INDeLER: eLearning Personalization by Mapping Student's Learning Style and Preference to Metadata

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***Abstract*—This paper presents the process of developing Student profile by mapping students categories explored with Felder- Soloman's ILS questionnaire to the appropriate value of the personalization vector XYZ, and by deriving vector's values from the acquired student's answers on Preference test. Obtained vector values perform the PeLCoM metadata and they provide recommendations for creating personalized eLearning experience.**

The architecture of Personalized eLearning System INDeLER is presented. INDeLER system derives student's profile, provides sequencing of personalized eLearning sessions and supports scenario for designing lessons content tailored to the individual student needs.

Further, we describe how the personalization system INDeLER includes teacher's influence to the eLearning experience by composing different pedagogical aspects and corresponding didactic and methodological processes to the unique way of teaching tailored to the particular student needs. The example of INDeLER personalization process is also shown.

***Index Terms*—eLearning personalization, learning styles, metadata, pedagogical methods**

I. INTRODUCTION

Having different backgrounds, strengths and weaknesses, interests, ambitions, senses of responsibility, levels of motivation, and approaches to studying, students can not be alike among themselves. Teaching methods also vary. Some teachers are mainly giving lectures, while others spend more time on demonstrations or activities; some focus on principles and others on applications; some emphasize memory and others understanding. How much each student learns in a class is governed in part by that student's native ability and prior preparation but also by the compatibility of the student's attributes as a learner and the instructor's teaching style [1].

Moreover, even if a teacher knew the optimum teaching styles for all students in a class, it would be impossible to implement them simultaneously in a class of more than two students. But in the eLearning environment it is possible to prepare lectures and teach each student exclusively in the manner that is best suited to those attributes. Web-based education is accessible to a large number of learners and it has a valuable advantage over traditional classroom teaching. It can be adapted to individual learner, which is hard to achieve in common teaching process.

Online learning gives the wide range of opportunities to examine student's different levels of motivation, different attitudes about teaching and learning, and different responses to specific environments and instructional practices and to tailor the eLearning experience towards exact student needs.

It is often stressed that current eLearning systems lacks in accompanying, guiding and motivating individuals and should follow more user centered approach. One of the main problems with eLearning environments is their lack of personalization. It is not possible to discover everything that affects what a student learns in a class, and even if instructors could do, they would not be able to figure out the optimum teaching style for that student.

The need for personalisation in e-learning is self-evident and adaptation strategies are quite demanding. In [2] is stated the importance of adaptive questioning in accordance with learner's answer by detection of misconceptions about electricity and remediation. Recently, a few attempts have been made to model user cognitive and affective attributes in order to achieve system's adaptability according to the needs of an individual user. And while researchers agree on the importance of adaptation towards user's cognitive and affective characteristics, there is *"little agreement on which features can and should be used and how to use them"*[3].

In [4], a mechanism is developed to model student's learning styles and present the matching content to individual student, based on the Felder-Silverman Learning Style Theory. Guidelines and examples on content adaptation and presentation depending on various learning styles in combination with instructional design theories are presented in [5]. Lessons are designed on the base of combinations of educational material modules, supporting several levels of adaptation towards individual learning style. Paper [6], gives guidelines for preparation of learning materials according to different learner's characteristics, based on pedagogical strategy and motivation factor with a strong psychological background, applying categories of Kolb's learning styles.

The implementation of personalized eLearning systems is based on *Web Intelligent Tutoring Systems* (ITS) and *Adaptive Hypermedia* (AH) and is founded on psychological theories. The aim of AH is to improve efficiency of hypermedial applications by upgrading them to personalized applications, [7]. Term *AIWBES* (*Adaptive and intelligent Web-based educational systems*), [8] mark the Web based Intelligent tutoring systems which have oportunity to be adaptable to the student needs. Some of them are described in [9], [10] and [11]. AHA [12] or WebCOBALT [13] are adaptable systems but not intelligent. Examples of tutoring systems which use the technique of adaptable presentation are ELM-ART [9], InterBook [10] and MetaLinks [14]. Some examples of ITS architecture are SQLT-Web [15] and CALAT [16].

Having in mind the student's psychological background and prior knowledge, this article examines three important aspects of student diversity: diversity related to the knowledge level and learning objective, diversity of the learner's behavior and diversity of the learning modalities and learner's preferences.

In this paper, we outline our approach to personalization according to obtained user profile, which contains user's preferences, knowledge, goals, navigation history and possibly other relevant aspects that are used to provide personalized adaptations. We give an example of: design of lesson content, adaptation of teaching strategy and creation of different visualization type of the learning materials, taking into consideration specific *learning style* (Felder-Silverman), and other student's preferences such as knowledge about subject matter, learning motivation, her/his learning intention and her/his behavior. Analyzing coordination between student's learning style and his/her other preferences for specific teaching material we generate the student's profile and personalize eLearning experience according to characteristics memorized in the profile.

The paper is organized as follows. After Introduction, Section II classifies personalization requirements according to the types of adaptation and possible influence factors in learning expirience, especially student's psychological characteristics.

Section III, presents the process of developing Student profile by mapping students categories explored with Felder- Soloman's ILS questionnaire to the appropriate value of the personalization vector XYZ, and by deriving vector's values from the acquired student's answers on Preference test.

Section IV presents the architecture of Personalized eLearning System INDeLER, and specifies its modules, specially module for deriving student's profile and module that provides sequencing of personalized eLearning sessions tailored to the individual student needs.

In Section V, as an example, we present our approach in designing lessons towards learning style and student's preferences contained in student's profile. Section VI concludes the paper.

II. PERSONALIZATION ASPECTS

We summarize influence of learning theories, learning strategies, cognitive styles, learning styles and the theory of multiple intelligences on the educational process and point which didactic and methodic elements of the teaching process can be adapted to the individual student's needs. On the basis of that, we designed the Personalized eLearning Course Model (PeLCoM) [17], and Information Learning Object Model for Personalized eLearning (ILOMPeL) [18]. The granular units of the Model are eLearning Objects (LO) and each LO is described by a set of metadata which are presented by three-dimensional vector XYZ [19].

In a three-dimensional Personalized eLearning Course Model, represented on the X, Y, Z axis we define:

- 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;
- the Y axe enables personalization from the aspect of curriculum visualisation and the type of presentation (mathematical-logical, linguistic, musical, visual etc.);
- 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 on a lesson, [20], [21].

We noticed the granular units of learning resources called eLearning Objects and their metadata. Mapping between them and defined personalization requirements is described. TABLE I summarizes different aspects which may have influence on eLearning personalization process, marks the pedagogical methods which can be modified in the way to fit individual student's needs and describes the mapping between them and PeLCoM metadata values.

The first column denotes main influential factors in learning experience and the second column marks the psychological aspects which can be measured and which determine Students Profile. According to the received results, the third column describes possible teacher's influence on the eLearning experience, which can be modeled according to the different pedagogical aspects

TABLE I
PERSONALIZATION TABLE

Influence factors in learning experience --------------------- **Adaptation**	**Why to personalize?** Student's influence - psychological aspects	**What to personalize?** Teacher's influence – pedagogical aspects *(corresponding didactics and methodic processes for personalization)*	**How to personalize?** Using Personalized eLearning Course Model	**Metadata values**	**Results of learning experience 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 corresponding to educational goals	X3={1, 2, 3, 4, 5,6}	Personalization of the learning contents from the aspects of : ▪ choosing the various learning resources,
	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 • System 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 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}	
3.3. Adaptation to the learning modalities and learner's preferences	**Learning modalities** (Gardner)	-▪Curriculum visualisation -▪Curriculum presentation	►**Yaxe**: type of lesson's of presentation ►**Yaxe**: lesson's visualization	Y1={1, 2, 3} Y2={1, 2,3}	Personalization of the learning experience from the aspects of: *Visulization Type:* ▪Formated text or Multimedia or Audio; *Presentation Type:* ▪Discussion or Categorization or Simulation.

and corresponding didactics and methodic processes. The forth column presents mapping of values in the second column to the PeLCoM metadata, which define the various personalization possibilities according to the pedagogical aspect marked in the third column.

Possible metadata values are given in the fifth column and the last column describes resulting personalization of the learning experience.

III. DERIVING STUDENT PROFILE

A. *Mapping results of Felder-Soloman ILS Questionnaire to Metadata*

According to Keefe [22], learning styles are characteristics of cognitive, affective and psychological behavior that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment. Sharp [23] describes an instructional module based on the Felder-Silverman model that makes students aware of differences in learning styles and how they may affect personal interactions, teamwork, interactions with professors, learning difficulties and successes.

Here, we analyze the student's learning style categories developed by Felder and Silverman [24], [25], and [26]. We use the Index of Learning Styles® (ILS) [27], which is a forty-four-item forced-choice instrument developed in 1991 by Richard Felder and Barbara Soloman to assess preferences on the four scales of the Felder-Silverman model. After finishing ILS Questionnaire and receiving results, they are mapped to the apropriate value of the personalization vector XYZ, with the aim to personalize eLearning experience. Short category description and corresponding recommendation for making eLearning experience adapted to the individual student's needs is described in TABLE II.

TABLE II.
ADAPTING LEARNING EXPERIENCE TOWARDS FELDER-SILVERMAN MODEL USING PELCOM METADATA

Model Category	**Category description**	**How to adapt learning experience?** Recommendation:
1.What type of information does the student preferentially perceive→ Lesson's structure (X2), Lesson's visualization (Y1), Lesson's domain (X6)		
Sensing *or*	sights, sounds, physical sensations. Sensing learners tend to be concrete thinker, practical, methodical, and oriented toward facts and hands-on procedures.	▪ concrete and practical domain for practicing, marked by X6={3} metadata value, ▪ multimedia presentation of the lesson expressed by Y1={2} metadata value.
Intuitive	memories, thoughts, insights. Intuitive learners are more comfortable with abstractions (theories, mathematical models) and are good innovative problem solvers. They are abstract thinkers, innovative, oriented towards theories and underlying meanings.	▪ mathematical - theoretical domain for practicing, expressed by X6={1} metadata value, ▪ textual presentation of the lesson marked by Y1={1} metadata value.
2. What type of sensory information is most effectively perceived: → Lesson's visualization (Y1)		
Visual *or*	learners prefer and remember best what they see: pictures, diagrams, flow charts, time lines, films, and demonstrations, sketches, schematics, photographs, or any other visual representation of course material. Color-code their notes with a highlighter so that everything relating to one topic is the same color.	▪ lesson's visualization with multimedia effects and animation, with movies, simulations, graphs, and so on, as it is shortly marked by Y1={2} metadata value.
Verbal	learners prefer written and spoken explanation. They have to write summaries or outlines of course material in their own words. Working in groups can be particularly effective: they gain understanding of material by hearing classmates' explanations and they learn even more when they do the explaining.	▪ write summaries or outlines of course material expressed by X2 ={1} metadata value, section S1 – lesson's summary and map of the lesson's parts. ▪ lesson's presentation through collaboration, group working and discussion, marked by Y1={1} metadata value.
3. How does the student prefer to process information: → Lesson's structure (S2), Lesson's presentation (Y2)		
Active *or*	through engagement in physical activity or discussion. Active learner or extroverts reacted more positively than introverts when first confronted with the requirement that they work in groups on homework.	▪ lesson's structure which contain parts: S3 – Examples, S4- Practice, S5 – Tests, sequenced in the shown order and expressed by X2={4, 3, 5} metadata value. ▪ the lesson's presentation with a lot of interaction and collaboration, expressed by Y2={1} metadata value.
Reflective	through introspection. Reflective learners prefer to think about information quietly first. "Let's think it through first" is the reflective learner's response. Reflective learners prefer working alone. Sitting through lectures without getting to do anything physical but take notes is hard for both learning types, but particularly hard for active learners.	▪ lesson's structure which consists of following parts: S2 – lectures, S3 – Examples, S5 – Tests, sequenced in the noted order and expressed by X2= {2, 3, 5} metadata value. ▪ lesson's presentation using theories and classification, marked by Y2= {2} metadata value.
4. How does the student characteristically progress toward understanding: → Course program organization (Z1), Lesson's structure (S2)		
Sequential *or*	left brain dominant, atomistic, analytic, serialist, auditory. Sequential learners have linear thinking process, and learn in small incremental steps. They tend to think in a linear manner and are able to function with only partial understanding of material they have been taught.	▪ course program content organization in the linear (sequential) manner, expressed by Z1= {1} metadata value. ▪ to outline the lecture material for themselves in logical order, expressed by X2= {1} metadata value.
Global	right brain dominant, hierarchical, visual–spatial, holistic thinking process, learn in large steps. Global learners learn in large "big picture" jumps. They think in a systems-oriented manner, and may have trouble applying new material until they fully understand it and see how it relates to material they already know about and understand. Once they grasp the big picture, however, their holistic perspective enables them to see innovative solutions to problems that sequential learners might take much longer to reach, if they get there at all.	▪ course program content organization in the spiral way, which starts from the main concepts and explanation of all relevant relationships between them, and then iteratively goes down to the lower level and explains other concept and relevant relationships, marked by Z1={3} metadata value. ▪ to get an overview of the entire chapter, as the first iteration of learning, marked by X2={1}metadata value.

B. *Mapping results of Preference test to metadata*

Beside parameters which determine the learning style, student profile is determined by results of Preference tests containing questions on student's preferences, pre-knowledge, previous activities, etc. Table III summarizes data acquired with Preference tests and nominates rules for mapping test results to metadata values XYZ. The first column in Table III, with the title "Student's profile" states various information about particular student. The second column presents terms for collecting defined data. The third column lists the rules for mapping test results with metadata vectors XYZ, based on which personalization is performed. The fourth column presents metadata description and in the last column possible values for stated metadata are given.

TABLE III.
SUMMARIZED DERIVATION OF STUDENT'S PROFILE METADATA BASED ON PREFERENCE TEST

Student's profile	Questions	Rules *	Metadata	Met. Value
Data about knowledge level				
Knowledge about the subject matter (prior knowledge) and learning history	Preferences test: 10, 11, 12	Rule 1 Rule 2	Content of teaching materials X1 Lesson's volume X4 Lesson's level X5	X1={1,2,3} X4={1,2,3} X5={1,2,3}
Data about educational goal				
Learning objective Subject matter's knowledge level	Preferences test: 1,2,3,4	Rule 3	Lesson's type X3	X3={1,2,3}
Learner's activities: - Learning strategies	Preferences test: 9	Rule 4	Course program organization Z1	Z1={1,2,3}
Data about learning modalities and learner's preferences				
Learner's preferences	Preferences test: 5, 6	Rule 5	Lesson's domain X6	X6={1,2,3}
Learner's learning modality	Preferences test: 7, 8	Rule 6	Lesson's visualization Y1 Lesson's presentation Y2	Y1={1,2,3} Y2={1,2,3}

**Rules for calculating final answers' metadata value*

C. Student profile example

After answering Felder-Soloman ILS Questionnaire and Preference test by student S09, acquired results on student profile are shown in Table IV. The third row states the possible categories for ILS Questionnaire, and the next row gives student's answers. The sixth row presents the question numbers for Preference test and student's answers are written in the next row. The following notation is agreed upon:

- Felder-Silverman categories are denoted with: A (Active), R (Reflective), S (Sensing), I (Intuitive), Ve (Verbal), Vi (Visual), Seq (Sequential), Glo (Global);
- Weight component is presented as an index of the corresponding category. For instance, if the result is Active with weight component 7, we write it down as A7;

TABLE IV
STUDENT PROFILE FOR STUDENT S09 WITH DERIVED METADATA VALUES

Resulting value of personalization tests											
Felder and Soloman ILS Questionnaire											
StId	A-R	S-I		Vi-Ve			Seq-Glo				
S09	*A5*	*I3*		*Vi7*			*Glo3*				
Preference Test											
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
c	*b*	*c*	*c*	*c*	*c*	*c*	*a*	*b*	*b*	*b*	*c*
Derived student's profile metadata value											
X1={1 }, X2={1}, X2={4,3,5}, X3={3}, X4={2}, X5={2} X6 ={3}, X6={1}, Y1={2}, Y2={1}, Z1={3}											

- Answers to questions from Preference tests are denoted with a, b, and c, where answer a has the smallest weight, and answer c has the highest weight (e.g. for particular question answer a denotes the lowest – BASIC learning level, and answer c denotes the highest – ADVANCED level).

The last row brings metadata values for personalisation vector XYZ which are derived from on student answers.

IV. ARCHITECTURE OF INDELER SYSTEM

We have accepted the eLearning concepts that suggest creation of Learning Objects (LO), introduced by eLearning standards, such as IMS (Instructional Management System) [28] and SCORM (Sharable Content Object Reference Model) [29]. When they are labeled with metadata, an e-Learning system can mix and match learning objects to create individualized learning experiences [30]. 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" [31].

In that direction we have designed the personalized eLearning course model *PeLCoM* [17], and in paper [19] we give an overview of the concept of eLearning Objects, summarize the standardization efforts with respect to their metadata and discuss LO properties and roles within PeLCoM model.

Further, based on SCORM information model and model PeLCoM , we have developed the Information Learning Object Model for Personalized eLearning (IMOOS/ILOMPeL) [18]. IMOOS's structure provides various ways of accessing and delivering learning materials according to pedagogical and physological principles which we have included, as well as according to individual differences among learners which influence learner's success and efficiency.

That presents the initial steps towards development and refinement of the architecture for Personalized eLearning System INDeLER (INDividualized eLEaRning).

The architecture of the INDeLER system is the third level archirecture, with the user interface at the first level, application modules at the second level and data base at the thirtd level.

The architecture of personalized eLearning system INDeLER contains several components: User Interface Module, Expert Personalization Module, Learning Module, Student Profile Database and Learning Objects Repository, as can be seen on Fig.1.

User Interface Module consists of *Student Interface* and *Teacher Interface*.

- *Student's Interface* enables registering to system, loging in, admission to course and assessments.
- *Teacher's Interface* enables supervising the course and student's activities, guideline, control, and creating teaching materials etc.

Teacher's Module consists of Domain Module and Pedagogical Module.

- *Domain Module* is responsible for definition and modification of *topic network* and *course content* which is domain knowledge base. Course content is presented by inter-related learning objects (LO). Domain Module provides searching facilities for specific teaching unit that needs to be presented to student. Structure of domain is presented with Information Learning Object Model for Personalized eLearning (ILOMPeL) [18].
- *Pedagogical Module* is responsible for didactic and diagnostic functionality, control and recommendation (*view – control – suggest*). Didactic functionality provides preparation of teaching materials that enables variety of combinations in order to adapt to particular student charachteristics. Diagnostic functionality comprises evaluation of student's performances, provides feedback with modification of student profile and gives directions for further work.

Expert Personalization Module consists of Personalisation Module and Student Module. The primary function of Expert Module is to partake in creation of learning syllabus for particular student according to defined parameters in student profile. In order to derive conclusions Expert Module uses specific knowledge linked to domain that is presented as metadata.

- *Personalization Module* takes student profile data and, based on functional dependences of learning materials, generates syllabus for specific student, determines learning strategy that is the most suitable for him/her and defines presentation and visualization of learning materials which are appropriate for that student.
- *Student Module* generates and modifies student profile in several steps:

- gathers student data and builds *Student's information profile database,*
- processes gathered data, derives student psychological characteristics and generates *Student's psychological profile database,*
- maps the student profile to metadata of XYZ vector, and stores processed data in *Student's metadata profile database,*
- followes the process of learning and his/her results and stores data in the *Student's history database*,
- modifies student profile according to data provided by *Student's history database* or teacher's recommendations.

Learning Module consists of *Sequencing Module* and *Presentation Module*

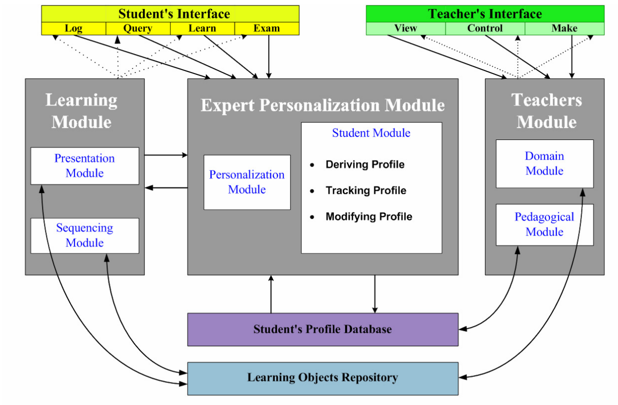

Figure 1. The architecture of personalized eLearning system INDeLER

- *Sequencing Module* performs sequencing LOs into learning units, based on metadata for specific student, obtained from Personalization Module. It is done in a following way:

- sequencing on lecture level determines programme content type and selects the group of lectures with given learning goal;
- sequencing inside the lecture determines lecture structure and its parts;
- sequencing different presentation and visualization views of the same lecture by selecting group of dependent LOs that supplement basic LO.

- *Presentation Module* enables sequencing several views of the same lecture. It is implemented by design of dependent classes containing different visualizations of LO, although each LO in its primary presentation is in black and white. Here, three view types are considered: text, text and audio (voice, music) and text and video (grafic, algorithams, simulations, animations, etc.).

Students' Profile Database contains student model providing system ability to perform individualized help at hand. Among other, it contains information on student knowledge and learning skills. Student profile is regulary updated according to the perfomed activities with system.

Learning Objects Repository contains *domain knowledge* and *pedagogical rules*. Domain knowledge is represented as interrelated learning objects. Teaching materials are represented with a collection of LOs containing knowledge elements themselves, presentation units (what students actually see on the screen) and assessment units for testing students. Learning materials are classified by their function, eg. introduction, problem description, example etc. Presentation units are classified by their media type, e.g. text, grafics, animation, video e.g. [28].

V. SEQUENCING OF PERSONALIZED ELEARNING SESSIONS

Personalization algorithm performs sequencing of personalized sessions that will present course learning material based on information from student profile, generated by Student module. On the basis of generated profil for student S09 presented in Table IV, the Personalization module will perform sequencing of sessions for *Programming in C++* course, with several iterations (i), in the following way.

At the beginning, personalization is performed for all course lectures deriving collection of lectures that should be presented to a particular student. A final syllabus for specific student is formed by creating the sequence of presentation.

i1) Based on metadata value Z1={3} of student profile, spiral organization of course learning materials will be offered to the student [20], [21].

i2) Based on parameter value for X3={3} of student profile, algorithm selects lecture by its type and student attends complex lectures containing assesments, too.

i3) Based on metadata value X2={1} and X2={4,3,5} the most appropriate lecture structure for specific student learning style is defined. Since X2 has two values defined, it is interpreted as two learning iterations. In the first iteration student is presented with course content with inter related lectures, so that student can get an overview of what to expect. Next iteration suggests election of sections that will constitute each lecture. The sequence of metadata in vector X2 designate the flow of sections in that lecture. If metadata X2 has values {4, 3, 5}, then presented lecture will contain: section 4 – assessments (*tasks*), section 3 – exercise *(examples)* and section 5 – *tests*.

After the first phase of personalization the response of eLearnig System INDeLER is shown on Fig. 2. containing the screenshot of *eLearning personalization session* for learning C++. On the basis of user profile, system has performed personalization of learning materials and teaching methods. Left frame gives the suggested course content which is the most appropriate to student S09 according to content structure and learning objectives. Besides, lecture personalization is performed and lecture content is presented in the right frame. Student is first offered assessments that should be solved, and after that solved examples are shown to self-evaluate previous task. Lecture parts that contain introduction and theory overlap because student with this type of learning style is not interested in such learning approach.

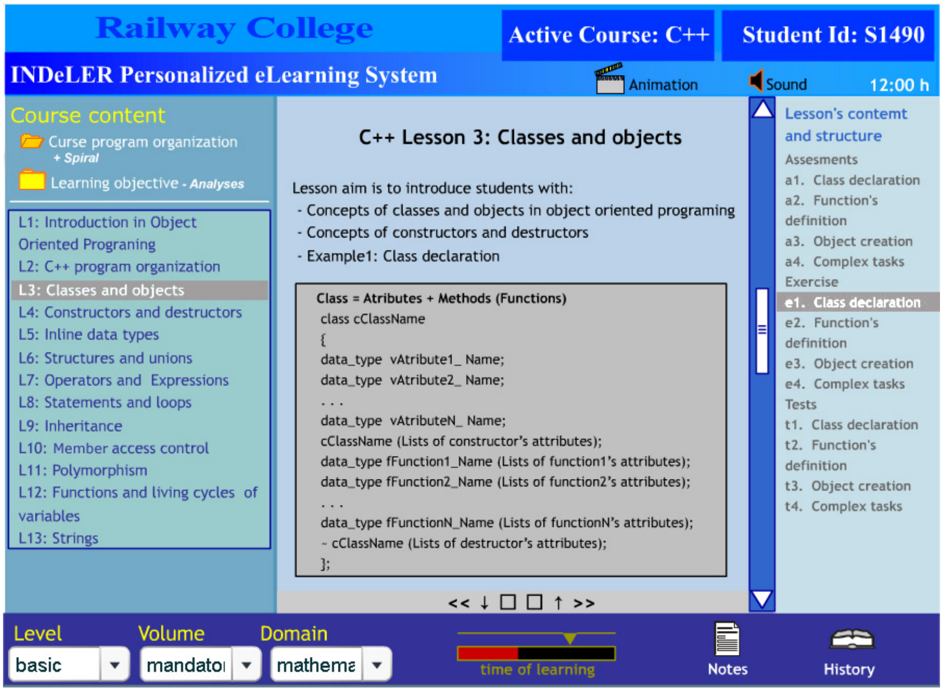

Figure 2. INDeLER screenshot with eLearning personalized sessions for learning C++

Personalization level, scope and domain of teaching material, that belongs to recommended lecture view, is realized in the following way.

i4) On the basis of metadata values for student Lesson's level X5={2}, Lesson's volume X4={2} and Lesson's domain X6 ={3}stated in student profile, a selection of learning objects is done. LOs with stated values are selected according to information model describing hierachical structure of lecture [18], and sequenced in the unique lecture view. That makes possible to sequence several different valid views into a single lecture. Personalized lecture view for this student will contain education materials of intermediate difficulty (prepared for average learning level), scope of presented materials is moderate and for application domain and exercise, a case study is recommended.

A part of selected lecture is presented on Fig. 3 in the central frame and lesson content is presented in the left frame. Sections and their content according to particular level, scope and learning domain are specified, with highlighted active section part. Right frame presents the course content with highlited current lecture.

Personalization from the aspect of presentation of learning material and the way of interpretation is realized in the following way.

i5) On the basis of metadata values for Lesson's visualization, Y1={2} and Lesson's presentation, Y2={1} stated in student profile, LO selection and linking is performed. Since Y1={2}, it means that sequencing of multimedia presentation of lecture is done.

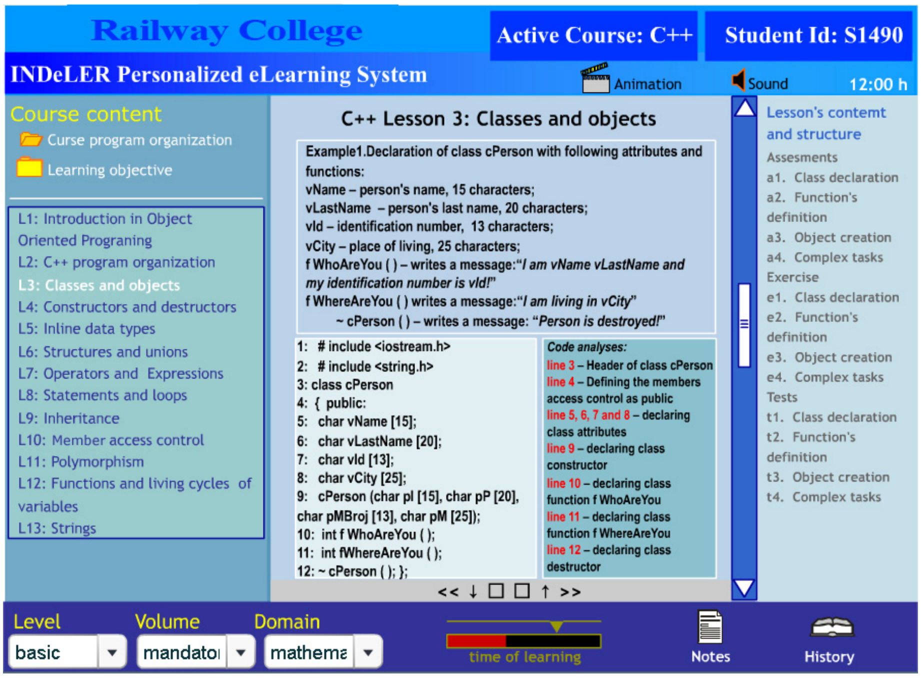

Fig 3. INDeLER screenshot of eLearning personalizated session while student positon is on Lecture L3: *Classes and Objects*, and on Example1: *Class declaration*

The central frame on Fig 4. shows multimedia presentation of lecture part. The upper frame contains source code for research example, lower left frame shows simulation of input-output operations and entered data, while lower right frame simulates the state of operational memory. Moving up and down through the source code, two additional screens are activated showing input or output of data to the screen (right) and memory occupation state (left).

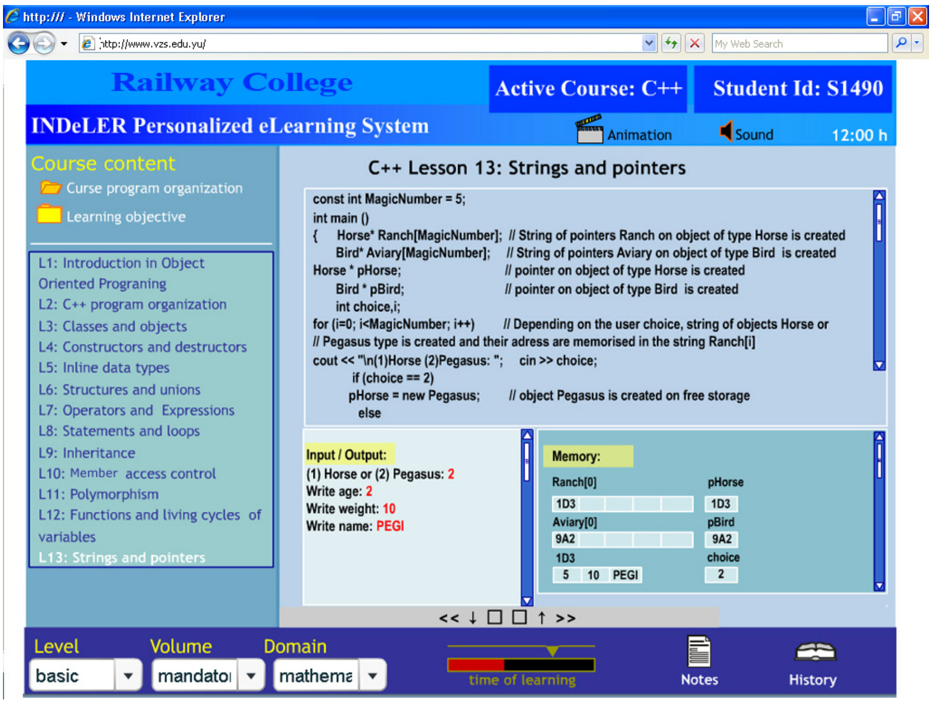

Fig 4. INDeLER screenshot of eLearning personalization showing simulation of input-output operation and simulation of memory state

According to the prior research and analyses about influence of learning style, etc. on the eLearning process, we have conducted an experimental study to examine whether model PeLCoM and system INDeLER by differently formatted elements of learning styles, have an influence on the learner's success, efficiency and motivation. We have compared performance of students who have attended the personalized eLearning sessions with those who have attended non-personalized sessions.

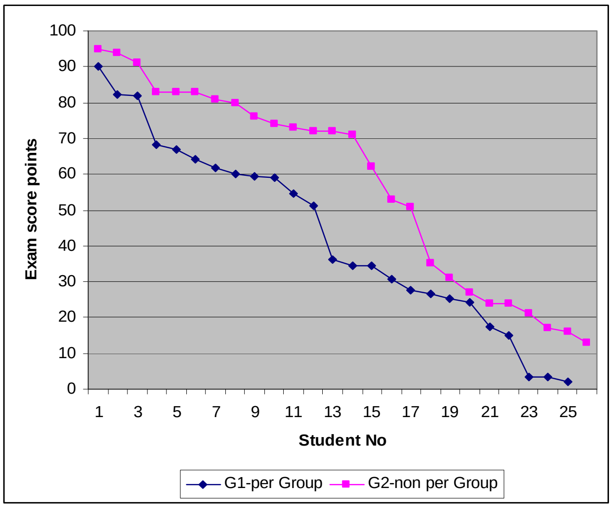

Fig. 5. Comparative exam results for students in G1 and G2 groups

For students in personalized group G1-Per Group, who attend lectures personalized by INDeLER and for students in non personalized group G2-non Per Group, who attend classical lectures, the achieved results are shown on Fig. 5. Students are presented on x-axe by Student number, on the scale from 1 to 25 and achieved results are presented on y-axe by an exam score points, on the scale from 0 to 100.

We have noticed that proposed personalization method approximately increases the student's final results by 9% if the student is excellent, by 30% if the student is good, and have the minor effects if the student is bad, where the classification excellent, good or bad is defined according to the characteristics from student profile, specially their prior knowledge. Here, we must mention that 'bad' students did not pass the prerequisite tests for necessary previous knowledge, so they don't have possibility to follow the presented lessons.

The experimental study is still going on, with stress on analyzing relationships between students profile characteristics, personalized recommendation and achieved success.

VI. CONCLUSION

We enumerate influential factors in learning experience (which we intend to adapt) and summarize how these factors are mirrored by student's psychological characteristics (students influence), on one side. On the other side, the choice of pedagogical processes that can moderate learning experience according to these factors (teachers influence) is performed. Besides, it is shown how PeLCoM metadata present corresponding didactic and methodic processes and possible results of personalized eLearning experience.

Algorithm for deriving students profile from psychological student's characteristics and information about student's preferences, prior knowledge and motivation, which is acquired by Felder-Soloman and Preference tests is presented. Felder-Silverman categories of learning style are mapped to appropriate value of the personalization vector XYZ, in the similar way as the final student's answers on Preference test are translated to the student's profile metadata (value of the vector XZY). Derived student profile is presented containing resulting categories of ILSQ, final answers to the Preference test and metadata values for XYZ personalization vector.

The three layer architecture for personalized eLearning system INDeLER is presented. It consists of User Interface Module *(containing Student's Interface and Teacher's Interface),* three main application modules*:* Teachers Module *(containing Domain module and Pedagogical Module)*, Expert Personalization Module (*containing Personalization Module and Student Module),* and Learning Module *(containing Sequencing Module and Presentation Module),* and two databases: Students' profile Data Base and Learning Objects Data Base. Developed architecture supports personalization model PeLCoM and offers personalized eLearning experience adopted to the needs of each individual learner.

Besides that, the sequencing algorithm based on student's profile is described. It composes the learning plan and generates the personalized eLearning sessions for each learning unit. Examples of personalized eLearning sessions by INDeLER personalization process, are presented and described.

The main purpose of this personalized approach is to tailor learning content, learning strategies and learning manner in the way that best fits student's personal characteristics, with the aim to increase acquired knowledge and to develop successful practice of that knowledge. This approach can be applied to undergraduate or graduate students, and we notice that it brings the best results if it is used in the form of blended learning.

We have conducted the experimental study where we have compared the achieved students results of personalized group G1, who attend lectures personalized by INDeLER and non personalized group G2, who attend classical lectures. We notice that personalized approach:

- Increases achieved marks by 9%, comparing passing grades in G1 and G2 groups;
- Increases the acquired knowledge of students who pass the exam by 15%, comparing G1 and G2 groups;
- Increases the number of students which pass an exam by 17 %, comparing G1 and G2 groups;
- Increases the exam score points by 34%, measuring for the all students in G1 according to G2 group.

We observe that student's attention and engagement are increased, compared to classical lectures and multimedia animation inducts deeper understanding and faster relating of the learning material. Except that we have detected that the students motivation and interest grow and their self-confidence and ambitions are also increased.

Future development will go toward evaluation of suggested eLearning personalization methods using INDeLER system. Further realization of an experimental study will examine and evaluate the efficacy of suggested personalization method.

REFERENCES

[1] R. M. Felder, and R. Brent, "Understanding Students Differences", *Journal of Engineering Education*, 2005, 94 (1)

[2] S. Michelet, J.M. Adam and V. Luengo, "Adaptive learning scenarios for detection of misconceptions about electricity and remediation", *iJET International journal Emerging Technologies in Learning*, Vol. 2, No. 1, 2007, www.i-jet.org

[3] P. Brusilovsky, and C. Peylo, "Adaptive Hypermedia", *User Modeling and User-Adapted Interaction 11*, Kluwer Academic Publishers, 2001, pp. 87-110.

[4] H. Hong, and Kinshuk, "Adaptation to Student Learning Styles in Web Based Educational Systems", *Proceedings of ED-MEDIA 2004 - World Conference on Educational Multimedia,Hypermedia & Telecommunications*, Lugano, Switzerland, 2004, pp.491-496.

[5] G. Magoulas, K. Papanikolaou, and M. Grigoriadou, "Adaptive webbased learning: accommodating individual differences through system's adaptation", *British Journal of Educational Technology*, 2003, Vol 34(4), http://www.dcs.bbk.ac.uk/~gmagoulas/bjet.pdf. doi:10.1111/1467-8535.00347

[6] D. Milosevic, M. Brkovic, and D. Bjekic, "Designing Lesson Content in Adaptive Learning Environments", *iJET International Journal of Emerging Technologies in Learning*, 2006. www.i-jet.org

[7] H. Wu, G. J. Houben, and P. De Bra, "AHAM: A Reference Model to Support Adaptive Hypermedia Authoring", *In the Proc. of the "Zesde Interdisciplinaire Conferentie Informatiewetenschap"*, Antwerp, Belgium, 1998, pp. 77-88.

[8] P. Brusilovsky, and C. Peylo,"Adaptive and Intelligent Web-based Educational Systems", *International Journal of Artificial Intelligence in Education*, IOS Press, 2003., Vol. 13, 156-169.

[9] P. Brusilovsky, E. Schwarz, and G. Weber, "ELM-ART: An intelligent tutoring system on World Wide Web", C. Frasson, G. Gauthier and A. Lesgold (eds.) *Intelligent Tutoring Systems. Lecture Notes in Computer Science*, Vol. 1086, Proceedings of Third International Conference on Intelligent Tutoring Systems, ITS-96, Montreal, 1996. Berlin: Springer Verlag, pp. 261-269.

[10] P. Brusilovsky, E. Schwarz, and G. Weber, " A tool for developing adaptive electronic textbooks on WWW", In H. Maurer (Ed.), Proceedings of WebNet'96, *World Conference of the Web Society*, 1996. (pp. 64-69)., San Francisco, CA, AACE. http://www.contrib.andrew.cmu.edu/~plb/WebNet96.html.

[11] P. De Bra, "Teaching Hypertext and Hypermedia through the Web", *Journal of Universal Computer Science*, 1996., 2(12), .http://www.iicm.edu/jucs_2_12/teaching_hypertext_and_hypermedia

[12] P.De Bra, and L. Calvi, "AHA! An open Adaptive Hypermedia Architecture", *The New Review of Hypermedia and Multimedia*, 1998., 4, 115-139. doi:10.1080/13614569808914698

[13] H. Mitsuhara, Y. Ochi, K. Kanenishi, and Y. Yano, "An adaptive Web-based learning system with a free-hyperlink environment", In P. Brusilovsky, N. Henze, E. Millán (Eds.), *Proceedings of Workshop on Adaptive Systems for Web-Based Education at the 2nd International Conference on Adaptive Hypermedia and Adaptive Web-Based Systems, AH'2002* (pp. 81-91). , 2002. Málaga, Spain.

[14] T. Murray, "MetaLinks: Authoring and affordances for conceptual and narrative flow in adaptive hyper books", *International Journal of Artificial Intelligence in Education*, 2003., 13(2-4), 197-231.

[15] A. Mitovic, "Porting SQL-Tutor to the web", *Proceedings of International Workshop on Adaptive and Intelligent Web-based Educational Systems*, In Conjunction with ITS 2000, 2000., Montreal, Canada.

[16] K. Nakabayashi, M. Maruyama, Y. Kato, H. Touhei, and Y. Fukuhara, "Architecture of an intelligent tutoring system on the WWW", In: B. d. Boulay, R. Mizoguchi (eds.) *Artificial Intelligence in Education: Knowledge and Media in Learning System*, Proceedings of AI-ED'97, World Conference on Artificial Intelligence in Education, Kobe, Japan, 1997, Amsterdam: IOS.

[17] D. Jovanovic, and S. Rudan, "Individualno vodjen e-Learning sistem", *INFOTEH2005*, Vrnjacka Banja 2005. sekcija:7. E-obrazovanje, 7.3.pdf, pp. 1-6

[18] D. Jovanovic, M. Zizovic, and D. Jokanovic, "Struktura informacionog modela personalizovanog eLearning sadrzaja", *INFOFEST2006*, Budva, 2006. pp. 244 – 251

[19] D. Jovanovic, and M. Zizovic, "eLearning objects' types in the Personalized eLearning Model", *TRANSPORT2006*, Sofija, 2006.

[20] D. Jovanovic, and S. Andjelic, "Prosireni spiralni model organizacije nastave iz predmeta algoritmi i programiranje u Visoj zeleznickoj skoli", *YUinfo2004*, Kopaonik, 2004. Programska oblast – Primenjena informatika, pp. 1 – 6, 103.pdf

[21] D. Jovanovic, "Organizacija nastave iz predmata Algoritmi i programiranje na smeru Informatika u Visoj zeleznickoj skoli", *LogVD2004*, Ziline, Slovakia, 2004.

[22] J. Keefe, (ed.) "Student Learning Styles: Diagnosing and Describing Programs", National Secondary School Principals. Reston VA. 1979.

[23] J.E. Sharp, "A Resource for Teaching a Learning Styles/Teamwork Module with the Soloman-Felder Index of Learning Styles", *Proceedings: Frontiers in Education Conference*, Washington, D.C.: ASEE/IEEE, 2003.

[24] R.M. Felder, and L.K. Silverman, "Learning and Teaching Styles in Engineering Education", *Engineering Education*, Vol.78, No. 7, 1988, pp. 674–681. Available at: http://www.ncsu.edu/felder-public/Papers/LS-1988.pdf.

[25] R.M. Felder,"Matters of Style," *ASEE Prism*, Vol. 6, No. 4, 1996, www.ncsu.edu/felder-public/Papers/ LSPrism. htm.

[26] R.M. Felder, "Reaching the Second Tier: Learning and Teaching Styles in College Science Education", *Journal of College Science Teaching*, Vol. 23, No. 5, 1993, pp. 286–290. Available at: ww.ncsu.edu/felderpublic/Papers/Secondtier.html.

[27] R.M. Felder, and B. Soloman, "The Index of Learning Styles® (ILS)", 1991. http://www.engr.ncsu.edu/learningstyles/ilsweb.html

[28] Getting Started in IMS, Available at: http://www.imsproject.org/pressrelease/ims_getting_started-20020729.pdf

[29] SCORM Content Development Course, http://www.scorm.tamucc.edu/scorm/home.htm

[30] IEEE LTSC: IEEE P1484.12 Learning Object Metadata Working Group, Scope & Purpose, Available at: http://ltsc.ieee.org/wg12/s_p.html

[31] Knolmayer G. F., Decision Support Models for Composing and Navigating through e-Learning Objects, Proceedings of the 36th Hawaii International Conference on System Sciences (HICSS'03)

[32] J. Vassileva, "Reactive Instructional Planning To Support Interacting Teaching Strategies", Proceedings of AI-ED 95, *World Conference on AI and Education*, AACE: Charlottesville, VA, 1995, 334-342.

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