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Augmenting Moodle with Adaptability Environment Based On Learning Styles

Mostafa Saleh, Reda Salama, Sayed Bokhary
Faculty of Computing and Information Technology KingAbdulazizUniversity P.O. Box 80221, Jeddah21589 Saudi Arabia
Corresponding Author: Mostafa Saleh

----------***ABSTRACT***----------
The Learning Management System (LMS) Moodle is currently the most popular software solution which provides many modules for various teaching and learning purposes. However, several aspects related to adapatbility are typically missing in Moodle. Personalization and Adaptation are among the main challenges in the field of e-learning. This paper presents a framework for extending Moodle to support adaptability by incorporating learning styles features to Moodle. We use the users module and lesson module from Moodle and add the extra modules of adaptation by adding modules based on student learning styles.
INDEX TERMS: *Adaptive e-learning, Learning Objects, Learning Styles, Student Models, Open Source LMS, Moodle, Personalized teaching model*

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I INTRODUCTION

E-learning is taking a great attention worldwide. It is supposed to contribute to enhance the traditional education if properly implemented. It can be beneficial to most forms of e-learning, e.g., training, continuing education, open education. It can even be used as a supporter and enhancer for traditional in-class education.

As each learner has different learner's characteristics; so, utilizing diverse educational settings may be more appropriate for one group of learner than for another. Adaptive e-learning is an e-learning system that is more effective by adapting or personalizing the presentation of information to individual learners based on their preferences, knowledge and needs. Adaptive e-learning systems try to acquire knowledge about a particular learner and offer personalized services [1]. These notions bring out the idea of Brusilovsky about adaptive e-learning systems [2] as an alternative to the traditional "one-size-fits-all" approach in the development of educational courseware.

Learners are the main actor in the e-learning environment and they are usually having varied and diverse cognitive and psychological traits. One of the important facets of the adaptive model of e-learning is to adapt the presentations of the learning material to meet the needs of each individual learner during the course delivery process. To achieve such goal, we need to detect the learner profile to adapt the content and presentation of the learning material. This profile is called Student Model (SM). Also, the learning materials are composed of small granular multimedia objects referred to as Learning Objects (LOs), to achieve a high level of adaptation.

Student model should be used for tailoring the teaching strategy and learning material for dynamically adapting it according to the student's abilities and his/her previous knowledge. Student model is often based on various different dimensions. In this project, we focus on the student model in one dimension, namely; the cognitive model, especially the learning style. A learning style is defined, among many definitions, as "the unique collection of individual skills and preferences that affect how a student perceives, gathers, and processes learning materials" [3]. Therefore, the concept of student model, especially learning styles, is considered as a central component in this research's implementation. Course authors should design their courses with their students' styles in mind, course delivery should match the student style, and student assessment should also be adapted to match each specific student's learning style. Student portfolio helps identifying the student model.

Learning Objects are stored in what is called Learning Objects Repositories (LOR). Learning objects are drawn from a LOR based on a certain criteria, which is described in terms of metadata attributes that are used to specify the selection criteria of the appropriate required material. In this research we suggested adapting the LO metadata of a standard LO model such as SCORM by adding extra attributes necessary for supporting the concepts of the student model, especially the dimension of the **learning styles**.

Learning styles mean that individuals differ in regard to what mode of instruction or study is the most effective for them [4]. So, they are distinct individual patterns of learning that vary from person to person. It is

necessary to determine what is most likely to trigger each learner's concentration, how to maintain it, and how to respond to his or her natural processing style to produce long term memory and retention [5].

There are many learning style models exist in literature, e.g. the learning style model by Felder and Silverman [6], Kolb [7], Mumford and Honey [8]. They agree that learners have different ways in which they prefer to learn. After a comprehensive study of the e-learning environment, we selected Felder and Soloman's Index of Learning Styles (ILS) [9]. The ILS is a 44-questions, freely available, multiple-choice learning style instrument, which assesses variations in individual learning style preferences across four dimensions or domains. These are Information Processing, Information Perception, Information Reception, and Information Understanding. Within each of the four domains of the ILS there are two categories. In FSLSM's there are four dimensions (Visual/Verbal, Global/Sequential, Active/Reflective, Sensing/Intuitive). Since the LSM doesn't easily change over time, it is identified for each student once, at the time he/she joined the e-learning system. The LMS is identified through the index of FSLSM questionnaire [9].

Learning management systems (LMS) are used to manage the process of creation, delivery, and assessment of the learning process. Some universities designed and developed their own systems, but most of the educational institutions started with systems off the market, commercial systems such Blackboard [10], or open-source systems such MOODLE [11],[12]. These systems enable fast utilization of the wide functionalities: exchange learning materials, do tests, communicate with each other in many ways, track and trace the progress, and so on.

Personalization and Adaptation are among the main challenges in the field of e-learning. However, just few Learning Management Systems (LMSs) support such features, mostly as experimental ones. As a matter of facts, the integration of personalization aspects into state-of-the-art and widely used LMSs is a complex task and it is taken into consideration from the scientific community [13].

Student modelling could be achieved by analyzing his behaviour data [14], [15]. On the other hand, there are researchers [16] who focus on learners' knowledge, while at the same time considering information about learning style as this arises from questionnaires.

Substantial efforts that took place were [14], [15],[16]. Popescu developed the WELSA system which is an AEHS that adapts educational resources to the learning styles of users [15]. Graf attempted to exploit the advantages of LMS and combine them with those of AEHS, proposing the use of adaptation techniques in Moodle [14]. Although the FSLSM was used in this case, its visual/verbal dimension was ignored in the development of educational resources, mainly because it is time-consuming [14]. This, however, may result in erroneous outcomes as the educational process is not fully personalized.

Kazanidis and Satratzemi developed the ProPer system which is a SCORM-based AEHS that adapts presentation and navigation according to a complex user model where learners' knowledge, educational objectives and learning style are represented [16].

El-Bishouty, et al. [17] made the learning systems more intelligent, adaptive, and customized. For accomplishing this goal, they investigated online course structures and developed a complete learner and context profiles. The profiler includes a number of information relevant to learner and his/her context. They exploited learners' cognitive skills, learning styles, and context. They focused on recognizing students' working memory capacity automatically by investigating their behavior in a learning management system (LMS). They developed a technique and an interactive tool for investigating course contents in learning management systems (LMSs) based on students' learning styles.

Cela et al. [18] studied how people learn online. They investigated the communications among students, the course content , and the instructors. Their research helped designers to improve learning activities by adapting them to the learning styles of the participants.

Kim et al. [19] developed a learning style recency-frequency-durability (LS-RFD) model for quantified investigation on the level of activities of learners for delivering the components of teaching-learning activities based on the learning style of the learner among different constraints for personalized service. According to results, user characteristics can be divided into groups for teaching-learning activity by classifying the level of preference and activity of the learner.

Atman et al. [20] used Felder and Silverman's Learning Styles Model and studied only active/reflective and visual/verbal scope of the model. Rather than using questionnaires, they investigated learner behaviors with the help of literature-based methodologies.

Brusilovsky et al., [21] developed user modeling and adaptation in distributed E-learning systems. They proposed CUMULATE, as a standard student modeling server in the distributed e-learning architecture, KnowledgeTree. They developed a particular topic-based knowledge modeling methodology and implemented it as an extrapolation agent in CUMULATE and used in QuizGuide that is an adaptive system that facilitates students to select the most appropriate self-assessment quizzes.

In this paper, we present a proposal for adding adaptive features to Moodle by augmenting it with learning style of the learner. The rest of this paper is organized as follow: section 2 presents Moodle as a LMS.

Section 3 discusses the Felder–Silverman learning style, and present the FSLSM's four dimensions of learning style. Section 4 presents the design for adapting Moodle with learning style features. Section 5 gives a case study by presenting a Web Programming course. Section 6 is directed to the conclusion.

II MOODLE AS A LMS

On 2001, a PhD Student named Martin Dougiamas, of the Curtin University of Technology started a research project aiming to create a community of developers, teachers and students around a new free open source tool for creating online courses. This software was called the Modular Object-Oriented Dynamic Learning Environment. The community of Moodle users would interact via a web site at (http://moodle.org) contributing to make evolve the Moodle software. With improved documentation and new certification, Moodle had established itself by 2007 as a leading award-winning open source LMS. From 1000 registered sites in 2004, it had gone to half a million users in 2008 and over a million users in 2010, with over 50 Moodle partners with over 100 languages translations. For instance, the Faculty of Computing and Information Technology (FCIT) at King Abdulaziz (KAU) have used Moodle for 6 years, from 2009 to 2014, to support the educational process at the college as a coordination environment among students, instructors, and course coordinators. As of December 2011 it had a user base of 72,177 registered and verified sites, serving 57,112,669 users in 5.8 million courses. At November 2017, it has a 73,351 sites serving 94,973,428 users in 232 countries, with 10,900,558 courses.

On its official website, Moodle is defined as: "a course management system (CMS) - a free, open source software package designed using sound pedagogical principles, to help educators create effective online learning communities" (http://moodle.org/). But as Dougiamas [22] says "Unfortunately the subject of my thesis, Moodle, became popular beyond my wildest dreams and I've been somewhat preoccupied with it to the detriment of my final thesis-writing year.". Because of Moodle's success Dougiamas has not been able to finish his PhD research, but has created a successful project and gathered a huge community around it.

III LEARNING STYLES (FSLSM)

Each student has his/her own learning style model which is defined in terms of the FSLSM's four dimensions (Visual/Verbal, Global/Sequential, Active/Reflective, Sensing/Intuitive). Felder and Silverman's learning style categories have been adopted in the work reported here for two reasons. First, the underlying approach is based on a sufficiently large experimentation which has validated the proposed classes on an Engineering student population. Second, although other approaches are maybe based on a stronger cognitive model formalization, the Felder and Silverman's theory provides some useful pragmatic instruments to customize teaching depending on the student's profile.

Since the LSM doesn't easily change over time, it is identified for each student once, at the time he/she joined the e-learning system. The LMS is identified through the index of FSLSM questionnaire (https://www.engr.ncsu.edu/learningstyles/ilsweb.html). It is considered as an easy way to identify the learner's learning style in more details. This questionnaire contains 44 questions and describes the learning style dimensions by using scales from -11 to +11; while zero indicates the origin of the axis, each direction on the axis refers to one of the two properties of the dimension. This means that no one has a property in the pure but rather most of us are having a mix of the properties at different ratios of the mix. For instance, a student with Visual/Verbal value of +5 is more of a Visual person and prefers to receive visual knowledge which will be more effective for his/her understanding, however, he/she can still understand this same knowledge if presented verbally but not as efficient as if it is visually presented.

Although the model is defined in a scale along each axis, but for simplicity, and instead of dealing with this scale in a fuzzy fashion, we decided to use a binary scale of only one of the two values of each dimension. For example, if the value for a certain student is -5 on the dimension of Visual/Verbal style, then this student is considered Verbal as he/she lies on the Verbal side of the axis. Therefore, as examples, one student may have an LSM like (Visual, Global, Active, Sensing), while another may be (Visual, Sequential, Active, Intuitive), etc. So, we designed a questionnaire by grouping all the items related to the same dimension in one cell in the questionnaire table to select for example Visual or Verbal or Neutral (to mean any style can fit with me).

In Information Processing (Active and Reflective learners), active learners tend to understand information best by: doing something active with it; discussing or applying it or explaining it to others. Reflectors are people who tend to collect and analyze data before taking an action. They may be more interested in reviewing other learners' and professional opinions than doing real activities. In the e-learning systems, a learner with the active learning style can be presented with an activity first, then an example, explanation and theory. For the learner with the reflective style this order would be different;(s)he is shown an example first, then an explanation and theory, and finally (s)he is asked to perform an activity.

IV DESIGN

To augment Moodle with learning style, we updated the Moodle database with user model information. The learner has to answer ILS questionnaire. But instead of answering 44 questions, we have grouped the group of questions related to each style direction in one group, and the learner should choose between for example Visual style group of Verbal style group or choose Neutral to mean that he/she is neutral between the two styles. This encourages the learner to concentrate in choosing a whole group of observations. Table 1 gives example of these group selections for (Active/ Reflective/Neutral) theme.

Although the model is defined in a scale along each axis, but for simplicity, and instead of dealing with this scale in a fuzzy fashion, we decided to use a binary scale of only one of the two values of each dimension. For example, if the value for a certain student is -5 on the dimension of Visual/Verbal style, then this student is considered Verbal as he/she lies on the Verbal side of the axis. Therefore, as examples, one student may have an LSM like (Visual, Global, Active, Sensing), while another may be (Visual, Sequential, Active, Intuitive), etc. So, we designed a questionnaire by grouping all the items related to the same dimension in one cell in the questionnaire table to select for example Visual or Verbal or Neutral (to mean any style can fit with me).

Table 1: group selection for Felder learning style dimensions (Active/ Reflective/Neutral).

A	B	C
Active	**Reflective**	**Neutral**
I understand something better after I try it out.	I understand something better after I think it through.	
When I am learning something new, it helps me to talk about it.	When I am learning something new, it helps me to think about it.	
In a study group working on difficult material, I am more likely to jump in and contribute ideas.	In a study group working on difficult material, I am more likely to sit back and listen.	
In classes I have taken I have usually gotten to know many of the students.	In classes I have taken I have rarely gotten to know many of the students.	
When I start a homework problem, I am more likely to start working on the solution immediately.	When I start a homework problem, I am more likely to try to fully understand the problem first.	
I prefer to study in a study group.	I prefer to study alone.	
I would rather first try things out.	I would rather first think about how I'm going to do it.	
I more easily remember something I have done.	I more easily remember something I have thought a lot about.	
When I have to work on a group project, I first want to have "group brainstorming" where everyone contributes ideas.	When I have to work on a group project, I first want to brainstorm individually and then come together as a group to compare	
I am more likely to be considered outgoing.	I am more likely to be considered reserved	
The idea of doing homework in groups, with one grade for the entire group, appeals to me.	The idea of doing homework in groups, with one grade for the entire group, does not appeal to me.	

We have make some changes on creating Student Learning Style by creating a onetime survey which has 4 groups, each group is divided into 3 categories A, B & C.

- In group 1, if the learner selects A then his Learning style is Active if he selected B then Learning style is Reflective if he selected C then it is neutral and any of them can fit.
- In group 2, if the learner selects A then his Learning style is Sensing if he selected B then Learning style is Intuitive if he selected C then it is neutral.
- In group 3, if the learner selects A then his Learning style is Visual if he selected B then Learning style is Verbal if he selected C then it is neutral.
- In group 4, if the learner selects A then his Learning style is Sequential if he selected B then Learning style is Global if he selected C then it is neutral.

After filing the survey, the student Learning Style will be generated for the student for all courses. Then the learner is ready to select any course and start the course play. We also made some changes in course play technique as the student course Syllabus will be generated automatically depending on the ontology (concepts and relationships between them). Figure 1 shows the items used in creating the learning object based on the learning style and ontology. Also, for each learning object, we have two versions: the generic contents for the learning object, and the recall content to be presented for the learner while previewing the learning object as a prerequisite preview to recall the information as shown in figure 2. Also, the created Learning Objects files will be distributed in file system in folders with Learning Objects name and sub-folders depending on the Generic / Recall, Sensing / Intuitive, Active / Reflective and Visual /Verbal learning styles as shown also in figure 2. After creating the Learning Objects, we create concepts for them and put the relationships between their concepts as shown in figure 3.

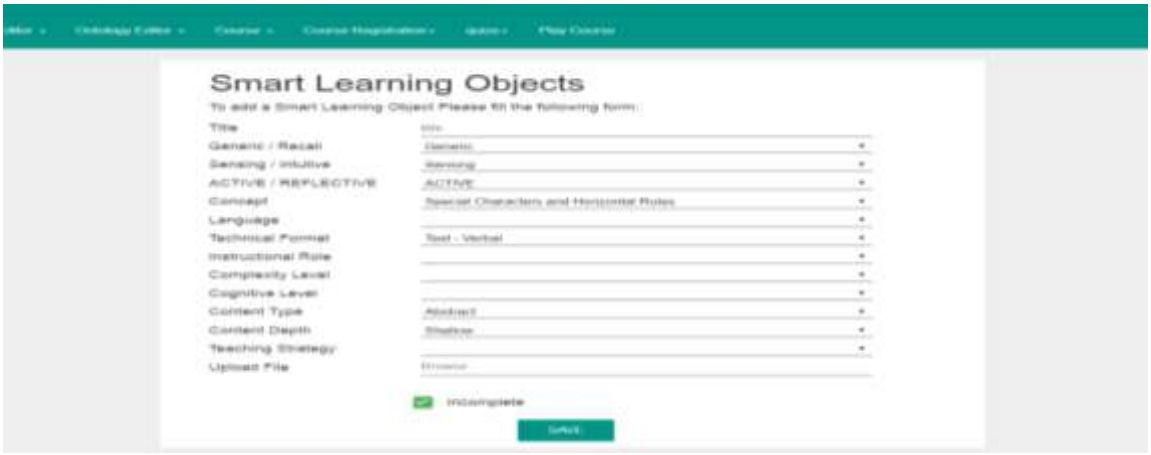

Figure 1: Creating the learning object based on the learning style and ontology

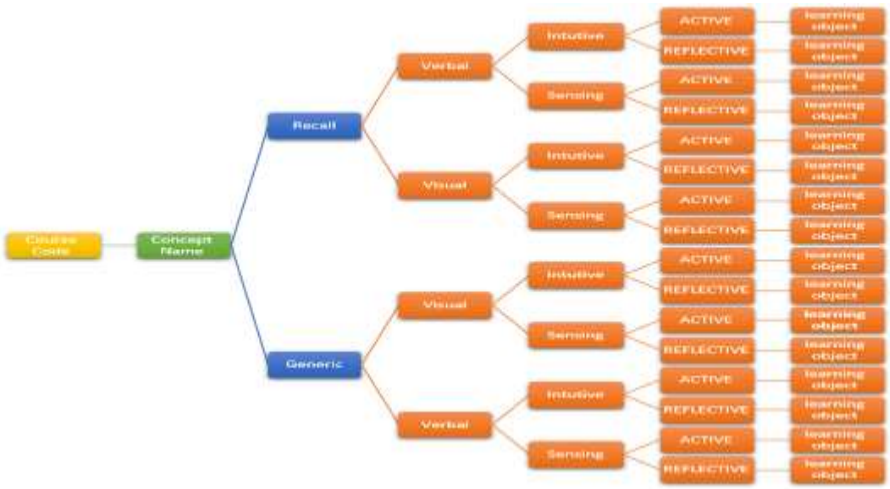

Figure 2: Learning object material in hierarchical manner

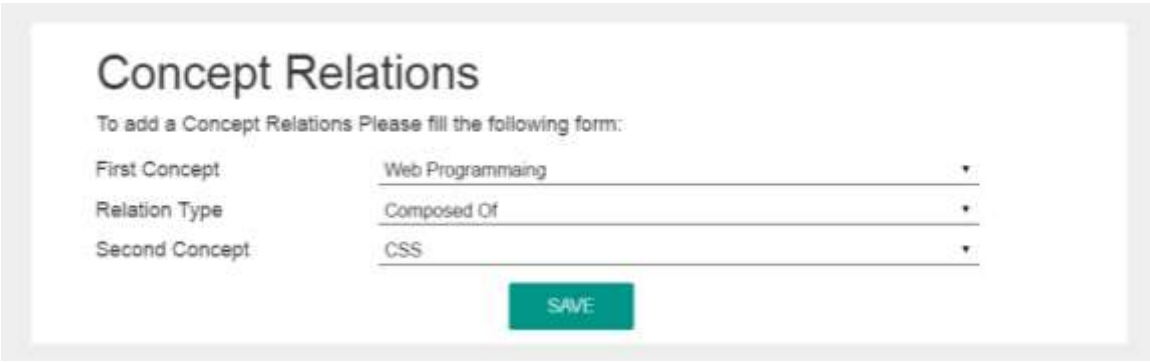

Figure 3: Concepts relationship

V TEST CASE

In order to be able to test the ideas as well as the prototype implementations, we have designed sample lectures for the Web Programming course (CPIS358) at the department of Information Systems, Faculty of Computing and Information Technology (FCIT), King Abdulaziz University (KAU). For web Programming course, some topics, such as JavaScript, PHP, HTML are discussed and presented based on the domain ontology prepared for the course.

Global student will see figure 4 to enable him to navigate through the different concepts as he/she needs much more freedome, while sequential student will will be guided by step by step navigantion.

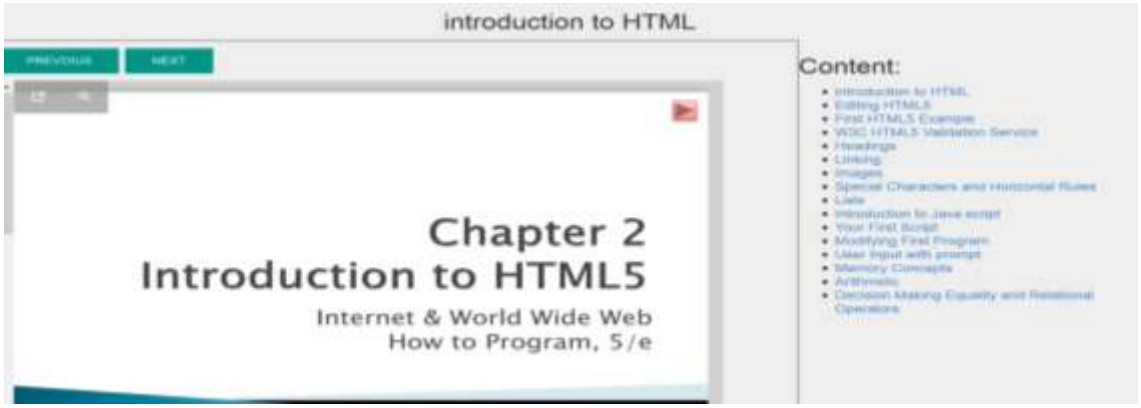

Fig. 4: Global presentation of the material to the learner

The system also saves the navigation of the student throw out the course in a log table. As follows in figure 5.

course	time	concept	stdid
CPIS-358	10:04:07 2016-05-08	66	1108685
CPIS-358	10:04:16 2016-05-08	67	1108685
CPIS-358	10:04:21 2016-05-08	66	1108685
CPIS-358	10:13:55 2016-05-08	65	1108685
CPIS-358	10:14:40 2016-05-08	64	1108685
CPIS-358	10:18:27 2016-05-08	63	1108685
CPIS-358	10:18:31 2016-05-08	61	1108685
CPIS-358	10:18:35 2016-05-08	73	1108685
CPIS-358	10:18:39 2016-05-08	61	1108685
CPIS-358	10:18:40 2016-05-08	61	1108685
CPIS-358	10:18:41 2016-05-08	73	1108685
CPIS-358	10:18:43 2016-05-08	74	1108685
CPIS-358	10:18:45 2016-05-08	75	1108685
CPIS-358	10:18:47 2016-05-08	62	1108685
CPIS-358	10:18:50 2016-05-08	63	1108685
CPIS-358	10:18:53 2016-05-08	71	1108685
CPIS-358	10:18:57 2016-05-08	72	1108685
CPIS-358	10:19:06 2016-05-08	72	1108685
CPIS-358	10:19:21 2016-05-08	72	1108685
CPIS-358	10:19:23 2016-05-08	72	1108685
CPIS-358	10:19:29 2016-05-08	72	1108685
CPIS-358	10:20:23 2016-05-08	72	1108685
CPIS-358	10:47:16 2016-05-08	72	1108685
CPIS-358	10:47:28 2016-05-08	62	1108685
CPIS-358	10:47:31 2016-05-08	73	1108685

Fig 5. Student navigation log file.

VI CONCLUSION

This paper presented a framework to adapt the well-known LMS (Moodel) with adaptively mechanism by augmenting it with the learning style. We have adapted the FSLSM by grouping all the questions related to each dimension in one group to enable the learner to choose the most appropriate. Also, we prepared a Web Programming Course to be used with the students at the Department of Information Systems, FCIT, KAU. Students are interactive with it, and did excellent work with the course.

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