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Design and development of an innovative individualized adaptive and intelligent e-learning system for teaching–learning of probability unit: Details of UZWEBMAT

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ABSTRACT

In this study, an innovative adaptive and intelligent web based e-learning system, UZWEBMAT (Turkish abbreviation of Adaptive and INtelligent WEB based MAThematics teaching–learning system) was designed, developed and implemented. This e-learning system was intended for learning and teaching secondary school level permutation-combination-binomial expansion and probability subjects. Content which was prepared according to Turkish curriculum for secondary school mathematics course was transformed into learning objects in three different ways in accordance with VAK (Visual–Auditory–Kinesthetic) learning styles. Primary/secondary/tertiary learning styles of learners registering the system are determined and each learner receives the content appropriate for his/her dominant learning style. Also, they can be directed to contents of other styles according to their performances thanks to an expert system. Learning objects constituting the content were prepared according to constructivist approach. An active role for the learner was the purpose. Tips and intelligent solution supports within the learning objects were presented with expert system support to the learners. With this structure, UZWEBMAT bears the characteristics of intelligent tutoring system as well as an adaptive e-learning environment. All the movements of learners studying with UZWEBMAT are recorded and the necessary information is reported to both learners and teachers in a visualized way.

1. Introduction

Today, learning environments vary and evolve in parallel with rapid development of informatics technology. In this sense, e-learning environments have become common in recent years. Traditional e-learning environments present pre-determinated content in the same sequence to all learners. Therefore, they became the focus of many criticisms due to their structure. These criticisms and new approaches led to the birth of a new concept which is Adaptive Intelligent Web Based Education Systems (AIWBES). AIWBESs were developed as an alternative to traditional e-learning environments that are developed according to "one-size-fits-all" approach (Brusilovsky, 1996; Brusilovsky, 2001; Brusilovsky & Peylo, 2003). AIWBESs are systems where Adaptive Educational Hypermedia System (AEHS) and Intelligent Tutoring System (ITS) architectures are conceived together.

Though AEHSs and ITSs are often used together, they do not mean the same concept literally (Brusilovsky & Peylo, 2003). AEHSs are environments where individual differences of learners are entirely taken into account offering different content and browsing support to each individual. As for ITSs, they are computer systems which are designed using artificial intelligence methods and which know what to teach, how to teach and whom to teach (Brusilovsky & Peylo, 2003; Murray, 1999). ITSs are considered as education systems in which artificial intelligence methods are employed. They are also considered as systems offering intelligent problem solution supports and acting as intelligent solution analysts (Brusilovsky & Peylo, 2003; Keleş, Ocak, Keleş, & Gülcü, 2009; Muñoz-Merino, Molina, Muñoz-Organero, & Kloos, 2012).

Design of AIWBESs is one of the important research topics for researchers' education and computer sciences. Key concept in these systems is being known which characteristic of the learner will be computerized and how to use this information. Tendency of researchers regarding this topic is taking learning styles, which is considered as the preference of taking, using and saving the information, into account (Kainnen, 2009). According to researchers, e-learning environments developed taking into account learning styles are more efficient than traditional e-learning environments. Besides, according to many previous studies, e-learning environments employing a specific learning style are more efficient for learners with higher level of satisfaction and reduced period of time for learning (Bajraktarevic & Fullick, 2003; Chua, Liaob, Chenc, Lind, & Chen, 2011; Manochehr, 2006; Mustafa

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& Sharif, 2011; Papanikolaou, Grigoriadou, Kornilakis, & Magoulas, 2003; Popescu, 2010; Sangineto, Capuano, Gaeta, & Micarelli, 2008; Triantafillou, Pomportsis, & Demetriadis, 2003; Wang, 2008; Wang, Wanga, & Lin, 2010). From this aspect, learning styles can be taken as basis for constructing user model in design of AEHSs (Brown, Cristea, Stewart, & Brailsford, 2005; Karampiperis & Sampson, 2005; Liegle & Janicki, 2006).

In this study, an individualized adaptive and intelligent e-learning environment based on learning styles, UZWEBMAT, was developed and implemented. In addition to embodying AEHS and ITS characteristics together, this system bears many innovative characteristics than other present systems. These characteristics are described in detail in Section 3.

Thanks to UZWEBMAT, an innovative e-learning environment which adapts itself according to individual learning differences of learners was produced. Content of UZWEBMAT covers secondary school level permutation–combination–binomial expansion and probability subjects. UZWEBMAT was constructed upon VAK (Visual–Auditory–Kinesthetic) learning styles. An adaptive and intelligent e-learning system taking into account individual differences of learners and giving feedbacks to each learner according to his/her performance was implemented. Owing to this structure, UZWEBMAT is an e-learning system which aims at achieving individual learning, which is considered as necessary and important by our current education system, at the highest level.

This paper reveals all characteristics and differences of UZWEBMAT system in detail as well as defining it. Section 2 deals with learning styles and their importance in terms of learning environments. Section 3 deals with related studies, present systems and innovations within UZWEBMAT. Section 4 deals in detail with UZWEBMAT architecture, content and characteristics. Lastly, Section 5 deals with our conclusions and road map regarding future studies in relation to UZWEBMAT.

2. Learning styles and their roles in learning environments

In recent years, how learners learn is one of most argumentative questions in educational system. In this sense, approaches aiming taking into account individual differences of learners while creating learning environments attracted attention. For years, many researchers conducted many studies in relation to maintain educational activities taking into account differences in learning processes of individuals (Adey, Fairbrother, Wiliam, Johnson, & Jones, 1999). Learning styles concept is one of the prominent concepts often mentioned while taking into account individual differences of learners.

Learning styles are considered as one of the factors influencing learner achievement. Learning styles is one of studies topics since 1940s by psychologists and educational scientists (Zhang, 1999). Since that date, many studies were conducted regarding learning styles. Main purpose of these studies was to reveal the fact that individuals employ different methods over the course of learning. Learning style can be defined as learning preferences and differences of the individual in the broadest way (Adey et al., 1999). Degrading learning processes from complicated phase to simple one lays the underground for learning style theory. Learning style concept can be considered in a wide frame due to various perspectives and variety in previous studies according to Zhang (1999), it is possible to mention about almost 30 different learning styles. Besides, many researchers create and use their own learning style instruments from the combination of present styles. Coffield, Moseley, Hall, and Ecclestone (2004) states almost 71 different models in his studies. Of the most used learning styles in literature, Felder–Silverman, Kolb, Dunn and Dunn, Honey and Mumford and VAK/VARK come first.

Main purpose for selecting VAK learning style for UZWEBMAT is the reason that this learning style is appropriate for structural characteristics of topics constituting the content of the system. Hence, there are various studies in literature indicating the difficulties encountered while teaching–learning permutation–combination–binomial expansion and probability subjects (Gürbüz & Birgin, 2012; Kafoussi, 2004). Education is generally teacher centered, related subjects often cover abstract concepts and this structure leads learners to misconceptions are some prominent difficulties (Gürbüz & Birgin, 2012; Manage & Scariano, 2010). Underlying reason of these misconceptions are often teacher based lecturing environment, lack of appropriate educational materials, learners' having misconceptions in relation to these subjects (Gürbüz, 2010; Gürbüz & Birgin, 2012; Manage & Scariano, 2010), learners' developing negative attitude towards probability subject and teachers' lacking an efficient and effective teaching method while lecturing this subject. This and similar lacks obligate studies for developing appropriate materials for teaching and learning related subjects, developing and implementing e-learning environments as well as assessing the results. In this sense, concretization and presentation of these subjects to learners and creation of learning environments with enriched contents aiming at eradicating misconceptions is of much importance. Thus, VAK learning style is an effective learning style for this subject.

3. Related works and innovation of the UZWEBMAT

This section deals with studies regarding AIWBESs based on learning styles and comparison of UZWEBMAT. Examined studies are given in Table 1. Information in the table, learning styles and system in each style are given in alphabetical order.

In addition to classifications in Table 1, studies were classified according to educational levels as well. Sequence of 38 studies examined within the context according to educational levels can be listed as follows; university level ($n = 26; f = 68.4\%$), secondary school level ($n = 3; f = 7.9\%$), primary school level ($n = 1, f = 2.6\%$) and non-defined ($n = 8, f = 21.1\%$). When studies with defined levels were examined ($n = 30$) it was seen that majority of these ($n = 26, f = 86.7\%$) are at university level. Additionally, it drew attention to the fact that primary and secondary school level studies are quite limited in number. As for topic based assessment of the studies, there are studies about various topics (mainly computer sciences) whereas there is only limited number of mathematics researches. Hence, there is one and only secondary school level mathematics study in literature (TSAL Tseng, Chu, Hwang, & Tsai, 2008). In this sense, it is fact that these studies lack in terms of especially secondary and high school level (Brown, Brailsford, Fisher, & Moore, 2009; Mustafa & Sharif, 2011). Thus, design, implementation and assessment of an adaptive and intelligent e-learning environment may contribute much to literature. UZWEBMAT was developed as a more innovative system taking into consideration other systems in literature.

The most distinguishing characteristic of UZWEBMAT from other AIWBESs in literature is its structure. Inherently, UZWEBMAT bears the characteristics of both AEHS and ITS. AEHSs of studies examined in literature mainly offer adapted content to learners according to learning styles (Bachari, Abelwahed, & Adnani, 2011; Brown et al., 2009; Mustafa & Sharif, 2011). As for UZWEBMAT, it is distinguished from other studies literature since it possesses the characteristics of both types. Thus, while UZWEBMAT is making adaptations based on learning styles, it presents this content with the support of expert system. UZWEBMAT can both be considered as a strong AEHS in terms of controlling content and system structure and ITS. All the systems in literature determine learning style of the learner and present the content only appropriate to that