Modelling of e-Learning Processes:
an Approach Used in Plovdiv e-University

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Abstract: Most of the e-Learning systems don't have means for modelling a learning process and in particular the structure and content of the virtual learning courses. In PeU learning environment virtual courses are designed by using directed graph with nodes of two types: informative (learning materials or groups of them – AND, OR, MORE etc.) and controlling (Join_Split, Repeat, Check_Point, etc.). For the development and editing of courses in PeU, the authors use environment with visual programming elements.
Key words: Modelling of e-Learning Process, Learning Graph, Test Assessment

1.   Introduction

The main objectives aimed at during the design and creation of the future e-Learning Environments (ELE) are based on platforms not depending on the application area. Such environments should support the learner through the whole learning period – from the defining of the goals to the assessment of the results and construction of courses that are user adapted.

The dynamic progress of the information and communication technologies led to a certain **dropping behind of the process of creation of adequate education software.** Most ELE prototypes don't provide environments for publishing the learning materials by the authors or for reusable learning objects or means. A serious disadvantage of the known systems is the accent on the formal learning environment (operations and manipulations on objects) instead of on the instructive side (concepts and relations between them). Only some of the existing virtual environments offer services for the authors of learning materials – distance **publishing and republishing** of learning materials in a database (DB). Other disadvantages of the known systems are: the learning materials are mainly in English; high price; the system use from teachers and learners requires Internet connection; few possibilities for feedback are offered to the teachers, etc.

Despite of the laid down **tendencies in the development of the e-Learning systems**, it's difficult to predict the determining characteristics of the next stage of their development. The amazing progress of Information Technologies in USA and the dropping behind of Europe in the development of e-Learning, caused the initiative 'e-Learning: Designing tomorrow's education' [3], ratified by the European commission on 25.5.2000. The answers of the following **questions** are especially important: how will the future e-Learning systems look like; what kind of new ideas and technologies will be used for their realization; is it possible to predict their main functional characteristics and elements; what new methods for learning, support, communication and management of the process of education will be provided, etc.

The main three trends in the development of the future ELE are related to the application of *cognitive methods/elements*, *integrating with other subsystems* (of management, planning, etc.) and changes influenced by the new technologies [13].

Examples of **elements and models** supposed to be used in the realization of future ELE are: metadata and ontology for knowledge representation; fuzzy models of the learners and the teachers; intelligent support of the creation process of learning materials; test assignments and courses; learning cooperation and support; etc. It's also predicted that there will exist automated support of dynamic learning strategies based on: specific user necessities; semantic Web-structures; Web-management of learning objects; teacher's models (including formal models of professional qualities); grouping of learners with similar models and creation of environments for group work; communication with the teachers and information exchange with them; relation of the learner's models with the

corresponding standards and representation of the results of the learners, etc. It is desirable that the learners have the possibility to choose the set of learning topics (in the ontology of the given subject domain) and to generate courses, adapted to their capabilities.

The first researches in the field of Virtual University Environments in Bulgaria were carried out in the Sofia University [8, 9, 10] – the ARCADE system, the Plovdiv university [2, 12] – PeU, the Rousse University – the eLSe system [6] and Technical University of Sofia – the FLAME system [5].

2.   PeU e-Learning System

The PeU 2.0 is a software product with design and realization based on PeU 1.0. PeU 2.0 not only keeps the main characteristics of its prototype but also expands the functional possibilities of its **five subsystems** (information, authoring, test, communication and administration). The system supports **six types of users**: guest, student, teacher, author, administrator and system administrator.

The authoring subsystem supports virtual learning materials in a DB (with .doc, .pdf, .txt, .html, .mp3, .wav, .midi, .mpeg, .mpg, .avi, .gif and .exe format), which can be published and edited at a distance. Each learning course consists of virtual learning materials from different authors on the base of concepts. The author models the structure of the learning courses, programs and the learning process with visual programming means.

The test subsystem supports creation, editing and assessment of 18 types of test questions and assignments [11]. 16 of them are elementary, 2 – composed and 14 can be automatically assessed. The first type of composed assignments is presented as a list of elementary assignments, included in a DB, and the second one allows the author to design a list of own assignments. The assessments can be made automatically (by default), manually (by the teacher) and using external procedure (specialized program that makes the check and assessment).

An independent module for **offline** creation of test assignments is under development. Unlike them the virtual learning materials can be included in the PeU 2.0 after their creation in different program environments. The data transfer from PeU 2.0 to the offline module and back is to be done via XML format.

The information subsystem provides means for supplying the user with the learning content and for this an **index of the concepts** is supported together with a list of corresponding learning materials. The subsystem supports queries for: the users, the materials, the courses, the test assignments and questions, the concepts and the programs.

The information for the student's progress is saved and this allows continuing of the learning process (according to the corresponding learning plan) even after its interruption. The learners can take notes during the learning course.

Unlike Peu 1.0, the learning subsystem enables new features like **printing** of the learning course (or of a part of it) on paper, **downloading** the learning course as hypertext document (including on a CD-ROM disc) with possibilities for separate reviewing.

For providing regional, national and international cooperation, the environment provides portability to/from other platforms by bringing out the structure and data of the integrated DB in **XML format**. A converter with possibility for choosing a standard for e-Learning, in which the virtual learning resources to be transformed, is under development.

The **communication subsystem** proposes information and means for supporting different types of relationship among users: **asynchronic** (e-mail, forum, calendar, reminder, shared files, personal web pages, SMS) and **synchronic** (chat, audio conference, face-to-face meeting).

The **administrative subsystem** registers the users and supports the DB with information about the different subjects and objects of education (learning groups, authors, teachers, administrators, guests, items and messages from the reminder, rooms and messages of the chat, etc.), and supports different relations among the users (sharing of learning materials, test assignments, courses and programs).

The creation (generation; visualization; change and deletion) of a learning course can be done with specific access rights. The accessible learning courses can be copied in a DB and only the authorized users can use them. After the author of a certain learning course gives the right for its use, following changes in the course (even if they are made by the owner of the author's rights) are not presented in the content of the given learning materials. As a result the DB may contain more than one versions of one and the same learning course (or material) – versions that are created or changed for different levels, cases and periods of use.

An important distinguishing characteristic of the system is the link with a *virtual library* for access to additional learning materials. Links to the library Internet subject catalogue of the Plovdiv institutes of higher education are provided, together with their local library electronic catalogues and the users may use a set of remote library services.

3.   Modelling e-Learning Process

PeU 2.0 has characteristics that make it different from other ELE: presentation of a learning course (based on concepts and relations between them), description of the learning materials (via different characteristics), etc.

Learning is built on the base of **concept approach**. Learning concepts can be presented in different points of view, called **layers**. The examples of different layers in case of presenting one concept are: introduction, definition, example, classification, comparison and application. Each concept, and therefore the learning materials connected with it, has characteristics, called **resources** [7]. Examples of resources are: knowledge level, time, price, etc. For each concept in a learned subject domain there is a view point (layer) and a list of couples (resource, value of resource).

The structure and content of the learning courses, included in PeU, are modelled with a **directed graph**, whose nodes are learning materials (lectures and assignments, groups of them) or controlling ones, and the edges – relations of type *predecessor_of.* A special **Graph Editor** is used for developing, creation and editing of learning courses (Fig. 1).

Figure 1. The Graph Editor Menu (a learning course under development)

The used groups are *AND*, *OR*, *More* and *SubGroup*, and the controlling nodes – *Check_Point*, *Join_Split (n, m)*, *Repeat*, *Begin* and *End* (Table 1).

Table 1. Elements of a PeU graph, modelling learning process

Graphical sign	Function
Н	Begin (0 inputs, 1 output)
К	End (n inputs, 0 outputs)
Т	Test assignment (n inputs, 1 output)
	Learning material (n inputs, 1 output)
	SubGroup (1 input, 1 output) presents a subgroup of learning materials and test assignments
И	*AND* Group (1 input, 1 output) contains a set of learning materials and test assignments
ИЛИ	*OR* Group (1 input, 1 output) contains a set of learning materials and test assignments
ОЩЕ	*MORE* Group (1 input, 1 output) contains a set of (additional) learning materials and test assignments
⟶	Relation of type *predecessor_of*
	Check_Point (1 input; from 1 to 5 outputs) contains a list of new test assignments and/or pointers to other assignments of the learning course
M L	*Join_Split* (n, m) (at least n inputs and at least m outputs)
N	*Repeat* (1 input, 1 output and 1 pointer to the beginning of the repeating section)

The *AND* group determines the compulsory learning materials for which the learning sequence is not important. The *OR* group with optional learning materials allows easy realization of the eligibility in education (the learner can choose the sequence of the learned materials). The *MORE* group leaves additional materials. The *SubGroup* realizes the idea for presentation of a learning process including part of the course as a substructure.

The nodes of type *Check_Point* provide adapting of the strategy for implementing the education towards the learner depending on his/her current results. The current results are received on the basis of the assignments included in the *Check_Point* (e.g. as an average grade of these assignments or as a direct assessment by the teacher). The assignments can be included in the learning graph and (eventually) accomplished earlier or can be new – specific for the *Check_Point*. The interpretation of the checkpoints in the process of virtual education allows effective realization of the **feedback** learner – teacher: the reaching of a *Check_Point* by a concrete learner is automatically indicated in the teacher's notebook for the corresponding course – it is expected that either a check of assignments

will be done (usually for the open test) or a resolution for the final assessment of the assignments, included in the *Check_Point*. In some cases the assessment is automatically performed by the system. Therefore, depending on the obtained results, the student may continue his/her learning (including own choice in some cases) using different graph paths. Passing over the *Check_Point* can be done only after assessment (automatic or manual) of the included test assignments.

The nodes *Join_Split* (n, m) and *Repeat* allow effective realization of the main elements of a learning process such as: achieving a goal with tracing of exactly one graph path, at least n paths, or any m paths to the goal; repetition of a set of learning actions not more than m times; transition to the next action only if the current state is reached at least by n different ways (paths); repetition of a path not more than n times, etc.

When used in combination, the checkpoints and the controlling nodes allow realization of learning strategies, known in various education systems and attained by specialized modules for each separate learning course. For example, it's not problematic the authors of the courses to realize different learning strategies and didactic methods depending on: the achievement of a learning goal, the next (first, second, etc.) assignment, the increasing or decreasing in the learner's results, etc.

The proposed approach allows not only the application of traditional methods for education management but the experimenting of new didactic approaches too. Such a possibility (as far as we know) isn't offered by any other e-Learning system.

4. Conclusion

PeU 2.0 is comparable to the best European samples for ELE [1]. The system not only satisfies almost all of the 108 criteria for assessment and comparison of the virtual learning environments [4], but also possesses a number of unique functional characteristics:
- modelling the learned **subject domain** as a set of concepts;
- description of **learning materials** (through lists of learning concepts, layers and used resources);
- modelling the **learning course** and logic relations between the concepts used in it with means of the visual programming;
- support of an **integrated DB** (including the subject domains, learning materials, learning courses, educational plans, etc.);
- automatic construction, creation, editing, viewing and assessment of **18 types of tests**;
- use of almost all kinds of **asynchronic and synchronic communication** between users, etc.

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