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Integration into mathematics classrooms of an adaptive and intelligent individualized e-learning environment: Implementation and evaluation of UZWEBMAT

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ABSTRACT

The purpose of this study is to design an adaptive and intelligent individualized e-learning environment based on learning style and expert system named UZWEBMAT and to evaluate its effects on students' learning of the unit of probability. In the study, initially, learning objects were prepared in three different ways in relation to Visual–Auditory–Kinesthetic (VAK) learning style for each subject of the probability unit. These were appropriate for secondary school mathematics curricula. Then, they were transferred into the digital environment. Each student may follow a different course, and the solution supports s/he will get may also differ highlighting the individual learning. The sample of the study consists of 81 10th grade students from two high schools in Trabzon, Turkey. Qualitative and quantitative data were collected from students to answer research questions. Quantitative data were given as frequency distribution and percentages. Qualitative data were analyzed using qualitative data analysis methods. Results of the study indicated that opinions regarding UZWEBMAT are rather positive. Aiming at individual learning, UZWEBMAT provides the most appropriate environment for students. In addition, UZWEBMAT can be used as well to reinforce traditional classroom education.

1. Introduction

Online education offers big and important opportunities to educators as well as students. The computer, which is a dynamic force in distance education thanks to internet and web and enables a new and interactive means of overcoming time and distance problems to reach learners, ranks first among these opportunities (Baki & Güveli, 2008; Baki & Çakiroglu, 2010; Botsios, Georgiou, & Safouris, 2008; Kim & Gilman, 2008; Wagschal, 1998; Wang, 2008). Traditional web based learning environments started to be criticized in terms of their limited aspect presenting the same content to each user under a predetermined roof (Berge, 2002; Brusilovsky, 2001). Traditional web based learning environments do not take into consideration certain different parameters such as students' learning differences, previous experiences and learning abilities. Due to this structure of traditional web based learning environment, many students cannot deal with online course requirements and take control of their learning (Berge, 2002; Picciano, 2001; Saba, 2002).

An adaptive learning system is usually a web-based application program that provides a personalized learning environment for each learner by adapting both the presentation and the wandering in content (Retalis & Papasalouros, 2005). Adaptive Educational Hypermedia Systems (AEHSs) refer to one of the approaches to adaptive learning. According to Brusilovsky (2001), Adaptive Hypermedia is an alternative to the traditional "one-size-fits-all" approach in the development of Hypermedia Systems. In a traditional web based learning environment, the same material is offered to students without taking into consideration students' pre-information, learning style or individual differences relating the topic. This is not something acceptable since individual differences, pre-information and the needs of students can be different. These differences may have an impact on their learning. Unlike traditional web based learning systems, AEHSs create a user model determining the individual differences of each student such as their knowledge levels about the topic, preferences and learning styles (Brown, Cristea, Stewart, & Brailsford, 2005; Brusilovsky, 2001; Brusilovsky & Peylo, 2003; Romero, Ventura, Zafra, & de Bra, 2009). These systems can be designed according to many parameters such as learning styles, learning speeds, needs and pre-information about the topic.

Learning process is complicated. People may learn differently (Franzoni & Assar, 2009). Many parameters such as perception of

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information by individual, his/her processing the information, learning styles, general abilities, developmental characteristics and environmental factors play a role during this process. Knowing learning styles' and designing and implementing learning activities in relation to these styles prove that many students, who used to be considered as having difficulty in learning, do not have difficulty in learning. In fact, when they are provided with appropriate environments and stimulants, they are capable of learning easily, too (Graf, Kinshuk, & Liu, 2009; Liegle & Janicki, 2006). In the broadest term, Learning Style (LS) can be defined as individual learning preferences and learning differences (Akkoyunlu & Soylu, 2008). Simplifying learning processes from complexity to simplicity is the underlying structure of LS theory. Some of the learning styles that are present in literature are Dunn and Dunn, Kolb, Felder and Silverman; Honey and Mumford and VAK (Visual–Auditory–Kinesthetic) (Akkoyunlu & Soylu, 2008; Brown, Brailsford, Fisher, & Moore, 2009; Franzoni & Assar, 2009; Graf et al., 2009). Many LSs were suggested in addition to the above-mentioned ones, and studies were conducted about them. VAK LS is a model that can be considered a basis among the said learning styles. This model appears as a LS that is based on individuals' seeing, hearing, touching and working with moving objects (Kainnen, 2009). VAK LS was designed by Sarasin (1998) and developed by Coffield, Moseley, Hall, and Ecclestone (2004). Learning styles are considered relevant for the adaptation process in the user model, and have been used as a basis for adaptation in AEHS (Brown et al., 2005; Georgiou & Makry, 2004; Karampiperis & Sampson, 2005; Manochehr, 2006; Mustafa & Sharif, 2011; Papanikolaou, Mabbott, Bull, & Grigoriadou, 2006).

1.1. Previous research

Recently, many researchers have attempted to design and develop individualized learning environments based on learning styles. Triantafillou, Pomportsis, and Georgiadou (2002) developed AES-CS. Witkin and Goodenough LS was employed in this system. Two different LSs, field dependent and field independent, were used in this system. Those who learn field dependently follow a course from general to specific while those who learn field independently follow a course from specific to general. Arthur was designed and developed by Gilbert and Han (1999). VAK LS model was taken as basis in this system, and visual-interactive, audial-voiced and text-writing based content was prepared and presented to the student. The system was developed in order to teach C++, a computer programming language. CS383 was developed by Carver, Howard, and Lane (1999). Felder–Silverman LS was employed in this system. The system was designed for "Computer Systems" course. Brown, Fisher, and Brailsford (2007) developed the system named DEUS. Felder–Silverman LS was taken as basis in this system. The system was prepared at primary school level to teach life-cycle and flowery plants subjects of biology course. eTeacher was developed by Schiaffino, Garcia, and Amandi (2008). Felder–Silverman LS was taken as basis in this system. This system was prepared in order to teach artificial intelligence course taught in the department of system engineering. iWeaver was developed by Wolf (2003). Based on Dunn & Dunn LS, this system employed the adaptive version of this style. This system was developed in order to teach Java programming course. It was enriched with style based media components and other learning instruments. Four different contents were prepared and presented according to the perceptions of individuals. ILASH was developed by Bajraktarevic, Hall, and Fullick (2003). Hsiao LS was employed in this system. This system was designed to teach "characteristics of waves" and "solar system" subjects of physics course. INSPIRE was developed by Grigoriadou, Papanikolaou, Kornilakis, and Magoulas (2001). Honey & Mumford LS was employed in this system. WHURLE-LS is built upon on WHURLE system developed by Moore, Stewart, Zakaria, and Brailsford (2003). Based on Felder–Silverman LS, this system presented visual/oral contents to students. The system was designed and applied at Nottingham University Department of Computer Sciences and IT to teach internet and www (Brown, 2007). Mustafa and Sharif (2011) developed AEHS-LS, which employed VARK (visual–auditory–read/write–kinesthetic) LS. This system was intended to teach JavaScript.

There is a lack of rigorous user evaluation in adaptive systems in the published literature. Studies tend to be fairly small in terms of sample sizes, and statistical measures of significance are rarely used (Brown et al., 2009; Mustafa & Sharif, 2011). There are no comprehensive studies for many of the systems. It is possible to encounter with comprehensive evaluation studies about this limited number of systems. Of these systems, detailed qualitative and quantitative data were obtained relating WHURLE-LS. Findings derived from quantitative data indicate that there is no significant difference between content presentation according to learning styles and the student success. The findings obtained from qualitative data show that the system was positively evaluated by the students and they liked the content presented according to learning styles (Brown, Brailsford, Fisher, & Moore, 2009; Mustafa & Sharif, 2011). Quantitative data were obtained for evaluation of DEUS system. At the end of data analysis, no statistical difference was found between content presentation according to learning styles and achievements of students (Brown, 2007). A detailed study was conducted to evaluate AEHS-LS system. Results of the study indicated that LS based learning environments positively influenced academic achievements of students (Mustafa & Sharif, 2011).

There are many studies that show the use of adaptive educational hypermedia based on learning style in teaching or learning especially for higher education (Brown, 2007; Brown, Brailsford, Fisher, & Moore, 2009; Carver et al., 1999; Gilbert & Han, 1999; Moore, Stewart, Zakaria, & Brailsford, 2003; Mustafa & Sharif, 2011; Wolf, 2003). However, a small number of studies have been conducted in high school classrooms (Brown et al., 2009; Mustafa & Sharif, 2011). It is seen that these studies are mostly about computer sciences courses (Akbulut & Cardak, 2012; Brown, Brailsford, Fisher, & Moore, 2009). From the perspective of academic level and subject, there is almost no study on secondary school mathematics subjects. In this sense, this study is expected to fill this gap in the literature. In this sense, an individualized e-learning environment named UZWEBMAT, which can be adapted by means of LS and expert system to teach the unit of probability for the 10th grade mathematics course, was designed and developed. Permutation–combination–binomial expansion and probability subjects, which are sub-topics of the unit of probability, form the content of UZWEBMAT. UZWEBMAT is an example of AEHS based on VAK LS. There are various studies in the literature indicating the difficulties encountered in teaching–learning the probability unit subjects (Fast, 2001; Gürbüz & Birgin, 2012; Kafoussi, 2004; Munisamy & Doraisamy, 1998). The lectures given in teacher centered environments, lack of appropriate educational materials, negative attitude of learners towards probability subject, and the fact that some teachers do not use effective and efficient teaching methods while teaching these subjects are some of the predominant difficulties encountered (Fast, 2001; Gürbüz, 2010; Gürbüz & Birgin, 2012; Manage & Scariano, 2010; Memnun, 2008). Such problems and other similar deficiencies make it necessary to develop and implement appropriate materials and e-learning systems to teach and learn related subjects and evaluate the results. In this sense, concretization and presentation of these subjects to learners and creating enriched learning environments to eradicate negative learner attitudes are of much importance. Main reason for selecting VAK learning style for UZWEBMAT system is that it is the most appropriate learning style for structural characteristics of the sub-