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Adaptive Model for E-Learning in Secondary School

Todorka Glushkova
Plovdiv University "Paisii Hilendarski"
Bulgaria

1. Introduction

The application of ICT[1] in the classroom training process allows us to compare two basic stages – a computer based training and e-learning (Stoyanov, 2005a; Stoyanovich, 2001). These two concepts are similar but there are some differences between them. The computer based training (CBT) is an attempt to automate education, replace an educator, and develop self-paced learning. It is place-, time- and content-predetermined learning. E-Learning has its origins in CBT. The main focus of e-learning is not only to educate without barriers of time and distance, but to adjust to the user's goals and needs. It is a just-in-time, in the workplace, customized, on-demand method of learning. For the realization of this kind of training we need to develop appropriate learning resources and mobile services. E-Learning is the next stage of the learning process; it is a new educational paradigm. We consider the passage from CBT to e-Learning a step-by-step process from traditional education and use CBT to adaptive lifelong learning.

A system for electronic and distance learning DeLC[2] (Stoyanov, 2005b) is developed by Plovdiv University "Paisii Hilendarski"(PU) with Institute of Information Technologies (IIT), BAS- Bulgaria; Telecommunication Research Centre (TRC), University of Limerick, Ireland; Software Technology Research Laboratory (STRL), De Montfort University, Leicester, UK; Software Technology Group (SWT), Humboldt University, Berlin, Germany and the secondary school "Hristo Smirnenski", Brezovo, Bulgaria. In compliance with the main objectives of the project we establish a network of educational DeLC-portals that provide an adapted learning process to their customers and exchange learning resources and services.

The information society requires the application of new methods and approaches to the independent as well as the classroom education of students. According to the characteristics of education in Bulgarian schools DeLC-models and approaches will be applied, which focus primarily on the adaptability and some aspects of their application (Glushkova, 2005). The approach that we follow is related to the study of adaptability as a key feature of any e-Learning system. It can be seen from different viewpoints regarding the planned features, but we will concentrate our attention mainly on those aspects which stem from the pedagogical practice and experience. We will examine the adaptability in terms of:

[1] ICT-Information and communication technologies
[2] DeLC-Distributed e-Learning center

- students' knowledge at the beginning of each learning session;
- students' goals and plans in terms of their training;
- specifics of different school subjects;
- cognitive characteristics of students;
- emotional types and characteristics of students;
- students' habits and preferences;
- temporal characteristics of training;
- achievement of certain states in the learning process;
- training from anywhere;
- mode of access to learning resources etc.

We will explore the implementations of each of these aspects of adaptability in the basic models of the e-Learning system – the user, pedagogical and domain model. On the other hand, we will examine the main features of e-learning, according to the accepted definition above – a personalized learning process from anywhere at any time. Thus, drawn from the educational theory and practice, aspects of adaptability and the main features of e-learning will be implemented in the basic models by which the target adaptive e-Learning system will be created, which concentrates the theoretical and practical experience in it. (Figure1.)

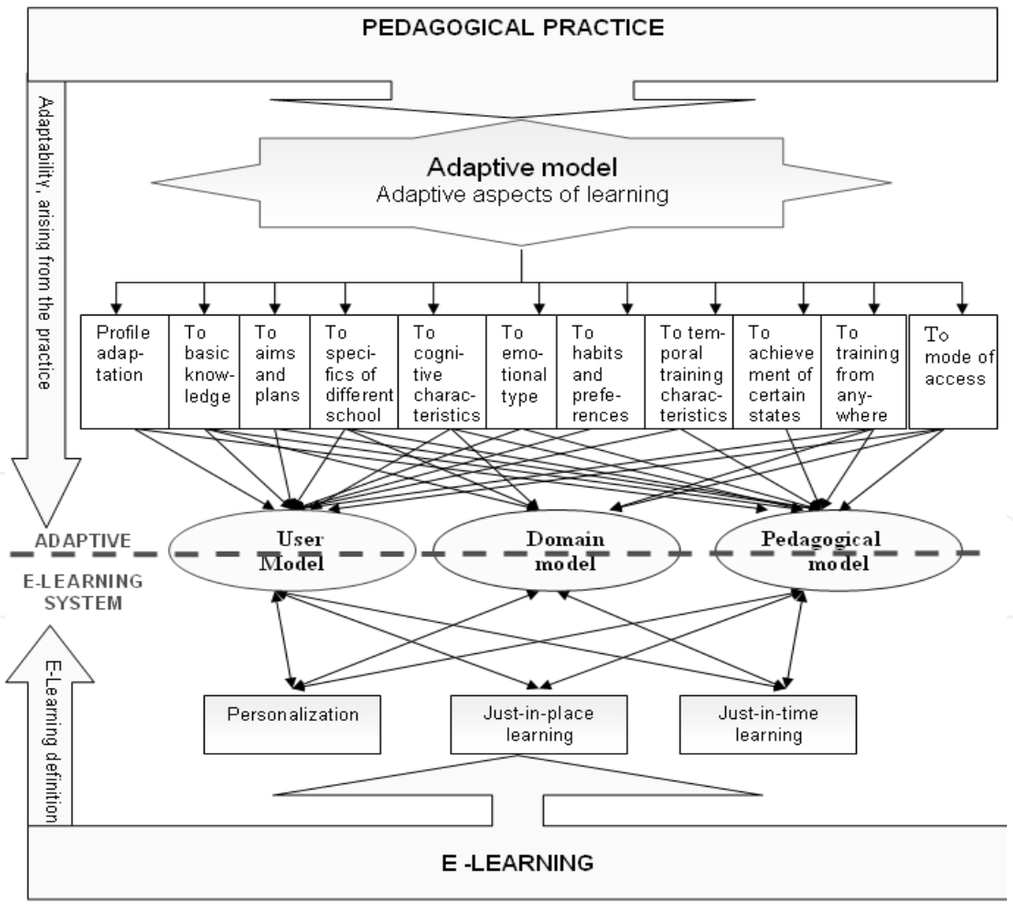


Fig. 1. Relationship between adaptability in the learning process, the basic models of the system and the key features of e-learning.

The three basic models – the user, domain and pedagogical ones, are in a dynamic relationship and dependency between them. Each one affects the status of the others and we need a mechanism for dynamic linking and reporting of relationships between them. Because adaptability in its various aspects is implemented to varying degrees in each of the three basic models, we could look at them as concrete expressions of adaptability of the system for e-learning. Therefore, the basic models are the result of the analysis of possibilities to realize the adaptability of the system and can be used as concrete forms to manage different adaptive aspects.

On the other hand, each of the base models provides mechanisms for the implementation of the key features of the e-Learning system - personalized access to resources from anywhere at any time. The user model provides the most direct property personalization of the learning process and greatly influences the provision of appropriate services and resources anywhere and anytime. The pedagogical model specifies both a customized learning process and appropriate educational process from anywhere, anytime. The domain model is connected with the characteristics of each school subject and provides a mechanism for a more effective personalized learning process, in accordance with the timing of training.

The structure of the manuscript corresponds to the described methodology. In section 2 "Adaptive model of the school e-learning system" discuss various aspects of adaptability associated with personalization of the learning process and access to educational resources from anywhere, anytime. Here are reviewed and adaptive levels of the system in horizontal and vertical plan. Section 3 "Adaptability in the basic models of e-learning system" describes the three basic models of system-UM, DM, PM, in which are implemented the described aspects and levels of adaptability. The results of the partial implementation of the proposed model of e-learning in secondary schools are encouraging. Work on the realization of the full adaptive model continues.

2. Adaptive model of the school e-learning system

Adaptability is an abstract concept which can have different specific forms of manifestation in e-Learning systems. There are different definitions of this concept according to the specific characteristics and goals of any such system. We will consider the adaptability as feature of the system that ensures maximum satisfaction of students and teachers in the e-learning process.

2.1 Adaptability and personalization

A key requirement of the e-learning system, according to the basic definition, is its personalization. This determines the key role of the user model (UM) and the adaptability, which implements it (Brusilovsky, 2001). There are different definitions specifying the UM as a source of user information and mechanisms for changing the behavior of the system according to consumer needs and desires (Kass,1988); as the basis of specific knowledge in dialog systems, which contain information and suggestions on various aspects of the user, related with their behavior during the dialogue with the system (Kobsa,2004) etc.

In its building the model will be based on the view that the knowledge and assumptions about the individual consumer must be able to be separated from other knowledge about the system, which is provided clearly, and can be managed, stored and changed. In terms of the personalization we will look at some basics about the nature of the system views.

2.1.1 Aadaptation to the role of the user

Users of the system can be differentiated according to their role as:

- Students from different classes and forms of education;
- Teachers - as authors of e-content or as trainers and consultants in the educational process;
- Parents who monitor the individual progress of their children;
- School Administration, which analyzes global trends in education for different groups of students, etc.

We will focus our attention mainly on the first two groups. To formalize this type of adaptation we will use a stereotypical approach (Figure 2.).

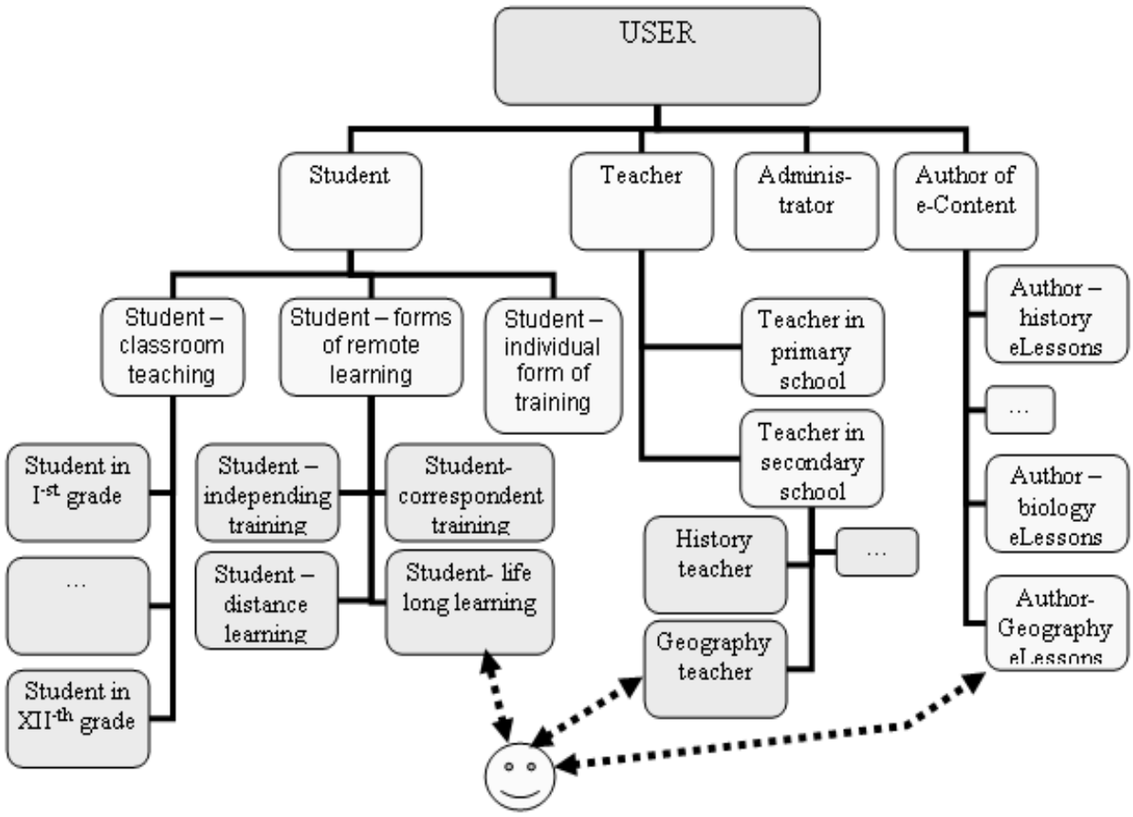


Fig. 2. Stereotypical hierarchy and association of users.

2.1.2 Adaptation to the base knowledge of the student

This aspect of adaptability is associated with defining the areas of consumer knowledge by measuring the level of understanding of various concepts in a subject area (domain) of the particular student. There are different approaches for the realization of this kind of adaptability. Besides the stereotypical approach, we can use the overlay model and the combined approach. The overlay model considers the user's knowledge as a subset of common knowledge, supported by the system. This model is among the dominant types of user models, usually represented as a hierarchical or semantic network of nodes directly linked to concepts from the subject domain. We can use a logical or numerical value for

assessing the student's knowledge. The statutory curriculum in all subjects in school education is a prerequisite for creating domain ontologies, including basic concepts and relationships between them. To each concept there will be attributed a relative numerical value (in%), which shows the degree of certainty of the system about the student's knowledge. We use the initial test, including knowledge of various school subjects for the class to determine basic knowledge of the student who is new to the system. The test results are evaluated on three levels: as a general result for the student; as a comprehensive assessment of each school subject and as an evaluation of the level of knowledge about each concept. The evaluation of the first level is used to determine the stereotypical group of the student; the evaluation of the second level – to determine the student's sub-stereotype in their studies of this subject area, and the results of the third level - to realize the model of overlapping with concepts from the domain.

If a student is known to the system, it has preserved information about their past learning sessions and the results from tests in the respective school subject. These values are initialized by the system when the student is identified at the beginning of this training course and are used in the next training cycle. We assume that the student knows a concept if the system assesses their knowledge at a level above 50%. In an established hierarchical structure, the assessment of any concept is derived from the average score of its subsidiary concepts. We will therefore appreciate the level of knowledge of each term in the formula:

$$Mark_Term = \frac{1}{k}\sum_{i=1}^{k} MarkSubTerm[i] \tag{1}$$

MarkSubTerm [i] is the evaluation of the i-th subsidiary concept; k-number of subsidiaries (1)

Each subsidiary of the concept itself can be regarded as a parent for its subsidiary concepts and receive the same assessment formula, etc. The assessment of student knowledge on each school subject can be calculated as:

$$Mark_Subject = \frac{1}{n}\sum_{j=1}^{n} Mark_Term[j] \tag{2}$$

Mark_Term[j] is the evaluation of the j-th basic concept; n-number of these concepts.

The evaluation of the test as a whole can be present by formula (3). This formula is calculated in% of student achievement, taking into account the weight of each subject in it.

$$MarkTest = \frac{1}{num_test_quest}.\sum_{i=1}^{m} num_quest[l].Mark_Subject[l] \tag{3}$$

Mark_Subject [l] - assessment of students in l-th domain; num_quest [l]- number of questions on this domain, m - number of domains; num_test_quest -total number of questions in the test.

This model has many advantages, mainly related to its simplicity and small resource requirements. However, it is difficult to locate the unknown concept to the individual user, particularly if the school subjects are not represented by a hierarchical tree model but as ontological network structures. Due to the fact that this model should be applied to each

individual student, this would hamper the system and would reduce its effectiveness. To ignore these shortcomings and to multiply the effect of using the above two approaches, we combine them. The combined approach is based on a combination of stereotypical and overlay models. The algorithm includes the following steps:

1. Users are associated to certain stereotyped groups in the hierarchy according to their profiles;
2. The system sets the initial value of 50% of all concepts from all subject areas taught in the previous class. This is determined by the Bulgarian Educational Standards (BES) that determine the minimum level of knowledge in each school subject upon completion of each class. Therefore, students know at least 50 percent from the previous class concepts. After doing the initial test knowledge of each student is valued on three levels:
   - as a common assessment test by formula (3), which is needed for its accession to any substereotype for the form of education and class - "beginner" (<60%), "good" (60% -80%) and "excellent" (>80%);
   - as general knowledge of the school subject. For each topic of the curriculum there will be developed lessons that are classified into three main groups providing "basic knowledge" (to 60%), "good level" (from 60% to 80%) and "high level" (>80%);
   - as an assessment of the level of knowledge about different concepts in the domain. These values are used by the system for selecting the most appropriate lesson containing the necessary information on the topic;
3. If a student is already taught in the system, it stores information about their knowledge of the answers to the questions and doing tests in previous training sessions, and initializes the level of knowledge of the concepts from the domain with these values;
4. The three levels of evaluation are constantly changing during the training, thus the system adapts dynamically to the respective user. If initially, for example, the student was assigned to the sub-stereotype "beginner" with knowledge of the history of "good level" and in the course of training gets higher and higher learning outcomes, he go into the next "high level" of knowledge in this subject area. Thus, the system will offer lessons from increasingly higher level of difficulty in the other subject domains. It will enable them to move to the next sub-stereotype of „good" or even "excellent".

2.1.3 Adapting to the goals and plans of the student

To provide the student with educational resources and services that are appropriate for them, the system needs information about the goals and plans for their implementation. Usually the student does not set them explicitly, which leads to considerable difficulties. The system must have mechanisms to detect them. This can be achieved by monitoring the behaviours of students during the learning process. Since the implementation of elementary, indivisible tasks is trivial, we need a mechanism for decomposing the goals and to create scenarios for the implementation plan of the user. The scenario is a sequence of elementary actions. The process of determining the plans is ongoing. They must be updated dynamically depending on the student's behavior. Periodically, the system must compare this behavior with predetermined conditions corresponding to the current plan. If there is a compliance it is assumed that the user wants the implementation of exactly this

scenario and continues with its execution, otherwise they launch another, a more appropriate, one. In the e-Learning system a special model of the goals and objectives is developed, called Goal & Task Model (GTM), which can be considered as part of the pedagogical model. We will use the mechanisms that have user stereotypes and a cluster model. Originally, stereotypes are activated by static user groups and they define basic stereotype goals. For example, if the student is associated to the sub-stereotype "beginner", the system assigns a common group goal - "to obtain a minimum of knowledge". Then a dialogue starts, which can specify their personal goal. If the student clearly defines their goal, the system temporarily associates them with a particular cluster of users with similar personal goals; it chooses a plan and a scenario for its implementation. If a student does not clearly define its goals, the system defines a common goal for the sub stereotype and starts a scenario for its implementation.
A multiple repetition of the same objectives in turn could influence a change for the typical stereotype goals. So, while adapting to the personal goals of students, the system will adapt to the general objectives in stereotypical groups to which these students belong.

2.1.4 Adaptation to the nature and specifics of the school subjects

The organization of learning according to the specifics of different subjects is another aspect of the adaptability of the systems. For example, if the achievement of key objectives in mathematics education need to pay more attention to the application of theoretical knowledge obtained in solving practical problems through interactive methods and continuous interaction with the system, the training in geography will focus on cartographic material and additional knowledge; in history education attention will be paid to animated diagrams, charts and other methods that help the absorption of factual material. In a classical classroom training the school subjects are grouped in different cultural and educational fields, according to different global didactic goals. Based on this structure we can create a stereotypical hierarchy of educational subject areas, stereotyping them according to the specific teaching objectives and features of the methodological approaches in the learning process.
The topics for each course and for each class are predetermined by the curriculum, in which there are fixed both the level of knowing concepts and the mandatory minimum knowledge of relevant subjects. We will discuss the following groups of e-Learning resources:

- mono-lessons (related to only one domain)
- bi-lessons (linked to more than one domain);
- additional reference materials;
- educational games and other interactive and collaborative services.

The mono-lessons are connected to only one domain. They are developed by teachers in a specialized development tool SELBO[3] (Stoyanov,2008; Mitev, 2008) and include information on certain topics of the syllabus for the class. The authors plan this adapting during the creation of the lessons according to the specifics of the domain and global objectives of the course. Based on the stereotypical hierarchy of domains parent domain are originally initialized with default values, and then subdomains are specified. After specifying the specific domain and subdomain for a particular topic, SELBO initializes relevant ontology

[3] SELBO- SCORM Editor for eLearning Based on Ontologies

and proposes appropriate templates and tools for creating an e-Lesson. For example, if the teacher creates a lesson in Math, SELBO will propose not only the corresponding ontology, but also a structure of the lesson with the formal definition of the concepts, animated charts and diagrams to illustrate the causal links, examples and a large number of practical tasks in which at different levels the knowledge, obtained so far, is verified. The created e-Lessons are recorded in a special repository- Lesson DB and are provided to students for training in this domain. The bi-lessons are linked to concepts from two or more domains. The created lessons are stored in the e-Learning system. They will be provided to students as additional learning resources in some of these domains. The reference materials such as dictionaries, encyclopedias, reference books, etc. are developed as additional learning resources. The students can use them in the training process in various disciplines, regardless of their classes. These materials are mostly related to language education, as well as natural and social school subjects. Educational games can be used for training in all subject areas in a primary school; the interactive forms, online competitions, crosswords, training tests, etc. can be used mainly for training in languages, mathematics, and natural and social subject domains. The discussion forums, consultation and other synchronous and asynchronous communication services can also be used for teaching in all subject domains. The teamwork and project learning can be used largely for training in information technology and social sciences. The use of these kinds of learning resources is particularly important in the training of disabled students.

Therefore, adaptability to the relevant school subjects take place on several levels. Initially the domain in the hierarchy is determined. Then the appropriate subdomain is specified, which is connected with the class and form of education, and the system offers it the appropriate learning resources – e-lessons, reference materials and other interactive and collaborative services.

2.1.5 Adaptation to cognitive characteristics of students

Training in a subject area is an individual process of information search, navigation in space education, formulating hypotheses and making conclusions. To examine the level of cognitive activity we will use estimates of the student of the first two levels - as a comprehensive evaluation of a test and as an evaluation of individual school subjects. In addition to these values we will monitor the number of used training resources and visited navigation links, which in various combinations can provide a different presentation of educational materials. We will use three types of navigation links: "from general to the particular concept", "connection with parallel concepts for search of analogy and formulating hypotheses" and "random link". We will appreciate the learning resources according to their number and types - images, text, animations, videos, etc. The high number of visited images, animations and other support and help materials will be described as the presence of low levels of abstraction. The content will be determined in terms of detail, abstraction and structuring.

In building the model we will determine the direction of change in cognitive activity, the level of general and domain knowledge to students, as well as the observed values of the content, the number of connections and types of learning resources. The tendencies to raise the level of inductive thinking and from there the type of cognitive activity will be defined in the next Table. (+1 trend to increase; -1 - to decrease, 0 - no change).

knowledge in the domain		general level of knowledge		
		"beginner"	„good"	„excellent"
basic knowledge	number of links	+1	+1	0
	Number of info. resources	+1	0	0
	Learning content: - detail - abstraction - structuring	 +1 +1 +1	 +1 +1 0	 +1 0 0
Good level knowledge	number of links	+1	0	-1
	Number of info. resources	0	0	0
	Learning content: - detail - abstraction - structuring	 +1 +1 0	 0 +1 0	 -1 0 0
High level knowledge	number of links	0	-1	-1
	Number of info. resources	0	0	-1
	Learning content: - detail - abstraction - structuring	 0 +1 0	 -1 0 0	 -1 -1 -1

Table 1. Trends in changing of observed parameters and cognitive activity.

The table shows that the proposed model leads to the generation of nine 5-dimensional vectors (4.):

$$MarkTestMarkSubject=(numLinks, numInfRes,contentDetail,contentAbstr,contentStruct) \quad (4)$$

The adaptation to specific cognitive characteristics of students can be realized in the following algorithm:

1. If a student is new to the system, after solving the initial test formulas (1) - (3) determine the extent of its general and domain knowledge. If not - these values are initialized with the entry of the student into the system.
2. According to these values the system defines their general type - "beginner", "good" "excellent" and type it in the selected domain - "basic knowledge", "good level" and "high level".
3. The system initializes the values of vector (4). LMS[4] starts the lesson, which meets these values most closely.
4. The system also has additional resources such as dictionaries, picture atlases, reference books, etc., and additional domain-dependent services. We can create a few basic scenarios, corresponding to the values of the vector, and determine a sequence of presentation of learning resources (tutorials, additional materials and services), so that the learning process will correspond most completely to the type of cognitive activity of students and will help to improve their abstract and inductive thinking.

[4] LMS-Learning management system

For example, if a student from 5th grade is from the stereotype of "beginner" and the sub-stereotype "good" in Teaching Geography, the system sets the values of the five global variables, respectively (1.0, +1, 1.0) and runs a scenario which begins with an educational game (eg a crossword, which increases the interest and number of links). Then LMS selects a lesson and starts it in the topic, in which the information is detailed, and there are more opportunities for connections with additional reference materials or fun - type "curious" or "Do you know that ..." (Figure 3).

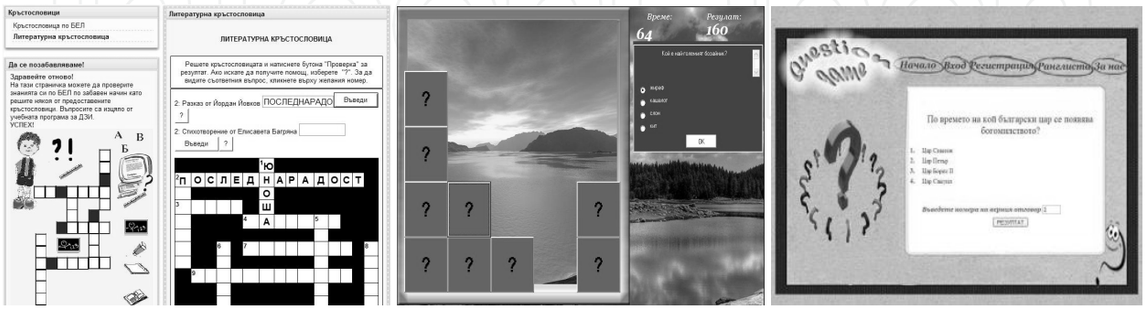


Fig. 3. Servises by type of cognitive activity.

Training can be completed with a test that is desirable to look like an educational game, which ends with encouraging results. If the game is the kind of "puzzle", "quest treasure" or "question game", where each step is connected with the right answer to a question from the lesson, this will increase the degree of abstractness of training.

2.2 Adaptability in accessing the system at any time

Learning is a continuous process of obtaining and processing information throughout life. Over a long period of twelve years students should be familiar with the concepts, tools for research and facts on various school subjects. Therefore, training should be done systematically and incrementally, by following the sequence in the training of various school subjects, and order of study of educational topics in each of them. This sequence is regulated by law in Bulgaria as a defined curriculum and syllabus for each class and form of education. This means that in a specific interval of time (class, term, etc.) in the e-Learning system there must be available only resources from certain school subjects and topics covered in accordance with the relevant curriculum.

Each school subject has its own peculiarities. On their basis we described a model for using different types of learning resources - tutorials, reference materials, educational games and other collaborative learning services. Some of these resources are largely independent of time training - such as reference books, dictionaries, atlases, etc. Others depend on real time (date, time) such as collaborative services, group work, discussion forums, real-time consultations with teachers, etc. The third set of resources, including mostly e-Lessons and tests, can be considered from various aspects in terms of time usage. On the one hand they depend on relative timing of training but on the other, they depend on real time, as these lessons and tests will be available only for a certain time interval (eg one month). This is due to the fact that the electronic lesson is a combination of three elements: structure, content and process. The first element doesn't depend on time; the second depends on the real time, to the beginning of which a student must have already acquired basic knowledge and skills;

and the third element depends on the relative progress of training time. Therefore we can describe the training period from two aspects (Figure 4.):

- as real-time with characteristics date and time or time interval;
- as relative time. It is characterized by the achievement of certain conditions.

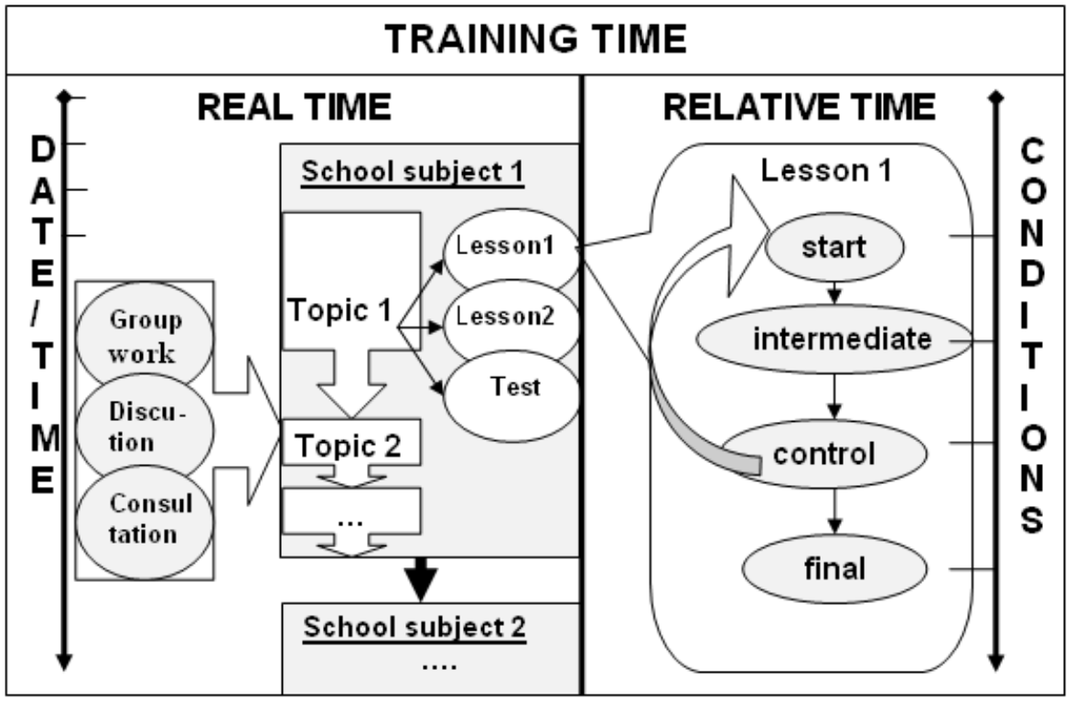


Fig. 4. Adapting the system in terms of training time.

In this sense, if a student from 5th grade wants to be trained in the system, he will have access only to the 5th grade school subjects and will not be able to study physics for example, because he doesn't have the necessary basic knowledge in mathematics. Therefore, the student must go through the topics successively and thus build a system of knowledge of this school subject. When he starts an e-lesson in the current theme, the content of this lesson will depend on the real time (eg, the time when the student is in the 5th grade). However, the learning process will depend on the relative conditions, through which it passes successively depending on the educational scenario and the behavior of the student during the session. When the training ends with a test, it can be performed with any group of students from the fifth grade, who study the same topic in this real period of time. Then it is necessary to set a specific date and time. The evaluation of the student can be done personally, in which case it is relative in time. When in the course of training the student wishes to comment on the learning material with other students from their stereotyped group, or to ask their questions to the teacher, they can do it in real time. In organizing the group work it is also necessary to plan and organize various activities in real time.

There are many mechanisms that provide opportunities for learning activities in real time. Therefore we will concentrate our attention mainly on the implementation of the personalized learning process in relative time.

In order to observe the changes in the educational system we must follow certain values of its parameters. The condition is the vector with specific values of the observed parameters. The adapting of the system in this aspect requires the definition and classification of meaningful conditions. We can have a look at a few basic conditions:

- a start-condition in which LMS starts the e-Lesson and the learning process begins;
- an intermediate state - a key condition that determines whether the learning scenario is performed correctly;
- a control condition - when the system enters this state, the learning process must be interrupted and the current scenario must be corrected;
- a final state - a condition that determines the successful conclusion of the learning process.

This aspect on the adaptability of the system is directly related to the adaptation to user goals and plans. Dynamically, during the learning process the system checks the values of the key parameters and a predetermined combination of them detects the presence of some of the above types of conditions. Once you have determined the school subject and theme, the system identifies the educational goal - personal (if it is defined clearly) or the total for the stereotypical group. LMS initializes a start-condition and initiates the learning process, while continuously monitoring the change of the values of the observed parameters. If the process is in an intermediate state, this means that the scenario is appropriate for the particular student and the teaching and learning continue to the next state. If the system gets into a control condition, then the process stops and a new training scenario starts. When the parameters' values determine the final condition, we assume that the goal is achieved and the learning process is completed.

If the author of an electronic lesson determines the duration of an operation, the end of this time period will automatically initialize the control condition, which, if it meets the conditions for a successful completion of the training, passed to a final condition. Otherwise, the system returns to the initial state, and there is launched a process to search for a more suitable lesson on the same topic. If a student has not successfully completed the training due to lack of knowledge, a new easier lesson on the same topic is sought and launched and the student is associated to the lower sub-stereotyped group – e.g. from "high level" to "good level of knowledge". If the cause is related to the speed of the current learning process, the cognitive type of the student must be corrected.

2.3 An adaptation to the manner of access to learning materials

The adaptation to the manner of access to learning materials is another important aspect of the modeling system. If the user uses different standard or mobile devices to gain access during a learning session, it is necessary to develop a mechanism and describe the different basic scenarios for the realization of this task. Access can be realized in two ways: fixed or mobile. In the first case, access is obtained through the browser. Due to some differences in the functionality of the most popular browsers, as well as consumer preferences, it is necessary to use a mechanism for transmitting this information to the system in order to provide GUI[5], which is appropriate for the browser. If the user uses a mobile device, the system must keep information about the characteristics of this device and adapt to them.

[5] GUI- Graphical User Interface

This task requires the standardization of access and use of an intelligent adaptation to different types of mobile devices.
If the user is located near the school, they can use wireless mobile access. The Infrastructure model is based on the principles of the system DeLC for providing mobile services (Stoyanov, 2008b). When the user comes within the range of any of the info-stations in the area of the school, the system activates services for the supplying of information. Depending on the device for mobile access - GSM, PDA, laptop, etc., the Info-station establishes a connection to the info-center, initializes the parameters of communication and maintains them until the end of the session with this device. Since various events may occur in the training process, which are related mainly to the change of the mobile device or user location, we can consider the following basic scenarios:

1. The mobile device and user location are not changed to the end of the training process. In this case the e-Learning session continues by adaptation to the specifics of the device.
2. The mobile device remains the same, but the user's location is changed. At first the user is within range of one info-station, but in the session they move and go within range of another info-station. Since the session is established between a mobile device and an info-center by info-stations, a mechanism is needed to transmit the parameters from one info-station to another. This scenario is realized at an info-center.
3. During the learning session, the mobile device is changed, but the user's location remains the same. The replacement of the mobile device leads to filing of its parameters to the info-station, which must suspend the session, to replace the old values of the parameters with the new ones; to transmit these parameters to the info-centre; to adapt the transmitted training resources to the parameters of the new device, and then to resume the transmission of information. Therefore, if the info-station establishes a session break, it must wait a certain time to change the mobile device, prior to transmitting information to the info-center to end the session. This scenario is realized at an info-station level.
4. During the same user session both the mobile device and user location are changed. If initially the user changes the mobile device for training and then their location, as the system passes within range of another info-station, it starts with scenario 3, followed by scenario 2. If initially the user passes within range of another info-station, and then immediately changes the device, the system starts with scenario 2 of the info-center, followed by scenario 3 of the info-station. Formally, there is a third possibility, in which these changes occur simultaneously. To ensure the continuation of the user's session in this case it is necessary to develop a model for a dynamic communication between the Info-center and Info-stations. The user session will be stopped and there will start the initialization of the parameters of a new device to adapt the graphical interface according to these parameters. Finally the signal must be checked down from another info-station in order to pass parameters from the new device to this info-station and to connect and resume the session.

2.4 Adaptive levels

The main elements of the adaptive model are "condition-action" rules that change the parameters of the environment and realize the adaptation to a user‘s knowledge, goals,

abilities, preferences, etc. The implementation of the model requires the consideration of various aspects of adaptability of horizontal and vertical principles. The first one we presented in the previous section. We discussed the different aspects of adaptability and the interactions between them. The second one is based on the classification of the species' adaptability to the level of implementation and realization in the course of the training. We will distinguish the following three adaptive levels:

1. **Elementary adaptive level (EAL) –** An adaptation to the static profile information of the student as name, class, type of training, the type of device to access educational resources (mobile or fixed), etc. At this level the adaptation is based on a stereotype approach. The teachers generate a set of e-Lessons for learning in typically school subject domains, based on typical teaching objectives, methods and techniques relating to a particular group of traditional users (eg. regular education fifth grade, math). The educational resources are common to all groups of students. The adaptability of this level is realized in the phase of preparation of the typical training materials before the beginning of work in the system.
2. **Static adaptive level (SAL) –** This level builds on the elementary level and is directly related to mechanisms to provide adequate learning materials for individual students according to their knowledge base, personal goals, plans and ambitions. Adaptation mechanisms are set in advance by the authors of educational resources and services, foreseeing the actions and behavior of the typical learner. This can be realized based on the log-information about past interactions between this student and LMS and a set of rules set by the authors of the educational materials. The basic knowledge of students is determined by initial testing or by the current results from already completed training sessions. According to the level of this knowledge the system classifies the student to some sub-stereotype - beginner, good, excellent. The system then compares individual goals and plans of the student with the global didactic goals and targets, according to the Bulgarian educational requirements. As a result, from the Lesson DB is extracted this, which most fully meets the basic knowledge, stereotypical characteristics, objectives and plans of the individual student. Adaptability of this level is achieved before the system operation or in its initial phase when the concrete training scenario is specified. Adaptability can be improved significantly if using intelligent agents as personal assistants for each student, which will monitor and guide the entire learning process.
3. **Dynamic adaptive level (DAL) –** This level complements and builds on the previous two ones. It is related to the dynamic interaction between students and the system during the training (in run-time). After selecting the most appropriate e-lesson in the previous adaptive level, LMS starts the learning process as a sequence of actions set by the author of e-content and the behavior of the individual student. Based on the intermediate results during the training and information from previous sessions, the system adapts dynamically to the changing characteristics of the learning environment, generates new "condition-action" rules and continues the training process or starts a new more appropriate e-Lesson. At this level, in the process of dynamic interaction between learners and the training system it is essential proactive to use intelligent proactive agents, who interact with the system and with each other, so as to provide a flexible change of training scenarios, depending on the behaviors and actions of the individual student.

3. Adaptability in the basic models of e-learning system

The examined aspects of adaptability are not independent of one another. They are in constant interaction and interdependence among themselves. Each of them is implemented to varying degrees in the basic models of the e-learning system – user model, pedagogical model and domain model.

3.1 User modeling

The user model is an important element of any educational system in order to be personalized and tailored to the individual characteristics, knowledge, goals, preferences and requirements of learners. We will separate the information about students from the rest of the knowledge in the system and will describe it on three levels - elementary, static and dynamic. The first level includes the profile information with individual user characteristics such as name, grade, form of education, birth date, e-mail, global goals, preferences, etc. The next level describes the stereotypical hierarchy where users with similar characteristics are combined and presented together in the system. The dynamic level includes specific information about the student in the process of working with the learning environment. It is related rather to the studied school subjects and the user's evaluation during a real session. This defines the relationship between the user model and the adaptability to the student's knowledge and the need for application of a combined approach (Glushkova, 2006).

The user model describes the concept of the system for a user's knowledge, interests and goals. This model must be continuously updated according to the dynamic changes in the accumulation of knowledge. The algorithm involves the following steps:

- Step 1. filling the static profile information. According to the form of training and student class, the user is associated to a certain sub-stereotype in a stereotypical hierarchy. The initial parameters of the model are completed in a dialog mode or are set the default values from the common stereotype model.
- Step 2. According to the stereotype, which the student joins, the system offers a comprehensive initial test. The results are used to initialize the individual user's profile and are grouped into three levels: as a general assessment, an evaluation of knowledge in each domain and an evaluation of each concept. (formulas (1),(2),(3)).
- Step 3. In the dialog mode the system determines the school subject, topic, personal goals and plans. Then it searches, offers and starts an appropriate lesson, according to the student stereotype ("beginner" , "good" and "excellent") and its level of knowledge in the domain.
- Step 4. Conducting of the individual learning process.
- Step 5. Saving the new values for the student's knowledge of the three levels - as a general assessment; level of knowledge in the domain and a valuation of each concept. The values are calculated by the formula (5):

$$New\ score = average\ (continuous\ assessment,\ assessment\ from\ the\ last\ session) \quad (5)$$

- Step 6. Updating of the student's profile information.

The dynamic level of the user model supports interaction with other models of the system. The student's basic knowledge is associated with the domain model. The pedagogical model is related to the GTM which is initialized by the user profile (Figure 5).

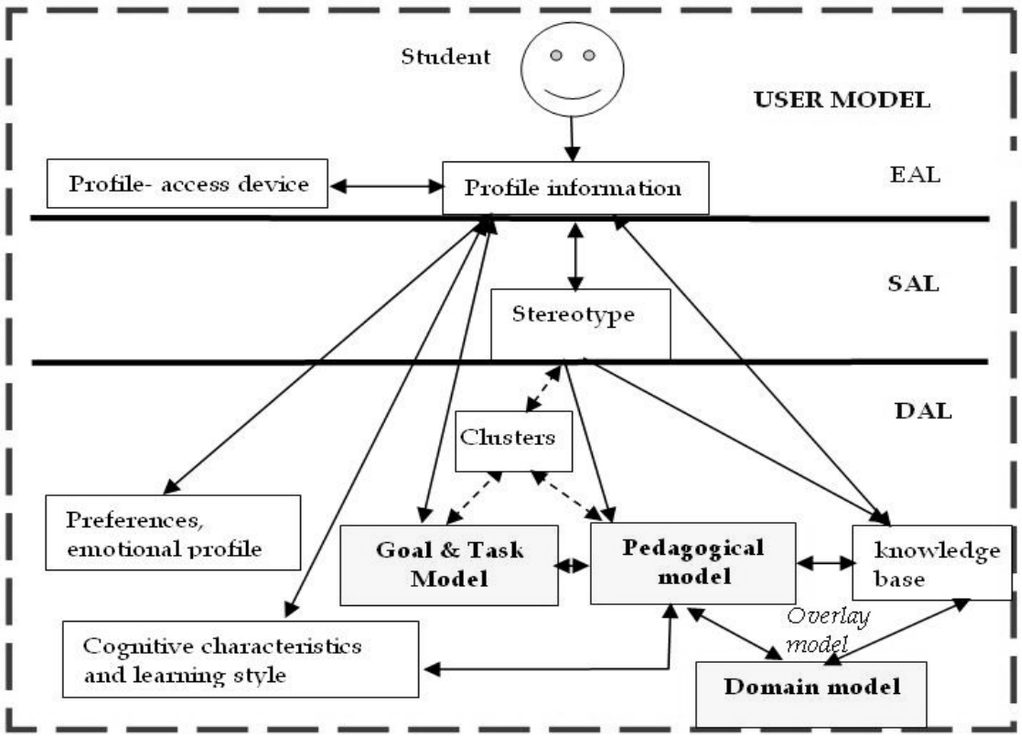


Fig. 5. Interaction of the user model with other basic models of the system.

3.2 Domain model

The domain model (DM) is one of the logical models for each e-learning system due to the need for structuring, clear presentation and processing of knowledge in different subject areas. The model presents the various domains in the system, regardless of the other knowledge in it. The DM is a conceptual model describing the key for the domain objects and relationships between them. For formal description logical structures can be used as frames, semantic networks, ontologies, a system of rules, etc. The model can be realized in the process of software development: the concepts are presented as classes: their characteristics and properties such as attributes and methods. We accept this approach and use ontologies and UML class-diagrams to describe concepts and relations between them.

The process of creating DM goes through several stages. Initially, we define a hierarchy of subject areas according to the curriculum and describe it as a meta-ontology. In the classes, representing different groups of domains, there are described relations with the appropriate services or additional resources such as dictionaries, encyclopedias, reference books, etc. The next step is a presentation of the specific subject areas into the system. Each domain contains semantic information, which is formalized by the creation of domain ontologies. For each area we can create different ontologies for the representation of knowledge. The knowledge in each academic discipline is expanded and supplemented into each next class, as each concept or relation is studied at different levels. For example, the term "triangle" is originally defined in the third grade as a "closed broken line with three vertices" and connects with the terms "vertex" and "line". In the fourth grade the students study the types of triangles; in the fifth - the term "person of triangle", in the seventh - the triangle is already a part of the plane,

in the ninth and tenth its metric and trigonometric relationships are discussed, and in the twelfth the methodology of analytic geometry is examined. This approach for accumulation of knowledge is used in the process of creating ontologies for different classes with "part_of" connections. Given the fact that across school subjects there are links and dependencies between them that will be reflected in the appropriate ontologies, we get a complex multi-layered network of ontologies and links between them.

3.3 Pedagogical model

The pedagogical model (PM) is key to any training school system. It interacts with other basic models, ensures the acquisition of specified knowledge and the achievement of specific didactic objectives. The model will be looked at from two aspects - during the creation of electronic tutorials and the training of students in the system.

As already mentioned, training resources and tutorials are created by teachers in a special domain-based development environment. Let us concentrate our attention on two basic characteristics of the lesson - the content and structure. The content of lessons is related to specific topics, which in turn are part of specific domains. Therefore, the e-lesson is a semantic structure of the knowledge contained in a particular area. Formally, it is an instance of a particular part of the ontology, describing the subject area, in which the individual concepts are associated with real information resources that represent them. The structure of the e-lesson depends on defined didactic goals and the characteristics of the subject area. The didactic goals, that are related to obtaining certain knowledge, determine the type of lessons (for new knowledge, practice, summary and testing). To formalize them we will use Bloom's taxonomy, according to which there are six cognitive levels - knowledge, comprehension, application, analysis, synthesis and evaluation (Bloom,1956). The author of the lesson can structure the learning resources in different ways depending on their goals. As a result of studies on the structure of the lesson came to the conclusion that there is similarity between different kinds e-Lessons and the cognitive levels of Bloom's taxonomy. I.e. formalization of the different kinds of e-lessons according to didactic goals can be realized by creating standard scenarios for training and templates, that describe them. Each template we will seen as a combination of: learning resources, structure and scenario for training

The created e-Learning resources are stored in online repository. They are associated with concepts of ontologies and provide itself into the development environment for creating e-Lessons. The structure of lesson is determined by the author using the parameterization of some of the basic templates. Thus creates an instance of the template in which no free parameters. To conduct educational process itself must determine the training scenario. It is directly related to didactic goals, basic knowledge and behavior of students. The authors of the lessons describe the various options and determine the rules under which will be held the learning process. Formalization of these scenarios can be realized also through the parameterization of the basic templates. Therefore, the e-Lesson will be presented in the system as a specific instance of some basic template, which (by setting values of parameters) is associated with specific learning resources. In this template are determined the structure and rules for training (Figure 6). Creation of educational resources(SCOs[6]) will not be examined in the model, as they are created as independent units, stored into special SCO-

[6] SCO – Sharable content object

repository. They are used for creation of e-Lessons and are associated with the concepts from different ontologies.

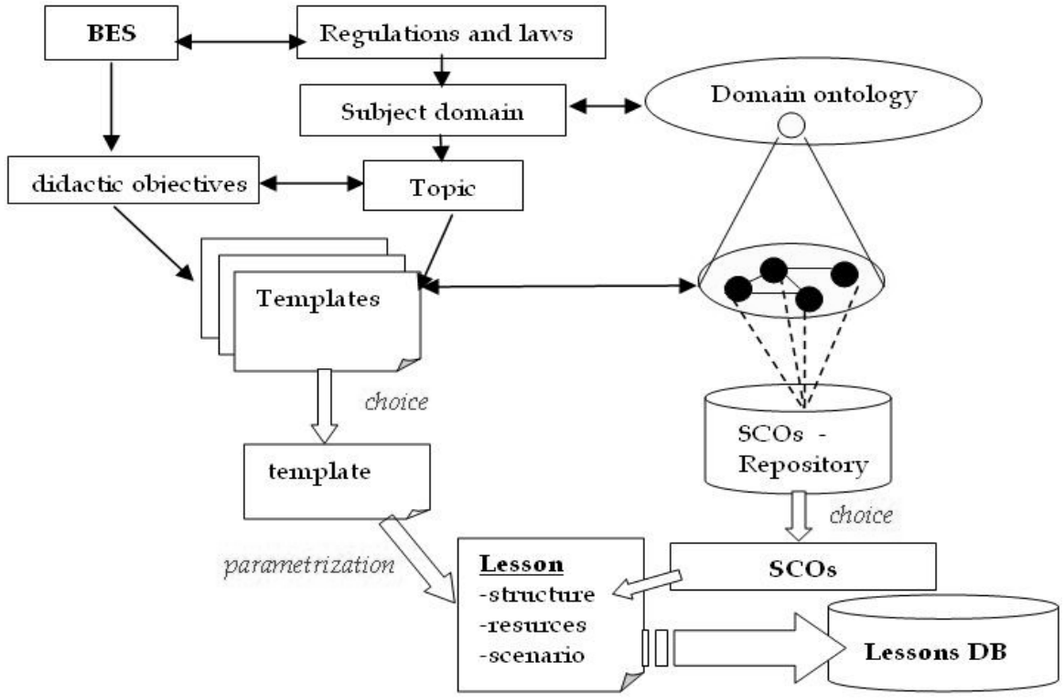


Fig. 6. The pedagogical model in the process of creating e-lessons.

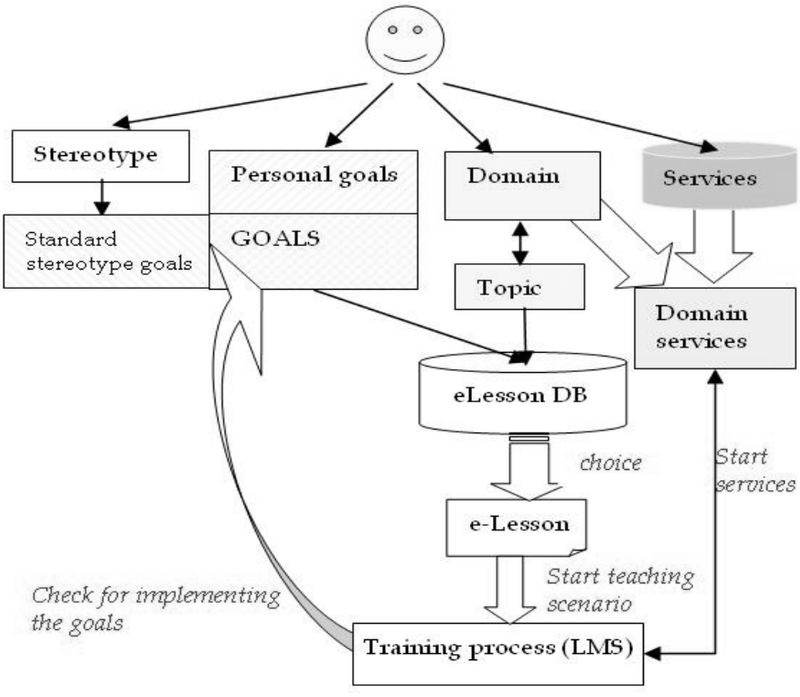


Fig. 7. The pedagogical model in process of learning.

The second aspect, which we will discuss the pedagogical model is a learning process in e-Learning environment. After identification, the student is associated with a particular Stereotype, which is connected to a system of standard didactic goals, pedagogical theory and practice. The student can determine their own goals that overlap with the standard ones and define the goals with which the student is present in the system. After selecting a specific school subject and topic, from the services available in the system, are selected ones which are suitable for the particular domain and theme. According to the didactic goals and theme from the Lesson DB will be elected the appropriate e-Lessons. Depending on individual student characteristics such as basic knowledge, cognitive type, emotional activity, etc., the system defines one of these lessons and LMS starts the training process. During the learning process the student can use the services defined by the educational scenario. The LMS monitors the level of implementation of goals and if it is established that they are inappropriate, it is updated and the process starts all over again (Fig.7).

4. Conclusion

The implementation of proposals in the manuscript adaptive model will allow for better training of students from independent form of training and distance learning, and pupils with special educational needs and disabled children. Based on figure 1 we designed an adaptive model on the basis of which is developed the first version of education e-learning portal of the secondary school "Hristo Smirnenski" Brezovo (Glushkova, 2007). According to the profile characteristics, form of education, basic knowledge and goals, students have access to resources and services, which are appropriate for their learning. E-lessons are created according to SCORM[7] standard *(http://www.adlnet.gov)*. We use basic templates from SCORM Best Practices Guide for Content Developers (*http://www.dokeos.com/doc/thirdparty/ScormBestPracticesContentDev.pdf*) and parameterized them according to specific didactic goals and requirements of the authors. The authors create standardized electronic lessons through a special domain-oriented authoring tool (SELBO). It uses intelligent editors (a combination of component and agent) to manipulate the learning content and aid the content developer during the content creation. Ontologies provide developers with predefined resources covering a specific domain that can be used directly in the content. SELBO also utilizes education templates that define pedagogical goals and agents to govern them. Furthermore, the environment employs schemes for adapting itself to its user and for collaborating with the SCORM-learning management system (LMS). The establishment of educational environment is based on adapted nine-layer architecture of the corporate portal of Delphi group. For a particular realization of the educational portal is used portal framework Liferay (*http://liferay.com*), into which is implemented LMS of SCORM RTE[8]. There are many services that support the training process in different subjects and raise the level of interactivity in learning (Glushkova, 2008).

We continue the work on the implementation an agent-oriented version of e-learning system, as well as the realization of scenarios related to adaptability in mobile learning. The team elaborate model for management of the dynamic adaptive level by ITL and polices (Sloman, 1994).

[7] SCORM- Sharable content object reference model

[8] RTE – Run-time environment

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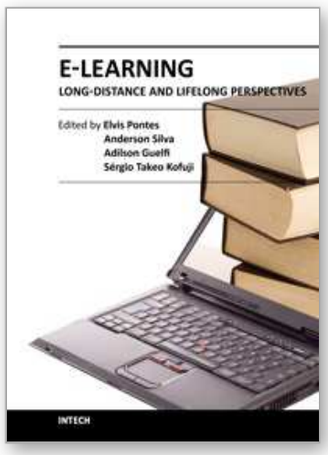
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E-Learning - Long-Distance and Lifelong Perspectives

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E-learning enables students to pace their studies according to their needs, making learning accessible to (1) people who do not have enough free time for studying - they can program their lessons according to their available schedule; (2) those far from a school (geographical issues), or the ones unable to attend classes due to some physical or medical restriction. Therefore, cultural, geographical and physical obstructions can be removed, making it possible for students to select their path and time for the learning course. Students are then allowed to choose the main objectives they are suitable to fulfill. This book regards E-learning challenges, opening a way to understand and discuss questions related to long-distance and lifelong learning, E-learning for people with special needs and, lastly, presenting case study about the relationship between the quality of interaction and the quality of learning achieved in experiences of E-learning formation.

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InTech Europe
University Campus STeP Ri
Slavka Krautzeka 83/A
51000 Rijeka, Croatia
Phone: +385 (51) 770 447
Fax: +385 (51) 686 166
www.intechopen.com

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

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