INCORPORATING PEDAGOGICAL PRINCIPLES IN DEVELOPING AN ADAPTIVE HYPERMEDIA EDUCATIONAL SYSTEM

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Abstract

An essential factor for usable and expedient operation of web-based educational systems is incorporation of pedagogical principles. However, the extent of incorporating pedagogical principles in recently developed e-learning systems is not broad enough. The purpose of this paper is to illustrate the present development and future capabilities of a new, pedagogically based, AHES (Adaptive Hypermedia Educational System). The developed system is called AS.A.L.E.S. (Asynchronous Adaptive Learning and Evaluation System) and provides new opportunities to the transfer of knowledge between educators and learners by widely incorporating pedagogical principles in order to enhance the effectiveness of the learning procedure. The AS.A.L.E.S. system introduces new capabilities in the way the presented educational material is adapted to learners' needs and supports collaboration and sharing among learners.

Introduction

While electronic learning and web-based education provide more expedient virtual access to the learners around the world, some shortcomings, mostly from the perspectives of pedagogy and collaboration, confine the benefits (Siadaty & Taghiyareh, 2006). A main objective of web-based educational systems, and especially AHES (Adaptive Hypermedia Educational System), is to maximize the learning outcome through adaptation, during the transfer of knowledge between educator and learner. In order to achieve this, the incorporation of learning theories and pedagogical principals is considered to be very important. It has been argued that "very little online learning employs constructivist, problem oriented approaches to learning in any significant way" (Mara & Jonassen, 2001, p. 309). However, recently developed web-based educational systems have shown a small degree of incorporation of pedagogical principles into their development.

In this paper the current state and the future development of a new pedagogically based adaptive hypermedia educational system, called AS.A.L.E.S., is presented. The paper is structured as follows: section 2 presents the desirable pedagogical principles of modern web-based educational systems along with a comparative study of pedagogical characteristics supported by these systems; section 3

provides an overview of the AS.A.L.E.S; section 4 presents the conclusions and directions for further work.

Pedagogical Characteristics of Existing Web-Based Educational Systems

For modern web-based educational systems to be successful, they must be rooted in strong pedagogical foundations. According to G. Zardas, desirable pedagogical characteristics of modern AHES should include: *initial* and *continuous adaptation*, *adaptive presentation*, *adaptive assessment* and *adaptive collaboration* (2008). *Initial adaptation* refers to the classification of the learner to a proper level of education on a selected topic, based on the degree of his knowledge and experience. Presumably the educational material has been organized according to different levels, based on its degree of difficulty and complexity. As a result, the educational material of that level is presented to the learner, along with the complementary material of previous levels when needed. *Continuous adaptation* refers to the adaptation process, where the learner has to take a test and achieve a minimum progress score on his current classification level in order to be able to move to a higher level of educational classification. *Adaptive presentation* deals with the way the system presents the appropriate educational material to a specific learner at a specific time. Since some levels of education are prerequisites of others, the system determines which levels of education the learner is able to access after the learner's initial or continuous adaptation process. According to the *adaptive assessment* the *learner* is able to get personalized support from the AHES during the assessment process. The learner is able to access educational material (text, video, sound and picture) from which questions may be derived during the assessment process. This type of "back trace" support or tutoring enhances learners' education in a cognitive and constructive manner. Through the *adaptive collaboration* in an AHES environment, learners could form educational groups based on their level of knowledge, needs and skills in a particular topic. Depending on their level of classification, learners could broaden their knowledge in a particular topic and level of knowledge by communicating with each other via forums, wikis, blogs and other forms of educational social software. Terry Anderson has introduced the concept of 'educational social software' which he defines, within a context of distance education, as ". . .networked tools that support and encourage individuals to learn together while retaining individual control over their time, space, presence, activity, identity and relationship" (2005a, p. 4). Based on the research findings of Barkley, Cross and Major, collaboration among learners promotes and improves learning and is an important factor in learning achievement, personal development and learners' satisfaction (Barkley et al., 2005). Through collaboration the educational material is built dynamically by the learners, with the discreet supervision of educators. However one might argue

that as educators become proficient with a constructivism pedagogy enabled during their education program via such social software, they more likely to encourage the use of this software in their learners (Rideout et al., 2007).

Table 1 (below) presents the results of a comparative study between four popular web-based educational systems, based on the degree of supporting the above mentioned pedagogical characteristics.

Table 1: Support of pedagogical characteristics

	MOODLE	ILIAS	ATUTOR	DOKEOS
INITIAL ADAPTATION	NO	NO	NO	NO
CONTINUOUS ADAPTATION	YES	NO	NO	YES
BACK TRACE FEATURE	YES	NO	YES	NO
SOCIAL COLLABORATION AT SECTION LEVEL	NO	NO	NO	NO
SOCIAL COLLABORATION AT SYSTEM LEVEL	YES	YES	YES	YES
ADAPTIVE PRESENTATION	YES	NO	NO	NO

By analyzing the results, one can notice that Moodle surpasses, in pedagogical attributes, all other systems. Atutor and Moodle are the only systems that support a kind of the "*back trace*" feature by presenting to the learners relevant supporting text to the question presented. However these systems can not indicate the exact section or paragraph of the learning topic from which the presented questions were derived. This feature is not supported by any e-learning system when the learning material is presented in other forms like video, sound or picture. Dokeos and Moodle classify the learning material to levels or pages and they present it to the learners progressively and according to the *continuous adaptation* process. None of the systems support *initial adaptation* and *social collaboration at section level*. However, all systems support *social collaboration at system level*. The last characteristic of *adaptive presentation* is supported only by Moodle.

The Adaptive Hypermedia Educational System AS.A.L.E.S.

The AS.A.L.E.S. is an adaptive hypermedia educational system that provides a usable and a dynamic learning environment. It aims to provide an effective adaptive learning environment based on innovative technological tools and pedagogical principles. The system has three main distinct environments, related to the different user level: the administrator's environment, the educator's environment and the learner's environment. The access to the environments is controlled by the user's ID. The system is able to recognize the user's category and presents to him the appropriate environment. In the following paragraphs, the general characteristics of the system along with the three users' environments are described:

Pedagogical Considerations

Pedagogical principles based on the theory of behaviorism are initially used to design the structure of the learning material. Educators organize, up to five levels, the learning material according to their degree of difficulty and complexity. Specific and well defined procedures are taken into consideration when learners are trying to access the learning material. Initial and continuous procedures are used to classify learners' knowledge and experience status on a selected topic, so the appropriate learning material is presented to them. After placing the learning material into the systems, the role of the educator is supportive. The knowledge acquired by the learners is not solely based on the material presented to them. Based on constructivist pedagogical principles, learners can create additional learning content through collaboration and sharing between other learners of the same classification level. Adaptation to learners based on user and usage data is relevant in collaborative learning (Gaudioso & Boticario, 2002; Gaudioso & Boticario, 2003). Today's Internet technologies can enhance social constructive learning by allowing learners to create learning content, to form learning networks, and to distribute their knowledge and experience.

General Characteristics

The AS.A.L.E.S. development was based on the ASP.NET 3.5 Microsoft platform and on C# as programming language. Its database uses MS SQL Server 2005. The AJAX technology is also implemented for more efficiency. AS.A.L.E.S. is modular in construction and supports many types of plug-in: activities, question types, graphical themes, authentication methods, enrollment methods, etc.

The learning material in the system is classified up to five levels (from introductory level one to advanced level five). This way, when a learner accesses the learning material of a selected topic, the appropriate learning content will be presented to him, based on his previous knowledge and experience. The

pedagogical philosophy of AS.A.L.E.S. includes behaviorist, constructivist and social constructionist approaches to education. Initially, the learning material and the assessment procedures are organized by the educators using specific rules and guidelines but later, the learners are able to enhance the learning material and learn more through collaboration.

AS.A.L.E.S. offers collaboration tools both on the system and on the section level. It can also provide personalized assessment support to the learners by highlighting the paragraph from which an assessment question is derived. Based on the pedagogical attributes mentioned in section 2, the pedagogical characteristics of the AS.A.L.E.S. are presented below (Table 2).

Table 2: Pedagogical characteristics of the AS.A.L.E.S.

	AS.A.L.E.S.
INITIAL ADAPTATION	YES
CONTINUOUS ADAPTATION	YES
BACK TRACE FEATURE	YES
SOCIAL COLLABORATION AT SECTION LEVEL	YES
SOCIAL COLLABORATION AT SYSTEM LEVEL	YES
ADAPTIVE PRESENTATION	YES

The Administrator's Environment

The administrator of the AS.A.L.E.S. is responsible for the scaling, tracking and maintenance of the system. His role is to manually create and oversee users' accounts, to monitor other users' activities, to adjust system's operations (i.e., skins, local settings, custom or windows authentication, etc.), to add new operational modules, and to put announcements and relevant information into the system.

The Educator's environment

The educator is responsible for three functions: the creation of the learning material on various topics, the creation of assessment tests, and the tracking of learners' progress. The pedagogical characteristics of the AS.A.L.E.S. are mainly based on the way the learning material is structured. The educator is able to organize the learning material into chapters and sections. The learning material is classified into levels of difficulty and complexity. Thus every chapter and section that is created by the educator is graded to a proper educational level (up to five levels). This is important for the initial and continuous adaptation process. The content of chapters and sections can take different forms, i.e., text, video, picture, sound, flash animation, etc. The educator can also create a repository of questions

which are connected to the learning material. The questions derive from a particular section and they are classified automatically according to the educational level of that section. The way assessment questions are built enables the system to support the initial adaptation process, the continuous adaptation process, and the "back trace" feature. The educator can constantly monitor the educational progress of the learners and is able to assign projects to specific learners or groups of learners. The tutor's role can be given to a learner by the learner when he has accomplished high assessment results, in order to assist him in the educational process.

The Learner's Environment

After learner's registration to a selected educational topic, the system presents to him a classification test. The test is generated, manually or automatically, from the repository of the assessment questions that the educator has created for each level of the learning material. Based on the test's results the learner qualifies into his appropriate educational level (i.e., three). At level three, the learner has access to the learning material of levels one, two and three. Prerequisite for the learner to access the next higher level from his current level of classification (i.e. level four), is to pass the assessment test of the current level. If he fails, the system may let him repeat the test of that level or all previous levels. It is up to the educator to decide about the number of test repetitions allowed or whether the learner should repeat the tests of all previous levels. A final assessment test is presented to the learner upon his studying completion of all the learning material presented to him. The score of this test is his final assessment score of the selected educational topic.

Based on pedagogical principles, the learner's assessment procedure supports the "back trace" feature. According to this feature, when the learner fails an assessment question the system highlights the text lines used as a source to the question creation. During the learning procedure, the learner's role is active. He is involved in different collaborative activities like: using wiki technology to enhance the learning material, taking part in forums, creating blogs and giving feedback to educators by rating the learning material. These activities can take place both at the system entrance level and at a section level of a selected educational topic.

Conclusions

In this paper, the new pedagogical based adaptive hypermedia educational system AS.A.L.E.S. was presented. A special emphasis was given to the constructivist role of the learner in the educational process. The learner is rather responsible in the educational process and this is in accordance with the individualization and adaptability of the learning process proposed (Bra, 1999; Dieterich et al., 1993).

Future design and implementation considerations of the system include: expansion of the "back trace" feature to other educational forms (video, sound, etc.), collaboration possibility among educators for the development of cross-learning subjects' learning material and a pedagogically designed synchronous communication module to serve learning participants during the educational process.

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