Scientific Research and Essays Vol. 7(11), pp. 1212-1229, 23 March, 2012
Available online at http://www.academicjournals.org/SRE
DOI: 10.5897/SRE11.1781
ISSN 1992-2248 ©2012 Academic Journals

Full Length Research Paper

ILOMPEL: Information and metadata modeling for personalized e-learning

Dragica Jovanovic[1], Malisa Zizovic[2] and Danijela Milosevic[3]*

[1]Railway College, Zdravka Celara 1, 11000 Belgrade, Serbia.
[2]University Singidunum, Danijelova 32, 11000 Belgrade, Serbia.
[3]Technical Faculty Cacak, University of Kragujevac, Svetog Save 65, 32000 Cacak, Serbia.

Accepted 10 January, 2012

This paper presents the pedagogically and psychologically engaged Personalized e-Learning Course Model (PeLCoM) and the Information Learning Object Model for Personalized e-Learning (ILOMPeL), based on variations of students' intellectual profiles. Developed information learning object model makes clear the set of learning resources and organizes them in the way that it is possible to pack them, sequence, and to compose them into a complex learning units, offering wide range of the personalized e-learning experience. Furthermore, the three types of LO are noticed and they are responsible for: the course content itself, content presentation and content aggregation. The role of each LO is described with a set of metadata, composed of the vector XYZ. The metadata defines properties, relationships and dependences between the learning objects and provides LO reusability, LO aggregations and LO sequencing in objects' hierarchies. Investigation and evaluation of the described personalized e-learning course model would help students in different parts of the learning cycle. Description and discussion of the possible results of the e-learning personalization evaluation process is done.

Key words: E-learning, evaluation, metadata, learning objects, personalization.

INTRODUCTION

The difference between face-to-face learning scenarios and e-learning environments is that the tutor can interact with the students and perceptually gage the competency levels and the learning motivations and "adjust" their teaching appropriately. But in the e-learning environments direct interaction is not possible so the principle "one size fits all" is usually applied.

The technological landscape of modern e-learning is dominated by the so-called learning management systems, such as Blackboard or WebCT. Learning Management Systems (LMS) are powerful integrated systems that support a number of activities performed by teachers and students during the e-learning process. But, LMS offer their users "one size fits all" service. All learners taking an LMS-based course, regardless of their knowledge, goals, and interests, receive access to the same educational material and the same set of tools, buffered with no personalized support.

Several approaches in this direction are currently investigated, ranging from federated or distributed learning repositories for example, (ARIADNE, 2010), which focus on the dynamic and networking aspects, learning management systems, which focus on course delivery and administrative aspects, and adaptive web-based educational systems (Brusilovsky, 2004; Henze, 2005; Weber at al., 2001) that offer personalized access and presentation facilities to learning resources for specific application domains.

Adaptive Web-based Educational systems (AWBES), a recognized class of adaptive Web systems (Brusilovsky at al., 2002) attempts to fight the "one size fits all" approach to e-learning. Adaptive textbooks created with

*Corresponding author. E-mail: danijela@tfc.kg.ac.rs or danijela.tfc@gmail.com. Tel: +381 637099077. Fax: +381 32342101.

such systems as InterBook (Brusilovsky at al., 1998), NetCoach (Weber at al., 2001) or ActiveMath (Melis at al., 2001) can help students learn faster and better. Adaptive quizzes developed with SIETTE can diagnose solutions of educational exercises and help the student to resolve problems.

Adaptive class monitoring systems (Oda at al., 1998) give the teachers a much better chance to notice when students are lagging behind. Adaptive collaboration support systems can enhance the power of collaborative learning (Soller at al., 2003). Modern AWBES such as NetCoach (Weber at al., 2001) or SIETTE (Rios at al., 1999) is comparable with modern LMS.

Systems like My Online Teacher (MOT) (Cristea at al., 2003) assist in developing rich adaptive hypermedia but are technically complex and offer little pedagogical support.

The Adaptive Course Construction Toolkit (ACCT) (Dagger at al., 2004) provides pedagogy, activity, subject matter, personalization and learning resource based support to the course developer in addressing some of the key barriers to the mainstream adoption of personalized eLearning. Projects such as: APeLS (Conlan at al., 2002), iClass (http://www.iclass.info), Knowledge Tree and Personal Reader (Henze, 2005) established the personalized eLearning based on new web based service topography.

An interesting design of service-oriented reference architecture for personalized e-learning systems (SORAPES) and validation of the architecture is described in (Palanivel at al., 2011). The SORAPES is designed by re-using web services and learning objects with layered architecture and highly-scalable personalized e-learning system. The work described in (Sciarrone at al., 2011) is part of the open learning project, where business practitioners and university researchers aim to combine the most frequently used e-learning technologies with the benefits of customized systems to develop an innovative personalized learning content delivery system. The proposed system integrates Moodle with LS-Plan engine, thus providing automated sequencing of the learning material based on the learner’s knowledge and learning styles.

Discussion on how learning styles and theories are currently used within personalized adaptable e-learning adaptive systems is extensively presented in Shaoling (2011). This paper aims to establish conditions for creating versatile online courses adjusted to individual learner's needs which enable the students to choose their own learning path.

Research efforts on modeling the student’s knowledge together with learning styles by using specific tests and, if necessary, updated on the basis of student progress are presented in detail in Alfonseca at al. (2011); Sangineto at al. (2011). An approach based on the modeling of learners' problem solving activity sequences, and on the use of the models in targeted, and ultimately automated clustering, resulting in the discovery of new, semantically meaningful information about the learners is extensively described in Kock et al. (2011).

Practical experience has shown that active participation of the learners is an important part of the learning process and that it can be enabled by means of personalization. The learning process has to enable active work by learners, to allow learners to share knowledge in groups, and to enable teachers to cooperatively develop learning content. To accommodate differences between learners: different learning objectives, different prior knowledge and past experiences and different cognitive preferences to the learning experience, the personalization of the learning experience towards the individual requirements has to be supported.

The major challenger to the development of personalized e-learning systems is to include variations in students’ intellectual profiles, the influence of the ability theories, Gardner's theory of multiple intelligences, cognitive controls, and in turn, cognitive styles and the learning styles in students’ way of learning with the aim to provide the highest degree of education efficiency.

After introduction, this study presents the pedagogically and psychologically engaged Personalized eLearning Course Model (PeLCoM) and the Information Learning Object Model for Personalized eLearning (ILOMPeL), based on variations in students’ intellectual profiles, conformant with the standards for Learning Objects (LO) and Learning Objects metadata. Afterwards, the three types of LO are noticed and their responsibility is declared: responsibility for course content itself, responsibility for the course content presentation and responsibility for course content aggregation. Also, the study presents the application profile, describing the role of each LO by the set of metadata, composed of the vector XYZ, after which it describes certain algorithms and rules for personalized sequencing of course curriculum into personalized lessons and modules. One way of calculating and evaluating e-learning personalization is defined in this study, by observing two groups of students attending the personalized or not-personalized e-learning sessions. Their performances are compared, formulas for calculating and evaluating e-learning personalization are denoted and five levels of satisfaction are determined, such as: perfect, excellent, very good, satisfactory and not satisfactory. Lastly, this study was concluded.

PERSONALIZED LEARNING COURSE MODEL

Requirements for personalized e-learning

We have defined basic criteria for enabling the personalization of e-learning, namely; the individualized approach and classes, by analyzing different aspects which affect the efficiency of learning, such as:

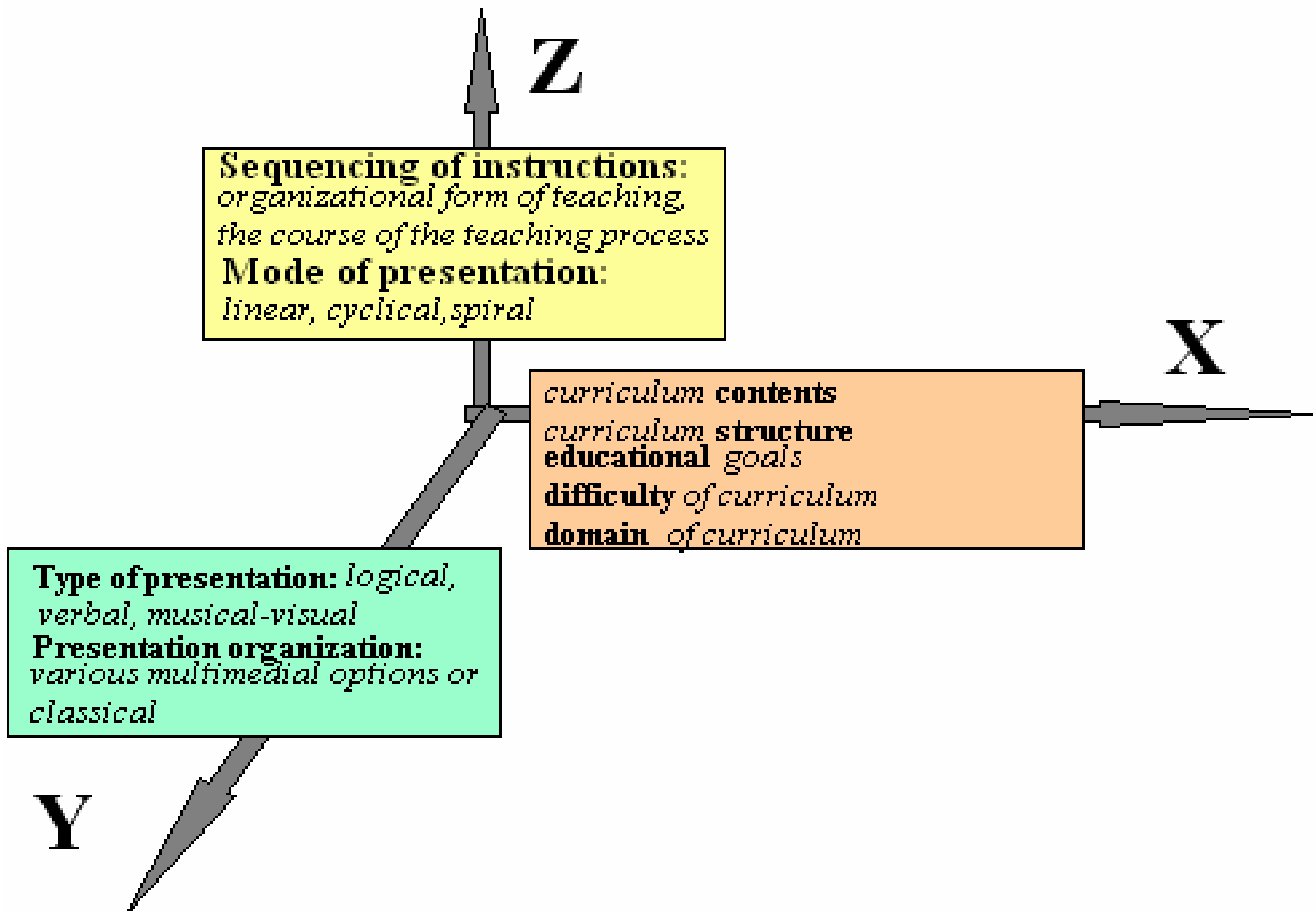

Figure 1. The three-dimensional personalization model.

psychological factors like learning styles and Gardner's theory of multiple intelligence, pedagogical and didactical methods, and educational goals well defined by Bloom's taxonomy, and learner's previous experience. These are:

1. Criteria by which it is possible to choose different levels of curriculum: basic level, average level or the advanced level.
2. Criteria according to which it is possible to attend different volume of curriculum: short – duration up to 15 minutes, or longer - up to 150 min.
3. Criteria which enable choosing different ways of introducing the program: linear, concentric or spiral.
4. Criteria by which it is possible to choose different entry points as initial points of learning.
5. Criteria according to which it is possible to choose different modalities of curriculum presentation: from the basic Black and White presentation to the wide range of multimedia effects in the presentation.

Having in mind the defined criteria for personalization, we designed the personalized e-learning course model. The granular units of the model are e-learning objects and each LO is described by a set of metadata which are presented by three-dimensional vector XYZ (Jovanovic at al., 2006). In a three-dimensional personalized e-learning course model, represented on the X, Y and Z axis Figure 1. We defined that:

1. The X axe: Enables personalization from the aspect of contents and structure of curriculum, educational goals, curriculum volume, the level of difficulty of the curriculum and the domain of the curriculum. On the X axis there is a list of all LOs which participate in the construction of a course, and they are ranked linearly in accordance with the hierarchical decimal notation of the course contents. This notation is represented by a value on the X axis, where X €R and X represents the basic identification of a LO. Each LO is described with a set of metadata.
2. The Y axe: Enables personalization from the aspect of curriculum visualization and the type of presentation (mat.-logical, linguistic, musical, visual etc.)

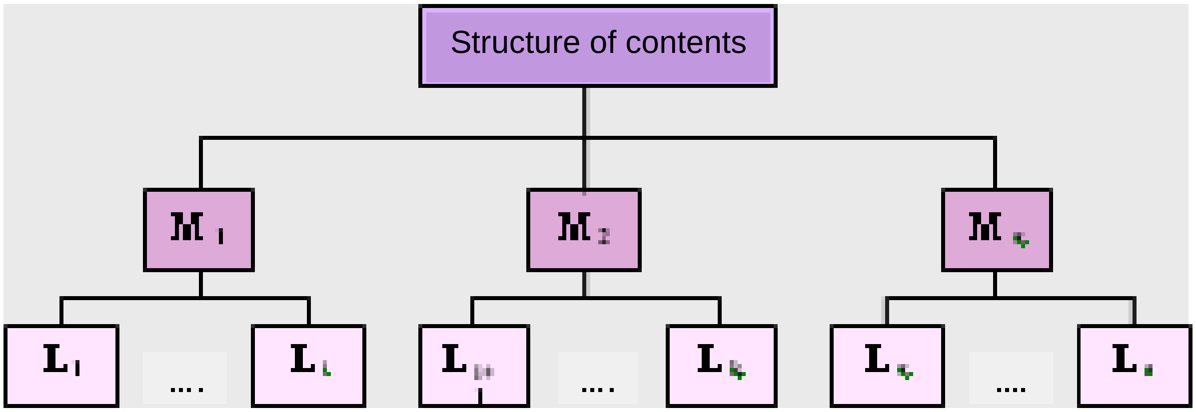

Figure 2. Hierarchical scheme of basic logical course structure.

3. The Z axe: Enables personalization from the aspect of sequencing teaching materials (and the syllabus) on the level of lessons by supporting different systems of program contents, and from the aspect of sequencing teaching materials that constitute a lesson (in a single lesson) by supporting the definition of different views of a lesson (Jovanovic, 2004).

The XY matrix contains granular LOs and comprises all possible variants, namely the maximal set of objects used for the course in question. According to rules defined by Z axe and applying the same rules to objects of the XY matrix, it is possible to generate a lot of valid subsections or many valid variations of a course.

The Z axes contain LOs which describe rules and algorithms for sequencing. Based on those rules and adequate information from the user profile base, the individualization of the course is performed. Sequencing of a lesson, module and course is carried out by consulting the user profile base or the direct choice made by the user, and by activating rules and algorithms which are memorized in the LO. The role and attributes of every LO in the PeLCoM are described by a set of metadata which are represented by a vector (X, Z, Y), where: X= (X_1, X_2…X_i), Y= (Y_1, Y_2…Y_j), Z= (Z_1, $Z_{2\ldots}Z_k$), i, j, k € N.

Information learning object model for personalized e-learning

According to the standards and definitions for e-learning objects adopted in the personalized e-learning course model and the presumption that LO are granular units of learning materials - resources, on one side and from the pedagogical and psychological engagement of presentation and visualization with the aim to personalize e-learning on the other side, we have designed the pedagogically and psychologically engaged information learning object model for personalized e-learning (Jovanovic at al., 2006, 2007). ILOMPeL structure provides various ways of accessing and delivering learning materials according to pedagogical and psychological principles which we have included, as well as according to individual differences among learners which influence learners' success and efficiency.

The basic logical course structure is defined by hierarchical scheme. The root segment of that scheme is course and on the lowest levels are: Modules (M), Lessons (L), Sections(S), LO, respectively as shown in Figure 2.

The course: This is defined as a set of learning materials which contains goals, tasks, and knowledge. Furthermore, it includes introduction, learning, practicing and testing for each learning unit which has been presumed for that knowledge domain. The Course is responsible for the transfer of new knowledge, explanation and assumption of that knowledge, definition of new concepts, and validation of rules and relationships valuable within some parts of learning content. The Course contains set of modules or topics. The Course is a logical unit sequenced according to the rules which describe relationships and constrains for clustering lessons into modules and respectively clustering modules into unique course. The main task is to define course content which means to define the number, linear position and content for each lesson which makes the course.

Module: This is a rounded part of learning materials which covers one topic of a course and consists of more lessons describing that topic. Module is also a logical unit which is sequenced on the basis of some set of rules. According to the existing set of lessons L= {Li ! I =1, x, x Є N}, it is possible to get the topic subsets (partial sets of L), where one lesson can be part of more different topics.

Content, sequence and names of topics are changeable

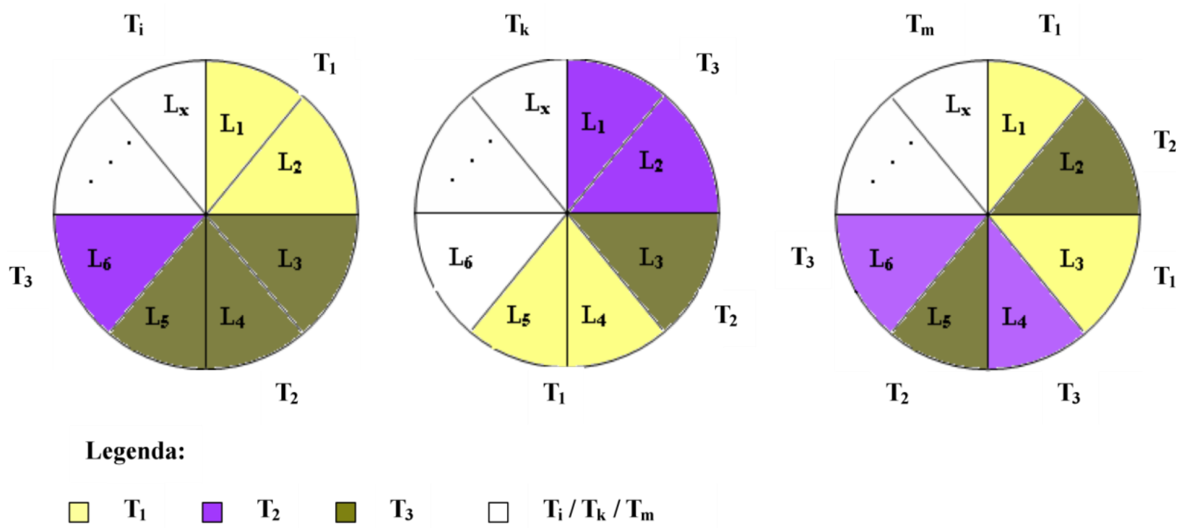

Figure 3. Hierarchical scheme of basic logical course structure: linear, cyclic and spiral mapping.

inside one course. In that way it is possible to generate different systems of program contents based on the same set of lessons, Figure 3.

Lesson: This is a basic educational unit. There is a physical and logical structure of lesson. Logical structure of the lesson is described by the set of rules which presents the hierarchical structure of the lesson. The rules define the way of teaching the lesson and the way of presenting the lesson by providing the various personalized views of the lesson. The duration of the lesson is defined by chosen logical structure and can be from 10 min which is a minimum for learning the simple lesson to more hours, for example 6 h per week which is the usual duration for higher education.

Lesson's structure

Having in mind the kind of learning units and analysis of the lesson's content, we have defined the lesson's structure which denotes: lesson's components, semantics of the components, and we have presented that with rules. The learning material presented by one lesson consists of five sections, and each section is composed of LOs. In other words, each lesson is presented by the set of LOs, which are not redundant between themselves:

Section 1: Describes the summary of the lesson and presents the table of content for that lesson and lesson's components map. Lesson's abstract describes the goal of the lesson and gives a short overview of the lesson. Lesson's content is divided into sections and lesson's map defines the links on each section and each LO inside section.
Section 2: Begins with introduction to the lesson, and contains the learning resources for getting, transmitting and adopting knowledge offered by lesson.
Section 3: Contains practicing the lesson by examples, simulations, tasks, etc.
Section 4: Contains lesson's practicing by individually doing and solving tasks or problems.
Section 5: Controls the level of acquired knowledge from particular lesson by tests, exams and questionnaires.

The lesson's logical structure is described by the set of rules, according to which LOs are connected into learning experience and present the lesson, actually the one view of that lesson, Figure 4. Our PeLCoM model allows different presentations of the same lesson depending on the student's learning style, learning strategy; student's learning goals, prior knowledge, etc. It means that it is possible to derive various views of the same lesson, each mapping the particular and individual student's needs.

Section components

Each Lesson has to contain five sections. Each section contains the set of LOs. For the each kind of section we have defined the corresponding type of LO which built that section. It is possible to combine LOs in various ways when building the section. Except that, for each lesson we have defined the different options for:

1. Lesson's level – describing the possible level of learning experience (Basic, Average, Expert level),
2. Lesson's domain – describing the various domains for

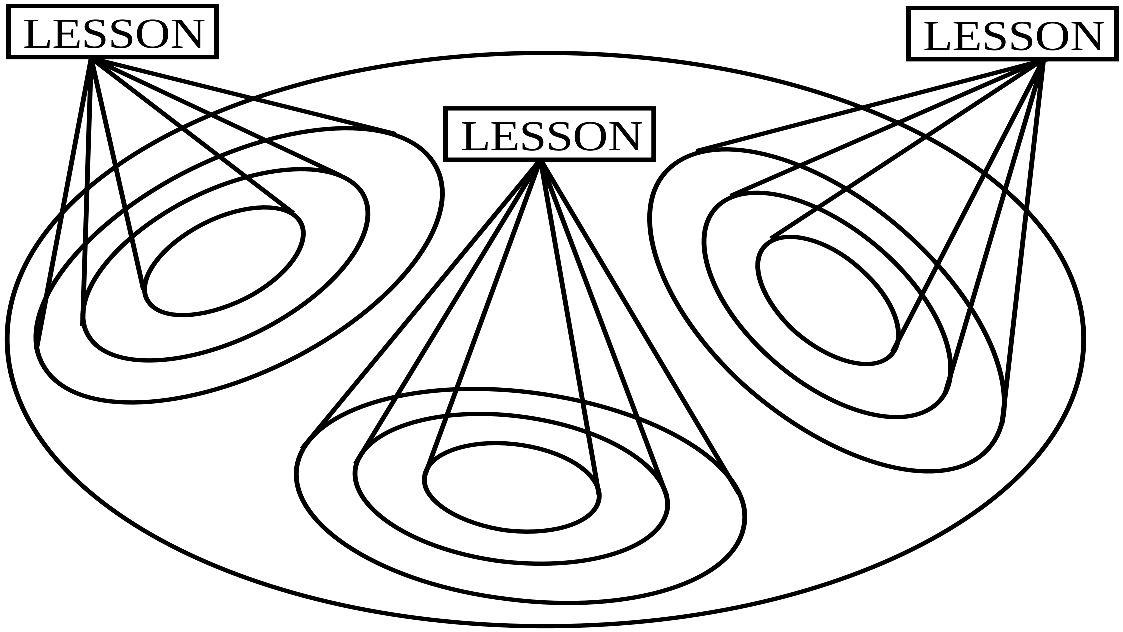

Figure 4. Personalized views of the same lesson.

lesson's practicing and training. According to preferred range of student's interest, the domains can vary from: mathematics, economy, banking, medicine, etc.
3. Lesson's range – describing the possible volume of the lesson (short, middle, long),
4. Lesson's presentation – describing the way of lesson's presentation, for example, simple text presentation, power point presentation or rich multimedia presentation.
5. Lesson's way of teaching - describing the way of lesson's teaching, for example, short logical teaching, rich linguistic teaching, teaching by visual effects, teaching by musical effects, etc.

Learning object

Learning objects represent reusable content units which can be used for a single learning session and in aggregations such as courses, if needed. For these goals to be accomplished, LOs have to be designed and realized so that it is possible to support them technically through a database system. LOs are on the lowest level of course hierarchies and they represents the granularly resources in the PeLCoM, which can be retrieved, used and presented.

ROLES AND TYPES OF THE LEARNING OBJECTS IN ILOMPEL

Learning Object Metadata (LOM) working group of IEEE LTSC defines a learning object as any entity, digital or non-digital, which can be used, reused or referenced in the course of technological support of e-learning. Examples of technologies that support learning applications include computer based training systems, interactive learning environments, distance learning, web-based learning systems as well as, collaborative learning environments.

Attributes of LO

The basic attributes of learning objects, contained in specifications and standards are: accessibility, discoverability, durability, interoperability, reusability, extensibility, affordability and manageability.

The most significant advantage of learning objects is the possibility of multiple usages. Cisco-vi Reusable Learning Objects (RLOs) are based on 7±2 Reusable Information Objects (RIOs).

Furthermore, each of the RIOs contains 7 ± 2 "building blocks", an overview and a summary. Every RIO can contain ''content items'', ''practice items'' and ''assessment items'' (Cisco Systems, 2010).

The basic idea is to enable the author to publish or present the same entry elements in several end mediums.

Size of LO

The appropriate size of LOs is a topic for discussion. In example, for text, LO can be a sentence, a paragraph, an

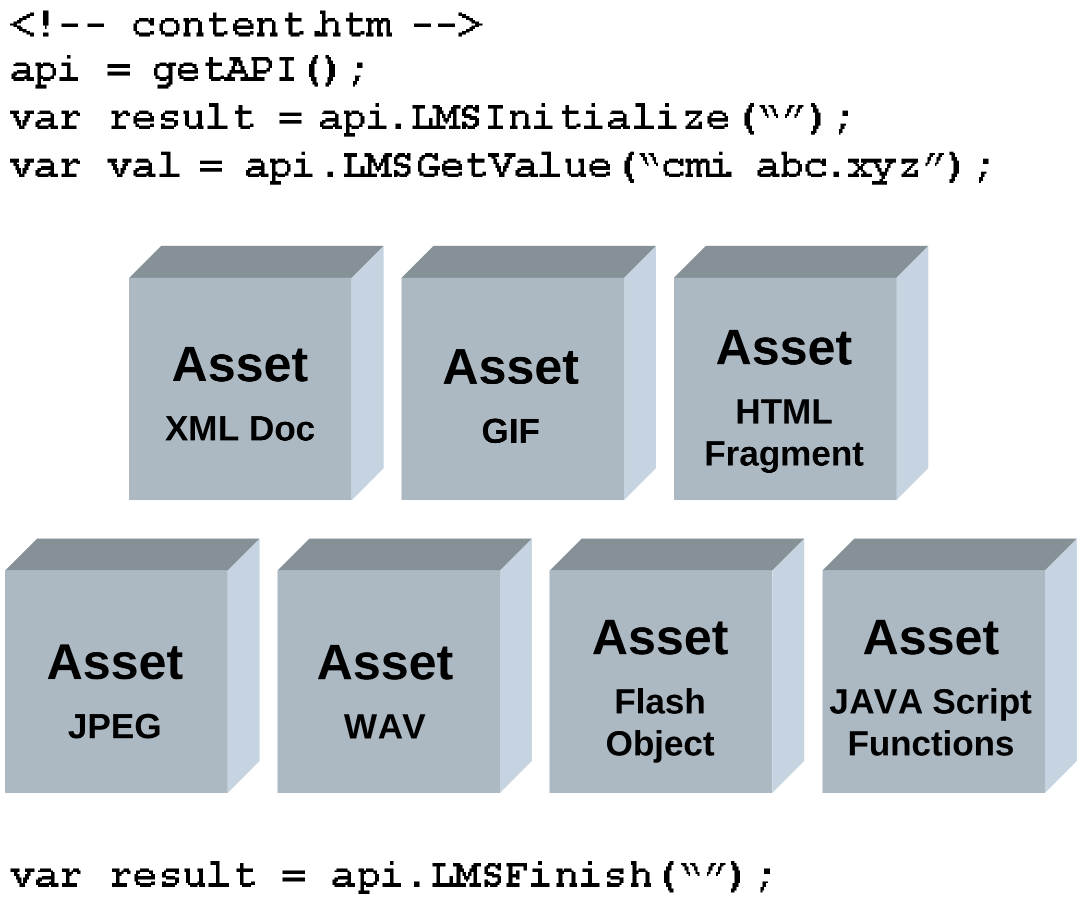

Figure 5. Sharable content object.

idea, a topic, one section, one chapter, one lesson or a course. It is even harder to determine the optimal size of an LO for acoustic or video streams.

Learning objects can be aggregated in an object hierarchy. Cisco Systems in their Reusable Learning Object Strategy (Weber at al., 2001) describe the basic hierarchy: Paragraph (Curriculum) -> Unit -> Module-> Lesson - RLO -> Section – RIO.

Role of LO

The presented personalized e-learning course model is based on a hierarchical organizational scheme of the course curriculum, the root of which represents the course itself, and on lower levels of hierarchy there are modules, lessons, sections and LOs, respectively.

The LO represents the lowest level of teaching materials' granularity in the PeLCoM that can be accessed and autonomously used and exhibited. This LO fulfils the following conditions:

1. The LO is defined as the smallest comprehensive learning unit, and at the same time the largest learning unit that can be potentially reused in different contexts of teaching materials and with different educational goals.
2. The LO is reusable. It is independent of the learning context and can be used in diverse lessons/teaching materials. In example, the Pythagorean Theorem can be used for solving mathematical problems, but also in physics.
3. The LOs can be aggregated in bigger learning systems such as sections, lessons etc.
4. The LOs are described with a set of metadata, which enables connecting several LOs, packing and sequencing into bigger learning units.

On a physical level a LO comprises an electronic units collection of medium, text, pictures (or other content that can be delivered to Web clients) representation. All these elements are connected in a unique whole which we call a LO or SCO (Sharable Content Object) **(**ADL, 2010) Figure 5.

The Model granularity is determined on the LO level. Those are elementary curriculum units or units of curriculum display/visualization which physically exist in a database and are not redundant. They are the physical structure of a lesson – on a physical level, a lesson consists of several LOs.

Types of LO

On the basis of preliminary results that were reached during research related to designing the PeLCoM, we have defined three types of elementary e-learning objects. Types of LOs were discerned on the basis of the function they have in the suggested model. The Model needs to contain knowledge semantics, syntax of the presentation (of that knowledge), dynamic sequencing of knowledge units and the possibility of eLearning course package delivery.

The PeLCoM we have the following types of LOs:

1. Types of containing the course contents: LO objects presented on the X axis of the personalized Model, which contain the units of the course curriculum.
2. Types of displaying/presenting the course contents: LO objects presented on the Y axis of the personalized Model, which embody the presentation of the course curriculum.
3. Types of aggregating the course contents: LO objects presented on the Z axis of the personalized Model – representing the composition and sequencing rules for the course syllabus (rules for merging LOs into sections, lessons and the course as a whole).

Application profile

In order to use the learning objects, they should be searched and located. The solution is to store not only learning objects but also descriptions of the learning objects, called metadata. Learning object metadata potentially includes information about the title, author, version number, creation date, technical requirements and educational context and intent.

There are several activities to standardize Learning Object Metadata (LOM). The Dublin Core Metadata Initiative (Dublin Initiative, 2004) promotes the adoption of interoperable metadata standards and develops specialized metadata vocabularies for describing resources. Today, the main source is LOM defined by the Learning Technology Standards Committee (LTSC) of IEEE, which was formed in 1996. Several other organizations cooperate with IEEE LTSC LOM. The Instructional Management System (IMS, 2010) defines metadata with respect to relationships as "Features of the resource in relationship to other learning objects"; the vocabulary is again referencing the Dublin Core. Differences between the metadata specifications of IEEE LTSC LOM, IMS, and the European ARIADNE project are compiled in a GESTALT document (Foster at al., 2000).

The Advanced Distributed Learning Initiative (ADL), a program of the US Department of Defense and the White House Office of Science and Technology to develop guidelines for large-scale development and implementation of distributed learning, focuses on the shareable courseware Object Reference Model (SCORM) (ADL, 2010), which is integrating several learning standards. ADL references IEEE LTSC LOM (and, thus, indirectly the Dublin Core Metadata) with respect to the relation attribute as best practice vocabulary (IEEE LTSC 2010).

Dr. Norm Friesen presented at International Open Forum: Global trends of eLearning - Policies, technologies, and application. Tokyo, March 14, 2005, that LOM: Learning Object Metadata:

1. IEEE 1484.1.1 2002: facilitates “search, evaluation, acquisition, and use of learning objects, for instance by learners or instructors or automated software processes.”
2. It “also facilitates the sharing and exchange of learning objects, by enabling the development of catalogs and inventories.”
3. Aims at “instructional neutrality” (Blandin, 2004).

The Draft Standard for LOM, Version D6.4 (IEEE LTSC, 2010) allows, among other things, to define the difficulty, typical learning time, relation between this learning object and other learning objects, if any. The IEEE Learning Object Metadata (LOM) standard, proposes a set of 77 elements, distributed among the nine categories is shown in Table 1.

Application profile

Application profile is a set of metadata elements, policies, and guidelines defined for a particular application. Application profile for the personalized e-learning course model, describes the role and attributes of every LO in the Personalized eLearning Course Model by a set of metadata, which is based on SCORM Meta-data Information Model (ADL, 2010).

The mentioned set of metadata is represented by a vector XYZ, where: $X= (X_1, X_2…X_i)$, $Y= (Y_1, Y_2…Y_j)$, $Z= (Z_1, Z_2…Z_k)$, i, j, k € N. For every functional type of a LO, the set of metadata that describes the purpose and attributes of the LO in question is defined. The metadata presented by the vector part $X = (X_1, X_{2…}X_i)$, describes:

X_1 – The contents of teaching materials/syllabus,
X_2 – Curriculum structure,
X_3 – Possible educational goals of the curriculum,
X_4 – The possible volume of the curriculum,
X_5 – The probable level of difficulty of the curriculum,
X_6 – The likely domain of the curriculum.
X_7 – Duration, estimated average time for finishing the

Table 1. The high level LOM categories.

Category	Description
General	This category groups the general information that describes this learning object as a whole.
Lifecycle	This category describes the history and current state of this learning object and those entities that have affected this learning object during its evolution.
Meta-metadata	This category describes this metadata record itself (rather than the learning object that this record describes).
Technical	This category describes the technical requirements and characteristics of this learning object.
Educational	This category describes the key educational or pedagogic characteristics of this learning object.
Rights	This category describes the intellectual property rights and conditions of use for this learning object.
Relation	This category defines the relationship between this learning object and other learning objects, if any.
Annotation	This category provides comments on the educational use of this learning object, and information on when and by whom the comments were created.
Classification	This category describes where this learning object falls within a particular classification system.

LO (in minutes). The average time for finishing particular view of a lesson can be automatically calculated.

The metadata presented by the vector part Y= (Y_1, Y_2...Y_j), describe:

Y_1 – The curriculum visualization type,

Y_2 – The modality of presentation.

The metadata presented by the vector part Z= (Z_1, Z_2...Z_k), describes:

Z_1 – The kind of course curriculum sequencing on the lesson level by supporting different program contents systems.

Z_2 – Type of sequencing the teaching materials which constitute a lesson (sequencing "inside" the lesson), by supporting the definition of different views to the same lesson.

Application profile represented by a metadata vector XZY is mapped to the SCORM Meta-data Information Model, Table 2. Each learning object – SCO is described with metadata. The educational category metadata seemed the most appropriate to apply for personalization. Also, the Relation and classification category is mapped to personalization vector XYZ.

To define multiple relationships between parent LO and child LO, which contain presentation source (application profile, Y2), the category <relation>, element <Kind> is used. There may be multiple instances of this category. If there is more than one target learning object, then each target should have a new relationship for instance. The vocabulary references the 12 qualifiers of the Dublin Core Metadata Initiative, cited earlier: IsPartOf, HasPart, IsVersionOf, HasVersion, IsFormatOf, HasFormat, References, IsReferencedBy, IsBasedOn, IsBasisFor, Requires, IsRequiredBy.

Parameters definition

Lesson's key *(x1)*: Each lesson has the unique identification called the key of the lesson (x1). Lesson's key may be presented by decimal classification notation (for example: 1, 2, 3,...99,...). It is possible to define that the part of the key is marking out whether that lesson can be the course entry point or not. Lesson's key also defines the content of learning material.

Lesson structure (x2): The lesson structure denotes lessons components, semantics of the components, and implicates some rules. Lesson structure is defined by identification called the key of the section and that key can take one of values from the set {1, 2, 3, 4, 5}. Each value denotes specific kind of section, as it is mentioned above. Each lesson has to include almost one or more (until all) of these five sections, in other words:

(∀ Li) (Li={Si1, Si2, Si3, Si4, Si5}, i=1..n, where C={L1,...Ln}, n€N)

(∀ Sij) (Sij≠ Ө, 'different from empty set' and Sij = {ELOx... ELOy}, x= 1...n, y= 1...n)

So, we can describe the learning process structure as a set of processes {S1, S2, S3, S4, S5}, where Si ∩ Sj = Ө, ∀i€{1,...,5) and ¥j€{1,...,5) and i#j. Then, we can compose the lesson by making the partial subsets of a set {S1, S2, S3, S4, S5}, such as: {S1} v {S2} v {S3} v {S4} v {S5} v {S1,S2} v {S1,S3} v...v {S1,S2,s3,S4,S5} to provide conditional knowledge appropriate for preferred student's learning strategy (Jovanovic et al., 2006).

Lesson type (x3) - Lesson's type describes the lesson's learning objective, based on Bloom's taxonomy.

Depending on lesson's content, relationships and

Table 2. SCORM metadata mapping to metadata vector XYZ.

Mapping between SCORM Meta-data and Metadata vector XYZ		
SCORM Meta-data information model		**Application profile for the personalized e-learning course model**
Category	**Element**	**Metadata vector XYZ**
1. *<general>*		
	<Aggregation level>	Z_2 – type of sequencing the teaching materials
5. *<educational>*		
	<interactivityType>	
	<learningResourceType>	Y_2 – the modality of presentation
		X_2 – curriculum structure
	<semanticDensity>	
		X_4 – the possible breadth of the curriculum, volume
	<context>	X_1 – the contents of teaching materials/syllabus
	<difficulty>	X_5 – the probable level of difficulty of the curriculum
		X_7 – duration, estimate average time for finishing the LO
	<typicalLearningTime>	
7. *<relation>*		
	<Kind>	Y_1 – the curriculum visualisation type
	<Taxon path>	Z_1 – the kind of course curriculum sequencing
9. *<classification>*		
	<Purpose>	X_3 – possible educational goals of the curriculum

Category <Educational>, element <interactivity Type>: {active, Expositive, Mixed, Undefined} is mapped to Y_2 – the modality of presentation, and denotes whether the presentation is recommended to include any or many multimedia effects, such as sound, voice or music, slides, video, movies, etc.

Table 3. Mapping between lesson's level and student's engagement per week.

Level no	Lesson's level	Hours per week	Mark
I level	Basic	2 h of lectures and 2 h of practice in groups	Minimal (6 or 7)
II level	Average	2 h of lectures and 4 h of practice including individual work and projects	Average (7 or 8 or 9)
III level	Advanced	2 h of lectures and 6 hours of practice including individual work and projects	Best (9 or 10)

structure of the lesson's learning material, we have defined the following type of lessons:

Type A basic: Comprehend the explanation, assumption and practice of the learning materials. Usually, illustrate the simple topic, such as Pythagoras's theorem.
Type B mixed: Comprehend the analysis and synthesis of the learning materials.
That type of the lessons connects more topics, for example, uses of Pythagoras's theorem with triangle, or with rectangle, or with circle, etc. Usually, that covers mixed tasks, project's tasks, etc.
Type C Complex: Comprehend the evaluation of the learning materials. That is manifested by graduate theses, master theses or PhD theses and other complex projects. The mapping between lesson components and type of the lesson is defined by Table 3.
Lesson range (X4): Describing the possible volume of the lesson (in short, standard, and extended).

Lesson level (X5): Describing the possible level of learning experience (Basic, Average, Advanced level). Inside each lesson there are eLearning objects of different level. We have defined the three types of lesson's difficulty and corresponding sets of eLearning objects which may be sequenced into the specified lesson's level, Table 3.

Lesson domain (X6): Describes the various domains for lesson's practicing and training. According to student's interest, the domains can vary from: mathematics, economy, banking, medicine, etc.

Lesson duration (X7): Estimated average time for finishing the LO (in minutes). The average time for finishing particular view of the lesson can be automatically calculated.

Lesson presentation (Y1): Describing the way of lesson presentation, beginning from simple text presentation, power point presentation or rich multimedia presentation, for example:

Y_1=1 black and white presentation,

Y_1=2 audio presentation and

Y_1=3 multimedia presentation. Every type of presentation can be realized in several different variations described by the V parameter – mode of presentation.

The way of teaching a lesson (Y2): Describing the way of lesson teaching, for example, short logical teaching, rich linguistic teaching, teaching with visual effects, enhancing with musical effects, etc., for example:

Y_2= 1 mathematical - logical,

Y_2= 2 linguistic,

Y_2= 3 musical, visual, etc.

Type of course's sequencing (Z_1): Describes how the lessons which constitute a course may be organized/sequenced, with the aim to support the different program contents systems. We define the following types of program contents:

Z_1=1 Linear structure of program contents,

Z_1=2 Cyclic structure of program contents,

Z_1=3 Spiral structure of program contents,

Z_1=4 Random structure of program contents based on possible entry points,

Z_1=5 Adaptable structure of program contents based on user's individual requests.

E-learning objects composition and navigation options

One of the purposes of the IEEE LTSC LOM project is to "enable computer agents to automatically and dynamically compose personalized lessons for an individual learner" (IEEE LTSC, 2010). When labeled with metadata, an eLearning system can mix and match learning objects to create individualized learning experiences.

Personalization requirements and LOs metadata mapping

We noticed the granular units of learning resources called eLearning Objects and their metadata. Mapping between them and defined personalization requirements is described in Table 4. The first column denotes main influential factors in learning experience and the second column respectively marks the psychological aspects which can be measured and which determines students profile. According to the results, the third column describes aviable teacher's influence to the eLearning experience, which can be moderate according to the different pedagogical aspects and coresponding didactics' and methodic' processes. The forth column presents mapping of values gotten in second column to the PeLCoM metadata, which defined the various personalization possibilities according to the pedagogical aspect marked in third column. Possible metadata values are noticed in fifth column and the last column describes resulting personalization of learning experienced.

SEQUENCING RULES AND DEFINITIONS

A. Sequencing lessons into course

1) A Course is a set of all lessons which belong to that course. Lesson is a set of learning objects which constitute that course. If we mark a Course with C, a particular lesson with L_i, where i €N, particular topic with Tij, where i, i €N, notes the type of organizing program content, and j, j €N, notes the order number of topic inside mentioned program content course organization, and particular learning object with LOi, i€N, which constitute mentioned course, then we can say:

C = {Tij | i, j =1, 2,...n, n €N} i T_{ij} $\cap$Tkv= Θ , i#k, j#v, ¥i, i=1,..., m, m €N and $\forall$j, j=1,..., m, m €N
C = { Li | i=1,2,...n, n €N} i L_i $\cap$Lj= Θ , i#j, ¥i, i=1,..., m, m €N and $\forall$j, j=1,..., m, m €N
C = {LOi | i=1, 2,...n, n €N} and LOi $\cap$ LOi = Θ, i#j, ¥i, i=1,..., m, m €N and $\forall$j, j=1,..., m, m €N

2) Lessons can be sequenced in various ways to perform the course. It is possible to teach the same learning material in different ways, like in a linear way of organizing program content, cyclic way of organizing program content or spiral way of organizing program content. Each system of program content is defined by set of topics and their particular sequence. If we mark:

Table 4. Personalisation table.

Influence factors in learning experience: adaptation	Personalization source/basement Student's influence: psychological aspects	What to personalize? Teacher's influence – pedagogical aspects: coresponding didactics' and methodic' processes for personalization	How to personalize? Using personalized e-learning course model	Metadata values	Results of learning expirience personalization
3.1. Adaptation to the knowledge level and learning objective	Learning objectives (Bloom taxonomy)	Types of educational goals: explanation, assumption, practice, analysis, synthesis and evaluation	→Xaxe: lesson's type coresponding to educational goals	X3={1, 2, 3, 4, 5,6}	Personalization of the learning contents from the aspects of choice from various learning resources ▪ according to the marked learning objective and ▪ according to the evaluated knowledge level, prefered domain and volume;
	Prior knowledge and preferences	• Volume of the curriculum • Level of difficulty of the curriculum • Domain of the curriculum	→Xaxe: curriculum's range →Xaxe: curriculum's level →Xaxe: curriculum's domain	X5={1, 2, 3} X4={1, 2} X6={1, 2, 3}	
3.2. Adaptation to the learner's behavior	Cognitive styles Learning styles	• Content of teaching materials • Learning process flow • Systems for teaching program's contents	→Xaxe: lesson's view →Zaxe: sequencing teaching materials (and the syllabus) on the level of lessons	X1={1,2,...n} X2={1, 2, 3, 4, 5} Z1={1, 2, 3}	Personalization of the way of learning from the aspects of: ▪ defining the optimal learning path through learning materials, ▪choice of best fitting learning strategy, ▪ choice of best fitting method for tasks decomposition, ▪ defining the rules for learning seassion management, ▪ defining the plan of learning content, ▪ defining the type of lesson's of presentation;
	Learning strategies	• Learning processes' sturcture {S1,...S5} • Type of lesson's of presentation (mathematical-logical, linguistic, musical, visual etc.).	→Zaxe: sequencing teaching materials that constitute a lesson →Xaxe: lesson's view →Yaxe: type of lesson's of presentation →Zaxe: sequencing teaching materials that constitute a lesson	Z2={1,2i, 3i, 4i, 5} X1={1,2,...n} X2={1, 2, 3, 4, 5} Y1={1, 2, 3} Z2={1,2i,3i,4i, 5}	

Table 4. Contd

3.3. Adaptation to the lrning es and learner's preferences	Leag modalities (Gardner)	-•Curriculm visualisation -•Curriculum presentation	→Yaxe: type of lesson's of presentation →Yaxe: lesson's visualisation	Y1={1, 2, 3} Y2={1, 2,3}	Personalion of the learning experience from the aspects of: *VisalizationType* ▪Formated text or Multr Audio; *Presentation Type:* ▪Discusion or Categorization orSimulation

- A course with a C,

- Particular topic with T_{ij}, where i notes the type of organizing program content, i €N, and j notes the order number of topic within mentioned program content course organization, j €N, and

- Particular view of the course with V_u, where u €N, then we can say:

i)= { T_{ij} | $Э_1$i, i=1,2,...m, m €N, ∀j=1,2,...n, n €N } (there is one **i** for each **j**)
ii) T_{ij} = {L_k | k €{1,2,...m, m €N}}, i=1,2,...v, where is i,j,v €N.

iii) T_{ij} ∩T_{il}= Ө, ¥i, i=1,..., m, m €N and ∀j, j=1,..., m, m €N

iv) V_1= {T_{1i} | i=1, 2,...m, m €N}

v) V_2= {T_{2j} | j=1, 2,...p, p €N}

vi) V_3= {T_{3k} | i=1, 2,...z, z€N}…

vii) V_x= {T_{xo} | o=1, 2,...v, v€N}

i) If we mark a picture of the particular lesson inside the one Topic with T_{ijv}, where i, i€N, marks the type of organizing program content, and j, j€N marks the order number of topic inside mentioned program content course organization, and v, v€N marks an order number of mapped lessons within that topic, then we defined mapping between a whole set of lessons and sets of topics which belongs to the different type of program content organization, as shown in Table 5:

3) Course entry point - according to the definition that course sequencing is possible only at the lessons level, it implicates that entry point can be defined only at the lessons level, too. Mapping between lessons is defined across matrix: Matrix of possible predecessors, Table 6 and Matrix of possible successors, Table 7.

Matrix of predecessors defines the mappings between one lesson and all other lessons that belong to the course and notes by 1 if Li is predecessor for Lx and by 0 if Li is not predecessor for Lx, or in short:

Lx = {1 if Li is predecessor, i =1…n; {0 if Li is not predecessor, i =1…n

Matrix of successor defines the mappings between one lesson Lx and all other lessons that belong to the course and notes by 1 if Li is successor for Lx, 0 if Li is not successor for Lx, or in short:

Lx = {1 if Li is successor, i =1…n; {0 if Li is not successor, i =1…n

Each lesson has a certain set of predecessor and successor and according to that the possible different program contents is as follows:

i) We defined the set of possible predecessor as: (∀Li) (∃ 1 or more Lj) { Lj | Li< Lj, where i, j € ={1,n} and i#j}
ii) We defined the set of possible successor as: (∀Li) (∃ 1 or more Lj) { Lj | Li > Lj, where i, j € ={1,n} and i#j}

A. Sequencing within the lesson

Course is a set of all lessons which belong to that course. Lesson is a set of learning objects which constitute that course. If we mark a course with C, particular lesson wit L_i, where i €N; particular section of the lesson L_i with Sj, where i marks the decimal lesson classification number, and j marks the order number of the section inside the lesson, j €{1, 2, 3, 4, 5}; and particular learning object which constitute mentioned course with LOi, i €N; then we can say:

1. ∀i, i=1,..., m, m €N and ∀j, j=1,..., m, m €N

Table 5. Mapping between linear, cyclic and spiral program content organization.

Decimal lesson classif. (unique key)	Program content organization			Possible entry point
	Linear	Cyclic	Spiral	
L1	T1.1.1	T2.2.1.	T3.4.1.	No
L2	T1.1.2	T2.2.2.	T3.5.2.	Yes
L3	T1.1.3	T2.1.1.	T3.8.3.	Yes
L4	T1.2.1	T2.3.1.	T3.8.1.	No
L5	T1.2.2	T2.1.2.	T3.5.1.	No
L6	T1.2.3	T2.1.3.	T3.4.6.	Yes
L7	T1.2.4	T2.3.2.	T3.8.2.	No
L8	T1.3.1	T2.2.3.		No
L9	T1.3.2	T2.3.3.		Yes
L10	T1.4.1	T2.4.1.		Yes
L11	T1.4.2	T2.6.3.		No
…..	…	…	…	…
L99z	T1.99z	T2.6.1.	T3.X.9.	Yes

Table 6. Matrix of possible predecessor.

For	Is predecessor			
	L1	L2	L3	L4
L1	0	0	1	0
L2	1	0	1	0
L3	0	0	0	1
L4	1	0	1	0
….				

Table 7. Matrix of possible successor.

For	Is successor			
	L1	L2	L3	L4
L1	0	0	1	0
L2	1	0	1	0
L3	0	0	0	1
L4	1	0	1	0
…				

and i#j, $LOi \cap LOj = \Theta$

C = {LOi | i=1, 2,...n, n €N}

(∀Lk) (∃1 or more LOi) Lk = {LOi | i=1, 2,...n, n €N}

(∀Lk) (∃1 or more Si) Lk = {Si | i=1..5}

The learning material presented in one lesson consists of five sections, and each section is composed of LOs. The intersection of each two LO which belong to the same lesson is empty.

2. By sequencing some or all of Si, i=1..5, inside the lesson it is possible to arrange the learning experience suitable for different learning strategies. The minimal lesson can contain only one of the possible Si, i=1..5, and the maximal lesson can contain all of the possible Si, i=1..5, exactly, Lk = {S1, S2, S3, S4, S5}

3. Each of Si, i=1..5, can be used as an entry point and in that way the different learning strategies can be

supported.

4. Default lesson will contain each of possible Si, i=1..5, set up in ascending order, and each Si have to contain minimum one LOi which is marked as obligatory or optional.

5. By sequencing the LOi inside the section it is possible to choose appropriate level, range, domain, presentation view and presentation way. $(\forall Sk)$ $(\exists 1$ or more LOi) Sk = {LOi | i=1, 2,...n, n €N}

6. For each LOi we can denote if it is obligatory or optional.

7. Lesson mapping defines the lesson's hierarchical structure, by including the maximal set belonging LOi.

E-LEARNING EVALUATION AND RESULTS

Our aim is to investigate and evaluate which type of learner used a specific kind of learning style, which dynamics of learning resources a learner has, which kind of presentation of learning resources a learner preferred, and which domain for practice and use a learner has chosen. It is a fundamental point that if we have diagnosed a learner as learning in a particular way then our pedagogy should work to provide teaching that matches the individual's preferred approach. Matching refers to the practice of linking learning styles with teaching styles. This is the fundamental rationale for Snow's ATI approach (Snow, 1989), as well as the point of most attempts to produce learner models in intelligent tutoring.

We present some of the characteristics of the learning preferences within the described three-dimensional personalized e-learning course model and investigate if that will help students in different parts of the learning cycle. The presented model individually combines the learning fragments depending on the user's skills, learning styles and learning strategies. It is important to study how the structure and organization of information may contribute to a better learning in relation to individual differences. Individual differences are observed by the way students interact with individually personalized e-learning materials.

To examine whether differently formatted e-learning courseware has an impact on the success and efficiency of learning process, an empirical evaluation was conducted. We used two samples of students and each group had to browse through two different versions of web-based courseware; one version was based on the proposed personalized PeLCoM and the other was not. Students had to complete a number of tasks. These tasks included the following: browsing, reading, searching for and memorizing information displayed on the computer screen. At the end of each round of the tasks, the students were asked to answer a series of questions to test their recall of the supplied information.

Before the start of the experiment we suggest determining the positions of the students on the learning styles dimensions using a web-based, self-administered Felder-Soloman Index of Learning Styles Questionnaire (ILSQ) (Felder-Soloman 1998; ILSQ, 2011), that assessed four learning style dimensions: introvert/extrovert, verbal/visual, sensitive/intuitive and global/sequential dimension, as it was done in (Barjaktarevic at al., 2003). The sample gathered 51 students, where 25 students in group G1 and 26 students in group G2.

The experiment had three phases:

Phase I: time period $\Delta t1$ (one teaching week) – pre-testing and distribution of students in two knowledge equivalent groups G1 and G2; student profile generation for G2 group and their cauterization in personalized groups according to the learning styles.

Phase II: time period $\Delta t2$ (ten teaching weeks) – traditional teaching and evaluation for G1 group; personalized learning for G2 group and testing their knowledge.

Phase III: time period $\Delta t3$ (three teaching weeks) – analyzing the obtained results of G1 (non personalized) and G2 (personalized) groups; deriving conclusions.

In the first part of the study, students completed pre-test and they proceeded to browse and study material, which was adapted so that it did not match their learning preference. Upon completion of the course the students completed the post-test.

These prime results and corresponding marks are the basis for determining students' learning style and prior knowledge level, as well as for evaluating personalization. Based on those marks, and according to the previous (statistical) experience, we can evaluate success of each individual student - user within a hypothetical non-personalized set attending a course session.

After the start of the study and completed a pre-test, the students group which attended the personalized eLearning sessions proceeded to browse and study the material that matched their learning preferences. Having completed that, the students were presented with a recall-type post-test. The questions were knowledge questions as they tested the recalling of facts, terms and concepts as suggested in Bloom's taxonomy.

Then, we overviewed each student from the personalized set, who attended an individually personalized course session. At the end of the course each student took an exam – tests and his/her success was marked. Respective average value and standard

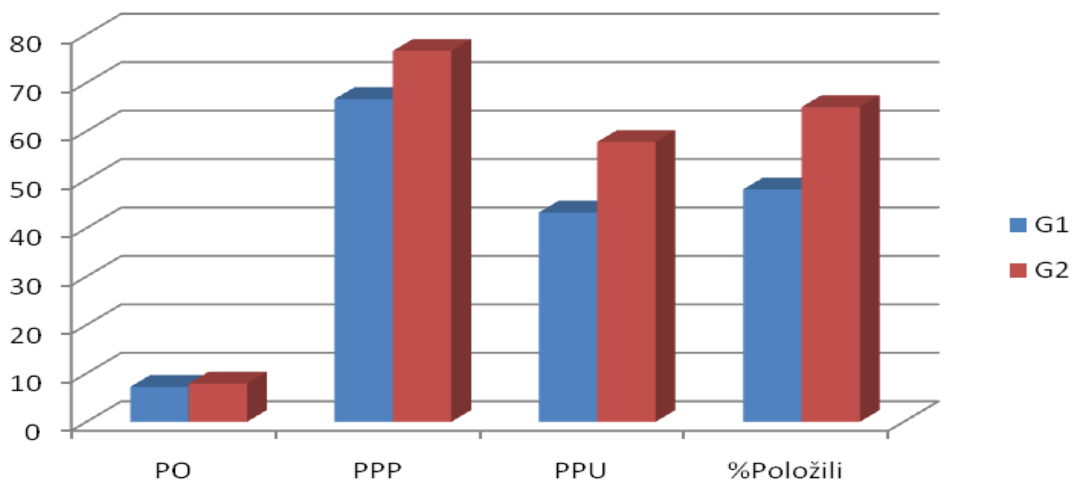

Figure 6. Comparative results achived by groups G1 and G2.

deviation value were calculated for each student from the personalized set, who attended a course session.

Figure 6 presents comparative results of both groups during the process of learing, quizzing and final examination from the Programing language C++ course. The X-axes shows categories that we followed: PO – average grade, PPP – average points of passed exams, PPU – average points for the whole group, %Polozili – total number of students who successfully passed the exam. According to the performed analyses we can conclude the following:

1. Personalized group G2 achieved 9% higher average grade comparing to G1 for succesfully passed students
2. Personalized group G2 obtained 15% higher average student score for students who passed the exam, comparing to G1
3. Personalized group G2 achieved 34% higher average score, comparing to G1
4. Total number of students who succesfully passed the exam is 17% greater in group G2 than in G1.

CONCLUSIONS

In this paper, we have presented the personalized e-learning course model, which fulfils the set demands for an individual teaching approach. The presented model enables us to apply algorithms and rules which perform sequencing of the course, and by that secure diverse view to a course. From the user's (student's) point of view it is possible to personalize the course: (1) from the aspect of contents and structure of the curriculum, educational goals, volume of the curriculum, level of difficulty, and the domain of the syllabus; (2) from the aspect of curriculum visualization and presentation (mathematical-logical, linguistic-verbal, musical, visual etc.); and (3) from the aspect of sequencing of teaching materials, by supporting diverse systems of program contents, and by supporting the defining of different views to a lesson.

According to the prior research and analysis about influence of learning style, etc. to the e-learning processes and to the learner's success, efficiency and motivation, we have:

1) Presented some characteristics of the learning preferences within the three-dimensional personalized e-learning course model and investigated if that would help students in different parts of the learning cycle. The presented model individually combines the learning fragments depending on the user's skills, learning styles and learning strategies.
2) Designed the information learning object model for personalized e-learning, which provides the pedagogically engaged learning content concepts, with the aim to serve for different educational purposes, situations and methods by providing creation and delivery of personalized e-learning sessions.
3) Described the role, types and attributes of LOs. The types of LOs are: types of containing the course contents, types of displaying/presenting the course contents and types of aggregating the course contents. The role of each LO type is described by the set of metadata. We present LOs metadata by vector XYZ, in a way that they enable us to apply algorithms and rules which perform sequencing of the course, and by that secure diverse view to a course.
4) Enumerated the rules for sequencing lessons into course and for sequencing inside the lesson. We define rules for sequencing or composing diverse e-learning materials' variants into personalized courses, or different personalized options of the same course. For each hierarchical level in the course scheme there are

determined algorithms and rules for personalized sequencing of course curriculum into personalized lessons and modules.

5) Conducted an empirical evaluation to examine whether model PeLCoM by differently formatted elements of learning styles has an influence on success and efficiency of learning process;

6) Defined one way of calculating and evaluating eLearning personalization by observing two groups of students attending the personalized or non-personalized e-learning sessions;

7) Compared performance of students who have attended the personalized with those who have attended non-personalized e-learning sessions, denoted formulas for calculating and evaluating e-learning personalization and determined five levels of satisfaction / successfulness such as: perfect, excellent, very good, satisfactory and not satisfactory.

Further development prospects comprise formal specification of the model and the development of ontology for its realization. We will also investigate and evaluate which type of learner has used a specific kind of learning style, which dynamics of learning resources a learner had, what kind of presentation of learning resources a learner has preferred, and what domain for practice and use a learner has chosen.

REFERENCES

ADL (2010). Sharable Content Object Reference Model (SCORM), V 1.2, The SCORM Content Aggregation Model, Available at: http://www.adlnet.org/

Alfonseca E, Carro RM, Martin E, Ortigosa A, Paredes P (2006). The impact of learning styles on student grouping for collaborative learning: A case study, User Modeling and User-Adapted Interaction, 16(3-4): 377-401.

Ariadne (2010). Alliance of remote instructional authoring and distributions networks for Europe, Available at: http://ariadne.unil.ch/.

Blandin B (2004). Are E-Learning Standards Neutral?, Proceedings of International Conference on Computer Aided Learning in Engineering Education.

Bajraktarevic N, Hall W, Fullick P (2003). Incorporating learning styles in hypermedia environment: Empirical evaluation, Available at: http://wwwis.win.tue.nl/ah2003/proceedings/www-4/

Bloom (2009). Bloom taxonomy. Available at: http://www.nwlink.com/~donclark/hrd/bloom.html

Brusilovsky P (2004). Knowledge Tree: A Distributed Architecture for Adaptive E-Learning, Proceedings of the thirteenth International World Wide Web Conference.

Brusilovsky P, Maybury MT (2002). From adaptive hypermedia to adaptive Web, Communications of the ACM 45(5):31-33.

Brusilovsky P, Eklund J, Schwarz E (1998). Web-based Educations for All: A Tool for Development Adaptive Courseware, Proceedings of the Sevenths International World Wide Web Conference WWW'98.

Cisco Systems (2010). Reusable Learning Object Strategy, Version 4.0, Available at: http://www.cisco.com/warp/public/10/wwtraining/elearning/implement/rlo_strategy.pdf.

Cristea A, De Mooij A (2003). Adaptive Course Authoring: MOT, My Online Teacher, Proceedings of ICT-2003, Telecommunications + Education Workshop, Tahiti Island in Papetee - French Polynesia, IEEE LTTF IASTED.

Conlan O, Hockemeyer C, Wade V, Albert D, Gargan M (2002). An Architecture for integrating Adaptive Hypermedia Service with Open Learning Environments, Proceedings of ED-MEDIA 2002, World Conference on Educational Multimedia, Hypermedia & Telecommunications, Denver, Colorado.

Dagger D, Wade V, Conlan O (2004). Developing Active Learning Experiences for Adaptive Personalized eLearning, Proceedings of Adaptive Hypermedia and Adaptive Web-Based Systems, AH2004.

Dublin Initiative (2004). Dublin Core Metadata Initiative. 2004. Available at: http://dublincore.org/

Felder-Soloman (1998). Available at: http://www4.ncsu.edu/unity/lockers/users/f/felder/public/

Foster P, Kraner M, Graziano A, Romano SP (2000). Getting Educational Systems Talking Across Leading-Edge Technologies, GESTALT - Project AC367, Work Package 4, D0401 Courseware Metadata Design V3, (GEMSTONES), Gestalt Extensions to Metadata Standards for ON-line Education Systems, Reference A367/BT/WP04/DS/P/005/b3, 2000.

Henze N (2005). Personalization Services for e-Learning in the Semantic Web, 2nd International Workshop on Adaptive Systems for Web-Based Education: Tools and reusability (WASWBE'05) at AIED'05, Amsterdam, Netherlands.

IEEE LTSC (2001). Draft Standard for Learning Object Metadata, Available at: http://ltsc.ieee.org/doc/wg12/LOM_WD4.htm

IEEE LTSC (2001). IEEE P1484.12 Learning Object Metadata Working Group, Scope & Purpose, Available at: http://ltsc.ieee.org/wg12/s_p.html [2001-05-03]

ILSQ (2011). Available at: http://www.engr.ncsu.edu/learningstyles/ilsweb.html

IMS (2010) IMS learner information package specification. Available at: http://www.imsproject.org/profiles/index.cfm

Jovanovic D, Rudan S (2005). eLearning system tailored to individual needs, Proceedings of INFOTEH2005, Vrnjacka Banja, Serbia, Section:7. E-education, pp. 1-6.

Jovanovic D, Zizovic M (2006). eLearning objects' types in the Personalized eLearning Model, Proceedings of TRANSPORT2006, Sofia, Bulgaria, pp XI-7:XI-13.

Jovanovic D, (2004). Organization of the Algorithm and Programming course at the Railway college, Proceedings of LogVD2004, Ziline, Slovakia.

Jovanovic D, Zizovic M, Jokanovic D (2006). Structuring of information model for personalized learning, Proceedings of INFOFEST2006, Budva, Montenegro, pp. 244-251.

Jovanovic D, Zizovic M (2007). Models of educational objects: analyses and evaluation, Proceedings of YUINFO2007, Kopaonik, Serbia, pp. 1-6.

Jovanovic D, Zizovic M (2006). Evaluating eLearning personalization, Proceedings of Uniteh2006, Gabrovo, pp III-261 – III-266.

Kock M, Paramythis A (2011). Activity sequence modelling and dynamic clustering for personalized e-learning, Journal User Modeling and User-Adapted Interaction, Kluwer Academic Publishers Hingham 21(1-2).

Melis E, Andrès E, Büdenbender J, Frishauf A, Goguadse G, Libbrecht P, Pollet M, Ullrich C (2001). ActiveMath: A web-based learning environment, Int. J. Artif. Intell. Educ., 12(4): 385-407.

Oda T, Satoh H, Watanabe S (1998). Searching deadlocked Web learners by measuring similarity of learning activities, Proceedings of Workshop WWW-Based Tutoring, 4th International Conference on Intelligent Tutoring Systems, ITS'98, San Antonio, TX, August 16-19.

Palanivel K. Kuppuswami, S (2011). Service-Oriented Reference Architecture for Personalized E-learning Systems (SORAPES). Int. J. Comput. Appl. Foundat. Comput. Sci., 24(5): 35-44.

Rios A, Millán E, Trella M, Pérez JL, Conejo R (1999). Internet based evaluation system, Lajoie S.P. Vivet M (eds.) Artificial Intelligence in Education: Open Learning Environments. IOS Press, Amsterdam, pp. 387-394.

Sangineto E, Capuano N, Gaeta M, Micarelli A (2008), Adaptive course generation through learning styles representation, Universal Access Inf. Soc., 7(1):1-23.

Sciarrone F, Vaste G (2011). Personalized e-learning in Moodle: the Moodle_LS Syst. J. e-Learning and Knowledge Society, ISSN: 1826-6223 7(1): 49-58.

Shaoling D (2011). Using Learning Styles to Implementing Personalized e-Learning System, Proceedings of International Conference on Management and Service Science (MASS), Wuhan, ISBN: 978-1-4244-6579-8.
Snow RE (1989). Aptitude-treatment interaction as a framework of research in individual differences in learning, Ackerman PL, Sternberg RJ and Glaser R (Eds.) Learning and Individual Differences: Advances in Theory and Research.
Soller A, Lesgold A (2003). A computational approach to analyzing online knowledge sharing interaction, Hoppe U, Verdejo F and Kay J (eds.) Artificial intelligence in education: Shaping the future of learning through intelligent technologies. IOS Press, Amsterdam, pp. 253-260.
Weber G, Kuhl HC, Weibelzahl S (2001). Developing adaptive internet based courses with the authoring system NetCoach, Bra PD, Brusilovsky P and Kobsa A (eds.) Proceedings of 3rd workshop on Adaptive Hypertext and Hypermedia, Sonthofen, Germany, Technical University Eindhoven, pp. 35-48.