magnetic field created by Helmholtz' coils. From the deviation of electrons, give on the screen of the cathode-ray tube, it is possible to estimate the specific charge of electrons [22].

In real experiment "Hall' effect" (Fig.7b) there are possibility to determine the character of the conduction (by electrons or by holes) and also the concentration and mobility of the carriers [22].



a

b

Fig.7. Real experiment equipments

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### Practical Applications of the Investigated Physics Phenomena

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For students of engineering courses it is important to investigate the deviation of charged particles in a magnetic field, because it is widely used in electronic devices (charged particle accelerators, electron microscopes, measuring instruments for the study of vibrations or very fast reactions, television sets, magnetic traps for charge particles, etc.). The Hall' effect is widely used in measurement work (miniature Hall effect counters, the modulation of electric vibrations, the taping of sound waves, the amplification of direct and alternate currents, etc.)

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### Conclusion

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Many fields of modern engineering are closely interwoven with physics. The physics teaching needs the study of many physics notions, methods and phenomena in a limited time. The major advantage of computer simulations, video clips and movies is an excellent visualization effect that is of special interest in the description of electromagnetic phenomena since the effects of magnetic field on moving charge and Hall' effect through action of abstract field that is hard to imagine. In this paper we present the development of a novel concept of teaching, allowing students to explore theoretical and experimental aspects of act of magnetic field on moving charge through simulation and real experiments.

The laboratory exercises presented in this paper can be used in addition of real laboratory experiments. It can also be profitably used by the distant learners, who have often scarce or null opportunity to access the laboratory in the university. Of course, when using simulation exercises, it is important to bear in mind that the actual reality is inevitably more complicated than the virtual one, so everybody should be invited to try, whenever possible, home made experiments or to directly look at physical phenomena in nature. Although the simulation exercises are very good as an educational addition, they could not recompense the classical education.

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## METHODOLOGICAL FOUNDATIONS OF FUNDAMENTAL ENGINEERING EDUCATION

Yakov Shifrin

*Abstract: In the paper, methodological aspects of nowadays high engineering education are considered. Thoughts generalizing author's long-term experience are set forth. Recommendations on the improvement of pedagogical process and training system for young teachers are given.*

*Keywords: fundamental education, educative process, ways of teaching, training of young teachers*

### I. General Statements

When solving problems of high school education, as initial one there should be considered an obvious contradiction between a huge and still increasing scope of human knowledge and limited terms of student learning. The contradiction noted above had been seen already by Socrates who lived in V century B.C. That is why he has worded his well-known sentence: "A student is not a vessel to be filled in (roughly speaking, to cram with – Y.S.) by a knowledge, but he is a torch to be inflamed". It follows from this that a main thing at high school is to teach a student to think and gain knowledge in its own way, by giving him a solid background. Namely such a background must constitute contents of the vessel. Otherwise the torch will not burn. Of course, any specialist has to learn during all his life. But study at high school should give a mold and a powerful impulse for the post-graduate student to be able to work on his own on the basis of fundamental background gained by him.

Unfortunately, recently at many technical universities, a trend of essential bias from the main goal of high school education pointed above is observed. The number of specialities being received by post-graduate students has sharply increased. This has entailed a lot of small courses, in order to justify the presence of corresponding specialities. The number of disciplines studied at a number of departments sometimes reaches 50 and more. Obvious disadvantages in such a plenty of courses being sometimes very small are as follow:

1. Narrowing of basic training of students, because the time for all the courses appearing additionally is being taken from that for basic disciplines.
2. Essential lowering of a level of department's methodological work. How can be discussed the improvement of principles when giving this or that course if only one teacher gives lessons on the course?
3. Sharp narrowing of the possibilities for young teacher to grow, because under a great deal of disciplines at a department, young teachers have to give practical and laboratory lessons on several subjects at once.
4. Essential enhancement of duplication of coupled disciplines. Moreover teachers often do not know contents of lectures being given by their colleagues at their department. It should be noted here that the duplication in giving these or those questions of different disciplines (one should not confuse it with some necessary covering of the material for succession) is one of most serious shortcomings of the high school educative process. As my long-term experience shows, it is very difficult to do without duplication. In order to slacken it, it is necessary, first of all, to intensify methodical relations between departments and those teachers who give similar questions in their courses (sometimes even within the same department). Usually teachers have lack of time for this. And nevertheless the duplication must be ruled out in any way. Apart from the fact that the duplication leads to the noticeable loss of study hours, it also muddles a student up, as different teachers set forth the same questions in different ways, sometimes even using different terms.

Insertion of a plenty of new specialities and a great number of associated new disciplines which appear to be mostly reflection of fast technological progress. Somebody has decided that it is needed to tell students about all the novel things. If such a tendency lasts, then in 10-15 years, the number of subjects in our study programs will increase by a couple of dozens else. But the matter of fact is in that growth of the technological progress rate does not need many specialities and a plenty of new courses to be inserted, but demands just *vice versa* – preservation and even enhancement of the fundamental base for post-graduate students.

By the way, only in this way one can speak about realization of a concept of the Bologna declaration. How can we join the Bologna program, if we have 70-80 disciplines for these or those specialists in the high school program?

The main conclusion following from the told above is an exigency to shorten the number of disciplines planned for study. One must very carefully and conservatively consider the increase in the number of disciplines to be studied and changes in contents of basic courses.

It is necessary to note here that strengthening of student fundamental training is far from only decreasing the number of specialities and disciplines. Each course and each lecture contain principal questions constituting foundations of the science as well as statements to be replaced by novel technological solutions. Correct classification of the material is a personal duty of each teacher. It is necessary to teach young teachers to make such a classification, because in the near future, the responsibility for a level of high school education will lay on their shoulders.

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## II. On Some Features of Educational Process

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A problem of strengthening of student fundamental training puts high requirements for the educative process itself. Let us point out these requirements.

1. At lectures and associated practical and laboratory lessons, to set forth mainly fundamental questions of this or that discipline and used approaches and methods. Sure, this does not mean that in the course of the educative process, concrete solutions, schedules and design have not be studied. Correct definition of proportions between fundamental questions and narrow engineering knowledge is the most important duty of each teacher.
2. Students should be taught to smartly simplify a problem. With this aim, one should thoroughly analyze assumptions and limitations accepted when considering these or those questions, as well as the domain of applicability of the results obtained in this case.
3. It is necessary to attract students' attention, when solving a problem, to a choice of an adequate mathematical apparatus and to smart usage of computing facilities. On one hand, a post-graduate student must not fear to use a rather complicated mathematical apparatus, when it is necessary. Along with this, he should be taught to have the engineering mode of thought – to be able to comparatively simply obtain an approximate estimate of this or that effect.
4. One should strive to set forth science in dynamics of its development, attracting attention of students to questions not solved yet, to give his view about possible ways to solve it. Namely such an approach teaches a student to think and turn over in his mind. It should be applied more and more often while a student is coming to under-graduate courses. Otherwise a student will not be morally ready for serious degree research, and moreover to work on his own after graduation from the institute.
5. A student, first of all, should be taught to solve intricate problems. Namely on the complicated material, it is convenient to teach a student to think and analyze these or those phenomena, to illustrate the material used for a discipline under study.

It should be noted here the following. Today some teachers have a dangerous tendency to lower a level of lessons (first of all, lectures) to adapt them to an average student (and sometimes to the backward one). This is unacceptable. A teacher must draw a student up. Further, namely this will make easier first steps of student's self-dependent life.

This question borders with that on attitude to talented students. Quite often in practice of our high school, when working with students, a teacher spends time mainly for drawing up backward students and sometimes even the careless ones. And this is being done in prejudice of personal work with strong students. Without doubts, this is a great mistake. Peculiar attention must be paid to strong students. Namely they will favour the development of science in the future and determine rate of technological progress. On average, there are several such students per year. Don't miss them. Modes of the work with them can be very different, beginning from extra tasks at practical and laboratory lessons and including the joint scientific work with consequent invitation of them to post-graduate course. I will give an example of this. In his time, academician V. A. Fok was giving a special course for 2 (!) students. And he was preparing to the lectures as if he had the entire group of students in front of him. And efforts of Vladimir Aleksandrovich were not wasted: both the students further became prominent scientists.

Sure, all the points noted above should be implemented not extemporaneously. They must be previously thought out while teacher is preparing to lessons.

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### III. On Training Young Teachers

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The importance of the question is determined by that future of any institute depends on how young teachers are being trained, in particular during their study at post-graduate course. Namely on this reason, questions of training skilled workers must be based on the clear and well thought-out system. The system, in spite of the obvious things – preparation to post-graduate examinations and scientific work in the field of the own dissertation theme – should encompass the following:

- the increase by post-graduate students of their level in mathematical and engineering learning;
- an active participation of post-graduate students in scientific-research and methodological work of the department;
- attendance by post-graduate students of lectures of skilled teachers giving basic courses;
- gaining by post-graduate students of a certain pedagogical experience.

When fulfilling all the points, it is needed, on one hand, to provide the necessary help for a post-graduate student, and on another hand, a strong control of his work.

All this is a copybook truth, but it is not done in due way anywhere and ever. And this noticeably worsens quality of training young teachers.

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### Conclusions

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In my paper, I paid main attention to how engineering high school education should be built, and correspondingly in what direction efforts of leading and teaching personnel of high school should be directed. The main thing is preservation and even strengthening of fundamental basic background of students. Namely this was a glory of the best higher education of the USSR. Everything must be done in order these traditions to be saved.

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## ABOUT THE EXPERIENCE OF DEVELOPING INTERACTIVE DYNAMIC ILLUSTRATIONS FOR EDUCATIONAL E-MATERIALS

**Evgeny Eremin**

*Abstract:* Publication describes the author's experience in the development of illustrative dynamic materials for eLearning courses. The presented illustrations offer multiply interactive possibilities for a student and powerful flexibility in creating theoretical or control pages for a teacher. Both specialized and universal ways for illuminating of educational materials are discussed. All interactive dynamic illustrations are realized as Java applets, although it is emphasized, that basic ideas are helpful for any other similar technology.

*Keywords:* education, eLearning, interactive illustration, dynamic illustration, electronic educational materials, Java applet.

*ACM Classification Keywords:* K.3.2 Computers and education - computer and information science education; I.6.3 Simulation and modeling - applications

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### Introduction

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Although distance learning originally arose from conventional «paper» materials, now this process cannot be envisioned without computer technologies [1–5]. Educational materials in an electronic form (e-materials) became an essential element of modern education even in its intramural forms. The amount of computer educational

resources is growing with constant acceleration, but the simple types are prevailing as yet: hypertexts with static pictures, linear presentations or short video clips. Nobody doubts the utility of these instrumentations, but it is also evident that they do not completely realize the powerful teaching capabilities of modern computers, often enforcing pupils to achieve passive familiarization with information on the screen.

The most accepted (at least in our country) way to induce students' activity while working with e-materials is quizzes and tests that control the digestion of information. The results of testing also give teachers or better to computer software some potential for the choice of further materials to study. A more «creative» pedagogical tool is interactive computer models, which are directly handled by pupils. In particular, such models are common in the natural science courses like physics [6–10]. Interactive computer models became one of the basic tools in CBT-courses (Computer-Based Training) on CD-disks [6–8]. Models based on Java applets are mainly spread as large libraries (see [9] for example), but some successful attempts to make them an important part of WBT-course (Web-Based Training) can be also found in the Internet [10].

The reply to the strategic challenges of modern education requires essential increasing of students' activities during the process of obtaining knowledge. This important problem objectively leads to the development of the interactive presentation methods for educational material with variability of behavior according to some built-in internal logic. This paper describes the experience of the successful, from this point of view, development of dynamic Java applets that can be put to use in educational materials for informatics course. These applets can be included into any frame with theoretical explanations and may be used as an instrument provided to students for doing practical exercises as well. Such multipurpose technology can be helpful in the development of educational e-materials. As a result teacher can construct unusual «live» and interacting with pupil pages that cannot be gained by any other conventional method. Java applets are not the only way to realize the examples which are described in this publication – booming Flash-technologies, with their rapidly increasing power, are suitable for this purpose too.

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### Illustrations based on applets and their values

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It is known that applet is the software, written in Java programming language and designed for the execution inside Web-page in a browser window. According to fundamental Internet principles, information for browser must be platform independent; hence applets can be imaged on computers with different architectures without any incompatibility problems. Applet's most important advantages in illustrating of educational e-materials directly result from its nature:

- applet is a **dynamic** illustration unlike static pictures and snapshots;
- applet is an **interactive** dynamic illustration and this essentially differentiates it from video clips.

We evidently see that applets are the tool for visualization of the learning content that increases the activity of the students; many distant learning courses lack this feature.

The use of programming language for creating applet illustrations has several values. For instance, it provides high veracity of a dynamic image: we see a virtual process that not just looks like original one, but completely accurate picture that is fully adequate to laws of nature we study. Due to existing mechanisms of parameters' input, we may generate new variants of illustration, let us say, adding or hiding particular objects. The potential to affect the applet's functioning from the outside is the main advantage over educational film. Let us note, that the possibility to stop watching a process and watch it repeatedly is proper to both means (to film and to the applet as well).

Important characteristic of the interactive applet's realization is the presence of *two* ways to control it. First, the parameters of the applet may be inputted with the help of conventional visual controls like text fields, lists, buttons and so on (Java language provides a special library called AWT – Abstract Window Toolkit, which contains all controls of familiar graphic interface). Second, any applet is able to read parameters directly from the text of the Web-page where it is installed. This power of two-way handling is rarely important from the didactic point of view: the first way is meant for a student, interacting with an illustration during learning a course, and the second one – for a teacher, developing the contents of a lesson and preparing suitable illustrations for it. These flexible features diversify the applets potential educational usage.

And one more additional feature of dynamic illustrations based on applets: they can be constructed as **specialized** or **universal**. Every specialized applet supports only one illustration, whereas universal one is suitable to attend complete series of exemplifications without any internal changes. It is evident that specialized

applets are easier to write, but universal ones approve themselves more usable, especially during complex review of cognized material, when teachers need to combine tasks from different themes. Of course the choice of applet's realization depends on concrete educational content.

Several examples of educational dynamic interactive applets, developed by the author, will be described in the next sections of the paper. Although their subject is devoted to learning of the fundamental principles of modern computers functioning, it is not essential condition. The adaptability of considered technology to other educational disciplines will be discussed after the description of examples.

### Example of specialized applets

As an example of specialized dynamic illustrations we shall discuss the series of Java applets, developed by the author [11], which were designed for learning of the governing instructions of a modern RISC processor. The suitable educational base for teaching this topic is MMIX model, proposed by the classic of computer literature D. Knuth [12–14].

Two typical examples from the series of applets under consideration are presented on fig. 1: first (left) allows the user to study the work of instructions, which determines the contents of microprocessor registers, and the second demonstrates the principles of how of processor's arithmetic operations work. Let us examine the selected applets in a more detailed way.

Generally, learning of the instructions that set data into processor registers does not lead to serious difficulties. Nevertheless, MMIX, being 64-bit processor with 32-digit binary RISC instructions, has some specific for such architecture peculiar properties. It is evident, that it is impossible to determine all bits of the register by means of one instruction which has smaller digit capacity. As a result, in MMIX and in real processors of similar architecture programmer can fill register's bits only by parts: all 8-byte register is divided into 4 equal parts, marked H, MH, ML and L; special command from the processor's instruction set is used for every part. Therefore 4 such instructions are required for full setting of a register value in the case of arbitrary binary code. To make easier and shorter the programming of registers' initialization in the most often and simple situations, one of these instructions (SET) not only writes constant into specified part of the register, but also clears the rest three parts.

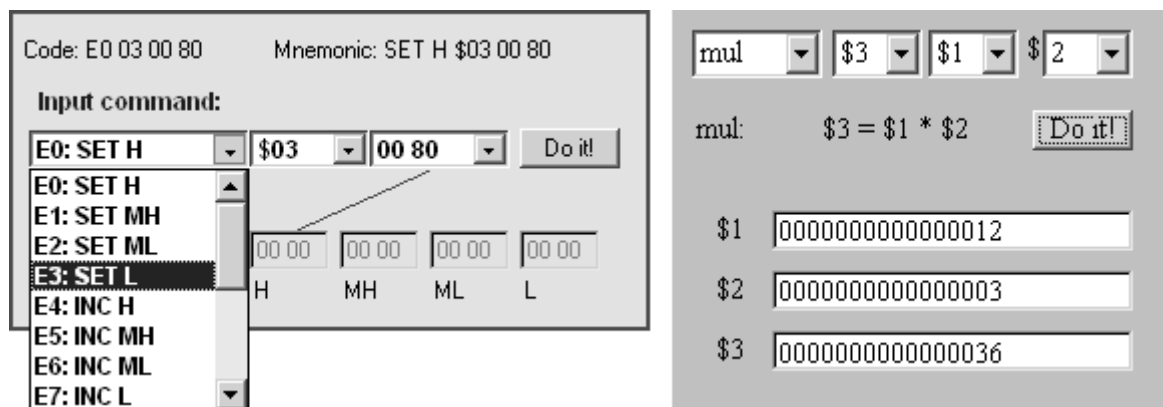


Fig. 1

Presented above brief description is enough to understand the helpfulness of the offered dynamic interactive model (fig. 1, left), which allows to study all the details of determining value in a register of large length. It gives possibility to test any instruction: SET, INC, OR, ANDN (shortcut from AND-NOT) for every quarter of the register. Furthermore, any *sequence* of such instructions can be simulated, that is even more important from practical point of view. Note that not only operation can be selected from the dropdown list; arguments of the instruction (register's number and value to set) also can be changed the same way.

We must emphasize that described illustration gives student possibility not only to learn the theoretical description of all MMIX instructions from this class, but also to do many exercises with its help, watching visualization of the results immediately.

The second example (fig. 1, right) demonstrates the execution of all arithmetic operations in MMIX RISC processor. This dynamic illustration is also able to form any required arithmetic instruction, define original

numbers for it and then check the result of the operation. As in the previous case, applet can execute any arbitrary sequence of supported commands.

The similar illustrations are developed for several other kinds of instructions [11]. Their complement gives possibility to make the learning of RISC processor's instruction set easier and more demonstrative.

### Example of the universal applet

The logical evolution of the complement from the separate interactive dynamic illustrations, described above, naturally leads to creation of one unified applet, which is able to execute any instruction, comprised into instruction set. Actually we get a virtual working model of a processor as a result, which can be built into any educational e-material. The complexity of writing of such applet will be required by the new appearing feature: the universal model is able to execute arbitrary sequence of commands that means absolutely all linear, branching or cyclic programs. The specialized applets permit to learn only separate groups of instructions of the same kind, just as the universal one may additionally become a base for learning processor codes programming.

The example of such universal interactive illustration for e-course is presented on fig. 2 (variants of its usage in educational e-materials can be find on the author's site [15]).

Applet realizes the computer educational model «E97» [16–19]. As we can see from the screenshot on fig. 2, educational model consists of the following parts (fig. 2):

- block of registers, which contents can be edited;
- memory, the contents of its cells can also be changed;
- virtual display screen for output of the results and echoing of keyboard input process;
- controls of the model.

If such illustration is included into Web-page, student after reading its text can input into model's memory required program and run it. As an example, on fig. 2 you can see the result of execution of the program that prints Latin alphabet on virtual computer's display.

An important feature of discussing universal applet is its ability to extract program from HTML page text and store this program into model's memory. So, as an alternative variant, a teacher can prepare examples of programs for the educational course in advance (various on different pages), and then a student just analyze given examples and run them.

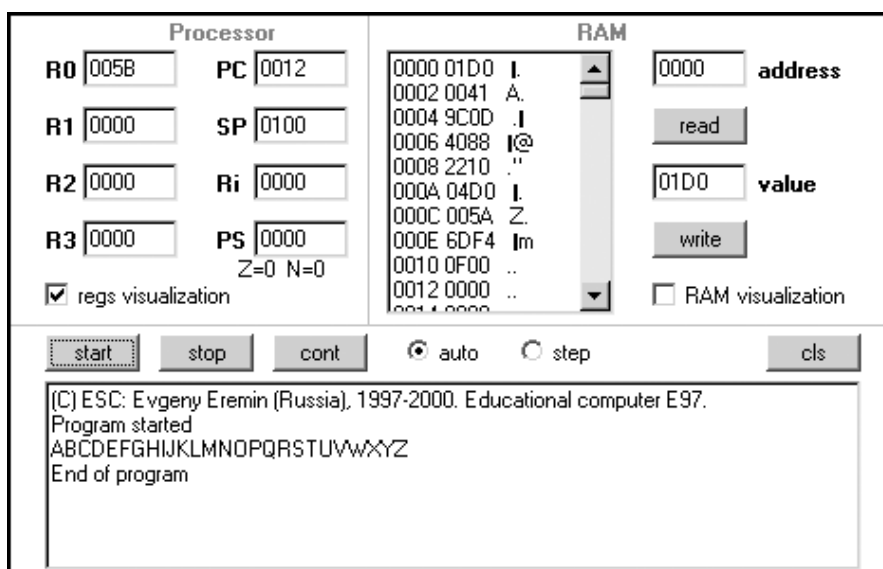


Fig. 2

As it was emphasize earlier, an applet model can play a role of some kind of empty «blank», which pupils fill with their solutions of the task, given on the page, and then verify the results by watching displayed results.

Thus, the value of universal illustration technology is confirmed in the following way: one applet is enough for all learning material, and it is easy for changes according to the contents of any educational page.



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## Conclusion

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Thus the technology of development of the learning materials with interactive dynamic illustrations, described in this publication, demonstrates essential values of the electronic form in comparison with conventional «paper» one.

It is necessary to emphasize that the subjects of the selected examples were determined exceptionally by the schedule of disciplines taught by the author. At the same time the described technology itself is easily applicable to many other (although may be not absolutely to all) educational courses. In the informatics area we may without special afterthought enumerate such questions like programming language constructions, number system notations, rules of queries composition for data bases or search engines, learning of the operating system commands (including OS with a graphic interface) and so on. The use of considered technology for illustrating e-materials seems to be quite real for other educational disciplines, for instance visualization of planets' moving in astronomy, demonstration of some objects' interaction in physics, realization of interactive electronic maps in geography and so on. In all cases the question is in illustrations which have dynamic character and require the dialog with a student.

As it was noted above, the choice of Java applets by way of realization interactive dynamic illustrations is not the only possibility. Graphic images, implemented with the help of Flash technology, also become more and more popular. It is important to accent that maximal effect we shall have not for simple Flash clips or screened comics, made up on basis of pictures that are changing by means of «Next» button, but for really interactive applications. In other words, the main idea of the publication is not just propagandize of including dynamic graphics into educational e-materials – the question is in its essential interactivity, when the pupil gets a chance to have an influence on illustration's behavior according to the given task or makes some experiments aimed at familiarization of the new educational material.

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## EDUCATION COMPLEX "MULTI-AGENT TECHNOLOGIES FOR PARALLEL AND DISTRIBUTED INFORMATION PROCESSING IN TELECOMMUNICATION NETWORKS"

**Adil Timofeev, Alexey Syrtzev, Anton Kolotaev**

*Abstract:* The paper describes education complex "Multi-agent Technologies for Parallel and Distributed Information Processing in Telecommunication Networks".

*Keywords:* multi-agent technologies, parallel and distributed information processing, telecommunication and computer networks.

*ACM Classification Keywords:* I.2. Artificial Intelligence

### 1. Introduction

Now multi-agent technologies and systems for data flow control in telecommunication and computer networks (TCN) are new and effective means of parallel and distributed information processing.

Making use of multicore Intel processors for implementation of multi-agent technologies enables conducting parallel and distributed multi-agent computations on modern multicore architecture of Intel processors.

### 2. Problem Set

Development of learning course "Multi-agent Technologies for Parallel and Distributed Information Processing in Telecommunication Networks" and embedding it into educational process on multicore Intel processors basis are very important education tasks.

So for their solution it is necessary to develop multi-agent technologies and systems for data flows control in telecommunication and computer networks. They are based on decomposition of complex (global) task on simple (local) condition-independent subtasks, which are distributed autonomously between processors-agents and solved by them in parallel till joint solution of a global task.

This problem can be solved by the use of multi-agent telecommunication network (MATCN).

MATCN contains the following systems (Figure 1):

1. Distributed communication system (DCOMS) which processes queries of users-external agents;
2. Distributed control system (DCS) which provides control for data flow routing in telecommunication system;
3. Distributed information system (DIS) which receives information from computer network and then transmits them to DCOMS
4. Distributed transport system (DTS) provides knowledge exchange with computer network

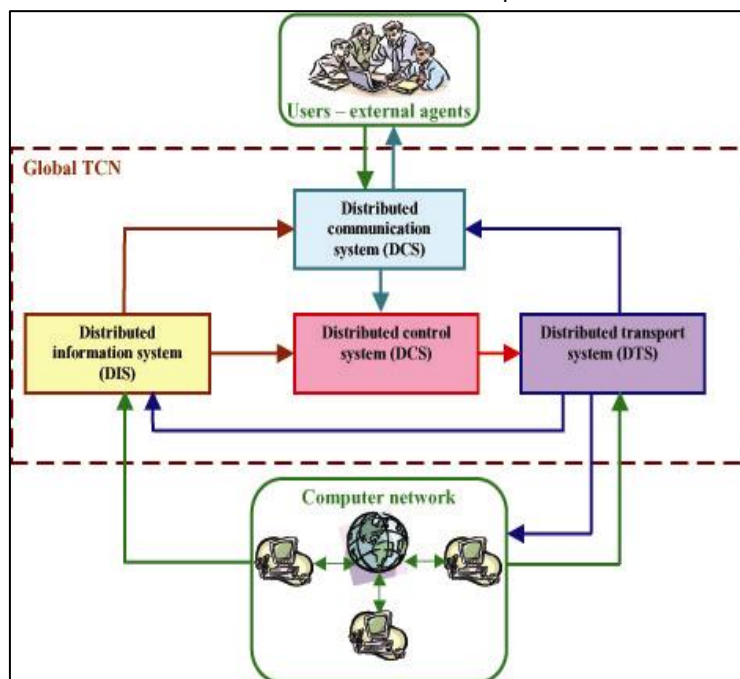


Fig. 1. Structure of multi-agent global telecommunication network

### 3. Lectures Course

1. Status, convergence and TCN development tendencies.
2. Design of multi-agent distributed TCNs and principles of parallel processing of information flows.
3. Mathematical models and system analysis of distributed TCNs.
4. Principles of network control and data flow distribution.
5. Criteria of communicability and optimal information flow routes existence.
6. Methods of multi-agent routing of information flows and its implementation guidelines on multicore Intel processors.

### 4. Topics for Laboratory Works and Seminars

- L-1. Multi-agent distributed telecommunication systems simulation library.  
 L-2. Practical work on multi-agent route planning for a group of mobile robots navigation.  
 L-3. Multi-agent data flow routing in distributed multi-agent TCNs.  
 L-4. Principles and software tools for data flow routers implementation on multicore Intel processors.
- S-1. Methods of adaptive, multi-agent data flow routing.  
 S-2. Methods of multi-agent distributed TCNs simulation.  
 S-3. Principles of multi-agent parallel-distributed control of information flows on multicore Intel processors platform (10 hours).  
 S-4. Improvement of global TCNs on a basis of multi-agent and GRID technologies and multicore Intel processors (4 hours).

### 5. Telecommunication Networks Simulation Library

The TCN simulation library TCNSym is used in laboratory and practical works to demonstrate distributed information processing algorithms by the example of routing problem in TCNs.

The simulation environment is implemented using C# language for .NET platform. The user is allowed to edit network graph model, set up parameters for routers, channels and traffic generators, start simulation in both offline and online modes (Figure 2). In the online mode statistics about a network being simulated is updated in real-time and presented via graph plotting and packet movement in the network animation (Figure 3).

Simulation experiment results may be exported to MS Excel for further analysis.

Currently there are number of unicast and multicast routing algorithms implemented in the simulation library: static routing, distance-vector routing, link state routing, Q-routing, reverse path multicast, reverse path broadcast, truncated reverse path broadcast, core-based trees routing etc.

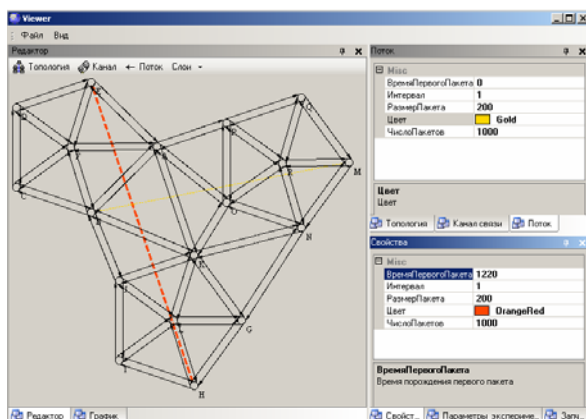


Figure 2. Setting up input data for a simulation experiment

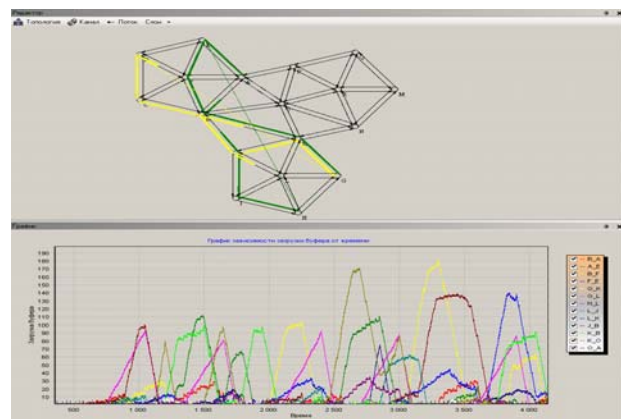


Figure 3. Running a simulation experiment in online mode

## 6. PH D Theses Related to the Project

- Veresov I.G. "Adaptive algorithms of information processing in multi-agent networks" (2003)
- Sheozhev A.M. "Development of neural network algorithms for medical-biological studies automation" (2004)
- Ostyuchenko I.V. "Multi-agent QoS control in telecommunication networks" (2006)
- Syrtzev A.V. "Mathematical and simulation modelling of neural network routers in multi-agent telecommunication systems" (2006)
- Kolotaev A.V. "Telecommunication network simulation library and language" (2006)

## 7. Conclusion

This learning course may be very useful for students who study multi-agent technologies in telecommunication networks, databases and control.

## 8. Acknowledgements

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## THE PRINCIPLES OF CREATION OF TEACHING MATERIALS AND ORGANIZATION OF UKRAINIAN LANGUAGE LEARNING PROCESS USING DISTANCE SUPPORT IN SENIOR CLASSES

Dina Rozhdestvenska

*Abstract:* The article deals with the topicality and problems of using information and communication technologies in secondary education, conditions and methods for Ukrainian language learning with the distance support in senior classes. The article shows the principal similarity of distance learning to training one. The common and specific principles of creation of teaching materials for a distance learning course are described. It reveals the conditions of effective organization of Ukrainian language learning with distance support on the material of distance course "Business Ukrainian and Culture of Communication".

*Keywords:* learning process with distance support, principles of creation of teaching materials, conditions of learning process effective organization with distance support.

*ACM Classification Keywords:* K 3.1.

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### Problems and Topicality of Distance Learning in Secondary School

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One of the important existing problems that should be scientifically and practically solved while implementing distance learning in secondary school is the creation of curricula involving different forms of combination of face-to-face and distance learning, providing the ratio of individual and general learning programs, and usage of the network resources [Khutorskoi, A.V., 2001].

For this purpose, an experiment with implementation of Ukrainian language learning with distance support in senior classes is being carried out. The pilot distance course "Speech Culture and Business Ukrainian" was tested in April-May, 2005 (<http://dl.kpi.kharkov.ua/techn3/tu196/DEFAULT.ASP?ukr>), an improved course "Business Ukrainian and Culture of Communication" (<http://dl.kpi.kharkov.ua/techn3/tu209/DEFAULT.ASP?ukr>) was started in senior classes in Kiev in 2005-2006 academic year.

According to the result of the experiment, methods of organization of mother tongue distance learning process are **one of the most complicated problems**. The reason for this is not only the necessity to change the traditional organizational forms of work which is required under the conditions of increase of independent and individual work of learners, and the necessity to reduce the usage of explanatory and illustrative methods of teaching as well as to enlarge the member of practical and creative research works, but also because it is necessary to develop learners' readiness to be rightful subjects of the learning process. Another difficulty in implementing distance learning support is the specific nature of the subject teaching itself: accentuated personal attitude towards the teacher and the subject, the necessity to work with a large quantity of text material, the peculiarity of the tasks that have to be done orally (when learners, pronounce something or speak out their opinions, etc).

The topicality of the research is also concerned with the fact that the experiments on usage of computer technology in the mother tongue learning process have not given unambiguous results. Some scientists [Attwell, P., 2001; Singleton, S. and Simmons, F., 2001] stress the positive effect of using computer programs for teaching reading and literacy, while the British Economic Society informs that the usage of informational and communication technology has not been useful for the development of learners' basic reading skills.

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### The main approaches of teaching process design

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To achieve successful implementation of distance support it is important, in the first place, to design the learning process and only then to carry out its computer realization. It has not been done yet for the distance support of Ukrainian language (as the mother tongue) learning in the secondary school. The designing process includes the following:

- 1) Creation of teaching materials for the distance course,
- 2) Software,

3) Organization of the distance support of learning.

Will consider the first and third points more in detail.

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### **Creation of teaching material**

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The researchers in the field of designing and the organization of distance learning process mark, that the development of teaching materials is one of the primary goals which are necessary for solving the given type of training into the school education. The ideal purpose for those who is going to develop the teaching materials for distance learning is their maximal simplicity and a transparency of the organization in use, keeping the maximal information saturation.

As far as the adaptation of well recommending itself distance (network) technologies in the educational process of secondary school will be successful, depends on many reasons. This is a methodically competent organization of educational process, and presence of didactic correctly created teaching materials with system of practical tasks, and the organization of didactic justified communications, and system engineering of the control of educational achievements with an opportunity of observation of efficiency of process of educational activity.

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### **The general recommendations for creation of teaching materials for distance leaning training courses**

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The positive possibilities of new environments for creation of teaching materials are traditionally emphasized: a possibility of variety of material contents, use of different ways of its performance with using of all spectrum of multimedia (the text, diagrams, audio, video, animations), expansion of possibilities for search and navigation, the creation of the objective and all-round monitoring system, attraction of network technologies for the organization of interaction etc.

The following principles of development of teaching materials [Efimova, L.A., Dmitrievskaya, N.A., 2002] are allocated in the literature. They are:

1. The Priority of the educational aims.
  2. Granting of additional opportunities.
  3. The Account of features of target group.
  4. The Friendly interface providing an effective interaction between pupils, teaching materials and the teacher.
  5. Use of teaching materials to provide fast loading pages, transparent navigation and unity of style, rational use of means of multimedia, readership of the text, friendly color scale, absence of technical mistakes. The performance of text materials with such characteristics as scanning, capacity, and also integrity and sufficiency.
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### **Features of the organization of training and development of teaching materials for distance support of learning of the course "Business Ukrainian and Culture of Communication"**

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The practice of realization of a distance learning course "Business Ukrainian language and culture of communication" (<http://dl.kpi.kharkov.ua/techn3/tu209/DEFAULT.ASP?ukr>) has shown, that the implementation of distance learning in its classical style into the process of teaching in secondary school can result to decrease of efficiency of educational process. To carry out the training with distance learning support as form of internal learning using the distance (network) course is more expediently. The organization of such type of educational process gives the following possibilities: preservation of personal contact of pupils with the teacher, leveling of lacks of materials of a distance course, use of operative management by educational process due to a variation of structure of motivation, rate, a rhythm, a level of complexity of an studying material etc.

In distance support there is involved a factor of the person of the teacher, influencing on quality of process and result of educational activity, keeping for him a position of the carrier of knowledge, as against the distance learning where the complete sets of teaching materials act as carriers of knowledge. Somewhat at such form of the organization of educational process the teacher feels an additional loading as his didactic and methodical functions he carries out directly during educational process in a mode of real time. The teaching material prepared and submitted in the course does not relieve him of necessity of fast reaction and rearranging a course of a lesson depending on individual trajectories of each pupil training, a degree of their information and computer competence, technical problems in work. The necessity of realization of work on creation of the special

educational environment which are taking into account the needs of the pupil and his specific features; the thought over system of submission of tasks and the personal approach to pupils it is underlined in connection with the absence of such at existing virtual schools [Khiltunen, O., 2001].

Besides, if for the distance learning organization, as a whole a serious problem is the indistinct curriculum for training, so for the learning with the distance support is a quite acceptable variant. More often, in a course it is placed too more material, than it is necessary to acquire, however the success of training is achieved due to criterion function in teaching a material that supposes various tactics of submission of the information by the teacher. Though overcoming of the tendency to glut by the theoretical information remains the important requirement to materials in a course. Also it is necessary to pay attention to the precise connection between the aims, tasks and material, placed in a distance course. In this aspect a distance learning is close to training: If in a training there is a surplus of the information, its participants lose understanding of the aim of training, and practical tasks are replaced with lectures, so a training, losing the interactivity, and together with its appeal, loses the training possibilities; if the same occurs in a distance support - the material of a distance course is ignored by pupils and, accordingly, is not acquired by them.

However a question on quantity of information in distance learning it is a question that does not have the unequivocal answer. It is necessary to note, that the lack of information is also bad, as well as its surplus. Proceeding from impossibility of exact definition of opportunities of mastering and - or performance of practical tasks by pupils - teaching materials are created much which allows to individualize educational process for pupils with different rate rhythms and cognitive opportunities.

Besides above-stated, the development of teaching materials for distance support of studying of the native language is perceived as enough complicated problem because of subject specificity. The matter is that at use of the distance course focused mostly on the written communications, from the system of methodical receptions of formation of language and speech competence oral speech "drops out": speaking, monologic and dialogical speech, and also those components of rhetoric, which connected to communicative and social competence. As an output from this situation the use of the organization of training with distance support of elements of active social training with the purpose to keep oral dialogue is used. Especially it is important in connection with that, that computer environment communications, being more controllable by the subject of dialogue, can provoke further avoiding of real / straight/opened (as though uncontrollable) communications.

The practice of work has shown also, that a teaching material it would be desirable:

1. Quantitatively to place within the limits of the first screen. It promotes faster and complete acquiring of material.
2. To form the teaching materials, depending on an studying subject, on different strategy: 1) by a principle of concentric circles (base concepts, base concepts and examples, base concepts, examples and the additional information), 2) by a principle of a circuit: the basic concepts - examples and practical tasks - the additional information, 3) by a principle of " the teacher's abstract " where in the compressed form the essence of studying questions is selected.
3. Logically to finish each of parts of a teaching material during the lesson so to have possibility to master them in any order.
4. To carry out the precise structurization of material on importance. Thus, important for the perception of the information from the screen is not only its correct structurization, but also an explanation of rules of this system. As the type of registration of teaching materials is similar to what is used everywhere for structurization of text resources of a network the Internet, sot, it goes the process of formation of information readiness of the pupil to use of information and communication technologies (ICT).
5. Taking into account different resource possibilities it is expedient to submit a teaching material in the text and graphic form as its presentation in such kind demands the minimal expenses.

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### **The conditions of the organization of the distance support of learning**

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Describing the essence of distance support of learning, it should be noted that the results of psychological and pedagogical research for the influence of the information and communication technologies on the learning process have proved that the usage of these technologies lead to great changes in the contents of the learning process as well as in teaching methods and methodology that helps to make radical changes in the construction of teaching the subject [Mashbits, E.I., 1988].

Using this postulate as a basic as well as our practical experience, we have drawn a conclusion that designing and organizing the distance support in the mother tongue learning is very close to planning and organizing the training learning. In particular, the effective learning process organisation in distance learning is possible under the following conditions.

1. Firstly, it is necessary to formulate not only the general academic purpose, but also the purpose of each lesson. The peculiarity here, which distinguishes the teaching with distance support from the traditional learning, is that learners must form the purposes by themselves. Or it is also possible that they may also accept some purposes suggested by the teacher. In learning with distance support and in training the learners' need to know how their efforts would be rewarded is observed more deliberately. As a result of their activities learners should be said what skills and knowledge they would acquire at the lesson, how they might use them in practice, and the development of what skills they should especially pay attention to.

The methodological basis of distance learning is similar to the one of training learning in the fact that they both are aimed at the subject who really cares for the needed knowledge, skills, experience etc. Practice shows that the learners in senior classes do not have any definite purposes, which they want to achieve while learning mother tongue.

We must note here that the traditional learning does not allow learners to choose what they want to learn on their own. Hence, while organizing the learning process with distance support, it is necessary to form a new type behavior, when learners can make their own choice. For this, learners should be questioned before every lesson and there should be some summing up at the end of the lesson (a sort of feedback) to record the increase (or its absence) in every learner's knowledge and skills after each lesson.

Purpose formulation can be replaced by learners' report about their expectations. These reports are important for the further work, even if the learners' expectations are quite different to what the teacher planned to achieve. They can be saved written on the blackboard or paper, or in the network course.

2. At the beginning of learning, when learners are not able yet to plan their activities and formulate their learning purposes, the teacher/tutor has to substantiate his/her choice of learning purposes. Learners who participate in the learning process with distance support should know why the particular learning purposes have been chosen. Hence, it is essential to formulate general academic purposes so that the participants could see their topicality and importance.

It should be noted here that for learners (training participants) it is important to know if the knowledge and skills they already have are taken into account. For this purpose, the first lessons involve some preliminary tasks, including learners' description of their work experience with the computer, software and Internet.

3. For distance support (like in training) it is important that students should realize how to achieve the chosen aims. So it is proper here to apply the required explanatory materials in a written or oral form to help learners get rid of fear and anxiety.

4. Distance support like training should have distinct division on the principle "beginning – middle – completion". Besides, the usage of the distance course involves activity algorithmization, i.e. a part of learners' actions are being repeated thought the course: checking e-mail, entering the course using a password and reviewing their marks and assignments for a lesson, etc.

It should be noted that the distance support unlike the classical distance learning, actually, does not allow students to choose time and pace of their work as it is restricted by lesson framework. But, as the assignments are given at the beginning of the lesson, learners can choose their performance tactic (in what order they should fulfill the tasks).

5. Though both the contents and the methods and techniques are equally important in a distance course. And the methods and techniques that have become classical (active on-line and off-line interaction) lose their effectiveness in distance support because of the presence of a real teacher directly. That's why the questions and problem aspects in learning are not mediated with written messages, but are substituted with direct contact. For a number of reasons (loss of time, limited access to the Internet at school, etc), it has not proved to be effective to use mailing lists for problem aspects to be discussed, as well as personal home e-mails.

However, the interactive services like Mail, Forum and Chat can be used if they are placed along with the theoretical materials of the course and linked with the user identification. And in our case, they were widely used. It should be noted here that the application of the interactive services which are actively used by learners outside school (chats, forums) may bring changes in the subordination "teacher – learner" in written communication



through these services. Similar change takes place in training and enables learners to be the trainer as their equal. Though, some negative tendencies are observed in distance learning [Rockenbach, B., Almagno, S., 2000], such as aggression, usage of swear words, flames etc. This requires a teacher/tutor to know how to protect himself/herself psychologically and to be able to identify users.

6. Applying a network distance course allows a teacher/tutor to store teaching information as well as practical information and examples, based on students' work. It is possible to correct and enlarge the course contents depending on the participants' aims and expectations.

The course provides a big quantity of didactic information for both categories of users (teachers and learners), such as glossaries and grammar references.

7. For Ukrainian language learning with distance support it is critical to develop a system of exercises involving speaking. Speaking activities are aimed not only at learning monological and dialogical speaking skills but they are a natural and effective way of experience exchange (and accordingly, of education and self-education).

The methodology of the course with distance support also involves elements of psychological training (included on purpose) to influence communicative processes, school anxiety and learners' lack of confidence. The researchers of foreign language distance teaching [Diomkin, V., Gulbinskaya, E., 2001] noted the disappearance of lack of students' confidence that, according to the authors, prevented learners from showing their abilities during the lessons. To achieve this some psychological exercises and tasks were performed at the lessons to teach students interaction, work in teams, ways to resolve conflicts and so on. Such elements of a practical rhetoric as report, presentations, self-presentation, speech deliveries, etc have been used.

Since psychological elements have been included into tasks, being carried out in the distance course frameworks, as well as into the training tasks, it was supposed that the formed skills (with individual preference in different environments) would be transferred, accordingly, to the virtual environment for one's learners and to the real life for other learners.

8. It is also necessary to develop a system of exercises to form a literately correct writing speech. Though, with the distance support, an interaction is mostly performed in writing, learners often use a hybrid of speaking and writing featuring simultaneously the elements of a public, dialogic and monologue speech [Voiskunskiy, A.E., 1991]. Their discourse is characterized by using shortened spoken forms, incorrect grammar constructions, chaotic dialogues, unnecessary emotions that hinder in understanding [Rozina, I.N., 2000].

9. The important and distinguishing feature of distance (as well as training) learning being an active process for the learner, not for the teacher/tutor, is being developed *with difficulties* at school lesson. The possible reasons for this are that learners do not possess enough psychological, personal, emotional, motivational and social readiness to use informational and communication technologies in their education and self-education.

Though, it is only fair to admit that teachers (who do not directly deal with informatics and programming) are not ready to use informational and communication technologies at their lesson either. Though it is the level of teachers' training that affects the quality of the lesson incorporating information and communication technology [Attwell, P., 2001]. The important thing is that using these technologies improves both teachers' and learners' work, the operational structure of their work; effects the motives of their activities, and greatly changes the system of participants' relationship [Mashbits, E.I., 1988].

10. The essential thing in learning with distance support is that learners should have **motivations to study** (they should be able to see life perspective, formulate their goals, and plan their time, necessary to perform tasks and other activities); they should be **ready emotionally to study** (self-regulation, composure); possess **personal readiness** (behavioral and learning reflection and self-reflection, ability to distinguish between the new and previous experience, presence of a researcher's attitude to the unknown, reflection and sensibility towards personal changes); learners should also have **informational competence** (moral fibre and lasting concentration of attention; ability to pick up the most important things from the message; to search, render and take notes on the information; to build the knowledge scheme on the studied language; critical thinking skills).

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## Conclusion

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According to the results of the performed work we have come to the conclusion that:

1. The realities of an existing education system do not allow, at present, the universal implementation and use of distance learning at school. As one of the directions of such implementation the distance support acts combining elements of traditional training with distance.

2. The distance support is one of the desirable forms of distance learning implementation in the secondary school educational process as it helps to keep a balance between the standardized school learning and tendency towards individualized learning; it also can eliminate faults of technical equipment (and also errors in its work) though presence of a real teacher in the classroom.
3. A well-organized distance learning of Ukrainian language may be effective enough if the psychological and pedagogical peculiarities of construction and organization of this form of education are observed.
4. Due to the factors of activity and interactivity the learning with distance support can give relief to the traditional learning process where the reproductive learning method prevails.
5. In the methodology of Ukrainian language learning with distance support, it is required to remember that the communication, both direct and indirect, i.e. through technical environment, between the teacher and the learner remained significant for development of learners' personalities rather than to be just a tool to receive the information on the subject.
6. It is necessary to develop such types of assignments within Ukrainian language learning that could be directed to a successful mastering the subject as well as to a development of learners' personalities.
7. To use the distance learning at school (and also its various variants of integration with traditional internal) it is expedient for profile education at the senior school. In this case the abilities of pupils, their interests in the given subject sphere and high motivation of educational activity, personal and emotional maturity will promote a learning efficiency.
8. The learning efficiency also can be increased for the account of subject focused and didactic competent development of the teaching materials including system of practical tasks, the test control, and also a number of the procedures, allowing to make educational process personally more significant for the pupil.

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## EXPLORING LINEAR FUNCTIONS – REPRESENTATIONAL RELATIONSHIP

**Manfred Bauch, Valentyna Pikalova**

*Abstract: Experiences from a German-Ukrainian project for the joint development of dynamic learning environments are reported. General methodological and technological aspects are discussed as well as special items arising from the cross-cultural collaboration.*

*Keywords: dynamic mathematics software, dynamic learning environments*

*ACM Classification Keywords: K.3.1 Computer Uses in Education – Computer-assisted instruction (CAI)*

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### Introduction

Dynamic learning environments are one way to foster an active learning process. Hence, in many countries research is done in order to develop dynamic learning environments. We report on our experiences from a German-Ukrainian cooperation on that topic.

Of course, the range of aspects in this context includes didactical and technological items. In our case, the underlying pedagogical models are a two-step problem-solving strategy and the concept I – You – We. Concerning the software, DG and GEONExT are under consideration.

When it comes to content, we have chosen the topic *linear functions*. It is a prominent topic involved in the curricula of both countries. Furthermore, it provides examples for a lot of interesting didactical issues.

Furthermore, however, the aim of cross-cultural deployment gives rise to special problems arising from different curricula and teaching traditions. In particular, the cross-cultural treatment sheds new light on the aspect of representational relationship.

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### ObDiMat

The considerations presented in this article arouse in the course of cooperation with Ukrainian and German partners.

In this joint project, the main objective is to develop dynamic learning environments that can be deployed both in Ukrainian as well as German schools. The larger framework was given by the network *ObDiMat* (formerly: *GEONExT Goes East*) that also includes further partners e.g. from Bulgaria and Czech Republic.

The work on this aim comprises both methodological research as well as the production of dynamic learning environment.

The experience in this joint work, in particular when heading for practical results, resulted in finding out four main strategies for the joint development of dynamic learning environments, which were described in detail in [Bauch et al., 2005]. Let us just give a brief survey here:

When a dynamic learning environment is given in one language a has to be transferred to another one, two alternatives to do so might be

1. Translate the original dynamic learning environment to the other language
2. Rewrite the given dynamic learning environment

The first alternative is the most straight-forward method. However, it may rather soon come to its limits due to reasons we will explain more detailed in a later section. If so, one cannot avoid the more costly way to rewrite the given dynamic learning environment. This is necessary for example when a change of the supporting software is desired or emphasis is shifted according to a different pedagogical model which is preferred.

When not an existing dynamic learning environment is considered but a new dynamic learning environment is to be developed, the two different methods that proved in our experience can briefly be described in keywords:

3. Set up an English master and then localize
4. Write the plot only and then realize in different versions

Again, these two alternatives differ in a similar way as above: Localizing an English version might bring along certain difficulties that require a more intensive rewriting. Such potential sticking points are tried to be foreseen and fixed in the proceeding number 4.

The discussion presented in the following refers to experiences coming along with joint work based on strategies 3 and 4.

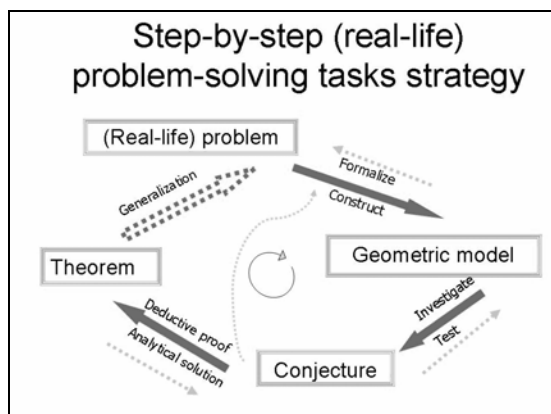
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### Dynamic Learning Environments

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To start with, let us introduce the pedagogical models and the technical basis of our project before we come to a discussion of the content.

The two pedagogical models, that are underlying our dynamic learning environments, are the ones preferred by the partners of this project. On the one hand, there is the concept of a *two-step problem solving strategy*. Its main features are evident from the following illustration:



The other pedagogical concept under consideration, called *I – you – we*, emphasizes the aspects of communication and collaboration. It features three main steps:

- *I* – individual work of the single student
- *You* – cooperation with a partner
- *We* – communication in the whole class.

Since these two models are concentrating on different dimensions of the learning process they are rather complimentary than conflicting. Thus, they can be combined with synergetic effects. This was outlined in [Bauch-Pikalova, 2003]. Similar advantage can be expected when other complimentary concepts are integrated.

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### DG and GEONExT

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As it was with the preferred pedagogical models, also on the level of technology the two partners had developed dynamic mathematics software on their own: DG and GEONExT. Besides the basic features that are common for any dynamic mathematics software, however, their concepts differ in some essential aspects.

The software DG is a stand-alone program for Microsoft Windows. With it, dynamic constructions for a wide range of topics in (analytic) geometry, algebra and analysis can be generated.

In contrast, GEONExT is a Java based software and available for a large variety of operating systems. It can be used as a stand-alone construction tool or be integrated as a Java applet into HTML pages. With a computer algebra system integrated, it is possible to benefit from the use of GEONExT when dealing with topics both from geometry and analysis.

These differences have substantial implications on the design of a dynamic learning environment as it will become obvious in the next section.

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### Dynamic Learning Environments

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Using GEONExT, it is rather easy – from a technological point of view – to provide material that enables the student to perform an active learning process.

The basis of such a dynamic learning environment is given by a sequence of HTML pages. Hence, we are free to integrate text, graphics and, in particular, dynamic constructions as a Java applet. In this way, the student's active learning by discovery is fostered.

Obviously, on the student's side the technical requirements are few (some browser with Java enabled), whereas the possibilities on the side of the developer build up a huge spectrum. Depending on the technology used, the simple presentation of a dynamic construction can be upgraded by mouse-over effects, pop-up windows to provide hints and solutions as well as interaction between text and applet.

All this potential, on the other hand, requires a careful analysis and selection in order to obtain a solution that effectively supports and realizes didactical objectives.

Though our further discussion will be based on the technical realisation of a learning environment as it was just described, let us have a look at alternatives. To be more precise: How do learning environments look like when they are realized with DG? Here, the main difference is that texts, even longer ones, can directly be written into the drawing area of the construction. Also buttons can be added into the drawing area in order to create a sequence of interactive drawings connected by hyperlinks. This obviously affects the design of a dynamic learning environment. For a discussion of such aspects we refer the reader to [Pikalova-Bauch, 2005].

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## Observations

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We now come to some crucial observations that were made when preparing the basis for the joint development of dynamic learning environments. Two prominent aspects are the following.

The curricula in the two countries differ notably. As a striking example, let us mention the following aspect: Trigonometric functions like sine and cosine are introduced in Ukrainian schools at a much earlier time than in Germany. Hence, for example, the standard proofs for the *Theorem of Pythagoras* are quite different: In Ukraine, the use of cosine plays a substantial role, whereas in Germany methods from elementary geometry are used.

Secondly, we are facing different teaching traditions in the two countries. As an effect, speaking about a theorem given a certain name can mean to deal with completely different situations. As an example, consider the so called *Theorem of Thales*. In Germany, it says: A triangle that has the diameter of a circle as one side and the third point lying on that circle always is rectangular. Opposite to this, Ukrainian students will immediately think of projective geometry when hearing the name Thales.

Closely related to these two aspects, difficulties may arise when trying to translate the index of a school book, e.g. [Pogorelov, 2004], a list of keywords from lessons or a catalogue of basic knowledge. When doing so, we found several German words which seem not to have a common equivalent in Russian school mathematics. Examples that caused such problems in translation were e.g. *Symmetrie* (= symmetry) and *Drehung* (= rotation). They can be found in German textbooks at rather prominent places. When translating plain text, you may use explanations as a substitute. However, what to do when the concept connected to such a keyword is a substantial component of a dynamic learning environment?

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## Cross-Cultural Aspects of the Topic *Linear Functions*

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Having all these prerequisites in mind, here is a list of some aspects from the topic *linear functions* that we have selected for a dynamic learning environment:

1. lines in the plane
2. description of a line; the notion of the slope
3. different types of equations
4. system of linear equations

In this list, we have deliberately chosen formulations that can be agreed by both German and Ukrainian teachers. When going through this list, again both will surely think about aspects that are worth a discussion, e.g. to what extent geometrical aspects of the topic should be treated explicitly? Since this is related to the aspect of representational relationship, we will discuss it in the next section.

But there are also differences that can be traced back to teaching traditions when it comes to notation. In German schools, it is common to denote the equation of a linear function by  $y=mx+t$ , whereas Ukrainian students are used to write  $y=kx+b$  for the same.

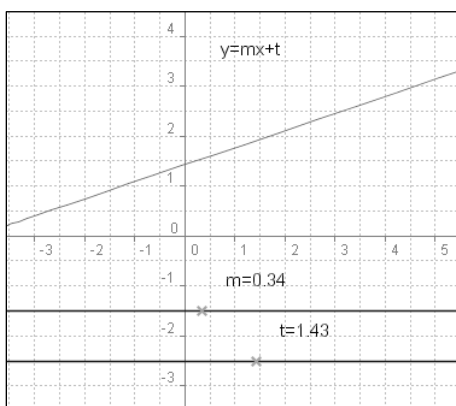
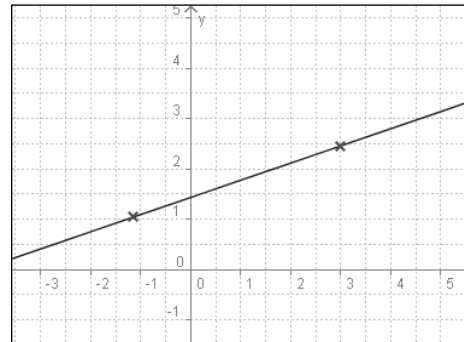
## Representational relationship

During our work on a dynamical learning environment for the topic linear functions, new impulses were given to considerations related to another important concept: representational relationship.

Spoken roughly, every description or depiction of a mathematical object or situation is a model of a concept lying behind.

Of course, this concept and its implications always play an important role in context with the design of a learning unit, no matter which medium it is meant for. However, the dynamic mathematics software delivers striking examples for the relevance of this concept:

Consider a dynamic construction that displays the plane together with a coordinate system and in it a freely movable line, given by two points (see illustration).



This line can be considered as a model for different concepts, e.g.

1. analysis: graph of a linear function
2. analytic geometry: line in a plane

Depending on the detailed design of the construction, the aspect emphasized or the possible interpretation may change. Let us look at some examples:

If it is possible to move the line in a position parallel to the y-axis, the interpretation as the graph of a linear function is excluded.

See the other way round: If the interpretation as the graph of a linear function is intended it might be useful to design the dynamic learning environment in a different way. One possibility might be to

vary the parameters of the linear function (see illustration).

In our project to jointly develop a dynamic learning environment for the topic linear functions, we rather naturally came across aspects closely related to the concept of representational relationship.

As an example, consider the notion *slope of a line*. In this respect, German curricula stress the *slope triangle*, whereas in Ukrainian education the basic notion is the *slope angle*. Seemingly just a small difference, it has further implications on the conceptual level: In the line equation  $y=ax$ , the coefficient  $a$  is interpreted in one case as the ratio of two lengths (given by the legs of the slope triangle), in the other case it is the tangent of the slope angle. The reader can easily work out further implications, e.g. which further topics in mathematics education are connected to the one approach or the other.

## Conclusion

In this article, we reported on a Ukrainian - German project dealing with the development of dynamic learning environments both on the level of methodological research as well as practical implementation.

Generally speaking, many aspects occurred as they do always in the context of dynamic learning environments. In particular, it proved that this field is a very sensitive one and offers both chances and risks. Chances e.g. in the sense that the integration of a new tool respectively a new medium offers the chance for new approaches in mathematics education and for the support of concepts like active learning and learning by discovery.

It is also accepted that the development and deployment of dynamic learning environments is not for free. In particular a short-term balance will show considerable initial outlays. However, and this has always to be taken into consideration, these expenditures will pay off in the long run. In particular, the long-term effects due to active learning and a deeper understanding supported by dynamic mathematics software recompenses the efforts.

This proves in our joint project. Of course, one hope of joint development is that it will pay off by the large number of potential users. More important, however, the cross-cultural cooperation rewards rather immediately with interesting new insights on several aspects and – on the long run – with the potential of a broader understanding

of mathematical topics due to a larger spectrum of approaches that are included and presented by a qualified didactical treatment of the subject.

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# METHODOLOGY FOR TRAINING TEACHERS IN BASIC AND SPECIFIC COMPUTER SKILLS

**Arsenia Grigороva, Desislava Dimkova, Monka Koceva, Milena Staneva,  
Boyanka Stefanova, Maria Shishkova**

*Abstract:* This article describes methodology for training teachers in Maths, Physics, Astronomy and Professional subjects in basic and specific computer skills.

*Keywords:* teachers, IT education for teachers, methodology for training, curriculums, education process, online tests

*ACM Classification Keywords:* K.3.0 Computers and Education - General

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## Introduction

The high school pupils have new requirements towards teaching style and methods. This fact requires that besides the teachers in Computer Science those teaching other subjects should be also IT competent and manage computer aided teaching. ITs are a modern tool for visualization of the taught material that makes the introduction of the curriculum much easier, more interesting, modern and comprehensible. On the other hand, ITs allow exploiting Bulgarian and world information sources as well as the contemporary communication devices in the teaching process.

The methodology offered has been developed by a team from Institute of Mathematics and Informatics under a contract with the Bulgarian Ministry of Education and Science.

Aim of the Project is to provide a methodology and training 250 instructors supposed to supervise training in basic and specific computer skills for

- teachers in Maths, Physics and Astronomy and
- teachers in professional subjects (mechanics, electronics, economics, engineering, etc.).

## Curriculum

The team has prepared 40 lesson curriculums for the training courses to be supervised by the instructors. The methodology is based on the previously prepared curriculums.

The choice of the topics and programs (software) aims at informing teachers non-specialists in computer science of the basic IT principles; training teachers in the basic computer skills; training teachers in the basic principles of processing of various types of information; providing a new up-to-date tool which will help the teachers in the tuition process .

Each of curriculums comprises three modules: Introduction; Basic and Specific.

The ratio of the material in the modules is 2:4:4.

Dividing program in modules allows two courses to be organized depending on the level of the teachers:

- Beginners including the three modules;
- False beginners skipping the Introduction.

The duration of the above mentioned courses could vary and entrance level of teachers could be unequal also, but the output level of teachers should be on approximately the same at the end of the course. The teachers achieved more than 60% of the entrance test requirements will be trained in the false beginner's course.

At the end of the course the skills acquired are evaluated by a complex practice test and developing of certain Unit (connected with the subject teachers teach in their school), using the modern information and communication technologies.

The following tables show the unit contents in each module. The material foreseen in the curriculums differs mainly in the specific module. Specific module for teachers in Maths, Physics and Astronomy includes unit for notion and skills for writing mathematical and physical formulae and embedding them in a document, but specific module for teachers in Professional subjects includes unit for notion and skills for data analysis, statistical processing and chart creating.

Each unit is supplied with methodology manual, reference materials and tests and exercises.

Table 1

### Introduction module

UNITS	CLASSES
Information, basic informational activities, informational processes; security, authenticity, actuality; ethical principles of using information. Computer – introduction architecture: memory, CPU, periphery; software – system and application programs.	4
Windows operational system: windows, menus, information structure (directory and file); Windows Explorer; MS Office applications.	
Introduction in word processing – basic activities: entering, storing, editing, formatting, printing. MS Word: creating, rudimentary editing and storing of a text document.	4
MS Word: opening, closing of a document, selection and editing of a text in a document.	

Table 2

### Basic module

UNITS	CLASSES
MS Word: Notion for style and hard formatting, formatting of symbols, page formatting, using templates, headers and footers.	4
MS Word: paragraph formatting, numerating and bulleting, frames and background.	



MS Word tables and graphical objects	4
MS Excel tables and graphics.	
MS PowerPoint: Creating and demonstrating presentations, using templates.	4
MS PowerPoint: Using appropriate auxiliary means for presenting information from different application programs – sharing information between programs from MS Office packet. Printing documents created via MS Office.	
LAN and WAN.	4
Internet: Information searching and storing.	
Internet: Using E-mail; participating in Internet based discussion forums.	

Table 3

### Specific module for teachers in Math and Physics and Astronomy

UNITS	CLASSES
Writing mathematical and physical formulae and embedding them in a document.	4
Skills connected with writing complex mathematical and physical formulae.	
Using MS Word Drawing - diagrams, schemes, elementary drawings etc.	4
Skills for creating complex graphical images using MS Word and embedding them into a text documents and presentation materials.	
Creating and working with graphical images of geometrical drawing using specialized software.	4
Skills for creating complex graphical images using specialized software and embedding them into text documents and presentational materials.	
Creating an integrated document	4
Summarizing discussion	

Table 4

### Specific module for teachers in Professional subjects

UNITS	CLASSES
Data analysis and statistical processing	4
Skills for statistical processing and chart creating	
Using MS Word Drawing - diagrams, schemes, elementary drawings etc.	4
Skills for creating complex graphical images using MS Word and embedding them into a text documents and presentation materials.	
Creating and working with graphical images of geometrical drawing using specialized software.	4
Skills for creating complex graphical images using specialized software and embedding them into text documents and presentational materials.	
Creating an integrated document	4
Summarizing discussion	

### Methodology Manual

Methodology Manual aims at assisting the instructors in tutoring the material to teachers who are not specialists in Computer Science. The manual for each group of teachers includes 10 units. Each unit is covered within 4 lessons. During their course the instructor has to present the new material, demonstrate the operations, supervise

exercises on the computers and check the skills acquired. The suggested scheme of time division is 2 lessons for a lecture with demonstrations and 2 lessons practicing.

It is advisory to check the skills acquisition twice: at the end of the unit having gone over the new material and practiced the operations, and at the beginning of the next lesson performing a more thorough check of the acquired skills via execution of particular practical tasks. Following distribution of the material in a unit is suggested (table 5).

Table 5

Distribution of the material in a Unit

Discussion and check of the skills acquired in the previous Unit	20-30 min
Introducing new material with illustrations	45-60 min
Exercises on the computer – solving problems	45-70 min
Discussion and check on the newly acquired basic notions and skills	10-20 min

The time division of the units is based on a long experience gained while teaching courses to different learners. However, this time division is provisional. It may turn out that a certain group of learners does not need so much time to master a unit while another one is much slower in their progress. This is quite probable to happen in the groups of false beginners whose level can never be the same.

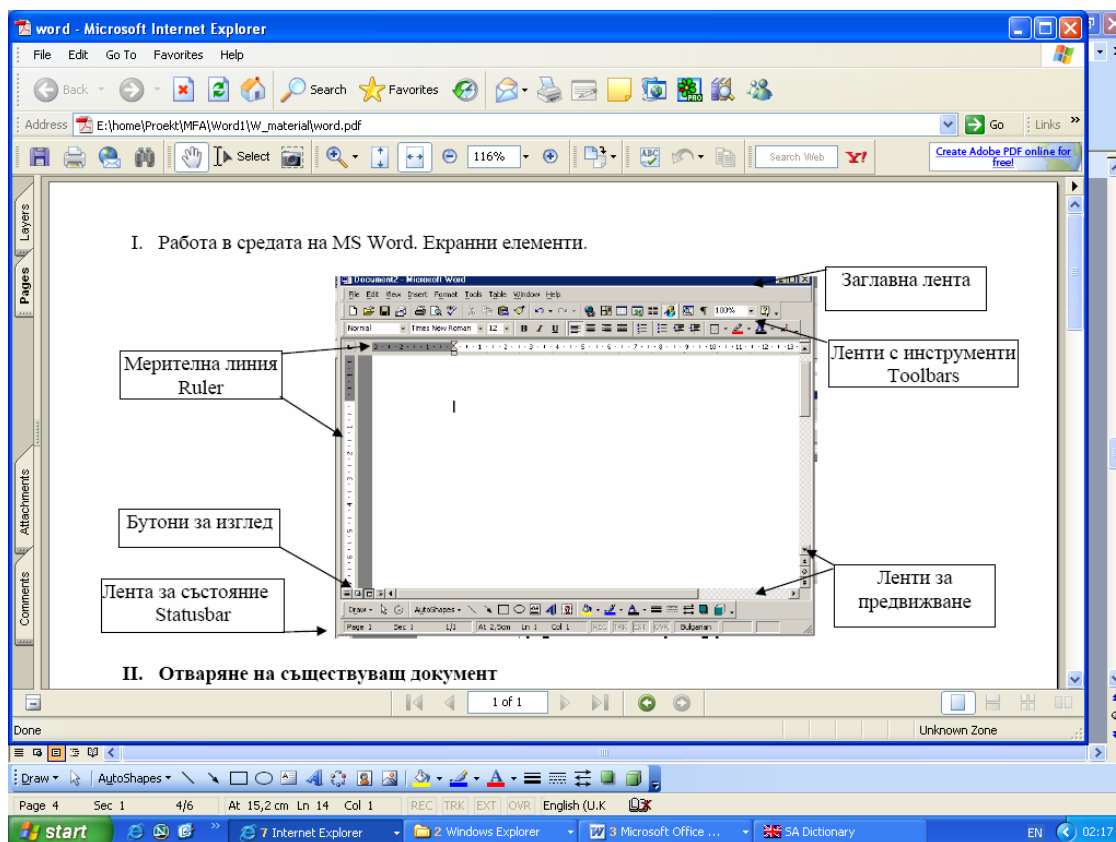


Fig.1. Part of illustrated material: main window of Word program could be seen as well as explanatory comments.

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Every unit in manual has the following structure:

- *Aims* – describes unit aims.
- *Expected results* – includes list of knowledge and skills, which teachers have to acquire at the end of each unit.
- *Educational material* (with comments and emphasis on the important specifics – see fig.1) – This section includes description of the new basic notions and terms and description of basic skills in the unit. Instructors are advised how to introduce the new notions, terms and skills.
- *Example problem* – one or two example problems with detailed instruction for solving them. Problems are selected thematically according to main subject of the teacher.

### Tests and exercises

The team developed for each unit:

- *Online check of the notion and terms* – includes 10 questions for estimating the theoretical knowledge at the end of the unit. After question answering, trainees could check their results immediately. For example:

**5) 1024 KB are equal to**

a) 1 MB

b) 1 B

c) 1 GB

- *Self-teaching test (homework)* – problem for solving at home. Non detailed instructions are offered. The aim of *Self-teaching test (homework)* is to exercise the material and self-checking acquired skills in the unit.
- *Practice test* – problem for checking the skills acquisition at the beginning of the next lesson.

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### Conclusion

The developed program and accompanying methodology have already been applied. The team trained instructors. Each instructor received CD with all materials. They were obliged to train four groups of teachers from Bulgaria in basic and specific computer skills.

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## E-LEARNING

**Khaled Batiha, Safwan Al Salaimeh**

***Abstract:** E-learning means learning via electronic means and is therefore an all-embracing term covering learning via an electronic device. The "expectations" and "realities" for each of the delivery mechanisms within the electronic arena vary greatly for not just the learners themselves, but also the site providers. Because of this, each of these learning systems has vastly different design principles, which is not always understood by those unfamiliar with technology. What is appropriate for a CD-ROM off-line system is generally inappropriate for an on-line internet system. So when designing an e-learning system it is important to understand how the information is to be accessed by the learner. This paper will identify and suggest some ways to avoid e-learning's pitfalls and reap its rewards.*

***Keywords:** e-learning's, organization, computer literacy, evaluation, learning module.*

***ACM Classification Keywords:** C. Computer systems organization, C.2 Computer communication networks, K.3.2 Learning*

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### Introduction

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When the projected surge in technology-driven training hits your organization, you could face difficult questions (Broadbent 2002):

- Is your organization-public, private, or not-for-profit-ready to benefit from new e-learning approaches?
  - Are you personally ready to be a pioneer who develops, uses, or manages e-learning?
  - What can you-as an instructor, instructional designer, manager, or learner-does to reap the advantages of e-learning innovations?
  - Are you ready to help open the new frontier?
  - When your organization is faced with a decision about whether to use e-learning, how will it decide?
  - What drives decisions like these? Perhaps an influential decision maker read the latest article or advertisement in a management or training publication and convinced top brass that all learning materials should be converted to e-learning immediately, if not sooner.
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### E- learning – Challenges

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As e-learning evolves, challenges ranging from lack of equipment or computer literacy to deep-seated organizational resistance are being faced and resolved. However, there will always be new challenges. To meet them, learners, instructors, developers, and managers need the following characteristics (Broadbent 2002):

- A realistic understanding of the strengths and weaknesses of e-learning
  - Complete dedication to transform e-learning function successfully
  - Creativity, flexibility and the diligence required to adapt e-learning to the specific needs of individuals and organizations
  - The conviction to say no when they think e-learning is not the right solution to a business performance issue
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### The Ability for Self-paced Learning and Revision

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Another design principle of asynchronous, online learning is to provide the capability to complete the module in a number of sessions. Some e-learning courses assume that if the motivation is there to purchase, then the motivation is there to complete the module in one session. This is not a good way to approach the design, as determining the time that a user has available at any given moment and the speed at which they will read and take to progress through the module is impossible to determine. And there is the problem of heavy usage that

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certain Internet service providers may experience at critical times, which will impact on the learner and increase their level of frustration. In these situations the capability to log off and revisit at a later time is important (Morrison 2003).

Users should be allowed to undertake an unlimited number of sessions and the server should return them to the last point of exit when they log in again. A further step that can be taken is to encourage learners to take the opportunity to revise the content, self-assessments, and feedback profiles by securely storing their information for 12 months after they complete the modules (Morrison 2003).

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### **Self-evaluations: Can Learners Evaluate Their Knowledge?**

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This is a somewhat controversial topic on the internet. Firstly, when delivering any kind of feedback instrument on personal preferences, work requirements, or other individual factors, there is an ethical obligation to ensure that the learner/user understands the content/theory behind what is being delivered and the appropriate interpretation that can be made from this. The ethical guidelines in which personal feedback is given should not be forgotten just because the medium has changed from face-to-face to electronic (Morrison 2003). In asynchronous learning, evaluations are one way of ensuring that a certain degree of understanding has been achieved and trainer contact should be made available for learners who require additional help with content.

Secondly, self-evaluations are important when the module is used as pre-work for a more comprehensive course involving face-to-face interaction with other learners and a facilitator. In this situation, there must be a checkpoint by which facilitators can determine if the e-module has been completed, and whether the learner has understood the content (Morrison 2003). While people can have the best intentions in the world to complete pre-course work, it is certainly not unusual for some to attend a conference or workshop without having fully completed the pre-work, even though they often indicate they have. For this reason it is important for the module to have evaluation sections at appropriate points so that learners can check their progress

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### **Workplace Examples**

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Applications of feedback instruments and HR training tools can often be difficult for some to visualize. This is important to overcome as the follow-on or actual usage of the feedback is where the learner is likely to get the most value (Morrison 2003).

Expecting e-learning to cover all aspects of a training workshop is a fatal mistake. While some products that are specifically skills based can replace the classroom, HRD is not so cut and dry. In many cases, the discussion and applications that follow the feedback and self-appraisals hold an equal portion of value to the self-understanding that is achieved by asynchronous learning (Morrison 2003).

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### **Conclusion**

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Learning design has always been difficult. Combining it with the limitations of the electronic medium has been a real challenge. The asynchronous nature of the interaction between "teacher" and "pupil" means that the learning module must be designed to cater for a wide range of learning styles. Users shouldn't be left with "self-marinating hype" but should be given an option for ongoing learning and improvement, the ability to review and revisit the module, and to have as many workplace applications as possible to provide examples of how to put this into action in real life.

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## MOBILE COMMUNICATION TECHNOLOGY AS A TOOL OF EDUCATIONAL PROCESS

**Victor Bondarenko**

*Abstract:* The article describes the application of mobile communication technology for enhancing of educational process.

*Keywords:* Mobile phones, education.

*ACM Classification Keywords:* H.4.3. Communications Applications

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### Introduction

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Technologies of mobile communication fast develop and distribute in modern society. Some books are printed which are devoted to development of applications for mobile phones [Pirumjan, 2003], [Gornakov, 2005]. But the problem of mobile communication using in educational process is investigated poorly. Wide distribution of mobile phones and distance education technology (e-Learning) in modern society makes necessary such investigation.

This fact makes very actual research in the field of using of mobile communication tools in educational process. Therefore, this article is devoted to a research of this problem.

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### Mobile Phones and Educational Process

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The use of mobile phones in educational process is based on such possibilities of mobile phones and services of mobile communication operators:

1. The Mobile GPRS-Internet allows to work in the Internet with the help of mobile phone, which is connected to the computer. A student enables to work with the Internet from any place without the urban phone line and to use materials on the Computer Science, which were saved on the educational portal [educator.narod.ru](http://educator.narod.ru), and also materials on the Electrical and Electronics Engineering, which were put on the portal [victorbondarenko.euro.ru](http://victorbondarenko.euro.ru).
2. SMS-messages allow the instructor to send the necessary text messages on the student's mobile phone.
3. MMS-messages allow the instructor to transmit fragments of multimedia manuals, which have the text, sound, animation on the student's mobile phone and E-mail.
4. The WAP allows to look through the WAP-sites directly on display of the mobile phone. WAP-sites can contain the useful educational information - multimedia courses, tests, tasks, which can be loaded on the student's mobile phone. Besides, WAP-sites give the access to the E-mail, which allows students to send letters to the instructor. These letters can have advisory character or they can contain the executed tasks. The access to WAP-sites is possible with the help of the GPRS service.
5. The conferencing (Multiparty call) permits to connect to talk 5 interlocutors simultaneously. This possibility allows the instructor to conduct of educational and scientific discussion. Using conferencing it is possible to ring up one more interlocutors, not interrupting current talk, and to connect him to talk, to accept a source call and to connect the new interlocutor to conversation. It is possible temporarily to interrupt talk to all interlocutors, except for one, to come back to talk to the students waiting on a line. The instructor has possibility to disconnect one from the interlocutors, not interrupting talk to the remaining interlocutors. It is possible to finish talk to all interlocutors.

The support of the considered possibilities of mobile communication technology in educational process is executed with the help of such instructor's software:

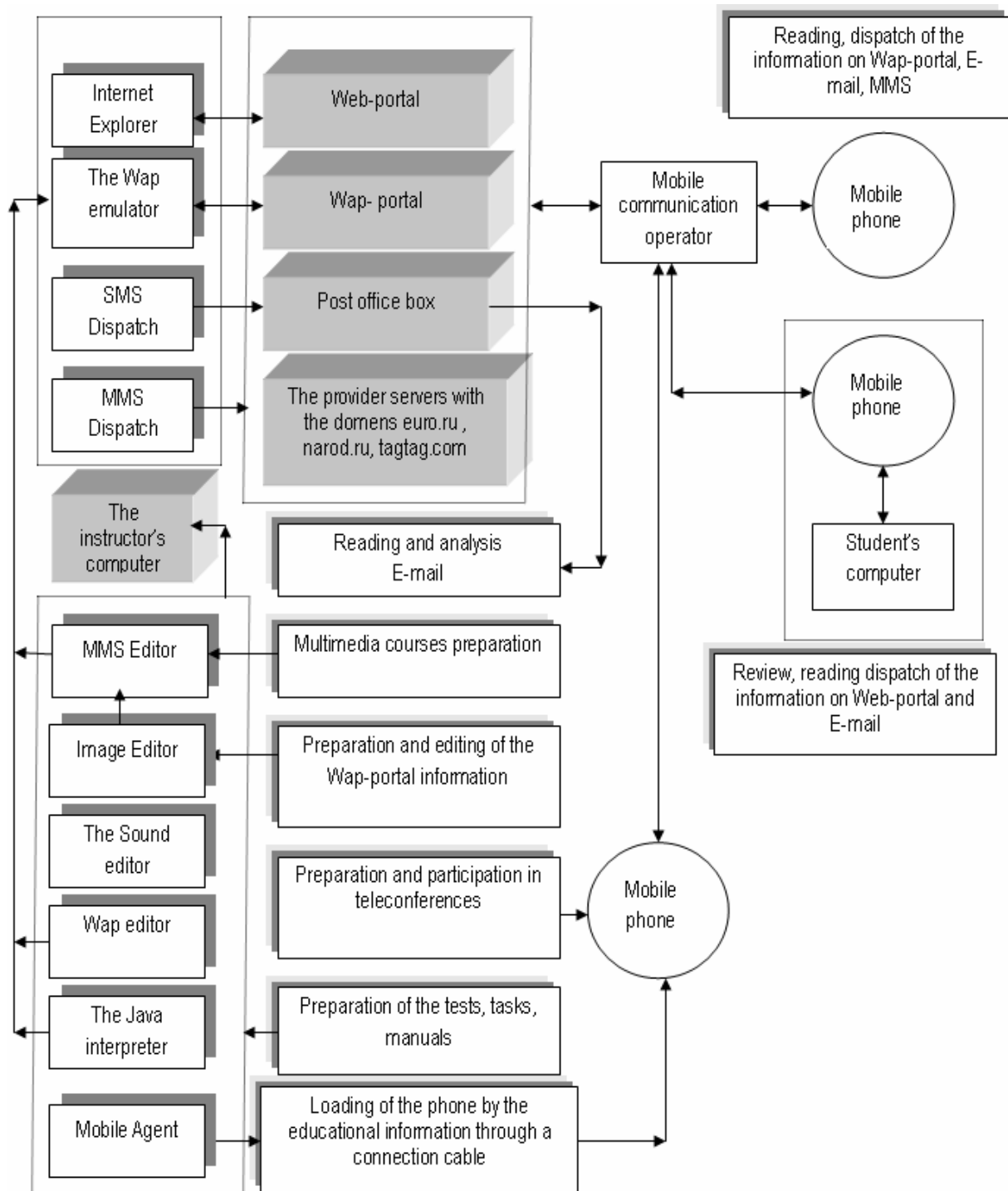


Fig. 1. The application of mobile communication technology to educational process.

1. The Web-browser (Internet Explorer) is used for review and the editing educational portals, where are contained materials that support the teaching of Computer Science courses ( [educator.narod.ru](http://educator.narod.ru) ) and also materials that support the teaching of Electrical Engineering and Electronics ([victorbondarenko.euro.ru](http://victorbondarenko.euro.ru)).
2. The Wap-browser (Klondike Wap Browser Personal Edition) is necessary for review and editing of the Wap-site ( [tagtag.com/educator](http://tagtag.com/educator) ) with educational materials.

3. The Mobile Agent system allows to write on the mobile phone with the help of a cable the educational information (lections, tasks) which is prepared on computer.
4. The SMS-messages dispatch system allows to send messages from the instructor's computer on the student's mobile phone.
5. The MMS-messages dispatch system sends MMS-messages from the instructor's computer on mobile phones of the students.
6. The MobileBASIC system 2.1, allows to build the tests, educational programs and other applications as JAR and JAD files, which can be executed on the mobile phone under the control of the Java-interpreter.
7. The MMS Home Studio system 1.1. 379 allows to form multimedia applications using the editor of figures the Sony Ericsson Image Editor 2.1. and also editor of a sound the Sonic Foundry Sound Forge 6.0.

Using the mobile phone possibilities which were considered, we will present mobile communication technology as a tool of educational process. The scheme of such technology is shown in fig.1.

The instructor prepares and places an educational material, which is necessary for learning, (tasks, lectures, multimedia courses, tests) on Web-portals educator.narod.ru, and victorbondarenko.euro.ru for using in the Internet. Simultaneously same information with changes oriented for using on the mobile phone, with the help of the editors is recorded on the Wap-portal.

The student reads out the necessary information from the Wap-portal on the mobile phone, executes the task and results of the executed work sends with the help of e-mail to the instructor, using for dispatch the mobile phone or the Internet.

In case of necessary consultation, the student can use such possibilities of the mobile phone: voice communication, E-mail and also SMS-messages. The SMS-message is used frequently also by the instructor, which can make in group the necessary announcements or appointments.

The instructor can use the conferencing for a difficult materials discussion.

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## Conclusion

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This mobile communication technology is introduced in educational process at the Financial Faculty of Kiev National Economic University. The technology can be introduced in educational process of all forms of learning, but this technique is most effective for preparation of students of the correspondence and remote forms of learning.

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## DEVELOPING A MOBILE DISTANCE LEARNING SYSTEM

**Petr Rogov, Nikolay Borisov**

*Abstract:* This article considers the basic problems of client-server electronic learning systems based on mobile platforms. Such questions as relational learning course model and student's transitions prediction through the learning course items are considered. Besides, technical questions of electronic learning system "E-Learning Suite" realization and questions of developing portable applications using .NET Framework are discussed.

*ACM Classification Keywords:* K.3.1 Computers and education: Computer Uses in Education – Distance learning

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### Introduction

Wireless connection is increasingly used all over the world especially in the field of business. Users with wireless access to information can work faster and more effectively than their colleagues dealing with cable networks. The keen interest in wireless data transfer technologies is stipulated for extensive application of mobile devices.

Wide spread of portable computing and its penetrating to various fields of human activities make developers think about use of new mobile platforms. It is obvious that mobile market development exerts great influence on the software based on client-server technology. In such cases, porting the client part of an application to the mobile platform becomes the aim to be achieved.

This tendency has also touched the field of electronic learning. As a rule, the e-learning software is based on client-server technologies. Thus, using the portable computer connected to the wireless data transfer environment the user receives an opportunity of planning the educational process. The term *distance learning* means the client's remoteness from the learning content server. Therefore, software developers should provide the student with access to e-learning server irrespective of his current geographical position.

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### Developing a Mobile Electronic Learning System

One of the most complicated problems of wireless networks is the absence of stable, guaranteed connection with a network server. Moving from one access point to another the client periodically becomes disconnected from a network. Thus, the e-learning software developer faces two problems:

1. The client-server system based on client's hardwired connection to server cannot normally function in the wireless environment;
2. The program module working on the client side should provide access to a learning content even if connection to the server is not temporary available.

Whereas the first task is only technical and the solution consists in the choice of a proper data transfer protocol and a way of connecting to the server, the second is rather complicated problem, both technically and algorithmically. We shall consider this problem in more detail.

Let us assume that to move from one access point to another student spends time not exceeding 2 hours. For this time, the typical student can study 1-2 lessons with the average information density. We also know that during studying this material the student can face questions, which were discussed in the previous lessons and return to them to restudy. Thus, to provide a full access to the learning content in conditions of no connection to the server the client application should predict sequence of student's transitions to the following lessons as well as probable jumps to the previous lessons. After the forecast is made the program should download the content of all these lessons from the server and keep it in a local storage. Since that moment the part of the learning course will be locally accessible, the user can easily continue studying in conditions of no connection to the server.

The electronic distance learning system E-Learning Suite (<http://www.elsuite.net>) is developed for solution of problems in question. Client to server connection is carried out using the HTTPS protocol, which provides a high degree of security of the data to be transmitted, and does not demand a permanent connection to the server. The prediction of the student's transitions from one lesson to another and the necessary data caching are carried out due to relational model of the learning course.

Conditionally, the student's process of study can be presented as a cyclic alternation of two stages: study of a theoretical material and test tasks fulfillment. Thus, we can divide all the learning course items into two groups: lessons and tests. Study units can be arranged in any order and quantity. Then it is necessary to construct a learning course model in which all the items will be connected in a single system. Such connections are sure to be the relations between lessons and tests. Relations can be also divided into two groups: relations between items of the same type and relations between different items. Thus, the electronic learning course can be presented as a complex relational data structure in which the items are located linearly, but the access to them and transition sequence is entirely defined by the established relations. In the context of such relational structure each item can be considered as separate object of the learning course. Hence, the learning course model becomes not only relational but also objective. Each course item possesses a set of properties. Their values are assigned by the relations connecting this item to others. For example, one of the main properties of the lesson is the ability to study it (i.e. whether a student has an opportunity to study the specified lesson now). In a classical sequential learning process model the study of the next lesson is allowed only if all the previous lessons are have been learnt. In the relational model it is not a prerequisite and can be set by the learning course author under his discretion.

One of the most important tasks during the automated learning is the tracking of the student's transitions within the set of the learning course items. For example, in the case of failure to pass a test it is advisable to restudy the appropriate material. In order to understand the restudy mechanism and links between learning course items it is required to describe structures of the lesson and test taken separately.

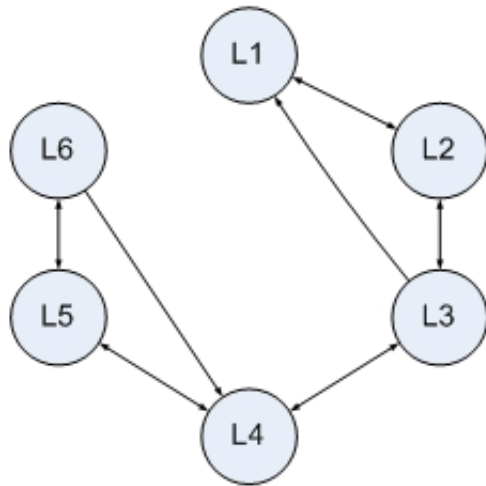
Each lesson in a learning course represents a set of separate topics combined by one common notion. Topics of the lesson constitute a logically completed consideration of any aspect of this concept. Thus, topics can form a complex hierarchical structure, i.e. each topic can include an unlimited quantity of subtopics. Number of topics in a lesson is not limited. Tests represent the sets of questions on various notions. Thus, each notion has its own questions set, the number of questions being unlimited. A teacher defines number of questions on each notion, included in a test. Therefore, the result of the test is not only a general mark, but also a differentiated score on each notion. During the study process this information can be used both for planning the further learning and for revising the material. For example, the test contains questions on three notions. By results of the test the student has perfectly studied two of them and has not studied the third. In that case there is no need to make the student learn anew the material studied, but it is quite enough to force him to revise the material he fails to master.

In the suggested learning course model transition sequence through the items, the restudy mechanism and links between items are realized simply enough. As it was mentioned above, each course item (including individual topics in the lesson) is an object with a set of properties. The most important lesson properties are flags, defining inclusion of the given lesson in the parent item and ability of transition to this item. Values of these flags are calculated as conjunction of elementary conditions. The developer of the learning course sets these conditions and their number is not limited. Such conditions can be, for example, the result of the specified test or the studying status of the lesson in question. The set of conditions that can be used to construct such expressions depends on specific system implementation.

Use of such links between course items allows speaking about the adaptive learning system. Such a system allows dynamic learning course generation according to the user's knowledge level. Being informed of the user's knowledge level on each notion the system can determine whether to include or exclude some topics (or lessons) of the learning course. The described behavior completely is adjusted by the course developer and weakly depends on specific system implementation.

The learning course model under consideration allows to predict student's transitions between the items because

this sequence is strictly set by the course developer. In addition, there is an ability to predict backward transitions sequence because it is possible to analyze existing links to the previous items for each topic and lesson. Therefore, the suggested learning course model allows to predict user's behavior with the fine precision and to cache the required data.



**Figure 1 – Learning course model**

Figure 1 schematically represents a learning course model. Arrows show transition ability between lessons. One can see that the student cannot proceed from lesson 1 (L1) to lesson 3 (L3) without studying lesson 2 (L2). However, having reached lesson 3 (L3), the student can return to lesson 1 (L1) for material revision.

One more problem connected with absence of the fixed connection to the server is learning statistics accumulation. If the connection is available, this information is collected in real time on the system's server. But if connection is not available, local saving of this information is necessary. Then, with the advent of the server-based connection, it is transferred to the central storage. In that case, danger of transmitted data falsification arises, so, the information stored in the local files has to be encrypted. The encryption algorithm with

the open key is expected to provide a high security level.

Working with the described relational learning course model, the transition prediction algorithm comes to analysis of the links between lessons and tests. Caching of the information consists in downloading the necessary lessons from the server and saving them on a local device. Considering Figure 1 let the student study lesson 4 (L4) at the moment of loss the connection to the server. In that case, according to a course structure, lesson 5 (L5) is the next to study. Hence, it should be cached first. Lesson 4 (L4) is also double linked with lesson 3 that means the student can return to lesson 3 for material revision. The next step will be the loading of lessons of the second and the following levels, counting from the current one. That is lesson 6 (L6) and 2. Lesson 1 should be the last to cache. It is necessary to note that the caching of the following lessons has the greater priority than the caching of the previous ones as the majority of students will go to the next lesson rather than to previous one.

Considering the question of development of a software system for portable computers we should not forget about the limited capabilities of the given class devices. The majority of pocket computers have limited operating and long-term memory. Low-speed data transfer channels are commonly used in wireless networks. All these limitations impose restrictions on a client part of the system.

Here it is possible to point out two basic problems: network traffic minimization and data caching optimization. Data caching optimization means disk space usage minimization. Traffic minimization is achieved by compressing the data transmitted through the network. Cached data is also stored in the packed form and unpacked only when required. Automated data caching is preferably for more powerful computers working in networks with unlimited traffic. If device features are strongly limited or the network traffic is chargeable (for example, working on the Internet) then data caching process should be supervised and adjusted manually. The adjustable parameters are:

- disk space quota used for the data cache;
- the maximum size of data downloading from the server in one session (or in the specified time interval);
- data packing method;
- manual choice of the learning course items which should be stored locally.

To increase client application usability the data caching process can be automatic, semi-automatic or manual. In an automatic mode the application independently, in a background thread, downloads all the necessary

information from a server and stores it on a local device. In a semi-automatic mode the application performs caching automatically, but does not break the limits on disk space and the network traffic. In a manual mode the application offers the user only the list of learning course items which should be downloaded. In this case, the decision on loading and storing is made by the user.

It is necessary to specify which existing mobile platforms are available as we consider a mobile application suite development. First of all, various solutions of Microsoft Company in the field of mobile devices: Windows CE, Windows Mobile and PocketPC, supporting .NET Compact Framework. The Microsoft .NET Framework has been chosen as a programming platform being one of the most modern tool for mobile development.

The opportunity to use third-party libraries similar to .NET Framework is considered for system portability maintenance not only between various systems of Windows family, but also Linux, etc. The Mono Project ([www.mono-project.com](http://www.mono-project.com)) is an example of such library.

Application suite architecture is also promoting portable system development. The system logic is concentrated in separate independent modules and the graphic user interface only displays the data being processed. Thus, it reduces the work necessary to port the application to a new platform.

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## Conclusion

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A large number of works all over the world is devoted to automated learning and knowledge control systems development. Nowadays this question is becoming more urgent because of wide spread of computer networks and mobile devices.

The automated electronic learning system users can be university students who, in addition to existing forms of correspondent learning, can receive as well more comfortable, electronic way to access learning material. Besides, employees of the large companies who needs to keep their professional skills on high level. Another application field is organization of job-seekers automated learning and knowledge control.

Using modern data transmission technologies, it is possible to speak about construction of large-scale electronic learning systems with a number of servers and various client types.

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## INVESTIGATING THE RELATIONS OF ATTACKS, METHODS AND OBJECTS IN REGARD TO INFORMATION SECURITY IN NETWORK TCP/IP ENVIRONMENT

Dimitrina Polimirova, Eugene Nickolov, Cecko Nikolov

*Abstract:* Possibilities for investigations of 43 varieties of file formats (objects), joined in 10 groups; 89 information attacks, joined in 33 groups and 73 methods of compression, joined in 10 groups are described in the paper. Experimental, expert, possible and real relations between attacks' groups, method' groups and objects' groups are determined by means of matrix transformations and the respective maximum and potential sets are defined. At the end assessments and conclusions for future investigation are proposed.

*Keywords:* File Formats, Information Attacks, Methods of Compression, Compressed Objects, Information Security.

*ACM Classification Keywords:* D.4.6 Security and Protection: information flow controls

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### The Situation

The new technologies' development extends the necessity of processing, transferring and saving of volume sizable information flows. These information flows, in the form of file objects, are an object of non-stop attacks according to their information security, which determines the significant necessity for investigation of methods and means for their protection.

Researches are carried out in two directions. The first one is connected with the development of different and new techniques for decreasing the volume of information flows (for example: different methods of compression). The other one is connected with the possibility of increasing the safety of their information security with respect to different attacks.

### The Problem

A general strategy for protecting file objects could include applying compression methods to objects to achieve simultaneously decrease in volume size of information flow and increase its information security with respect to different kinds of attacks, which it can be exposed on. In additional the use of password with fixed minimum and maximum length can be used. The possibility for encryption of objects, which are preliminarily compressed and protected by password, can be included as the last stage of the strategy for protecting. The main parameter to this stage is the length of applied key.

For the purposes of the investigation the following reservation can be made: it is enough to investigate only the influence of compression methods on objects exposed to one or more attacks, as the difference in their behavior before and after the attacks when standard and not corporate (government) requirements are used is taken into consideration.

### The Experiment

The experiment which is carried out is connected to objects, exposed to information attacks and processed by methods of compression to increase their information security.

To achieve the end of this investigation it is necessary to determine the sets of ATTACKS, METHODS and OBJECTS, which will take part in the experiments for determining the information security. With regard to this investigation the following tasks were posed:

1) To determine the SETS OF MAXIMUM attacks, methods of compression and objects.

The set of all attacks, known by now, has to be determined. They will form the set of maximum number of attacks ( $A_{max}$ ), which can be collected from the current information base of National Laboratory of Computer Virology of Bulgarian Academic of Sciences. It collects information for the information attacks, which were carried out to a

separate personal and/or corporate computers, and/or networks, and/or systems at the moment of the investigation. 89 different attacks will be analyzed [1]. This is a generalization of attacks, implemented in Bulgaria, Balkan Peninsula and south-east Europe. The attacks have been provisionally divided into malware and malattacks. In case of malware the direct participation of a user at the moment of the attack is missing, while in case of malattack the user's presence is required. Varieties, known for this period, are organized in 33 groups, respectively 20 for malware and 13 for malattack. To achieve calculative expenses reducing and visualization improving, conclusions on the base only of 33<sup>th</sup> groups not for 89<sup>th</sup> varieties are described below after experiments which were carried out.

For the purposes of the investigation, the current attacks will be denoted as  $a_i$ , where the index  $i$  changes from 1 to  $n$  (maximum number of known attacks).

The maximum numbers of objects ( $O_{max}$ ), which will be described, are different kinds of file formats. We shall understand as file format the specific organization of information within a file [2]. Different types of file formats exist for the different type of information. They are separated in 43 varieties, which will be called only *objects*, joined in 10 main groups. During the experiments the different file formats will be represented by different file extensions. (Over 18000 file extensions are known at the moment [3]). To achieve calculative expenses reducing and visualization improving, conclusions on the base only of 10<sup>th</sup> groups not for 43<sup>th</sup> varieties are described below after experiments which were carried out.

For the purposes of the investigation, the current object will be denoted as  $o_f$ , where the index  $f$  changes from 1 to  $l$  (maximum number of objects).

Different kinds of compression methods will be selected for protecting the objects exposed to attacks. They will create the set of maximum number of methods ( $M_{max}$ ), called only *methods*. Seventy three methods in 10 groups will be analyzed. Five of them are assigned to lossless methods of compression and the other five to lossy methods of compression [4]. To achieve calculative expenses reducing and visualization improving, conclusions on the base only of 10<sup>th</sup> groups not for 73<sup>th</sup> varieties are described below after experiments which were carried out.

For the purposes of the investigation, the current method of compression will be denoted as  $m_j$ , where the index  $j$  changes from 1 to  $k$  (maximum number of methods).

2) To determine the SETS of *POTENTIAL* attacks, methods and objects, which will take a part in the experiments.

The attacks, methods and objects having direct relation to the investigation and forming the sets of potential attacks, methods and objects have been singled out.

To turn out the unreal relations from the determined maximum sets, attacks, methods and objects have to be singled out by reducing. They will form the sets of potential attacks, methods and objects.

To determine the potential attacks, methods and objects, matrices have been devised with the results of *expert* assessment and *experiments* on the relations attack-object, method-object and attack-method. The results will provide the possibility to exclude from the analysis the attacks, methods and objects about which: 1) there is no sufficient information; 2) the information is not public; 3) the information is rapidly changing; 4) there is not enough authentic hardware and software.

The expertly determined sets of relations will be put to a partial test by means of a number of planned simulative experiments. Thus the set of possible attacks, methods and objects will be singled out and: 1) the possible attacks are expertly and experimentally estimated for the relevant object/objects in connection with relevant method/methods; 2) the possible methods are expertly and experimentally estimated for the relevant object/objects in connection with relevant attack/attacks; 3) the possible objects are expertly and experimentally estimated for the relevant method/methods in connection with relevant attack/attacks.

2.1.) To determine the *POSSIBLE RELATIONS* attack-object, method-object and attack-method.

Determination of possible relations attack—object ( $\Omega$ )

Two matrices are composed to determine the set  $\Omega$ :  $E_{(l,n)}$  and  $Y_{(l,n)}$ . By the vertical of the matrices are included all attacks  $A_{max}$ , separated in  $n$  varieties  $a_1, a_2, \dots, a_i, \dots, a_n$ ,  $\bigcup_{i=1}^n a_i = A_{max}$ ,  $\bigcap_{i=1}^n a_i = \emptyset$ . By the horizontal of the matrices are included all objects  $O_{max}$ , separated in  $l$  varieties  $o_1, o_2, \dots, o_f, \dots, o_l$ ,  $\bigcup_{f=1}^l o_f = O_{max}$ ,  $\bigcap_{f=1}^l o_f = \emptyset$ . A research is conducted, where an attack  $a_i$  is trying to get access  $\rho$  to the object  $o_f$ , where  $\rho$  will present the different type of an access (read, write, execute and delete). Graphically this process can be illustrated in this way:

$$U_1 \longrightarrow a_i \xrightarrow{\rho} o_f$$

where  $U_1$  is a user, who uses an attack  $a_i \in A_{max}$ , to get access  $\rho$  to the object  $o_f \in O_{max}$ ,  $i=1, 2, \dots, n$ ,  $f=1, 2, \dots, l$ .

In the first matrix  $E_{(l,n)}$  for each cell a logical processing is made with result logical 0 or logical 1 by the so called function of truth [5]  $I_x(B) \begin{cases} 1, x \in B \\ 0, x \notin B \end{cases}$  respectively for the attack and object:  $I_a(a_1), I_a(a_2), \dots, I_a(a_i), \dots, I_a(a_n)$ ,  $I_o(o_1), I_o(o_2), \dots, I_o(o_f), \dots, I_o(o_l)$  and in the corresponding cell of the matrix is filled out the result from the logical expression:  $I_a(a_i) \wedge I_o(o_f)$  on the of the experiments, which were carried out. If the obtained result is 1 (possible) ( $x=1$ ) then during the experiments the attack had gotten an access to the object ( $A \xrightarrow{\rho} O$ ), otherwise with result 0 (impossible) ( $x=0$ ), the attack's access is not accomplished. On the base of the obtained results the set  $F$  can be singled out, which include all attacks and objects, for which is completed the following condition:  $I_a(a_i) \wedge I_o(o_f) = 1$ .

In the second matrix  $Y_{(l,n)}$  for each cell the function of truth is produced on the base of expert assessments:

$Y_x(K) \begin{cases} 1, x \in K \\ 0, x \notin K \end{cases}$  for the attack and object:  $Y_a(a_1), Y_a(a_2), \dots, Y_a(a_i), \dots, Y_a(a_n)$ ,  $Y_o(o_1), Y_o(o_2), \dots, Y_o(o_f), \dots, Y_o(o_l)$ . For

each oriented graph  $A \xrightarrow{\rho} O$  the result from the following logical expression  $Y_a(a_i) \wedge Y_o(o_f)$  is filled out. If the obtained result is 1 (true) ( $x=1$ ), then an attack  $A$  can get access to the object  $O$  ( $A \xrightarrow{\rho} O$ ), otherwise with result 0 ( $x=0$ ), the attack  $A$  can not get an access  $\rho$  to the object  $O$ . From the obtained results the set  $E$  can be singled out, which includes all attacks and objects the following logical expression is realized for:  $Y_a(a_i) \wedge Y_o(o_f) = 1$ .

Crossing the set  $F$  with  $E$  ( $F \cap E$ ) the set of possible relations attack—object ( $\Omega$ ) can be singled out, where  $\Omega = [I_a(a_i) \wedge I_o(o_f)] \wedge [Y_a(a_i) \wedge Y_o(o_f)] = 1$ . On Figure 1 are graphically presented the obtained result for possible relations between attacks' groups and objects' groups. To achieve calculation expenses reducing and visualization improving is working only with groups.

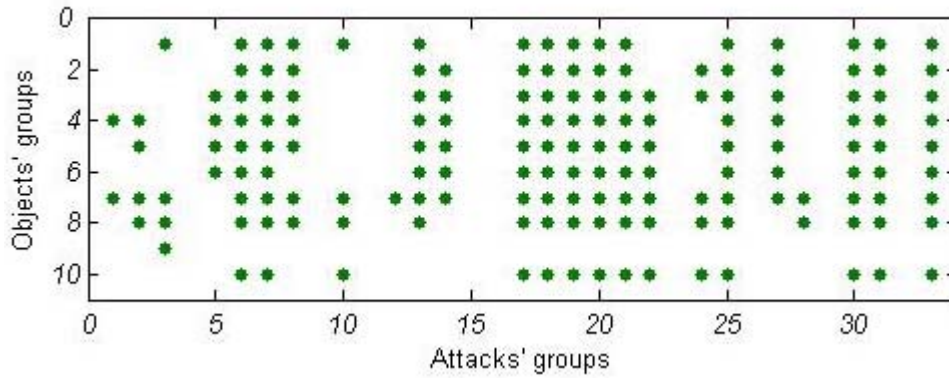


Figure 1 Possible relations between attacks' groups and objects' groups

Determination of possible relations method—object (Ξ)

Two matrices are composed to determine the set  $\Xi$ :  $E_{(l,k)}$  and  $Y_{(l,k)}$ . By the vertical of the matrices are included all methods of compression  $M_{max}$ , separated in  $k$  varieties  $m_1, m_2, \dots, m_j, \dots, m_k$ ,  $\bigcup_{j=1}^k m_j = M_{max}$ ,  $\bigcap_{j=1}^k m_j = \emptyset$ . By the horizontal are included all objects  $O_{max}$ , separated in  $l$  varieties  $o_1, o_2, \dots, o_f, \dots, o_l$ ,  $\bigcup_{f=1}^l o_f = O_{max}$ ,  $\bigcap_{f=1}^l o_f = \emptyset$ . A research is conducted, where each object is processes by each methods of compression.

Graphically this process can be illustrated by this way:

$$U_2 \longrightarrow m_j \longrightarrow o_f$$

where  $U_2$  is a user, who processes the object  $o_f \in O_{max}$  with methods of compression  $m_j \in M_{max}$ ,  $f=1, \dots, l$ ,  $j=1, \dots, k$ .

For each cell of the matrix  $E_{(l,k)}$  a logical processing is made with result logical 0 or logical 1 by the so called

function of truth:  $I_x(B) \begin{cases} 1, x \in B \\ 0, x \notin B \end{cases}$  for the methods and object:  $I_m(m_1), I_m(m_2), \dots, I_m(m_j), \dots, I_m(m_k)$ ,

$I_o(o_1), I_o(o_2), \dots, I_o(o_f), \dots, I_o(o_l)$  and in the corresponding cell of the matrix is filled out the result from the logical expression:  $I_m(m_j) \wedge I_o(o_f)$  on the of the experiments, which were carried out. If the obtained result is 1

(possible) ( $x=1$ ), then during the experiment the method has successfully applied to the object ( $M \longrightarrow O$ ), otherwise with result 0 (impossible) ( $x=0$ ), during the experiment the method has not successfully applied to the object. On the base of the obtained results the set  $C$  can be singled out, which include all methods and objects, for which is completed the following condition:  $I_m(m_j) \wedge I_o(o_f) = 1$ .

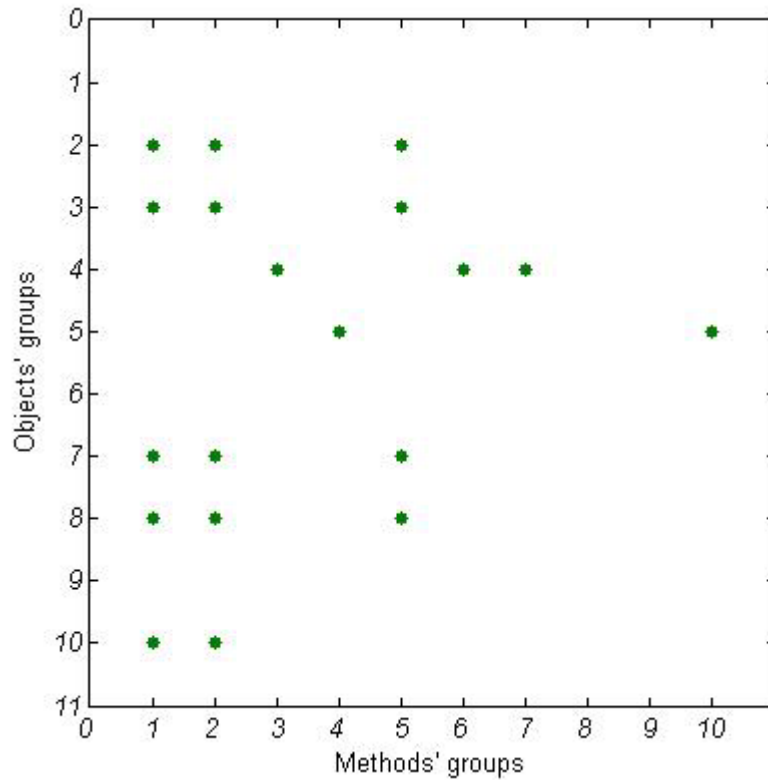
For each cell from the second matrix  $Y_{(l,k)}$  the function of truth is produced on the base of expert assessments:

$Y_x(K) \begin{cases} 1, x \in K \\ 0, x \notin K \end{cases}$  for the method and object:  $Y_m(m_1), Y_m(m_2), \dots, Y_m(m_j), \dots, Y_m(m_k)$ ,

$Y_o(o_1), Y_o(o_2), \dots, Y_o(o_f), \dots, Y_o(o_l)$ . For each oriented graph  $M \longrightarrow O$  the result from the following logical expression  $Y_m(m_j) \wedge Y_o(o_f)$  is filled out. If the obtained result is 1 (true) ( $x=1$ ), then method  $M$  can be applied to object  $O$  ( $M \longrightarrow O$ ), otherwise with result 0 ( $x=0$ ), a method  $M$  can not be applied to an object  $O$ . From the obtained results the set  $P$  can be singled out, which include all methods and objects, the following logical expression is realized for:  $Y_m(m_j) \wedge Y_o(o_f) = 1$ .



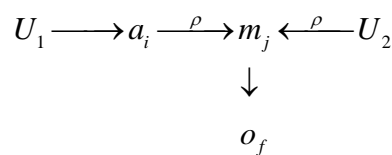
Crossing the set  $C$  with  $P (C \cap P)$  the set of possible relations method—object ( $\Xi$ ) can be singled out, where  $\Xi = [I_m(m_j) \wedge I_o(o_f)] \wedge [Y_m(m_j) \wedge Y_o(o_f)] = 1$ . On Figure 2 are graphically presented the obtained results for possible relations between methods' groups and objects' groups. To achieve calculation expenses reducing and visualization improving is working only with groups.



**Figure 2** Possible relations between methods' groups and objects' groups  
(Methods groups 8 and 9 were dropped out from the investigation after expert assessment.)

Determination of possible relations attack—method ( $\Theta$ )

Two matrices are composed to determine the set  $\Theta: E_{(k,n)}$  and  $Y_{(k,n)}$ . By the vertical of the matrices are included all attacks  $A_{max}$ , separated in  $n$  varieties  $a_1, a_2, \dots, a_i, \dots, a_n, \bigcup_{i=1}^n a_i = A_{max}, \bigcap_{i=1}^n a_i = \emptyset$ . By the horizontal are included all methods of compression  $M_{max}$ , separated in  $k$  varieties  $m_1, m_2, \dots, m_j, \dots, m_k, \bigcup_{j=1}^k m_j = M_{max}, \bigcap_{j=1}^k m_j = \emptyset$ . A research is conducted, where the different attacks try to get access to objects, preliminarily processed by method of compression. Graphically this process can be illustrated by this way:



where  $U_1$  is a user, who uses an attack  $a_i \in A_{max}$  to get access to a object  $o_f \in O_{max}$ , preliminarily processed with method of compression  $m_j \in M_{max}$  for a protection by an user  $U_2$ , as  $i=1, \dots, n, j=1, \dots, k, f=1, \dots, l$ .

For each cell of the matrix  $E_{(k,n)}$  a logical processing is made with result logical 0 or logical 1 by the so called

function of truth:  $I_x(B) \begin{cases} 1, x \in B \\ 0, x \notin B \end{cases}$  for the attack and method:  $I_a(a_1), I_a(a_2), \dots, I_a(a_i), \dots, I_a(a_n),$

$I_m(m_1), I_m(m_2), \dots, I_m(m_j), \dots, I_m(m_k)$  and in the corresponding cell of the matrix is filled out the result from the logical expression:  $I_a(a_i) \wedge I_m(m_j)$  on the of the experiments, which were carried out. If the obtained result is 1 (possible) ( $x=1$ ), then during the experiment the attack had gotten an access to the method ( $A \xrightarrow{\rho} M$ ), otherwise with result 0 (impossible) ( $x=0$ ), the attack did not have gotten an access to an object, processed with methods of compression. On the base of the obtained results the set  $D$  can be singled out, which include all attacks and methods, for which is completed the following condition:  $I_a(a_i) \wedge I_m(m_j) = 1$ .

For each cell from the second matrix  $Y_{(k,n)}$  the function of truth is produced on the base of expert assessments:

$Y_x(K) \begin{cases} 1, x \in K \\ 0, x \notin K \end{cases}$  for the attack and method:  $Y_a(a_1), Y_a(a_2), \dots, Y_a(a_i), \dots, Y_a(a_n),$

$Y_m(m_1), Y_m(m_2), \dots, Y_m(m_j), \dots, Y_m(m_k)$ . For each oriented graph  $A \xrightarrow{\rho} M$  the result from the following logical expression  $Y_a(a_i) \wedge Y_m(m_j)$  is filled out. If the obtained result is 1 (true) ( $x=1$ ), then an attack  $A$  can get access to an object  $O$ , processed with method of compression  $M$  ( $A \xrightarrow{\rho} M$ ), otherwise with result 0 ( $x=0$ ), an attack  $A$  can not get an access to an object  $O$ , compressed with method  $M$ . From the obtained results the set  $Y$  can be singled out, which include all attacks and methods, the following logical expression is realized for:  $Y_a(a_i) \wedge Y_m(m_j) = 1$ .

Crossing the set  $D$  with  $Y$  ( $D \cap Y$ ) the set of possible relations attack—method ( $\Theta$ ) can be singled out, where  $\Theta = [I_a(a_i) \wedge I_m(m_j)] \wedge [Y_a(a_i) \wedge Y_m(m_j)] = 1$ . On Figure 3 are graphically presented the obtained results for possible relations between attacks' groups and methods' groups. To achieve calculation expenses reducing and visualization improving is working only with groups.

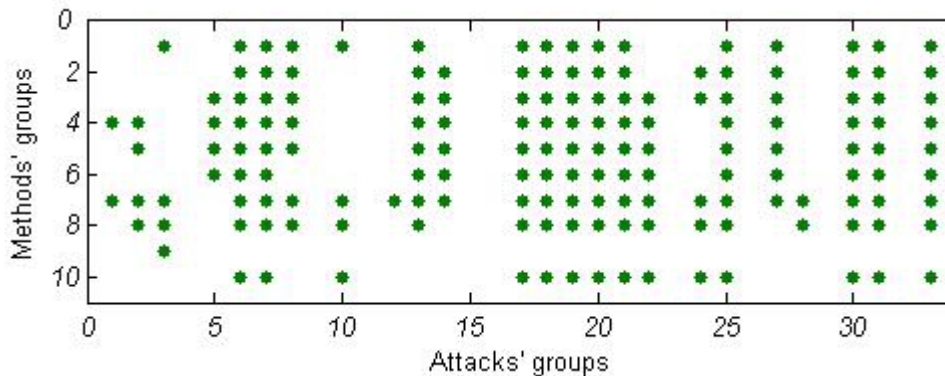


Figure 3 Possible relations between attacks' groups and methods' groups

2.2.) To determine the REAL RELATIONS between attacks, methods and objects.

Let the elements of the set  $\Omega$  and  $\Xi$  form a totality of elements  $\alpha \subseteq A$  then and then only, when for the elements  $\omega_z \subseteq \Omega$  and  $\xi_h \subseteq \Xi$  the following logical expression is realized for:

$$A = \Omega \wedge \Xi = 1$$

The elements of the set  $\Omega$  and  $\Theta$  form a totality of elements  $\beta \subseteq B$  then and then only, when for the elements  $\omega_z \subseteq \Omega$  and  $\theta_c \subseteq \Theta$  the following logical expression is realized for:

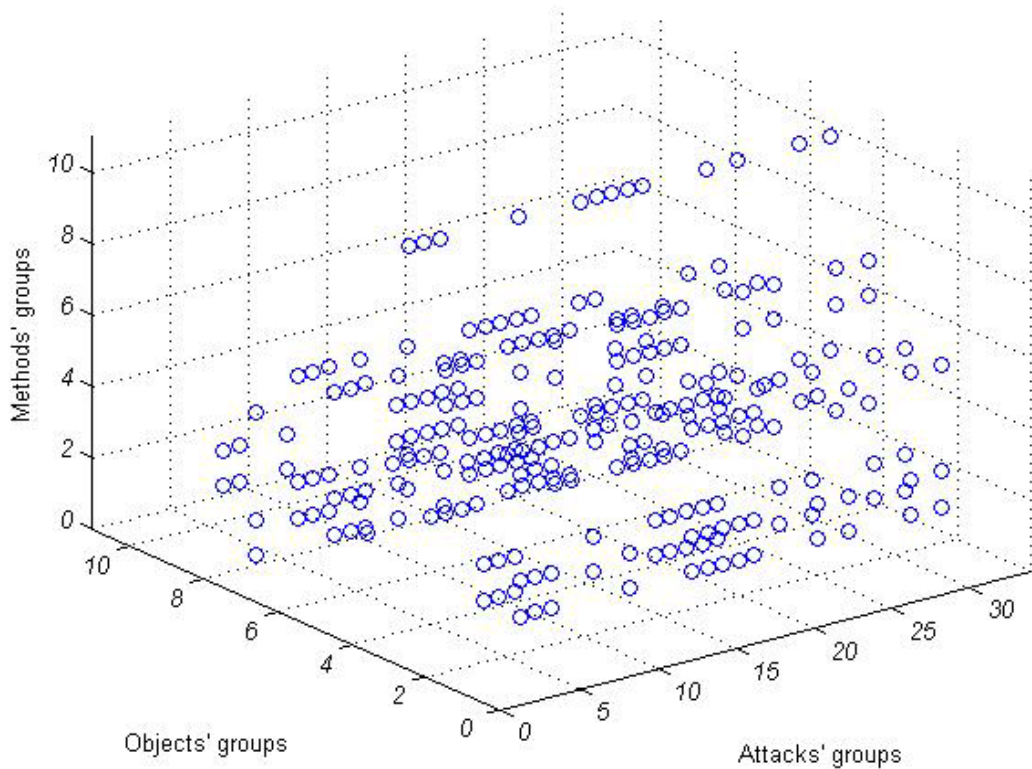
$$B = \Omega \wedge \Theta = 1$$

The elements of the set  $\Xi$  and  $\Theta$  form a totality of elements  $\gamma \subseteq \Gamma$  then and then only, when for the elements  $\xi_h \subseteq \Xi$  and  $\theta_c \subseteq \Theta$  the following logical expression is realized for:

$$\Gamma = \Xi \wedge \Theta = 1$$

The set of all real relations between attacks, methods and objects, shown on Figure 4 (to achieve calculation expenses reducing and visualization improving is working only with groups), is  $X = A \cap B \cap \Gamma$  or:

$$X = (\Omega \wedge \Xi) \wedge (\Omega \wedge \Theta) \wedge (\Xi \wedge \Theta) = A \wedge B \wedge \Gamma = 1$$



**Figure 4** Real relations between attacks' groups, methods' groups and objects' groups

2.3.) To find the *POTENTIAL SETS* of attacks, methods and objects.

The set of potential attacks ( $A_{pot}$ ) is expressed as *real* attacks (received from the real relations) in relation to the *maximum* number of attacks ( $A_{max}$ ) and can be denoted as  $A_{pot} = \{a_1, a_2, \dots, a_i, \dots, a_p\}$ , where  $p$  is the index the *potential attacks* alter for, where  $p \leq n$ .

The set of potential objects ( $O_{pot}$ ) is expressed as *real* objects (received from the real relations) in relation to the *maximum* number of objects ( $O_{max}$ ) and can be denoted as  $O_{pot} = \{o_1, o_2, \dots, o_f, \dots, o_p\}$ , where  $p$  is the index the *potential objects* alter for, where  $p \leq l$ .

The set of potential methods ( $M_{pot}$ ) is expressed as *real* methods (received from the real relations) in relation to the *maximum* number of methods ( $M_{max}$ ) and can be denoted as  $M_{pot} = \{m_1, m_2, \dots, m_j, \dots, m_p\}$ , where  $p$  is the index the *potential methods* alter for, where  $p \leq k$ .

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## Assessments

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The following assessments could be made from the experiments which were carried out:

1) The selected number of maximum attacks' groups (33), methods' groups (10) and objects' groups (10) is sufficient for determining the potential sets.

2) The following general conclusions can be made after the experiments and expert assessments which were carried out:

➤ from totally 330 relations attack's group—method's group, after expert assessment 190 relations are singled out, proved by experiments are 191 relations and 160 *possible* relations attack's group—method's group are formed.

➤ from totally 100 relations method's group—object's group, after expert assessment 25 relations are singled out, proved by experiments are 25 relations and 19 *possible* relations method's group—object's group are formed.

➤ from totally 330 relations attack's group—method's group, after expert assessment 176 relations are singled out, proved by experiments are 201 relations and 161 *possible* relations attack's group—method's group are formed.

3) The combination of 489 440 *possible* relations among attacks' groups, methods' groups and objects' groups determines 269 *real* relations among the triple combination attack's group—method's group—object's group.

4) The number of attacks', methods' and objects' groups, which take part in the determination of the *potential sets* of attacks, methods and objects, which will be used during the next investigations, are as follows: groups of  $A_{pot}=18$ , groups of  $M_{pot}=8$  and groups of  $O_{pot}=7$ .

5) The assessment of the potential attacks, methods and objects shows that assumptions made during the investigation will not affect the reliability of the results. The selected number of potential sets is sufficient for reaching conclusions and making recommendations.

6) The chosen methodology for analyzing the relations attack-method-object by means of matrix transformations is effective and operative, and it contains the necessary potential for new deep analyses in this and another related areas.

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## Conclusion

The investigation demonstrates the significant viability of such analyses. There is a possibility of specific planning of safety procedures and safety policies for the different computers, systems and networks configurations. Conditions are created for precise planning of economic expenses, connected with a specific safety policy with a specific configuration of computer, system and network. Future investigations will offer the possibility for exact determination of the relations attack-object-method.

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## CONCEPTUAL MODEL AND SECURITY REQUIREMENTS FOR DRM TECHNIQUES USED FOR E-LEARNING OBJECTS PROTECTION

Maria Nickolova, Eugene Nickolov

*Abstract:* This paper deals with the security problems of DRM protected e-learning content. After a short review of the main DRM systems and methods used in e-learning, an examination is made of participators in DRM schemes (e-learning object author, content creator, content publisher, license creator and end user). Then a conceptual model of security related processes of DRM implementation is proposed which is improved afterwards to reflect some particularities in DRM protection of e-learning objects. A methodical way is used to describe the security related motives, responsibilities and goals of the main participators involved in the DRM system. Taken together with the process model, these security properties are used to establish a list of requirements to fulfill and a possibility for formal verification of real DRM systems compliance with these requirements.

*Keywords:* Security, DRM protection, e-learning.

*ACM Classification Keywords:* D.4.6 Security and Protection.

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### Introduction

Over the past few years, the world of educational material publishing has been marked by the process of innovation and integration, caused by the advent of digital technologies. As a result of these changes, a new digital educational content market is emerging with a new commercial approach: from the distribution and sale of tangible products to the distribution and licensing of intangible products. This commercial change also has a very strong impact on educational content rights management (copyright and licensing, etc.). In the light of these factors, DRM (Digital Rights Management) becomes a need that cannot be delayed. Since the 1980s, the software and entertainment industry have sought technologies that can somehow limit copying or redistribution. While DRM has been most frequently used for movies, it is gaining more widespread use in educational media as well. Many audio files, such as Apple's iTunes files, have various built-in DRM schemes to limit the number of devices they may be played on. Many producers of e-books also use a similar DRM implementation to limit how many computers a book may be viewed on, and even how many times it may be viewed. In mid-2005, a number of content producers for television began also requesting DRM of their shows via the popular TiVo system.

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### Main Systems and Methods Used for DRM in E-Learning

Since the mid-1990s, the major technology companies have rapidly developed sophisticated, proprietary content protection schemes (DTCP, used to protect content within the home, was developed by Hitachi, Intel, Matsushita, Sony and Toshiba; HDCP, protecting digital video content across buses to PC monitors and to other display devices was promoted by Intel, etc.). Nowadays more sophisticated digital rights enforcement mechanisms are created executing specified user rights, coming as part of the content code, within the end user device. Protection mechanisms are being built into software such as Adobe Acrobat™, Apple iTunes™, Windows Media Player™, Microsoft Office™, etc. There are four different approaches for the creator of a document to assign certain rights only to persons in possession of legal rights. The first one is the "strong DRM" - some DRM technologies are designed to set and automatically enforce limits on user behavior, so that the user is unable to act illegally (e.g. copyright mechanisms which could not be overcome). The second method encourages learners to use learning objects only in legal way. In Potato system, for example, where the users play an active distribution part, they are motivated to re-distribute learning content they have paid for and earn money with it. The third method does not prohibit students to use illegally e-learning materials, but personalizes products to identify their origin in illegal environment (e.g. LWDRM technology). The fourth method consists in disabling access to content upon detecting an attempt at unauthorized use. Such "self-help" technologies is often directed and controlled externally upon detection of the prohibited activity and therefore, implemented in tandem with some sort of monitoring functionality.

All these DRM technologies use two kinds of anti-copying measures - passive and active. Passive measures change the e-learning object's contents in the hope of confusing most illegitimate users' computer drives and software, or simply block access to it. Active measures, in contrast, rely on software on the computer that actively intervenes to block access to the e-learning content by programs other than the DRM vendor's own software. Passive measures don't pose security problems, but they are relatively easy to overcome. The method of active protection is working much better but is linked to some serious security problems, that depend on the parties involved in DRM schemes and their disobedience to the main security requirements.

In recent years, there have been proposed different models of DRM systems with specific properties [1, 2, 3, 4]. These proposals incorporate various security requirements. Some of them are related to the principal DRM functionality, whereas other requirements realize the specific properties for which that architecture was constructed [4]. DRM systems are designed to provide a solution for a security problem and the understanding of the core security requirements is crucial for fundamental comprehension of the security of DRM systems.

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### **Examination of Participators in DRM Schemes**

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The main DRM participators are: the e-learning object author, the content creator, the content publisher, the license creator and the end user (student). They all must be present for a DRM system to function.

E-learning object author is the person(s) who creates the e-learning object and owns the copyrights. His/her impact on the DRM security is the least, but often it is the author alone who selects the used DRM technology.

The content creator is the person(s) or the media company that creates the e-learning content on the base of e-learning objects, submitted by one or more authors. He/she is responsible not only for the practical secure realization of the e-learning site but also for putting together all e-learning objects and the use of additional elements. Besides the implementation of DRM protection of learning objects, the content creator could use DRM technology to offer a revenue-generating alternative for traditional downloading. This means that the content creator plays a key role in DRM security.

The content publisher is the second most important participator from a security point of view. Generally he/she is responsible for the authentication of potential users, for the verification of their legitimacy and for ensuring their confidentiality and privacy. He/she also enables and tracks the content traffic. He/she works in close relation with the license creator.

License creator binds the content of the e-learning object to a license. He/she can use DRM technology to offer to the users a tailor-made access to content. By offering a clearly legitimate and known-quality alternative for downloading or acquiring a legal copy, license creator can stimulate the legitimate use of e-learning content. Also, as the content is bound to a license created by the license creator, most content distributed in this way will not spread beyond the license creator's control.

End user (student). To acquire a license, the end user accessing the protected content must contact the *license creator's server* specified in the metadata packaged with the protected content. Users are mainly drawn to DRM systems since they offer a legitimate, known-quality alternative to more dubious sources of content. Another advantage that DRM systems could offer to students, is the possibility to restrict the access to (and thus the cost of) e-learning content to precisely what the user wishes.

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### **Conceptual Model of Security Related Processes of DRM Implementation in E-Learning**

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In order to derive a generic model, we start with one component for the four main roles in a DRM system security: the content creator, the content publisher, the license creator and the end user (student). The content creator and the content publisher are linked to the license creator and the license creator in his turn is linked to the end user.

This model is very simple and doesn't reflect some particularities of DRM protected e-learning content, so it needs some improvements. The first improvement is caused by the need to distinguish two types of content: protected e-learning content (which DRM is to protect), and free content (which a user can access without license and permissions). These results in dividing the end user's component in two: one communicating with the content publisher and another, communicating with the license creator. A second improvement is bound to the two possibilities for delivering the protected e-learning content – the "predelivery" and the "postdelivery". The concept of "predelivery" assumes that access is provided to the requesting end user prior to the media itself being transferred (acquired) or as part of the normal downloading process. The "postdelivery" presumes the widest possible dispersion of e-learning content. This approach, known as *superdistribution*, embraces students who

have received the e-learning content from some source other than the main delivery channel (the e-learning site, the licensed shops, etc.). But to utilize this content, the recipient would have to contact the license creator and to provide the needed information and payment before receiving the right to access it. To reflect this particularity we shall split the distribution in two parts – one realizing content “predelivery” (content publisher) and another – for content “postdelivery” (other source). The last improvement is bounded to the main inherent characteristic of all DRM protected content: legal access to all protected content is granted only under a license, but DRM offers possibilities for different kinds of licenses. This results in splitting the license creator’s component in two parts: one reflecting the temporary licenses, allowing access to a part of the e-learning content or to all the content but for a limited time or numbers of use, and another for the permanent license granting permanent access to the e-learning content.

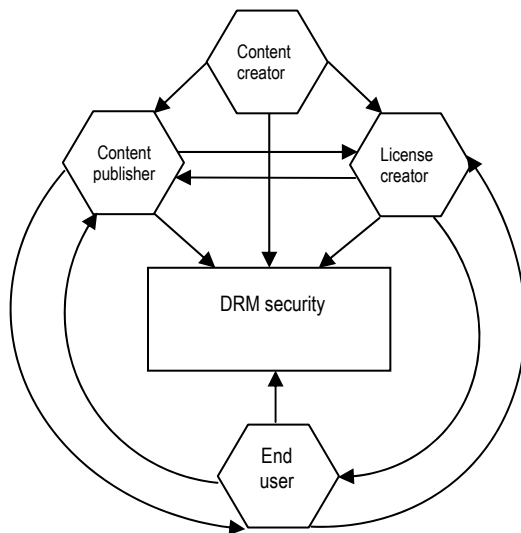


Fig.1 Conceptual model of DRM security

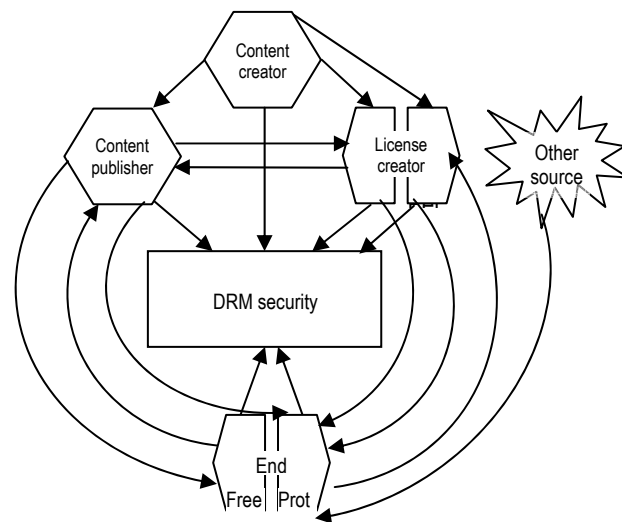


Fig.2 Improved conceptual model of DRM security

The content creator creates the content, which is published in the web (or company/university LAN/WAN) or distributed in some physical form (CD, DVD, etc.) by the content publisher and bound to a license by a license creator. If “predelivery” concept is used the content distribution is not obligatory bound or limited to the respective e-learning site/official channel of distribution. If the scheme of “postdelivery” is chosen, the content publisher is responsible for the legal content dissemination.

### **Motives, Responsibilities and Goals of the Main Participants in DRM Schemes**

Let's now draw a list of the general Motives (M), Responsibilities (R) and Goals (G) of the content creator, the content publisher, the license creator and the end user in using DRM protection.

#### Content creator

M-I: Could use the same DRM to protect his own copyrights.

R-I: Separates technically the learning objects (or parts of them) which will be DRM protected, based on author's copyrights and desires.

R-II: Selects the DRM technology to be used, based on such criteria as robustness, viability, security and price.

R-III: Implements the selected DRM scheme (appending it in the OS core components or binding it to specific applications used to access the protected content).

R-IV: Is responsible for the limiting of the impact of possible system breaking.

G-I: The site structure (or physical media) should use advanced technological methods (encryption, scrambling, etc.) to deny access to protected content to all illegitimate users, even to technically experienced.

G-II: The site structure (or physical media) should not use any potentially harmful methods of content protection (active protection measures as ActiveX controls, backdoors capabilities, etc.) which could put at risk the security of end users' systems.

Content publisher

M-I: Could get some profit by using DRM to offer more content to end users (not obligatory linked to the main e-learning site content).

R-I: Should ensure the right and secure functioning and accessibility of the e-learning site/physical media.

R-II: Should verify the rights of all users trying to get access to protected e-learning objects.

R-III: Should guarantee together with the license creator that the content used and the way of its use are not linked directly to the personal data of the end user.

G-I: Protected content should be accessible only by owners of a valid license issued by the license creator and under the conditions of this license.

G-II: All users that have not got such a license should be redirected to license creator without downloading and installing additional software to their systems.

License creator

M-I: Could use a DRM scheme to offer object-based or time-based licenses to end users.

R-I: Should deliver precisely the kind of license that has been requested, at the desired time for the licensee.

R-II: Should define clearly in the license agreements the end user's rights and responsibilities and should see to their observation.

G-I: To stimulate the legitimate use of e-learning content by offering affordable personalized access to different groups of users.

G-II: To keep the user aware of all agreements between the license creator and the end user.

End user

M-I: Is guaranteed a legal functional copy by buying a license for DRM protected e-learning content.

M-II: Won't be persecuted for illegal dissemination and use of e-learning content.

R-I: Order licenses or content on the user's behalf requires his intentional participation.

R-II: Must not share the licensed content he/she received legally free or against payment.

G-I: To acquire a consumable form of the content that he/she desires, at the moment he/she desires it.

G-II: Not to allow a decrease in computer's security caused by DRM protected content.

**Conclusions from the Conceptual Model and the Analysis of Principal Participators**

The proposed model of the DRM system security and the analysis of the motives, responsibilities and goals of principal participators in DRM allow us to establish the principal security properties of DRM technologies. Taken together, these results could be used as a basis for the determination of security requirements of a DRM system, based on proven security components and protecting the integrity of usage rights. The methods we used support some derivation from the general security requirements, but due to the systematic approach, the descriptions are sufficiently exhaustive for our goals.

**Main Security Requirements to Principal Participators in DRM Scheme**

Understanding and defining security requirements is a fundamental part of establishing effective DRM standards and technologies. Here we will apply the considerations expressed above as security requirements in the model of Fig. 2. Each responsibility and goal described previously will be translated into security property for the model.

Security requirements to content creator

R-I leads to the following requirements for the content creator:

- (1) (security) Neither the whole protected object nor part of it should in any state or conditions threaten the end user system's security.
- (2) (efficiency) The separation of DRM protected object must meet end user demands and expectations for convenience, performance and ability to deal with content.

R-II leads to the following requirements for the selected DRM technology:



- (1) (usability) It must not be too restrictive for consumers who legitimately paid for content and want to share it on several devices.
- (2) (privacy) It must allow a user to interact with it in an anonymous/pseudonymous way.
- (3) (privacy) It must give the user more control and privacy as regards to domain-based protected content without sacrificing content owner's control.
- (4) (universality) It must work with disconnected, multiplatform and multi-business end user's systems.
- (5) (usability, transparency) It must provide ease of use, be transparent and visible.

R-III leads to the following requirements to the DRM implementation:

- (1) (independence) The implementation can't rely on a software component on the user's device to perform integrity checking, decrypt the content or enforce the usage rights.
- (2) (authentication) No DRM component sends the protected content to another component, unless the receiving component is authenticated as an official component and allowed to receive the content from the sending component.
- (3) (self-protection) DRM software must preserve its integrity and efficiency even in extremely hostile environment.
- (4) (self-protection) Besides the basic requirements valid for secure software the DRM implementation must be reverse-engineering-proof and temper-resistant.

R-IV leads to the following requirements for the long-term DRM security:

- (1) (damages limitation) The possibility for "break once, run always" should be prevented.
- (2) (updatability) The DRM system components should allow updates of new or altered system protective measures preventing security breaches during their installation.

G-I leads to the following requirements for the degree of DRM security:

- (1) (secrecy) It must be neither possible to discover nor to alter the function that the DRM software performs and it must be also impossible to impersonate it.
- (2) (constraint) The selected DRM solution must force the user to fulfill the obligations previously established by the license before granting the rights and access to these contents.

G-II leads to the following requirements for the relation between the used DRM system and end user protection:

- (1) (safety) The DRM solution must correspond to the end user security point of view.
- (2) (priority) In case of contradiction between the requirements for illegitimate access prevention and these for end user security, the last must prevail.

#### Security requirements to content publisher

R-I leads to the following requirements for DRM system efficacy:

- (1) (proportionality) The end user should pay only what he gets and should get only what he paid in a form and under conditions corresponding to his license.
- (2) (completeness) E-learning content must be available to the end user at any time and with quality, conformable to the license terms and conditions.

R-II leads to the following requirements for DRM license scope:

- (1) (efficiency) The adherence to license terms must be strictly observed regardless of the location and the device from which the end user tries to access e-learning content.
- (2) (completeness) The license must be bound to the user, not to the device used.

R-III leads to the following requirements for the user personal data security:

- (1) (confidentiality) Personal data must be bound to the purpose of the service; they may be used only by consent of the end user or by a legal obligation.
- (2) (secrecy) Together with the license creator the content publisher must ensure the confidentiality of the personal data.
- (3) (protection) Together with the license creator the content publisher must protect the personal data against loss, distortion, and correctness with respect to the intended use.

G-I leads to the following requirements for DRM efficacy and secrecy:

- (1) (secrecy) The content is only accessible by the end user specified in the license and all information remains secret until it has been converted into an analogue form.
- (2) (trust) The end user is able to use the content only if all terms of any one valid license governing this content are met.
- (3) (robustness) The internal parameters of the content/licensed user pair cannot be influenced or disrupted by the license creator, the user nor any third party.
- (4) (secrecy) No secret information, necessary for the operation of the components or pertaining to content (e.g. cryptographic keys, content, etc.); can be discerned from the content creator - licensed user pair, nor from the communication channel between them.
- (5) (constraint) The DRM system protection ends at the end user.

G-II leads to the following requirements for no-forced use of DRM protected content:

- (1) (knowledge-ability) All potential users of e-learning content should dispose of reliable complete and exact information about the possibilities, the conditions and the way of acquiring a license.
- (2) (undependability) The advertising of license acquiring must not be linked to modifications in end user system and the license acquisition must be realized in an absolutely voluntary and conscious way.
- (3) (safety) The used DRM technology must guarantee that attempts to access DRM protected content will not modify the end user's system nor threaten its security.

#### Security requirements to license creator

R-I leads to the following requirements for DRM technologies' precision and completeness:

- (1) (integrity) The request for licensing should be received correctly.
- (2) (availability) The user should be able to immediately contact the license creator.
- (3) (availability) The user should always be able to receive license and content.
- (4) (integrity) The content/license should be received fully and correctly.
- (5) (authentication) Only authenticated users with whom an agreement has been reached will receive licenses for the content for which that agreement was reached.

R-II: leads to the following requirements for honesty in DRM use:

- (1) (lifetime care) License agreements should include control over content after delivery.
- (2) (limitation) Content providers can not make offers that violate the rights of end users.
- (3) (transparency) The responsibilities for observation of rights and obligations of end user must be clearly separated between the content publisher and license creator.
- (4) (knowledge-ability) User must be well informed about restrictions for content transportation and exchange between devices.

G-I leads to the following requirements for collaboration among participators in DRM scheme:

- (1) (completeness) License creator should offer licenses covering all possible combinations of individual and collective, limited and unlimited access to a part or the whole content of e-learning object.
- (2) (accessibility) The license price should be specified together with the author(s) and the content creator according to the target audience.

G-II leads to the following requirements for transparency for e-learning content protection:

- (1) (freedom) Personal data protection functions must be transparent so that users can at all times exercise their right of information confidentiality and deactivate these functions for the information and files that they "own".
- (2) (participation) If personal data is transmitted in conjunction with the use of the DRM, the user must have the possibility to consent to such transmission in every case.
- (3) (knowledge-ability) The user must be informed of the type and extent of data transmitted to the content publisher or any third party related to the protected content.

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### Security requirements to end user

R-I leads to the following requirements for end user's involvement in DRM scheme:

- (1) (knowledge-ability) End user must indicate what he wants to obtain.
- (2) (compliance) End user must strictly observe the limitations of the acquired license.

R-II leads to the following requirements for end user engagements:

- (1) (awareness) He must not let intentionally or unintentionally let others get access to DRM protected e-learning content unless this is not expressly indicated in the license.
- (2) (safety) He must keep his system free of malware and protected from exposure.

G-I leads to the following requirements for clearness in DRM participators' relationships:

- (1) (availability) The license creator services should be available at any time for the user.
- (2) (trust) The content publisher sends what has been agreed upon with license creator.
- (3) (authentication) The license creator must authenticate itself to the user.

G-II leads to the following requirements for end user commitment:

- (1) (trust) End user must not use in illegitimate way the DRM protected e-learning content.
- (2) (safety) End user must not allow the e-learning content he acquired legitimately to be distributed by illegitimate channels which could threaten his system' security (e.g. P2P networks).

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## **Conclusion**

In this paper we analyzed and described the key roles taking part in a DRM system as well as desired security properties. Then we built a generic conceptual model of security related processes of DRM implementation in e-learning and used a methodical way to describe the security related motives, responsibilities and goals of all participators involved in the DRM system. Taken together with the process model, these security properties allowed us to establish the core security requirements of DRM systems which lead to an improved understanding of the DRM security aspects.

This paper takes a practical stance towards security: it presents a list of requirements to be fulfilled and a possibility for formal verification of real DRM systems compliance with these requirements. Further developments can lead to the establishing of a theoretical basis in which it is possible to verify that a trusted DRM system complies with the requirements upon it. The process model used for establishing the requirements can be refined to include more details for a more thorough analysis of a particular system. However, such a requirement refinement requires some loss of the generic nature and therefore may result in confining the applicability of the resulting findings to systems exhibiting specific characteristics.

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