A Proposed Architectural Model for an Automatic Adaptive E-Learning System Based on Users Learning Style

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Abstract—**It has been established through literature that, if an e-learning system could adapt to learning characteristics of learners, it will increase learning performance and content knowledge acquisition of learners. This paper is a *basic research* work for knowledge that lay down a foundation for application and implementation. We reviewed trends in adaptive e-learning system development, make an expository on learning-style models towards learners' learning character and propose an Architectural model of Automatic Adaptive E-learning System (AAeLS) based on learning-style concept/models. The concept it to model an e-learning system that will automatically adapt to learning preference of users', the system learn about users' learning style while the user learn the material content of the system; thus the learning process in two ways, the system is learning when the user is learning. We recommend further work on implementation and testing of the model, in an *applied research*.**

Keywords—E-Learning; Learning Style; Adaptation; AAeL

I. INTRODUCTION

Any educational platform is aimed at providing students with required information to increase their active knowledge about a particular subject. However, learning process is a variable that depends on the prior knowledge, motivation and needs of individual learners, [7]. This understanding poses a problem that emphasizes the importance of developing an adaptive system, which considers the individual needs of learners towards an effective learning process and acquisition of knowledge.

This paper review the concept of learning style and its variation in students and proposes an architectural model for an adaptive e-learning (AAeL) system based on differential concept of learning style. An adaptive learning system is one that is able to provide content information in a way that adapts to the prior knowledge and skill of learners, their learning capabilities, preference or style, their performance level and knowledge state, interests, personal circumstances and motivation, [7].

Developing training material and making them accessible on the internet is not enough, it is more important that the knowledge materials are tailored towards various learning characteristics of learners for example, their *learning styles*.

A recent trend in technology enhanced learning is integrating adaptive educational system into e-Learning. The rationale is that adapting courses to the learning preferences of the students has a positive effect on the learning process, leading to an increased efficiency, effectiveness and/or learner satisfaction, [5].

A common feature of an adaptive e-learning system is that they build a model of learner characteristics and use that model throughout the interaction with the learner, [2]. The aim is to provide the students the appropriate content at the right time, means that the system is able to determine the knowledge level, keep track of usage, and arrange content automatically for each student towards best learning result, [18]. Modritscher et al, 2004 idealize realization of adaptation in respect of learning and teaching process in an ideal e-learning system to depend on the following four elements:

Adaptive content aggregation: Depending on the learning and teaching style the system could offer different types of contend beginning with static information units to fully interactive elements like simulations, games or questionnaires. Besides, the content can be assembled with regard to different background domains, levels of detail or multimedia formats.

Adaptive presentation: The presentation of the content can be enhanced with additional, prerequisite, comparative explanations and all possible variants of these methods as well as sorting content units towards criteria like relevance to background knowledge, knowledge level, and the like. These techniques can be realised using technique like conditional text, stretch-text, page variants, fragment variants and frame-based methods.

Adaptive navigation: Navigation can be adapted in terms of global or local guidance and global or local orientation. Therefore, an e-learning environment could offer direct guidance as well as sorting, hiding and annotating links.

Adaptive collaboration support: The kind of technique, which can be offered by a network-based education system uses the system's knowledge about learners to form a collaborating group and offers or suggests communication within these learners using collaboration software.

II. LEARNING STYLE

"Learning styles are characteristic cognitive, affective and psychological behaviors that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment." [15].

When learning content is properly channeled and designed to match students' learning style, they learn best and learning process becomes more effective and efficient, [15.

Adapting learning based on learning style is the process of acquisition of knowledge that is peculiar to individual students, the attitude and behaviours of learners and determines the preferred modes of presentation of material contents in a most effective way.

Jorge Mota, in his work attributed the drawback in the general acceptability of e-Learning platform as an alternative form of training to traditional classroom as the inconsideration of the variability of learners learning style in the presentation of educational content in most of the e-learning material produced.

To design an e-learning system that integrates learning style of learners to provide adaptation in the system one needs to identify the differences in learners' attitude toward learning and addresses those differences at individual and group levels of learners.

Kolbs' Developmental theory of learning

Kolb in his postulates defined four dimensions of learning mode, conceptualize and identify learning abilities as follows:

(a) Concrete Experience (CE) (feeling), (b) Reflective Observation (RO) (reflection, watching), (c) Abstract Conceptualization (AC) (abstractness, thinking), and (d) Active Experimentation (AE) (action, doing). Learners, according to the model, must resolve a dialectical tension between immediate concrete experience and analytical detachment. In Kolb's model there are two learning continuums. Learners must choose a location between AC to CE on one continuum and AE to RO on the others. The combination of choices one makes between abilities indicates both a preference for ones ability over another and a preference for a specific construct or combination of abilities, namely, a learning style [10][11].

However, adaptive e-Learning system is a prospective platform to test and validate the effectiveness of *learning style* concept to learning outcome.

Felder-Silverman learning style model

With several learning style models in literature, Felder-Silverman learning style seems to be a preferred model as it classifies learners in broader groups and have a more detailed description about learners' leaning styles, [16].

Another main issue is that FSLSM is based on tendencies, saying that learners with a high preference for certain behaviour can also act sometimes differently, [16], this statement is a justification for the proposed architectural model of this paper. The Felder Model is most appropriate for hypermedia course ware, often used in learning style and advanced learning technology related research, [16].

TABLE I.   IDENTIFYING LEARNING STYLES FROM PATTERN OF BEHAVIOUR USING THE FOUR DIMENSIONS OF FSLSM DESCRIPTION OF LEARNING STYLES

Active	Reflective
- Discusses, explain or test learned material. - In discussion forum, post more often in other to ask, discuss, and explain something. - Perform more self-assessment tests and more exercises as well as spend overall more time on exercise. - Spend very little time of studying examples since they prefer doing something by themselves rather than looking at how someone else has solved a problem.	- Thing about and work alone on learn material. - Participate passively in discussion forum and frequently reading the posting but only rarely posting by themselves. - They visit and spend more time on reading material like content objects as well as stay longer at outlines. - They tend to take longer on self-assessment tests as well as on the result page of self-assessments and exercises for reflecting on their results. - Expected to answer the same question in a self-assessment test less often twice wrong.

Sensing	Intuitive
- Prefer facts and data in learned materials - prefer examples, spend more time on examples - like to solve problems based on standard procedures, learn existing approaches and a high number of conducted self-assessment tests and exercises in order to check the acquired knowledge. - Patient with details, work carefully but slowly	- like to study abstract theories and their underlying meaning - learn from content objects and use examples only as supplementary material. Spend higher time on content objects and lower time on examples. - creative and like challenges - answer questions about developing new solutions, which require the understanding of underlying theories and concepts.

Visual	Verbal
- learn best from what they can see such as graphics images, and flow charts.	- Prefer to learn from words, regardless whether they are spoken or written. - Tend to like communicating and discussing with others. - high number of visits and

	postings as well as high amount of time spent in a discussion forum can indicate a verbal learning style. - Expected to visit reading material such as content objects more often.

Sequential	Global
- more comfortable with details - tend to go through the course step by step in a linear way.	- like to see the "big picture" and connections to other fields. - the outline of the course and the chapters are of interest global learners. - a high number of visits and more time spent on such chapter outlines as well as on the course overview page indicate a global learning style. - they are interested in relating and connecting topics to each other, this help them to interpret predefined solutions and develop new solutions. - tend to learn in large leaps, sometimes skipping learning objects and jumping to more complex material.

We are considering automation in determining students learning style in an adaptive e-learning system design. Student modeling can be in two different ways as distinguished by Brusilovsky, 1996. It can be either *Collaborative* or *automatic*. In the collaborative approach, learners provide explicit feedback which can be used to build and update a student model, such as filling out a learning style questionnaire. The automatic approach in the other hand builds and updates the student model automatically based on the users' behaviour and actions while using the system for learning, [16].

The problems of inaccurate self-conceptions of students are eliminated in the automatic approach. Moreover, it allows students to focus only on learning rather than additionally provide explicit feedback about their preferences, [16]. Another advantage of this approach is that, it analyses data from a specific time span rather than data which are gathered at one specific point of time. Common features of Learning Management Systems (LMSs) like content objects, outlines, examples, self-assessment tests, exercises and discussion forums a basis used by Sabine et al, 2009 in his automatic student modeling.

III. ADAPTIVE LEARNING SYSTEM BASED ON LEARNING STYLES

Essaid et al, establishes that implementation of personalized e-learning system is a highly explored area of research in distance Web-based education. There have been identified differences in styles of learning and thus imperative to embed in out e-learning system, the ability to fit the learning process to these different needs of learners.

It has been generally accepted that the manner in which an individual choose or inclined to approach a learning circumstance is an influential factor to his/her performance and achievement of learning outcomes, [17]. The knowledge of the fact that there are various ways of approaching teaching and learning makes the difference in the design of an e-learning system with adaptive properties.

Yasir & Sami, 2011, proposes an approach to improve learning process through an adaptive hypermedia that provides adaptation in course content presentation based on students learning style. Experiment and statistical analysis indicates a better academic achievement in students taught with an e-learning system that adapts to their learning styles, [20].

Yasir & Sami, 2011, in their proposal for an Adaptive E-Learning Hypermedia System based on Learning Styles (AEHS-LS), presents the system based on three basic model: The ***domain model*** structured the subject matter, the knowledge of which to be learnt, the ***student model*** presents the initial knowledge level of the learner and ***the adaptation model*** provides the methods and techniques to select and present contents that fits learners knowledge state and learning preference.

Yang et al, et al 2013 proposed a personalized presentation module for developing adaptive learning system which is based on the field dependent/independent cognitive style and the eight dimensions of Felder-Silverman's learning style of students.

In most proposed adaptive learning system, only one or two dimensions of a learning style model are considered while developing the system, [21]. Yang et al, et al 2013, improved on this by developing their system based on both learning styles and cognitive styles to adapt the user interface and learning content for individual students and they took into consideration the full dimensions of a learning style model. They established through their experimental results that the proposed system could improve learning achievements of students, decreases their mental load and improve learning gains.

Farman et al, 2010 presents a concept of identifying and integrating learning styles and affective state of learners into e-learning system, aim to provide the adaptation need of individual learners. Most of the approaches to adaptive e-learning implementation based on learning style lacks dynamism in the model, [14].

Natalia et al, in their *Adaptive Hypermedia Architecture System* specifies instructional strategies and strategies for monitoring a learner's preference. They concluded through their experimental research work, that psychological and/or

pedagogical knowledge is required in the process of creating adaptive behaviour itself and recommended that the authors with experience in pedagogical psychology is allowed to design different types of strategies and apply these strategies to the applications. They also recommend that authors of application or psychologist are allowed to do the structuring of the application and organization of material content to correctly suit different learning styles, [14].

Meryem & Buket**,** 2002 concludes in their research paper that learning style do not have effect on the achievement of students in different learning environment. In my own interpretation, Meryem & Buket**,** 2002 is not declining the fact that "learning style consideration in learning process improves learning achievement" but claim that a particular learning style will pose the same effect in either e-learning platform or in a traditional classroom.

IV. AUTOMATIC ADDAPTIVE E-LEARNING SYSTEM (AAELS) ARCHITECTURE

Our proposed architecture as shown in figure 2 below;
The domain model: contains the material content of course to be learnt and is to be designed by both the teachers that handles ways of presenting/teaching the material content example;

- Presentation of content objects and outlines

- Explanations on objects and testing learned materials

- Presentation of facts and data on learning objects

- Presentation of theories and abstract modelling of learning objects

- Graphics, Image, and flow chart presentation of learning objects

- Textual presentation of learning objects

- Online discussion and chat forum on learned materials

- Solved examples and do-it-yourself exercises

 e.t.c. .. .. ..
and author with psychological and pedagogical knowledge who categorizes the presentations into different learning styles. In this domain model we'll define different presentations of the same material content to meet needs of learners with various identified learning styles.

Leaners' model: the learner model of our proposed system, define three sub models; borrowing from**,** [20]. The three sub-models are:

The profile, the knowledge level and learning style of learners. The profile contains the static properties of learner, like the username, the password, unique ID, age, e-mail, the knowledge level and the learning style of learner will have dynamic properties in our model. We propose a feedback support from responses and activities at the presentation by the adaptation model which helps in modifying the user model.

Adaptation model: this defines the mode in which the learner's knowledge and learning style (learners' model) modify and determine content (domain model) presentation. The adaptation model is seamlessly updated and re-modified, as the feedback mechanism updates the users' knowledge level and learning preference. This is the automation concept of our model.
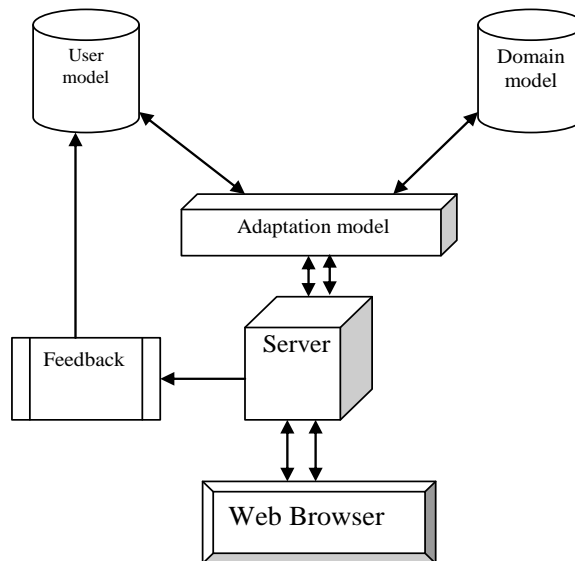

Fig. 1. AAEL-S Architecture

The proposed system can be implemented towards achieving the aim of an automatic adaptive e-learning system. The **domain model** structures the knowledge about the subject matter; the **learners' model** provides the description of the current state of learners' with respect to the knowledge about the domain to be learned, and the **adaptation model** implements the specified adaptation rules. The feedback mechanism in the proposed architecture enables the system to sense any change in the knowledge state and learning preference of learners and adaptation model is adjusted to fit the new needs of such learners, this process is going to be automatic without learners notice.

The system is to learn about the knowledge level and learning preference changes of learner while the learner learns the domain content from the system, the learning model is thus in two direction as depicted in figure 2 below:
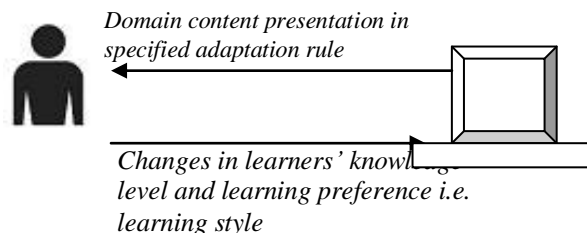

Fig. 2. two-way learning directions between learners and the AAEL-S.

V.   CONCLUSION

This work is an expository on Adaptive E-Learning system. The system architecture proposed is a modified and improved model of a related work, [20]. The proposed system is recommended for further work on implementation and testing.

The aim is to provide basic information towards designing an e-learning system that adapts to learners' preference of "learning Style" *automatically* i.e. Automatic Adaptive E-Learning System (AAeLS). The adaptation by the modeled system does not require the user/learner to perform any preliminary activity before it gets information about their adaptive needs; the system does that automatically as user/learner does his/her own study through the e-Learning platform.

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