

PALS2: Pedagogically Adaptive Learning System based on Learning Styles

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Abstract

One of the most contemporary research ideas for adaptive web-based educational systems is personalizing the educational contents, based on users' learning styles. Moreover, it is not the technology that students learn from, but its role should be elucidated as a means to enhance learning. By our proposed adaptive e-learning framework, we attempt to bridge in the gap between pedagogy and technology, emerging in recent web-based learning environments. This framework provides learners with pedagogically personalized learning contents based on their learning styles. Findings of the study indicate differences in performance between matched and non-matched students in one case of the study and in the other case, demonstrate no significant difference. Although these results pertain to an undergraduate educational session, however our proposed framework is general enough to be applied to effective and efficient pedagogy in any area at any level.

1. Introduction

Whilst electronic learning and web-based education provide more expedient virtual access to the learners around the world, some shortcomings, mostly from the perspectives of pedagogy and collaboration, confine the benefits [6]. It is no more possible to treat all students in the proliferating range of e-learning users -with very different prior knowledge of the domain, backgrounds, learning styles, interests and preferences - with the "one_size_fits_all" approach. Following the recent trend towards personalization on the World Wide Web, proposing an educational web-based system with the ability to adapt intelligently to the goals, tasks, interests, and other features of individuals and groups of users, has recently been a challenging research goal. Currently several web-based learning environments have been created that incorporate personality dimensions such as learning and cognitive style as a means of personalization. However, learning style tests and theories vary to about a dozen, some of them

incorporating similar dimensions [4,5], which indeed would make it even more overwhelming for researchers working in the field of computer science. Clearly the embedded potentials of the new technologies should be used as a means to enhance learning.. The aim of this paper is to investigate the appropriate use of learning styles in our proposed adaptive e-learning framework, in the design and implementation of personalized educational environments. Thereby the effects of "matching the educational contents to the learning styles of the learners" on their educational outcomes - concerning the underlying learning theories of pedagogy-, are explored.

2. The Design and Implementation Issues of the System

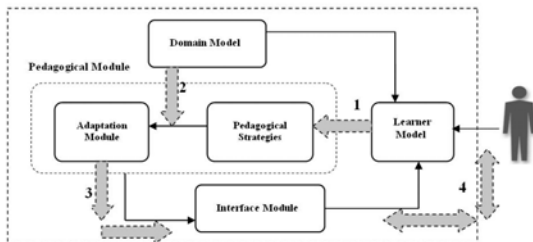
Considering that in almost every classical intelligent tutoring system (ITS), four key components can be identified, namely the domain knowledge module, the learner model, the pedagogical module and the interface module, and inspired from the Bloom's "School Learning Theory" [2], our proposed framework is as Figure I.

2.1. Learner Model

In our proposed learner model, we have adopted the Jackson's Learning Styles Profiler (LSP) [3] in order to model the learning styles of the learners. In his LSP, Jackson proposes five learning styles: sensation seeker, goal oriented achiever, emotionally intelligent achiever, deep learning achiever and conscientious achiever [3]. Our proposed learner model is a hybrid model, i.e., it consists of a stereotype model (which classifies the learners based on their entry behaviors/characteristics) and an overlay model (which is used to represent users' knowledge of the concepts of the subject domain) [1]. However, in order to compact the learning styles for study purposes, sample data were collected by requesting a group of 30 undergraduate students to fill out the Jackson's Learning Styles Profiler

questionnaire¹. Based on these results, indicating the preference degree of each of the five learning style for each student, the two most prevalent learning styles were recognized², namely, sensation seeker³ and conscientious achiever⁴ styles.

Figure I. Architecture of the system



2.2. Pedagogical Module

This module assumes responsibility for making decisions about what will be learned, how it will be learned, when it will be learned, and is composed of three main parts:

The pedagogical strategies: are issued from psychological and didactic research, pertained with the underlying learning theories (behaviorism, cognitivism and constructivism). These strategies are specified by a pedagogical specialist - expert in education- and not a computer scientist.

The adaptation module, which its role is to make adaptation decisions. At this moment, due to its flexibility and ease-of-use in every domain knowledge, adaptive presentation technique is decided to support the adaptation phase [7].

The adaptation process: this process consists of three main phases (Figure I): First, according to the learning style and background knowledge of the learner, the most appropriate pedagogical strategy is selected. Next, aspects of the strategy, which are applicable to the domain model, are delineated, based upon which, the implementation criteria would be defined. Finally, each learning object of the domain model is personalized on the basis of the criteria defined in stage 2. The interface module delivers the personalized contents to the learners and receives their feedbacks as well.

¹ This questionnaire was translated in Farsi with the permission from <http://www.cymeon.com>.

² In evaluating the JLSP questionnaire, the preference degree for each style is ranked on the scale of strong, very strong, moderate, low and very low. By "preferred" we mean styles with the rank higher than moderate.

³ Abbreviation: "SS"

⁴ Abbreviation: "CA"

2.3. Domain Model

The domain model is a knowledge representation of the materials that the learner has to learn and includes a set of domain concepts such as facts, lessons and problems forming a kind of semantic network. Our domain model consisted of Chapter two of Verilog course, thought as a supplementary content to undergraduate-hardware engineering students. The domain concepts were defined and then the links between them were carefully established.

3. Experimental Results

The main characteristic of our proposed framework is that it can be adapted to the learning style of the learner, based on the pedagogical strategy, which is considered to "match" with that style most functionally. this was a rolling process, as it comprised of pondering the characteristics, strengths and weakness of each of the two selected learning styles (SS and CA), considering their needs, preferences and the way they engage in and interact with the educational environment, and simultaneously having an eye to the key principles of each of the three learning theories (behaviorism, cognitivism and constructivism). Consequently, we decided to provide the sensation seeker types with the behavioral approach and the conscientious achiever learners with that of cognitivism. Applied techniques for mapping the former approach into practice were: providing a pre-test, breaking off the learning material into small pieces, sequencing the material from easy to more difficult and providing links for further exploration to fulfill this characteristic of sensation seeker learners. The latter approach was implemented by applying methods such as: providing the summary and outline of the content, chunking the educational material into meaningful groups and giving the learners the opportunity to revisit topics to strengthen their retention. In order to evaluate the proposed framework experimentally, we investigated the g research hypothesis that, "Matching the educational contents with the learning style of the learners along with considering the underlying pedagogical principles, affects the performance of the students in terms of learning outcomes."

The results presented in this paper are derived from a study of learning styles and performance among 44 undergraduate students at the University of Tehran. Students were randomly assigned to experimental and control groups. The ones in experimental group were provided with the personalized contents based on their learning styles whilst the other group was given the non-matched contents, originally designed for that course.

The academic performance was measured by the provided post-test. The post-test consisted of a 5-question Multiple-Choice Quiz related to the presented subject matter. Scores were calculated on the scale of 0 to 5, indicating number of correct answers. Table I represents the mean MCQ marks for the both groups.

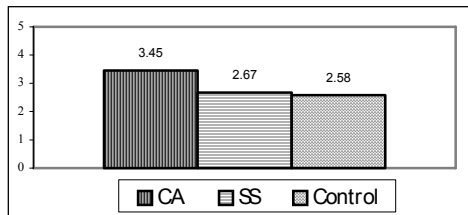


Table I. Distribution of mean MCQ mark for the sample students

At the first glance it seems that the proposed approach has effectively influenced the learners' performance and the mean MCQ scores of the both "matched" groups are higher than the control group. However in order to confirm the correctness of our hypothesis, we decided to compare each two groups of the learners separately. Using SPSS, a T-Student test (utilizing a p value of <0.05) was carried out to study the significance of any difference between educational outcomes of these groups (Table II). First, we compared the students in the CA and control groups. Statistical analysis – sig (2-tailed) = 0.20 - indicates that these matched students did perform better than students from the non-matched group, confirming our research hypothesis. Next, students in the SS and control groups were compared. From the analysis- sig (2-tailed) = 0.839, it was proven that no considerable difference between these matched students and non-matched ones could be demonstrated. Therefore, the observed increment of the means MCQ has no scientific basis. As a result, there is no evidence to support our research hypothesis in this case and it can be rejected.

Student Type	N	Standard Deviation	Mean MCQ Mark
SS	12	0.98473	2.67
CA	20	0.94451	3.45
Control	12	0.99620	2.58

Table II. Details of mean MCQ mark for students in matched and control groups.

4. Conclusions and Future Study

In this paper we have demonstrated how the use of learning styles, based on pedagogical principles, in an adaptive web-based educational system would affect learners' performance. Thereby our adaptation process is grounded on the underlying learning theories which

form the pedagogical strategies. Conclusions of this study confirm our hypothetical proposition in one case and disadvantage it in the other one. There are several probable reasons why these results occurred. It might be that, since learning styles are not static, initiating the user model once when learners first use the system, might not be adequate enough. Thus the resultant lack of adaptability due to the limitation of our experimental evaluation which investigated the hypothesis only in one session might not be as functional as it should be. Another factor to take into account is the way in which learners were assessed, using a MCQ simplified down to 5 questions. It is thus possible that learners were not assessed as effectively as they might have been. Until more evidence is acquired (e.g. from more extensive experimental evaluations), it is difficult to draw definite conclusions about the efficiency and effectiveness of using leaning styles as means of adaptation in adaptive web-based education systems.

The knowledge of learning styles could also be used to increase the self-awareness and 'metacognition' - i.e., being aware of one's own thought and learning processes- of students and instructors about their strengths and weaknesses as learners. Therefore, encouraging the learners to become knowledgeable about their own learning, -in other words, having a better self-awareness-, may lead to more effective approaches to learning and to more beneficial communication and performance. These concepts could effectively cover the focus of future works of this study.

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