Towards an Adaptive E-learning System to Address Individual Learning Styles: a Case Study

Mieassar A. al-jazairi, Thair M. Hamtini, Lama Rajab

Computer Information Systems Department, the University of Jordan, Amman, Jordan

Abstract - Adaptive e-learning system is an ongoing research area where adaptation techniques and students profiling methods are still under development. These days many outstanding researchers are looking forward to develop sophisticated adaptive e-learning systems that take into account students learning styles variations. The main goal of this research is to suggest a framework for an adaptive e-learning system, and evaluate it through a case study. The purpose of the framework is to suggest a basic structure for an adaptive e-learning system that takes into consideration students learning styles variation within a course and be suitable for their needs. An experimental evaluation was conducted on 72 IT students. The analysis investigated the impact of allowing learners to choose from multiple media representations (C-version) compared to having just one media representation on learning acquisition, and motivation (NC-version). Data analysis shows that participant’s motivation and learning acquisition increased under C-version; since more lessons were completed on it. The result of the C-version was greater than number of completed lessons under NC-version. Also, participant’s results were better under C-version in three lessons from four which reflect the increase in learning acquisition.

Keywords — e-Learning, Adaptive e-Learning, Learning Style Models, Multimedia learning, student modeling.

1. Introduction

E-Learning, often referred to as web-based learning; can be described as an instruction that is delivered using computer and communication technology (Engelbrecht, E 2005) [3]. These days the focus is shifted from developing systems and delivering instruction online to improved learning performance and increased motivation. Improving learning and performance largely depends on identifying characteristics of a particular learner correctly, such as their learning style (Shute, V. J. 1994) [18]. In short, enhancing learning, performance and motivation is a function of adapting instruction and content to suit the learner (Shute, et al., 2000) [19]. Taking specifically the learning styles to adapt the e-learning systems some researchers suggest that learning styles are not actually stable, but vary depending on the task the learner encounters (Schulmeister, R. 1996) [17]. Adaptive environments that allow for these fluctuations are scarce (McCarthy, B. 1990) [12]; mechanisms that predict these fluctuations are not existent at present (Wolf C. 2007) [21]. Also, those fluctuations in students learning styles will affect the selected media representations.

E-learning has many advantages, it is affordable, saves time, and produces measurable results (Hamtini et al., 2010) [8]. E-learning is more cost effective than traditional learning because it takes less time and more money is spent. The researchers found that the usage of e-Learning systems can enhance the learning process as well as overcoming many of the problems that are encountered in traditional learning processes. One of the problems that are encountered during the traditional learning process is that the students sometimes feel bored from the way that they perceive the educational instructions, or they do not enjoy the topic they study which may reflect negatively on the student’s outcomes.

To solve this problem, we suggest using an adaptive e-Learning system that takes into consideration students learning style. This system provides the student with suitable media representation to encourage them and increase their enjoyment for the course. The used e-Learning system should be intelligent enough to achieve this purpose and to deal with the students learning style variations and fluctuations.

2. Background and Related Work

Based on various definitions in literature review it can be concluded that learning is a process of permanent change in behavior and will begin when the learner interacts with their environment and receive concrete experience. Thus, the information achieved from the experience is integrated and compared with existing knowledge, which would enhance the learner to find new ideas to take into action. E-Learning can be described as “an creative approach for delivering well designed, interactive, learner-centered, and facilitated learning environment to anyone, anytime, anyplace by utilizing the attributes and resources of various digital technologies along with other forms of learning materials suited for open, flexible, and distributed learning environment”. Learning styles defined as learner’s approaches to receive information and learn. Learning styles affect the way students get and process...
information (Felder R.M., Brent R., 2005) [6]. Dunn and Dunn (1992) [2] suggest using learning styles in adapting lessons will motivate students and encourage them to succeed. Learning style model classifies students according to where they fit on a number of scales pertaining to the ways they receive and process information, (Felder and Silverman, 1988) [6]. Dunn and Dunn model contains five learning style domains and twenty one elements of learning style – these are shown below:

1. Environmental (sound, light, temperature, design).
2. Emotional (motivation, persistence, responsibility, structure).
3. Sociological (learning by self, pairs, peers, team, with an adult).
4. Physiological (perceptual preference, food and drink intake, time of day, mobility).
5. Psychological (global or analytic preferences, impulsive and reflective).

The preferences in the perceptual domain relate to how we perceive certain information with our senses (Mustafa, Y.E.A., and Sharif, S.M. 2011) [13].

The aim of adaptive e-Learning system is to provide appropriate information to the right student at the right time (Kolb, D. 1984) [10]. This means that an adaptive e-Learning system can track continually system usage and update content automatically to be more suitable for each one of the users; thus, allowing the users to receive the best result needed. The adaptation of learning process can be expressed in four elements:

1. Adaptive content aggregation: different content.
2. Adaptive presentation: Content displayed in different way.

Adaptive collaboration support: It provides communication between users and the aid of a collaboration application (Brusilovsky and Peylo, 2003) [1].

A large amount of information in adaptive E-Learning systems is needed to represent domain knowledge and to model the student learning behavior. This information can be divided into three main models (see figure 1):

1. Domain model: Information about the knowledge domain off course content to support adaptive course delivery.
2. Student model: Live user accounts within the system. Contains all student information, for example, their domain knowledge, behavior, learning level, and other information.
3. Adaptive model: Incorporates the adaptive theory of an adaptive e-Learning system by combining the domain model with the student model.

Some examples of learning styles usage in adaptive e-learning systems are described below. In Arthur system (Gilbert and Han, 1999) [7] course materials are presented in three different forms of media representations – audio, visual and text. Each student receives course materials in a format that best fit his/her learning method. For example, a student with verbal learning style receives course materials in textual format, and for visual student materials in visual format are presented. Thus, the connection between learning style and teaching style is achieved.

The Feedback System (Parvez and Blank, 2008) [15] provides personalized feedback for each learner taking into accounts his/her learning style. Feedback has different forms in this system. Feedback may be a definition, an example, a question, a scaffold, a picture, relationships, an application and an exercise. For example, verbal student will receive feedback as definitions, visual student will receive feedback as pictures and active student will receive feedback as exercises. Examples of other e-learning systems in which adaptation based on learning styles are used are the Multimedia System (Montgomery S, 1995) [14], the Concept Map Based System (Farell V., at el., 2018) [4], Lecomps5 (Limongelli C, et al., 2018) [11]. It is a web-based interactive adaptive learning environment, which aims to create an individualized learning environment that can accommodate specific individual learning styles.

### 3. SUGGESTED FRAMEWORK

Based on the perceptual domain of Dunn and Dunn learning style model, our system aims to adapt itself to the user learning style (Rundle, S., and Dunn, R. 1996) [16]. The preferences in the perceptual domain relate to how we like to perceive information with our senses. Table 1 below describes the characteristics of the three implemented learning preferences and which media representations best suited for it.
Building the basic learning style is carried out through the main introduction; this introduction is divided into parts and each part is displayed in different media styles. At the end a quiz with specific questions for each part will be displayed, allowing the system to create basic learning style. Building the learner basic learning style is a continuous process through the system and depends on learner results after each lesson in addition to learner selections for media representations inside lessons. This repeating will give an adaptive system that best suit the learner needs.

A learner’s basic learning style is the control style for lessons that does not allow learner to make choices. The course alternated between two conditions to check the choice impact: either learner had a choice between three media representations (dynamic adaptive) where participants were free to switch representations for every content page, or they had no choice (static adapted) where only one media representation is displayed which was matched for their basic learning style. Participants were assessed between lessons and had to complete a quiz. The quiz result is responsible for predicting the best media representation for the next lesson.

Course introduction consist of different parts, each part uses different media representation. When the learner completes the main introduction he/she should answer a quiz at the end. Based on quiz’s answers the system predicts the learner’s basic learning style. In the course version where the learner has a choice the system automatically display the first lesson using the media representation that best fit the learner basic learning style, and learner can change it using the media representation bar. The learner will always need to complete the quiz at the end of each lesson, no matter what medical representation was used during the lesson. The system depends on the selected media representations and quizzes answers to predict the best media representation for the current learner and suggest using it in the following lesson. In the course version where the user has no choice the system will display all the lessons using same media presentation that best fit his basic learning style (see figure 2).

In order to construct an adaptive e-learning environment, we choose the topic “Programming using HTML5”. A short course was created with title “Learn HTML5”, consisting of four lessons. The course content was built based on the educational website W3Schools that provide learners with tutorials and references relating to web development topics. HTML5 is a hot topic in the teaching industry. Actually, there are several reasons for choosing this topic for our eLearning course. Firstly, HTML5 was considered desirable learning objective for participants. Secondly, it is a new topic, which gives opportunities to develop different representations for the same concept by employing different media representations. Thirdly, HTML5’s doctype is as simple as can be, and it works across browsers. The course was designed to teach learners HTML5 basics and how to use the new elements such as Audio and Video elements (see figure 3). The course lessons are interrelated and depend on each other; that means the learner cannot move to the next lesson until he finishes the previous lesson and its quiz.

The goal of the quiz at the end of each lesson is to check the learner understanding. Each question related to specific media representation, and based on the learner’s answers, the system
updates the learners profile, predicts best learning style and most suitable media representation for the next lesson.

Figure 3: System basic user interface showing individual components.

4. Experimental Design and Evaluation

An experimental evaluation was conducted on 72 IT students. The analysis investigated the impact of allowing learners to choose from multiple media representations compared to having just one media representation on learning acquisition, and motivation. The generic targeted group consisted of students who have an interest in learning computer programming. The environment was designed for computer-literate participants, who could confidently navigate the Internet and use a web browser. Broadband Internet access was a requirement, due to media-rich learning components. A desirable prerequisite was that participant’s show diverse learning styles across multiple medias. As a result, participants were expected to be interested in learning different forms of media. Given these requirements, it was decided to evaluate the system with IT students in King Abdullah II School for Information technology (KASIT) in Amman, Jordan. First year IT students matched the participant profile, as they were likely to be largely computer and web-literate, with limited prior programming experience. Additionally, diversity in learning styles was expected in a sample of a student population (St Hill, 2002).

The independent variable was the level of choice. To investigate the impact of choice, participants were allocated to either of two conditions: choice (dynamic adaptive) and no choice (static adaptive). The dependent variable was the learning acquisition, measured by the quiz results after each lesson and motivation measured by number of completed lessons. The study was applied with 72 first year IT students. The participants were young adults of mixed genders.

Participants selected from first year students with limited prior programming experience. Three evaluation sessions were conducted with an average of 23 participants in each session. The sessions were held on-campus in KASIT labs at Jordan University in Amman. It was easy to conduct the evaluation by giving the learner an access to it from their home, but we avoided that because we wanted to also avoid drop-outs and its negative impact. Also on-campus evaluation reduces the risk of technical problems.

At the start of a session, learners take a brief introduction of the system and the user. The students were informed that the research was concerned with learning styles in general. Students were told that the media suggestions were based on previous selected media representations and quiz results. Furthermore, students were encouraged to try out other media representations during the lessons. The researcher’s main role is a technical support who only answered questions of general nature.

Despite the measures that were taken to maximize the participants’ motivation to complete all lessons, some participants quit the evaluation session early. Interestingly, from 72 participants only 60 participants completed the introduction and reserved a basic learning style. From 60 participants’ 30 participants completed the four lessons with their quizzes under choice version, and only 10 participants completed the four lessons with their quizzes under no choice version, the remaining participants distributed on different number of lessons. As a result of the drop-outs, the statistical analysis had to be carried out with an incomplete data set. A minimum inclusion criterion was chosen to achieve a balance between statistical meaningfulness and completeness of the data.

The minimum inclusion criterion for the analysis was set at two completed lessons, because completing two lessons from four can demonstrate an active involvement of the student. Participants with less than two completed lessons were excluded from the analysis. This criterion left 37 participants from choice lessons and 19 participants from no choice lessons for the analysis, compared to 72 participants. Of the 37 included participants under choice version, 37 participants completed 2 lessons, 34 participants completed 3 lessons and 30 participants completed 4 lessons. Of the 19 included participants under no choice version, 19 participants completed 2 lessons, 13 participants completed 3 lessons, and 10 participants completed 4 lessons.
The participants that quit the evaluation session early; were registered as users without completing the introduction or the lessons, whilst other participants complete the overall course with four lessons and quizzes. Interestingly, from 72 participants only 60 participants completed the introduction and reserved a basic learning style (see figure 4).

Figure 4 shows that 15 of all 60 participants who registered basic learning style was an auditory learners, while 44 of 60 was a visual learners, and only one participant who has a tactile-kinesthetic learning style

As our course allow students to select the preferred course version, C-version where they can use different learning style for each lesson, or NC-version where all lessons displayed with only one media representations which is student BLS, then figure 6 will shows students distribution within two course versions. 43 students visit NC-version and viewed its lessons while 51 students visit C-version and viewed its lessons.

System adaptation includes basic learning styles variations within the course. The learner’s basic learning style changed during the lessons based on quiz results and selected media representations at each lesson. Figure 7 shows how the learning style of the participants varied during the lessons. The analysis data set includes participants who completed minimum two lessons within the course to achieve a balance between statistical meaningfulness and completeness of the data. This criterion left 37 participants from choice version and 19 participants from no choice version for the analysis, compared to 60 participants who completed the introduction and reserved a basic learning style.
It was interesting to note that most of participants expressed multiple (two or three) learning styles within the course lessons. That’s mean learners tried different media representations during the lessons and these variations in media representations show variations in learners learning styles. As such, the distribution of media representation choices in the choice lessons was different from the overall perceptual style distribution for the participants. This indicates that offering participants a choice for sure can make a difference to their learning styles compared to the no choice lessons. Results and data analysis shows that our adaptive system succeed in offering an adaptive eLearning environment that allow learning style variations and let the learner select the most effective media representation that best suitable for his/her needs and interests. Data analysis shows that participant’s motivation and learning acquisition increased with choice, that’s because number of completed lessons was greater under the choice version, also participant’s results was better under choice version in three lessons from four.

In order to investigate choice affect on participant learning aquisition more data analysis have been applied on participants quizzes results. Taking in particular participants who entered both versions and completed 4 lessons with their quizzes, Figure 8 below compare number of corrected answers in both versions.

We can see that number of correct answers in C-version (lesson 2, 3, 4 continously) are higher than corrected answers in NC-version. But in lesson 1 the opposet case. We can explain this difference in number of corrected answers in lesson 1 under C-version to sudents previous knowlodge about lesson 1 content.

5. CONCLUSION

This paper suggested a framework for an adaptive e-learning system and evaluated it through a case study which uses the Dunn and Dunn learning styles model to investigate the effect of choice. Results were statistically analyzed and discussed. Data analysis shows that 24 participants from 37 who accessed C-version tried two learning styles within the course this means that the suggested framework allowed learning style variations and allowed learners to select the most effective media representation that best suitable for his/her needs and interests. Data analysis also shows that participant’s motivation and learning acquisition increased under C-version, because number of participants who completed four lessons under C-version was 30 participants while only 10 participants completed four lessons under NC-version. Also participant’s results were better under C-version in three lessons from four which reflect the increase in learning acquisition.
6. REFERENCES


