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Evaluation of an adaptive and intelligent educational hypermedia for enhanced individual learning of mathematics: A qualitative study

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ABSTRACT

The purpose of this study is to design a personalized adaptive and intelligent web based tutoring system based on learning style and expert system named UZWEBMAT and to evaluate its effects on 10th grade students' learning of the unit of probability. In the study, initially, learning objects were prepared in three different ways in relation to three sub-learning areas of 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's dominant learning style determines the content to which s/he will be directed since s/he is directed to the content that is appropriate for his/her learning style. The course to be followed by the students within UZWEBMAT and their browsing around the pages are decided by expert system integrated into the system. This expert system sets the situations in which s/he will get solution supports and the course s/he will follow in accordance with the performance of the student. Hereby, 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 and 3 mathematics teachers from two high schools in Trabzon, Turkey. Qualitative data were obtained both from the teachers and students participating in the study in order to answer the research questions about the implementation and evaluation of UZWEBMAT for mathematics teaching in a high school classroom. Obtained data were analyzed using qualitative data analysis methods. According to the results of the present study, positive opinions of students and teachers such as taking into account the individual learning differences and deriving mathematical relations and formulas through exploration became prominent. In addition, there were also other positive opinions of students and teachers such as providing permanent learning and introducing learning responsibility to the students. In this sense, it was concluded that UZWEBMAT is a beneficial instrument for both students and teachers.

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 which provides a new and interactive means of overcoming time and distance to reach learners, ranks first among these opportunities (Baki & Güveli, 2008; 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. As a result of 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). Furthermore, most online learners underestimate the time and effort required for online courses (Vergidis & Panagiotakopoulos, 2002; Xenos, Pierrakeas, & Pintelas, 2002; Yukselturk & Inan, 2006), fail to incorporate effective learning and task strategies (Dutton, Dutton, & Perry, 2002; Saba, 2002), have ill-defined educational goals and/or have limited motivation (Yukselturk & Inan, 2006). Unfortunately, these self-regulated learning skills, which many students lack, are critical for success and satisfaction in web-based learning environments (Berge, 2002; Inan, Flores, & Grant, 2010; McGrath, 1998). The adaptive hypermedia research received more attention during the last two

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decades in the area of technology-based education. There are many systems developed for learning purposes, which are referred to as adaptive e-learning hypermedia (Brown, Brailsford, Fisher, & Moore, 2009; Mustafa & Sharif, 2011; Tseng et al., 2008). In this sense, traditional web based learning environments are recently being replaced by individualized adaptive and intelligent e-learning environments.

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 navigation through the learning content (Retalis & Papasalouros, 2005). An approach to adaptive learning is considered to be Adaptive Educational Hypermedia Systems (AEHSs). 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 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 for each student such as their knowledge levels about the issue, 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 relating the topic.

Learning process is complicated. People may learn differently (Franzoni & Assar, 2009). Many parameters such as perception of information by individual, his/her processing the information, general abilities, developmental characteristics and environmental factors play a role during this process. It is out of question that learning process bears important differences for individuals being influenced by these many and different factors. Taking these differences into consideration during the design of learning–teaching processes will surely increase performance of learning activities. Additionally, knowing and learning these learning styles and designing and implementing learning activities in relation to these styles proved that many students, who used to be considered as having difficulty in learning, do not have difficulty in learning and in fact when they are provided with appropriate environments and stimulants they are capable of learning easily as well (Graf, Kinshuk, & Liu, 2009; Liegle & Janicki, 2006). Learning style (LS) can be defined as individual learning preferences and learning differences in the broadest terms (Adey, Fairbrother, Wiliam, Johnson, & Jones, 1999; 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 & Dunn, Kolb, Felder & Silverman; Honey & Mumford and VAK (Visual–Auditory–Kinesthetic) (Akkoyunlu & Soylu, 2008; Brown et al., 2009; Franzoni & Assar, 2009; Graf et al., 2009). Many LSs were suggested in addition to these and studies relating them were conducted. VAK LS is a model that can be considered as a basis among these 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). Paying attention to learning styles while preparing learning environments can create important advantages. Thus, educational technology faces a very challenging task in seeking to develop and possess even a few of the simple human abilities, combined with the computer qualities: speed, accuracy, capacity, reliability. In particular, the challenge faced by researchers in the field of AEHSs mainly considers learner preferences, interests, and browsing behaviors in providing personalized services. Stathacopoulou, Magoulas, Grigoriadou, and Samarakou (2005) propose that the idea is to introduce human knowledge and experience in the computer in order to make it behave like the best possible tutor, who can adapt his/her teaching to the learners' characteristics and abilities. It has been pointed out that learning style effects e-learning more than traditional instructor based learning. Moreover, Manochehr (2006) among others suggests that e-learning becomes more effective for learners with a particular learning style. 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; Mustafa & Sharif, 2011; Papanikolaou, Mabbott, Bull, & Grigoriadou, 2006).

1.1. Related works

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, which are 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++, which is a computer programming language. *CS*383 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 they named as *DEUS*. Felder-Silverman LS was taken as basis in this system. The system was prepared at primary school level to teach lifecycle 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 lectured in 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 is 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 & Magoulas (2001). Honey & Mumford LS was employed in this system. *WHURLE-LS* is a system constructed 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 utilizes VARK (visual–auditory–read/write-kinesthetic) LS. This system was intended to teach JavaScript.

There is a paucity 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; however, it is possible to encounter comprehensive evaluation studies relating a limited number of studies. Of these systems, detailed