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 opportunity 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 experience, especially student’s psychological characteristics.

Section III, presents the process of developing Student profile by mapping student’s 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.
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-item forced-choice instrument developed in 1991 by Richard Felder and Barbara Solomon to assess preferences on the four scales of the Felder-Silverman model. After finishing ILS Questionnaire and receiving 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 in TABLE II.

<table>
<thead>
<tr>
<th>Influence factors in learning experience</th>
<th>Why to personalize?</th>
<th>What to personalize?</th>
<th>How to personalize?</th>
<th>Metadata values</th>
<th>Results of learning experience personalization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adaptation</td>
<td>Learning objectives (Bloom taxonomy)</td>
<td>Types of educational goals: explanation, assumption, practice, analysis, synthesis and evaluation</td>
<td>▶ Xaxe: lesson's type corresponding to educational goals</td>
<td>X3= [1, 2, 3, 4, 5, 6]</td>
<td>Personalization of the learning contents from the aspects of: • choosing the various learning resources,</td>
</tr>
<tr>
<td></td>
<td>Prior knowledge and preferences</td>
<td>• Volume of the curriculum • Level of difficulty of the curriculum • Domain of the curriculum</td>
<td>▶ Xaxe: curriculum's range ▶ Xaxe: curriculum's level ▶ Xaxe: curriculum's domain</td>
<td>X5=[1, 2, 3] X4=[1, 2] X6=[1, 2, 3]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cognitive styles</td>
<td>▶ Content of teaching materials ▶ Learning process flow ▶ System for teaching program’s contents</td>
<td>▶ Xaxe: lesson's view ▶ Xaxe: sequencing teaching materials (and the syllabus) on the level of lessons</td>
<td>X1=[1,2,...n] X2=[1,2,3,4,5] Z1=[1, 2, 3]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Learning strategies</td>
<td>▶ Learning processes' structure {S1,...S5} ▶ Type of lesson's of presentation (mathematical-logical, linguistic, musical, visual etc.).</td>
<td>▶ Xaxe: sequencing teaching materials that constitute a lesson ▶ Xaxe: lesson's view ▶ Xaxe: type of lesson's of presentation ▶ Xaxe: sequencing teaching materials that constitute a lesson</td>
<td>Z2=[1,2,3,4,5] X1=[1,2,...n] X2=[1,2,3,4,5] Y1=[1, 2, 3] Z2=[1,2,3,4,5]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Learning modalities</td>
<td>-Curriculum visualisation -Curriculum presentation</td>
<td>▶ Xaxe: type of lesson's of presentation ▶ Xaxe: lesson's visualization</td>
<td>Y1=[1, 2, 3] Y2=[1, 2, 3]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Gardner)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table I: Personalization Table
### TABLE II.
**ADAPTING LEARNING EXPERIENCE TOWARDS FELDER-SILVERMAN MODEL USING PELCOM METADATA**

<table>
<thead>
<tr>
<th>Model Category</th>
<th>Category description</th>
<th>How to adapt learning experience? Recommendation:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensing or Intuitive</td>
<td>sights, sounds, physical sensations. Sensing learners tend to be concrete thinker, practical, methodical, and oriented toward facts and hands-on procedures. 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.</td>
<td>• concrete and practical domain for practicing, marked by X6={3} metadata value, • multimedia presentation of the lesson expressed by Y1={2} metadata value, • mathematical - theoretical domain for practicing, expressed by X6={1} metadata value, • textual presentation of the lesson marked by Y1={1} metadata value.</td>
</tr>
<tr>
<td>Visual or Verbal</td>
<td>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. 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.</td>
<td>• 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. • 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.</td>
</tr>
<tr>
<td>Active or Reflective</td>
<td>through engagement in physical activity or discussion. Active learners or extroverts reacted more positively than introverts when first confronted with the requirement that they work in groups on homework. 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.</td>
<td>• 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. • 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.</td>
</tr>
<tr>
<td>Sequential or Global</td>
<td>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. 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.</td>
<td>• 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. • 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.</td>
</tr>
</tbody>
</table>

### 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

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

*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), V (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

<table>
<thead>
<tr>
<th>Resulting value of personalization tests</th>
<th>Felder and Soloman ILS Questionnaire</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S09</td>
</tr>
<tr>
<td>Preference Test</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>b</td>
</tr>
<tr>
<td>2</td>
<td>c</td>
</tr>
<tr>
<td>3</td>
<td>b</td>
</tr>
<tr>
<td>4</td>
<td>c</td>
</tr>
<tr>
<td>5</td>
<td>c</td>
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<tr>
<td>6</td>
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<td>9</td>
<td>c</td>
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<tr>
<td>10</td>
<td>c</td>
</tr>
<tr>
<td>11</td>
<td>c</td>
</tr>
<tr>
<td>12</td>
<td>c</td>
</tr>
</tbody>
</table>

- 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 physiological 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 architecture, with the user interface at the first level, application modules at the second level and data base at the third 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, logging 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 characteristics. 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,
  - follows 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

**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, algorithms, 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 regularly updated according to the performed 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, e.g. 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.

1. Based on metadata value $Z_1=\{3\}$ of student profile, spiral organization of course learning materials will be offered to the student [20], [21].
2. Based on parameter value for $X_3=\{3\}$ of student profile, algorithm selects lecture by its type and student attends complex lectures containing assessments, too.
3. Based on metadata value $X_2=\{1\}$ and $X_2=\{4,3,5\}$ the most appropriate lecture structure for specific student learning style is defined. Since $X_2$ has two values defined, it is interpreted as two learning iterations. In the first iteration student is presented with course lecture 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 $X_2$ designate the flow of sections in that lecture. If metadata $X_2$ 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 eLearning 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.

![INDeLER: eLearning Personalization by Mapping Student’s Learning Style and Preference to Metadata](image.png)

**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.

4. On the basis of metadata values for student Lesson's level $X_5=\{2\}$, Lesson’s volume $X_4=\{2\}$ and Lesson’s domain $X_6=\{3\}$ stated in student profile, a selection of learning objects is done. LOs with stated values are selected according to information model describing hierarchical 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 highlighted 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, \( Y_1 = \{ 2 \} \) and Lesson’s presentation, \( Y_2 = \{ 1 \} \) stated in student profile, LO selection and linking is performed. Since \( Y_1 = \{ 2 \} \), it means that sequencing of multimedia presentation of lecture is done.

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).
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.

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 achieved marks by 9%, comparing passing grades in G1 and G2 groups;
- Increases achieved marks by 9%, comparing passing grades in G1 and G2 groups;
- Increases achieved marks by 9%, comparing passing grades in G1 and G2 groups;
- Increases achieved marks by 9%, comparing passing grades in G1 and G2 groups;
- Increases achieved marks by 9%, comparing passing grades in G1 and G2 groups.

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.

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