PERSONALIZED E-LEARNING BY MAPPING STUDENT'S LEARNING STYLE AND PREFERENCE TO PELCOM METADATA

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Abstract: The paper presents the process of developing Student profile by mapping students categories explored with Felder - Silverman'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 values of XYZ vector presents the PeLCoM metadata providing recommendations for creating personalized eLearning experience. Further, we describe how personalization system INDeLER includes teacher's influence to the eLearning experience by composing different pedagogical aspects. The example of INDeLER personalization process is also shown.

Key words: eLearning, personalization, student profile, metadata, pedagogical methods, learning styles, personalized sequencing

1. INTRODUCTION

Having different backgrounds, strengths and weaknesses, interests, ambitions, sense of responsibility, levels of motivation, and approaches to studying, students can not be alike between themselves. Teaching methods also vary. Some instructors mainly lecture, 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 a given student learns in a class is governed in part by that

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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 best suited to those attributes. Web-based education is reaching a large number of learners and beside that it poses a valuable advantage over traditional classroom teaching, and the possibility to adapt to individual learners, which is hard to achieve in common teaching process.

Although, it is often stressed out that current eLearning systems lack in accompanying, guiding and motivating individuals and should follow more user centered approach. One of the main problems with e-learning 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, they would not be able to figure out the optimum teaching style for that student. Recently, few attempts have been made to model user cognitive and affective attributes in order to achieve system's adaptively according to the needs of individual user. And while researchers agree on the importance of adaptation towards user cognitive and affective characteristics, there is "*little agreement on which features can and should be used and how to use them*"[2].

In [3], 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. Using a pre-course questionnaire to determine a student's learning style or the student may choose the default style and then provided with material according to his individual learning style.

Guidelines and examples on content adaptation and presentation depending on various learning style in combination with instructional design theories are presented in [4]. Lessons are designed based on combinations of educational material modules, supporting several levels of adaptation towards individual learning style.

Paper [5], gives guidelines for preparing 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.

This article examines three important aspects of student diversity: diversity to the knowledge level and learning objective, diversity to the learner's behavior and diversity to the learning modalities and learner's preferences.

In this article, we outline our approach to pursue personalization according to obtained user profile, containing user's preferences, knowledge, goals, navigation history and possibly other relevant aspects that are used to provide personalized adaptations. We give an example of designing lesson content tailored to individual users, taking into consideration specific *learning style* end other student's preferences such as, knowledge about subject matter, learning motivation, his learning intention and his behavior. Analyzing coordination between student's learning style and his other preferences for specific teaching material we generate the student's profile and personalize eLearning experience according to his characteristics memorized in his profile.

The paper is organized as follows. After Introduction, Section II counts personalization requirements according to the types of adaptation and possible influence factors in learning experience, especially student's psychological characteristics. Section III, presents the process of developing Student profile by mapping students categories explored with Felder- Silverman'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. In Section IV, we present by example, our approach in designing lessons towards learning style and student's preferences contained in student's profile. Section V concludes the paper.

2. PERSONALIZATION REQIREMENTS

We summarize induction of learning theories, learning strategies, cognitive styles, learning styles and the theory of multiple intelligences to the educational process and point which didactic and methodic elements of the teaching process can be adopt to the individual student's needs. Based on that, we designed the Personalized eLearning Course Model (PeLCoM) [6], and Information Learning Object Model for Personalized eLearning (ILOMPeL) [7]. 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 [8].

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

- **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 visualization 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 defining of different views to a lesson, [9], [10].

We noticed the granular units of learning resources called eLearning Objects and their metadata. Mapping between them and defined personalization requirements is described.

Personalization requirements are counted according to the types of adaptation and possible influence factors in learning experience, specially student's psychological characteristics. Table 1 summaries different types of adaptation which have influence on eLearning personalization, mark the corresponding psychological aspects which determine student’s learning process and suggest methods for acquiring that characteristic. 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. The third column marks the methods for acquiring students psychological characteristics and students preferences.

Table 1. **Personalization requirements**

Types of Adaptation	**Student's influence: psychological aspects**	**Method for aquiring students characteristics**
3.1. Adaptation to the knowledge level and learning objective	Learning objectives (Bloom taxon.)	Preference test
	Prior knowledge and motivation	Preference test
3.2. Adaptation to the learner’s behavior	Cognitive styles Learning styles	Felder and Silverman
	Learning strategies	Felder and Silverman
3.3. Adaptation to the learning modalities and learner’s preferences	Learning modalities (Gardner)	Felder and Silverman Preference test

3. DERIVING STUDENT PROFILE

Process of developing Students Profile begins by exploring student's categories of learning style according to acquired results explored with Felder and Soloman ILS Questionnaire [11], and by acquiring an appropriate student's answers to the Preference test, which discovers other relevant student’s information. Next step mapped the acquired results to the value of the personalization vector XYZ. The vector presents PeLCoM metadata which provide recommendations for making personalized eLearning experience, according to the requirements described in Table 1.

3.1. Mapping results of Felder- Silverman ILS Questionnaire to metadata

According to Keefe [12], learning styles are characteristic of cognitive, affective and psychological behaviors that serve as relatively stabile indicators of how learners perceive, interact with, and respond to the learning environment. Sharp [13] 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, and learning difficulties and successes. We analyze the student’s learning style categories developed by Felder and Silverman [14, 15, 16]. We use the Index of Learning Styles® (ILS) [11], 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 students finished ILS Questionnaire and received results, they are mapped to the appropriate 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 by Table 2.

Table 2. **Adopting learning experience towards Felder-Silverman Model using PeLCoM metadata**

Model Categories	**Categories' description**	**How to adopt learning experience? Recommendation:**
1.What type of information does the student preferentially perceive→lesson's structure(S2), lesson's visualization (Y1), lesson's domain (X6)		
Sensing *or*	*sensory:* sights, sounds, physical sensations. Sensing learners tend to be concrete thinker, practical, methodical, and oriented toward facts and hands-on procedures.	▪ concrete and applied domain for practicing, marked by X6={3} metadata value, ▪ multimedia presentation of the lesson expressed by Y1={2} metadata value.
Intuitive	*intuitive:* memories, thoughts, insights. Intuitive learners are more comfortable with abstractions (theories, mathematical models) and are good innovative problem solvers. They are abstract thinker, innovative, oriented towards theories and underlying meanings.	▪mathematical –theoretical domain for practicing, expressed by S6={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*	Visual 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	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.

Model Categories	**Categories' description**	**How to adopt learning experience? Recommendation:**
3. How does the student prefer to process information: →Lesson's structure (S2), lesson's presentation (Y2)		
Active *or*	*Actively:* through engagement in physical activity or discussion. Active learner or extraverts 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 by lot interactivity and collaboration, expressed by Y2={1} metadata value.
Reflective	*Reflectively:* 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 by theories and classification, marked by Y2= {2} metadata value.
4. How does the student characteristically progress toward understanding: → curse program organization (Z1), Lesson's structure (S2)		
Sequential *or*	Sequentially: 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 their self in logical order, expressed by X2= {1} metadata value.
Global	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 [48].	▪ 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 explain 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.

3.2. 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 3 summarize data acquired with Preference tests and nominates rules for mapping test results to metadata values XYZ. The first Student's profile column states various information about particular student. The second column presents terms for collecting defined data. The third column nominate rules for mapping test results to metadata vectors XYZ, based on which is personalization performed. The fourth column presents metadata description and in the last column is given possible values for stated metadata.

Table 3. **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 leaning 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}

3.3. Student profile example

After answering Felder-Soloman ILS Questionnaire and Preference test by student ST_09, acquired results on student profile are shown in Table 4. 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:

- Felder-Silverman categories are denoted with: A (Activ), 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 Activ with weight component 7, we write it down as A7,

- Answers to questions from Preference tests are denoted with: a, b, 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 personalization vector XYZ which are derived based on student answers.

Table 4. **Student profile for student ST_09 with derived metadata values**

Resulting value of personalization tests											
Felder and Soloman ILS Questionnaire											
St_Id	AR		SI		ViVe				SeqGlo		
ST_09	*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}			

4. PERSONALIZATION SESION EXAMPLE

Personalization system INDeLER includes teacher's influence to the eLearning experience by composing different pedagogical aspects and corresponding didactics' and methodic' processes to the unique way of teaching tailored to the particular students needs. The example of INDeLER personalization process is shown.

Algorithm for personalization performs sequencing of personalized sessions that will present course learning material based on information from student profile, generated by Student module. Observing that generated profile for student ST_09 is presented in Table 4, than the Personalization module will perform sequencing of sessions for *Programming in C++* course in the following way together with several iterations.

For example, personalization from the aspect of presentation of learning material and the way of interpretation is realized in the following way. 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. Whereas Y1={2} meaning sequencing of multimedial presentation of lecture, (Fig. 1).

The central frame on figure 1, shows multimedial 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 simulate the state of operational memory. Moving up and down trough the source code, two additional screens are activated showing input or output of data to the screen (right) and memory occupation state (left).

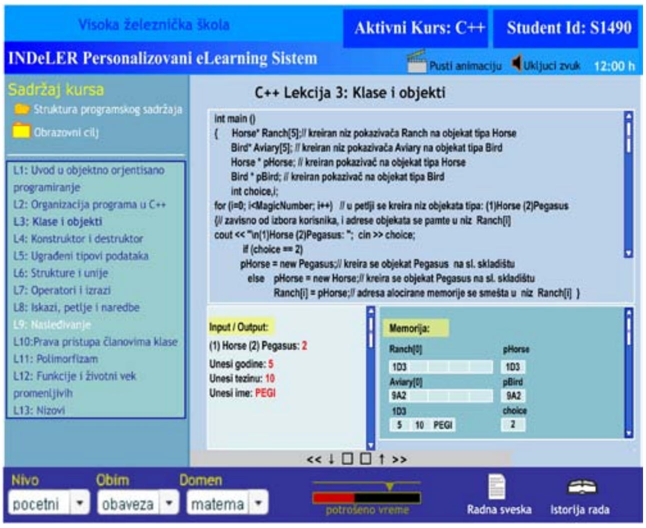

Fig 1. INDeLER screenshot of eLearning personalization showing Simulation of input-output operation and memory state

5. CONCLUSION

We enumerated influential factors in learning experience (which we intend to adapt) and summarize the way 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 that 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, as well 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. Also, 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 are presented and described. During experiment, we observe that student's attention and interest are increased in spite of (towards) classical lecture and multimedia animation inducts faster and deeper understanding and relating the learning material.

Future development will go toward evaluation of suggested eLearning of personalization methods using INDeLER system, and conducting an experimental study to examine the efficacy of suggested personalization method.

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