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Illustrating an ideal adaptive e-learning: A conceptual framework

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Abstract

Advancement in Internet and multimedia technologies has positively influenced the efficient use of e-learning environments. While removing the time and space limitations created a convenient learning environment for e-users, having a diverse audience (different goals, knowledge levels, backgrounds or learning capabilities) forced the designers of e-learning systems to create adaptive and flexible e-learning environments with the potential of improving the learner performance. Although e-learning systems with adaptivity functions have been developed to solve these flexibility problems by changing the presentation of materials to suit each individual user, they do not satisfy all adaptive related needs in theory and application. Therefore, more research and framework are needed to be able to use e-learning environments efficiently as an alternative to traditional ones. This study illustrates potential functions of an ideal adaptive e-learning with their definitions and practices.

Keywords: E-learning; adaptive learning; distance education; flexible learning; Internet.

1. Theoretical Framework

1.1. Learning

Learning is defined as a process where knowledge is created through transformation of experience (Arthurs, 2007; Kolb, 1984). The most common perceptions about learning include that it is a quantitative increase in knowledge or acquiring information or 'knowing a lot'; memorising or storing information that can be reproduced; acquiring facts, skills, and methods that can be retained and used as necessary; making sense or abstracting meaning; interpreting and understanding reality in a different way (Ramsden, 1992; Smith, 2003).

Learning is not an instant event, but it is a process that consists of some stages as every process does. Kolb (1984) defines learning process as a four-stage cycle that represents the way of perceiving, thinking, feeling, and acting which appears when we face with new experiences. The four stages in this experiential learning cycle include (1) concrete experience—being involved in a new experience, reflective observation—watching others or developing observations about one's own experience, abstract conceptualization—creating theories to explain observations, and active experimentation—using theories to solve problems, make decisions.

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There are different ways of knowing, just as there are different ways of learning or learning styles. Learning styles can be defined as individual's preferred ways of answering (cognitively and behaviorally). In other words, a learning style is a special repertoire of preferred learning ways and strategies that are used during learning process. These preferred methods can be cognitive, affective, motivational and behavioral (Slaats, 1999). Learning styles are not just a simple aggeragation of habitual or preferred processing strategies, but they also represent consistent patterns of learning activities that are systematically related to learning beliefs and motivational orientations. They are not taken to be invariable, as they may be affected by the characteristics of the learning context and its demands (Peterson et al, 2009; Vermunt, 1992).

1.2. Adaptive Learning

The term adaptive is defined as a capability to change when necessary in order to deal with different situations (Oxford Advanced Learner's Dictionary, 2009). Since our environment is very complex and every individual has characteristics which make her/him unique, being physically and mentally different individuals or learners makes adaptation concept imperative to create less complex, but more flexible environments (Nguyen & Do, 2008). Adaptive learning (AL) is considered to be an alternative to the traditional ''one size fits all'' approach and has encouraged the development of teaching and learning towards a dynamic learning process for learning. AL is characterized by diversity, as the teaching content adapted for some users may not be appropriate for the others and interactivity, as in many situations users learn via web-based tutoring systems where teachers of the traditional classroom are acting as a mentor when the on-demand assistance is required (Wang et al., 2008).

1.3. Adaptive E-Learning

The term e-learning has been widely used in education since mid-1990s. Although there is no consensus among e-learning researchers on its definition, e-learning generally is regarded as "the use of telecommunication technology to deliver information for education and training" (Sun et al., 2008). Appropriating learning requirements has encouraged a great demand on e-learning in diffeernt organizations from businesses to institutes of higher education. Some large and prestigious universites' attempts of offering all courses online have sent a signal to institutes on the strategic importance of e-learning regarding the progress of information and communication technology development (Sun et al., 2008).

When compared to traditional learning, e-learning has the same players and constraints, but its importance and effects on the efficiency of the learning process is different. The main players in both face-to-face teaching and e-learning are the teacher, the content and the student. The main constraints in traditional face-to-face learning are place and time. Such constraints are handled in e-learning by getting over the limitations of time and space to establish a convenient learning environment; that is, learners use a web-based learning environment to acquire knowledge at any time and any place (Amaral and Leal, 2004). What makes the most difference among other learning methods is that e-learning can be addressed to maximum number of participants with a maximum diversity of learning styles, preferences, and needs. Besides, e-learning has some advantages such as reduced overall costs and time; proof of completion and certification which are essential elements of training initiatives; and the possibility of consistent delivery of content with asynchronous presentation—on-demand availability and interactivity (Kruse, 2004). Such e-learning environments, satisfying the requirement that learners are a central role in learning, are becoming increasingly popular (Chen, 2009).

One of the considerations of such popular e-learning systems is to feature learner/user preferences, interests, and browsing behaviors to offer personalized services (Chen, 2009). These considerations bring out an idea of adaptive e-learning systems (Brusilovsky, 1999) as an alternative to the traditional "one-size-fits-all" approach in the development of educational courseware. Adapive e-learning systems build a model of the goals, preferences and knowledge of each individual student, and use this model throughout the interaction with the student in order to adapt to the needs of that student (Brusilovsky & Nijhavan, 2002).

An adaptive e-learning system is defined by Stoyanov and Kirschner (2004) as follows: "… is an interactive system that personalizes and adapts e-learning content, pedagogical models, and interactions between participants in the environment to meet the individual needs and preferences of users if and when they arise." Burgos et al. (2006) also defined adaptive e-learning as "a method to create a learning experience to the student, but also to the tutor, based on the configuration of a set of elements in a specific period aiming to increase of the performance of a predefined criteria" . These criteria could be educational, economic, time-based, user satisfaction-based or any other involved in e-learning.

2. Design of Adaptive E-Learning Systems

Numbers of designs have been used in adaptive e-learning. Most of researchers have suggested that four main approaches can be identified to present all adaptive e-learning systems: macro-adaptive, aptitude-treatment, micro-adaptive and constructivist-collaborative approaches (Fitre et al., 2009).

2.1. Macro-adaptive approach

The components of macro-adaptive approach that define the general guidelines for the e-learning process are mainly based on the student's profile. These components are learning goals or levels of detail (Burgos at al., 2006), delivery systems, intellectual abilities and prior achievement, cognitive and learning styles, academic motivation, and personality (Mödridsthcher et al., 2004). Learners differ from each other in learner characteristics such as intellectual capabilities, learning preferences, cognitive and learning styles, prior knowledge and experience, and self-efficacy and meta-cognition (Mödritscher et al., 2004). These characteristics affect e-learning environments in different ways. For example, learners' preferences are taken into account in various ways such as adapting language, presentation of learning content, and group models. On the other hand various systems in the scope of adaptive hypermedia, as with methods like adaptive navigation support, focus on learner control (Brusilovsky, 1996).

Macro-adaptive approach often involves a repeated sequence of "recitation" activity initiated by teachers' behaviors in classrooms since it is usually used within a group for purpose of providing the differentiation of instructions (Como & Snow, 1983; Park & Lee, 2004). For example, a typical pattern of teaching can be defined as the process which consist of three stages, namely, a) explaining or presenting specific information, b) asking questions for having some information about the student learning style, and (c) providing appropriate feedback for the student's answers (Park & Lee, 2004).

2.2. Aptitude-treatment interaction approach

This approach suggests different types of instructions and/or different types of media for different students (Burgos et al, 2006), that is, it adapts instructional strategies to students' aptitudes. One of the most important aspects of the aptitude-treatment interaction approach is the user's control over the learning process the level of which vary in accordance with the abilities of the students by giving them full or partial control over the style of the instruction or the way through the course. Snow (1980) defined three levels of control, complete independence, partial control within a given task scenario, and fixed tasks with control of pace. Several studies also found that the success of different levels of learner control is strongly dependent on the students' aptitudes, that is, it is better to limit the control for students with low-prior knowledge knowledge or to enhance learning for students who have high performance (Mödritscher et al., 2004).

Meta-cognitive abilities—which are highly related to the learners' experiences and have an impact on different variables, such as the degree of feedback and tutoring, the locus of control, and personality attributes—are considered to be very important characteristics in aptitude-treatment interaction approach (Park & Lee, 2004). Although aptitude-treatment interaction approach is generally considered to be very theoretical, problematic or time-consuming, the research on aptitude-treatment interaction is still on (Mödritscher et al, 2004).

2.3. Micro-adaptive approach

This approach requires monitoring the learning behavior of the student while running specific tasks and adapting the instructional design afterwards, based on quantitative information (Burgos, 2006). When compared to the macro-adaptive and the aptitude-treatment interaction approach, the micro-adaptive approach is rather based on on-task measurements. The student behavior and performance are observed by measuring response errors, response latencies and emotional states (Fröschl, 2005). Such measures considered during the course of instruction can be applied to the manipulation and optimization of instructional treatments and sequences on a much more refined scale (Park &

Lee, 2004). Thus, micro-adaptive instructional models using on-task measures are likely to be more sensitive to the student's needs.

Adaptive e-learning is consisted of two main processes in this approach. The first process can be characterised as a diagnostic process during which learner characteristics, e.g. aptitudes or prior knowledge, and indices of the task, like difficulty level, content structure or conceptual attributes are assested. The second process can be identified as a prescriptive process which optimizes the interaction between the learner and the task given to her/him by systematically adapting the composition and sequencing of learning content to the students' aptitudes and recent performance (Mödritscher et al., 2004).

2.4. Constructivist-collaborative approach

This approach focuses on how the student actually learns while sharing her/his knowledge and activities with others (Burgos, 2006). An important element which differentiates this approach from the first three is the use of collaborative technologies which are considered often as main component of e-learning. The learner has an active role in the learning process constructing her/his own knowledge using her/his experiences in a context in which the target domain is integrated. Akhras et al. (2000) argued that constructivistic learning might benefit from a system's intelligence including mechanisms of knowledge representation, reasoning, and decision-making. Therefore, an adaptive system provides learning by focusing on the way of gaining knowledge and should take into account the context, learning activities, cognitive structures of the content, and the time extension (Mödritscher et al., 2004).

The first three approaches are restricted to an oldfashioned view on e-learning and focus on the content and the learning process itself. With respect to new learning theories and technology, this approach treats topics like constructivism and adaptive collaboration (Modritscher et al, 2004). However a modern system based on adaptation should consider all of these approaches to provide a wide range of possibilities on e-Learning..

3. Implementation of Adaptive E-Learning Systems

There are many e-learning systems that provide only the same materials to all students and do not consider their needs or abilities. However, the students' needs, goals, backgrounds, knowledge levels and learning capabilities can vary (Surjono, 2009). That current existing e-learning systems do not handle all these differences resulted in the creating of adaptive e-learning systems with a specific set of user characteristics, in which the system or the learner render its components and interface according to different requirements (Haidar, 2006). Thus, adaptive e-learning systems try to solve the problems of current e-learning systems by changing the presentation of material to adapt it to individual student's needs and preferences (Surjono, 2009). Adaptive e-learning systems are structured by two technologies: intelligent tutoring systems and adaptive hypermedia systems.

The material which is given to them is still oriented just for well prepared and motivated students. Current existing e-learning may not fit to all students. The diversity of users within a group forced the designers of e-learning systems to create adaptive and flexible e-learning environments with the potential of improving the learner performance (Surjono, 2009). These problems resulted in the creating of Adaptive E-Learning Systems which serve a specific set of user characteristics, in which the system or the user render its components and interface according to different requirements (Haidar, 2006). Adaptive e-learning systems are structured by two technologies: intelligent tutoring systems and adaptive hypermedia systems (Surjono, 2009).

3.1. Intelligent tutoring systems (ITS)

ITSs are adaptive instructional systems applying artificial intelligence (AI) techniques (Surjono, 2009). The goal of ITSs is to provide the benefits of one-on-one instruction automatically and cost-effectively (Ong & Ramachandran, 2003). Web-based education systems have a lot of advantages, but they still lack the presence of a teacher, who in a traditional classroom employs various mechanisms to sustain the student's attention and provides appropriate guidance to the student based on his/her weaknesses and strengths in a particular subject. ITSs attempt to simulate the "teacher", who guides the student's lesson flow and uses pedagogical methods appropriate to students (Rane et al., 2005). However, a virtual teaching assistant that captures the subject matter and teaching expertise of experienced teachers provides a captivating new option (Ong & Ramachandran, 2003). ITSs' simulative "teacher" monitors individual's progress based on his/her level of understanding of the subject (Rane et al., 2005).

ITSs apply the micro-adaptive approach as the decision about learning diagnosis and instructional prescriptions are generated during the task. Furthermore, the combination with aptitude variables allows the expertise module to generate conditions for instructions based on the learner's characteristics (Mödritscher et al., 2004). ITSs have been studied for more than three decades by the researchers in education, psychology, and artificial intelligence. Today, prototype and operational ITSs provide practice-based instruction to support corporate training, K-12 and college education, and military training (Ong & Ramachandran, 2003).

ITSs consist of components representing the learning content, teaching and instructional strategies as well as mechanisms to understand what the student does or does not know. These components are arranged into the expertise module, the student-modeling module, the tutoring module and a user interface module (Brusilovsky, 1994), which all together compose ITS's architecture (see Figure 1).

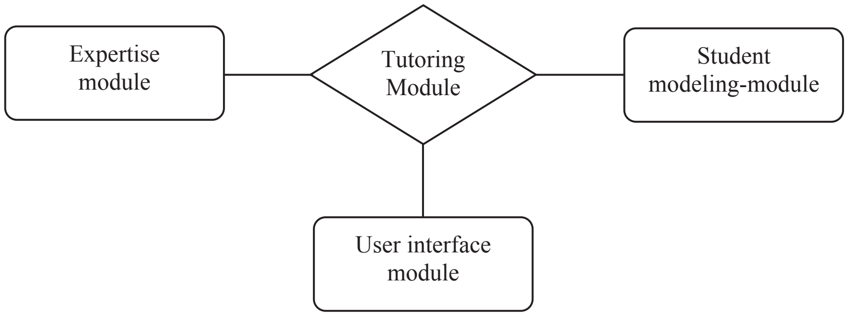

Figure 1: Components of an ITS

The "expertise module" represents subject-matter expert and provides the ITS with knowledge of what it's teaching. This knowledge enables the ITS to compare the learner's actions and selections with those of an expert in order to evaluate what the learner does and doesn't know (Ong & Ramachandran, 2003). Generating individual feedback and adapting the instruction content for a student, requires detailed as well as structured representation of the subject matter. This is exactly what "expertise module" is used for (Rane et al., 2005). The "student model" represents the student's knowledge, skills, and other attributes that affect how the student should be taught (Ong & Ramachandran, 2003). This information, which depicts the student's current knowledge level, is diagnosed by the ITS to adapt the instruction to the student's needs (Rane et. al., 2005). According to Wenger (1987), student modules have three tasks: (1) gather data from and about the learner, (2) use that data to create a representation of the student's knowledge and learning process, and (3) predict what type of response the student will make in subsequent situations, compare that prediction with the students' actual response, and use that information to refine the model of the student. The "instructor module" or "tutoring module" selects the learning material and decides how/when to deliver it. In ITSs, AI methods are mostly used to represent knowledge or natural language dialogues to adapt the contents to the students' needs and allow a more flexible interaction with the system (Garcia-Barias, 2006). This module generally addresses types of issues like control over the presentation of the instructional knowledge for selecting and sequencing the subject matter (Rane et. al., 2005). The "user interface module" is the communication component that controls interaction between the student and the system (Brusilovsky, 1994).

Research on prototype systems indicate that students taught by ITSs generally learn faster and translate the learning into improved performance better than classroom-taught partners. For example, an intelligent tutoring system was developed at Carnegie Mellon University in the mid-1980s called the LISP Tutor to teach computer-programming skills to college students. Students who used the ITS scored 43 percent higher on the final exam than the ones who received traditional instruction. When given complex programming problems, the traditional group required 30 percent more time to solve these problems, when compared to the ITS students (Ong & Ramachandran, 2003).

3.2. Adaptive hypermedia systems (AHS)

The development of AHS can be traced back to the early 1990s. AHSs are inspired by ITS and try to combine adaptive instructional systems and hypermedia-based systems. Adaptive hypermedia is a direction of research on the crossroads of hypertext (hypermedia) and user modeling (De Bra et al., 1999). AHSs maintain a model of the user and use this model to customize the user's interaction with the media. Brusilovsky (1996) defines AHS as follows: "… all hypertext and hypermedia systems which reflect some features of the user in the user model and apply this model to adapt various visible aspects of the system to the user"

AHSs can be useful in any application area where users of a hypermedia system have essentially different goals and knowledge and where the hyperspace is reasonably large. Users with different goals and knowledge may be interested in different pieces of information presented on a hypermedia page and may use different links for navigation. AHSs try to overcome this problem by using knowledge represented in the user model to adapt the information and links being presented to the given user (Brusilovsky, 1996). Also, although it is possible to offer users a way to initialize the user model through a questionnaire, AHSs can do all the adaptation automatically, simply by observing the browsing behavior of the user (De Bra et al., 1999).

The AHS model consists of three components: data collection, user modeling, and adaptation. During data collection, the hypermedia system collects data on the user. The user model is the adaptive system's representation of the user. The data collected on the user is compared against the user model and the user is classified as a certain type. Adaptation is the final result of the system (Hill & Carver, 2000). The AHS adaptation component has two forms of adaptation: (1) adaptation of the page content, also known as content-level adaptation or adaptive presentation, and (2) adaptation of the behaviour of hyperlinks, also called link-level adaptation or adaptive navigation support (Garcia- Barrias, 2006).

The application areas for AHSs range from educational hypermedia to information retrieval systems with a hypertext interface (De Bra et al., 1999). For example, a student in an adaptive educational hypermedia system will be given a presentation that is adapted specifically to his or her knowledge of the subject, and suggested set of most relevant links to proceed further. An adaptive electronic encyclopedia will personalize the content of an article to augment the user's existing knowledge and interests (Milosavljevic, 1997). A virtual museum will adapt the presentation of every visited object to the user's individual path through the museum (Brusilovsky, 1999).

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