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TECHNOLOGIES AND TOOLS FOR CREATING ADAPTIVE E-LEARNING CONTENT

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Abstract. The aim of adapting e-learning systems is to provide effective learning by supplying students with the opportunity to communicate with an environment that meets their needs, behaviour, and knowledge. The design and creation of learning materials is directly dependent on the learning objectives. The more different groups of students a course is adapted to, the higher the degree of personalization of the learning process is. In this article we present the results of a study on the types of adaptive systems depending on the technological tools and methodological approaches for implementing adaptability and personalization in learning. Special attention is paid to the applied technologies in the development and delivery of adaptive learning content as well as to the ways of modeling an individual learning path.

Keywords: adaptive e-learning content; adaptive learning systems; electronic learning content

Introduction

Adaptability within e-learning platforms is built in response to the fact that the learning process is different for each student. Adaptive education is an educational approach that provides adaptive e-learning services and learning materials specifically tailored for adaptive learning. The goal is to combine the ability to understand and discover the specific needs of a learner with the appropriate pedagogical strategy to improve the learning process. The modeling of the adjustment of the adaptive e-learning systems (AELS) from the point of view of the methodological aspects of e-learning can be done according to different criteria: user modeling, modeling the educational content, modeling the learning process, modeling the knowledge control, etc.

AELSaims to adapt some of its key functionalities (providing learning content, supporting navigation in a courseof studies, etc.) to the needs and preferences of learners. In this sense, adaptability can be seen as the ability of the system to adapt its behaviour and provide its functionality to users in accordance with their preferences, educational goals, learning styles, levels of knowledge, behaviour in the system, etc.

According to the initial design of adaptive e-learning (AEL), the content of an adaptive course should be suitable for students with different profiles (Modritscher & al., 2004; Brusilovsky, 2012; Tuparov & Tuparova, 2009). These profiles can contain information about the learner's goals, preferences, level of knowledge, shown performance, learning style, psychological profile, etc. Adaptability can be both individual and group; often the learning content is designed for groups of students who have similar values to one or more parameters of the student's profile. The more different groups of students a course is adapted to, the higher the degree of personalization of the learning process (Bontchev & Vassileva, 2012).

Types of adaptive e-learning systems

Adaptability in e-learning systems is expressed in the ability to adapt to user needs and preferences depending on the user behaviour and in response to the results shown.

AELS have been the subject of active research for the past three decades. What can be adapted is a topic that is constantly enriched and developed. This also leads to a large number of classifications, often with intertwined terms and ambiguity.

We will present types of *adaptive systems* depending on the technological tools and methodological approaches for realization of adaptability and personalization in learning.

Macro-adaptive learning systems – In them, learners' test results are dominant. Depending on these systems, the learning process is designed and conducted differently. A number of adaptive systems have been developed that better adapt to the different abilities of students. Since macro-adaptive instruction is regularly used within a class, it often includes elements such as explaining or presenting specific information, asking questions to monitor the learning process, and providing appropriate feedback to learners.

Computer-assisted learning systems – They combine the macro-adaptive and the micro-adaptive approaches (Modritscher et al., 2004). In them, the instructor has tools to monitor and control the learning process.

Another type of system that follows the macro-adaptive approach is the class of computer-managedinstruction (CMI) systems. As described in (Goldberg, 2019), CMI systems have functions for diagnosing students' learning needs and recommending learning activities suitable for those needs. For example, the PLM (Platon Learning Management) system provides tests at different levels of instruction, such as a learning module, lesson, course, and curriculum. According to the student's educational outcomes, specific instruction recommendations are provided, such as repeating the assessment or the whole unit, offering additional course instructions, etc. When mastery of all objectives in the module is achieved, the student can proceed to the next module. CMI systems provide very important macro-adaptive learning functions that allow the teacher to monitor and control the student's learning activities.

Intelligent Learning Systems (ILS) – they automatically personalize the learning process. Their main purpose is to simulate various aspects of teaching; in them, the system itself is the instructor or teacher. ILS are based on artificial intelligence and they can draw conclusions based on knowledge models, which is useful for promoting and evaluating learning. The main function of ILS is to adapt to the learner through understanding or awareness of his/her cognitive, meta-cognitive, and emotional states. Among the characteristics of research in the field of ILS, the emphasis is on the individualization of learning and the requirement that the system has its own expertise for solving problems as well as a specific skill for conducting instruction in order to interact with the learner.

The importance of intelligent learning systems has increased rapidly in recent decades (Bradac & Kostolanyova, 2017). There are various ways in which the approaches of artificial intelligence are used in adaptive educational systems. For example, in some systems the main focus is to study and evaluate learners' characteristics in order to generate learner profiles. The aim is to assess students' general level of knowledge and preferences, which should be used as a basis for the pedagogy that is further recommended.

Adaptive Hypermedia Systems(AHS) – they try to combine adaptive learning systems and hypermedia-based systems. These systems adapt to user characteristics, usually introducing user models for this purpose. Due to their popularity and accessibility, AHS have been used for educational systems, e-commerce applications, information systems, and support systems.

Adaptive hypermedia methods can be divided mainly into two areas of adaptation – content-level adaptation or adapted presentation, where the content is composed or presented in different ways or in different sequences, and link-level adaptation or adaptive navigation support (Almohammadi, 2017).

In (Brusilovsky, Kobsa & Vassileva, 2013) the adaptability in the adaptive hypermedia is described in detail, as the main accents arethe following:

- possibilities of the system to adapt – user characteristics (knowledge, goals, qualification, previous experience in hypermedia, preferences) and characteristics of the user environment (platform, geographical location);
- what can be adapted – content of the learning pages and the hyperlinks between them, which are called adaptive presentation and adaptive navigation respectively;
- methods and techniques for achieving adaptive presentation and adaptive navigation.

According to Brusilovsky, two main components can be adapted in AHS – the content of the learning pages and the hyperlinks between them. In (Brusilovsky, 2012), adaptability in adaptive hypermedia is comprehensively described from a technical point of view, deriving a taxonomy of adaptive hypermedia technologies, cited by a number of authors also as a taxonomy of Brusilovsky. The two

main types of adaptability from a technical point of view are the above-mentioned adaptive presentation and adaptive navigation, which are subsequently divided into eight subclasses of adaptability in terms of pedagogical aspects of adaptive e-learning (Brusilovsky, 2012; Bower, 2016).

Methods and tools for adapting the learning content

Three main components participate in a balanced formula for adaptability: user (learner, student), teacher (instructor, educator), and a set of predefined rules set by the instructor (Arnaudova, Terzieva & Rahnev, 2016). Adaptability is usually focused on the learner. The subject of our research are the methods and tools of adapting the learning content.

When adapting the learning content, resources and activities dynamically change their content similar to adaptive Internet-based learning systems, which use intelligent agents to adapt the presentation or an adaptive presentation (Bradac & Kostolanyova, 2017). In case of content adaptability, it isalso understood to submit learning materialsappropriate to each student's learning style. The purpose of the adaptive presentation is to adapt the content of each node (page) in accordance with the current state of knowledge, learning objectives, and other characteristics of the user (Brusilovsky, 2014). In adaptive presentation systems, pages are not static; instead, they are adaptively generated and compiled for each user. For example, an advanced learner may receive more detailed and in-depth information, while a beginner may obtain additional explanations.

The modeling of the learning content is directly dependent on the learning objectives. The system of goals reflects the set of knowledge, skills, and competencies that the learner must acquire at the end of the course. The course author is responsible for the creation and management of educational content. The main characteristics that the content must have are the following:

– to be well structured – in a suitable ontology and in an adequate place in the ontological graph;
– to allow for repeated use – i.e.to have the lowest possible structure of the learning objects; thus, it can be used in different places and for different purposes;
– to be described in detail according to the LOM standard or another one.

Standardization allows portability between platforms and storage in learning object repositories. Thus implemented, e-lessons can be used to independently achieve educational goals. This also makes it easier for the instructor or other Internet-based learning systems to find appropriate content.

According to the authors, the creation of static learning material is avoidedin modern web-based learning environments; educational material is presentedto the learner in a linear waydue to the large number of interdependencies and contingent connections between the different pages (Tuparov & Tuparova, 2012; Rahnev,

2014a; Sosnovsky & Brusilovsky, 2015). Often the authors create several versions of the learning resources so that the system can offer the most appropriate oneto the student.

In the general case, after the publication of the learning objects, it is not possible to change their structure, methods, or definitions of basic parameters (such as conditions or properties). However, if the learning objectis designed to allow for real-time changes, the teacher will be able to alter the way the learner perceives the course and the way it is conducted: 1) the teacher will be able to update the content based on predefined learning material or to create new content; 2) the teacher will be able to influence the learning path by uploading files, showing or hiding elements of the content and structure, etc.

The introduction of hypermedia has a major impact on adaptive learning systems. While other types of adaptive systems cannot be implemented without programming skills, adaptive AHS courses can be created using the latest writing tools such as SmexWeb. However, there are some limitations to AHS: De Bra states that the user may be directed to pages that are not relevant or understandable to him/her if the assumed relationship in the AHS is wrong or omitted by the user (De Bra, 2003). In addition, the assessment of the learner's knowledge is the most important factor for the successful implementation of AHS.

In hypermedia systems, content is not only textual but it also contains a number of multimedia elements. In this sense, a distinction can be made between an adaptive text presentation and an adaptive multimedia presentation. This also includes adaptations in the learning systems that implement intelligent agents to adapt performance (Almohammadi, 2017), adaptive natural language generation, machine learning, and others. Another aspect of adapting the content is the submission of learning material appropriate to the learning style of each student through the use of various multimedia elements such as text, sound, graphics, video, animation, etc.

Adaptive navigation methods refer to all possibilities for modifying the visual links, which provide navigation – for example, rearranging, hiding, adding annotations, etc. (Brusilovsky, 2014). The main methods for adaptive navigation are the following:

Direct guidance – the user can be directed to the material to be studied in accordance with his/her level of knowledge on the subject, learning objectives, pedagogical strategy, or other parameters involved in the user model (Brusilovsky, 2012; Rahnev & al., 2014b).

Adaptive link sorting – it aims to arrange all the links in a page in line with certain criteria such as their compliance with previous knowledge or similarity to the current document. The higher a relationship is in the sorting, the more it meets the criteria.

Adaptive link annotation – this is a method whose implementation techniques involve providing links along with additional marking, text, coloring, icon, or fad-

ing so as to give the learner some additional information about the nodes behind these links (Brusilovsky, 2012; Bower, 2016). The algorithm for generating annotations classifies the students' level of knowledge into three categories – minimum, average, and maximum. Thresholds for the level of knowledge can be set by the teacher. These three knowledge thresholds allow the adaptation mechanism to fine-tune how much knowledge each learner needs to demonstrate. The authors also note the motivational effect of the annotation of links – in their opinion, learners answer more questions;they work with the questions more persistently and research a greater variety of materials related to the questions. The adaptive annotation of links helps to significantly increase the commitment of learners to work with optional learning material.

The learners'level of knowledge or their abilities are also often included as parameters of adaptation in the construction of a personalized learning path. Some sources use Bloom's taxonomy to classify the ability of students (Alshammari & al., 2014; Brusilovsky, 2012), while others use test results to determine the learners'level of knowledge (Rahneva & al., 2008; Rahnev & al., 2014a;Bower, 2016).

Another parameter, as suggested by (Rahnev & al., 2014b; Arnaudova & al., 2016), is the number of visits to the same learning object. To meet the needs of students and to improve the quality of adaptive learning, it is necessary to take into account a number of factors during the formation of a personalized learning path,such as prerequisites for success (results of preliminary tests, number of attempts, etc.), pedagogical consistency, cognitive complexity, successor failure of other learners, and assessment time (Terzieva & al., 2018; Rahnev & al., 2019). The preconditions for achieving the pedagogical goals are fulfilled in order to extract information about the students'preliminary preparation and to choose a suitable pedagogical model for them.

In recent years, cognitive information processing capabilities have also been added to the abilities that influence e-learning. The creation of adaptive e-learning systems, integrating the cognitive load theory (Clark &Mayer, 2016), is beginning. In e-learning, it is easy to succumb to the temptation to provide vast amounts of information through different media simultaneously and leave it in the hands of learners to deal with the associations between sound and text or picture and concept, etc., which strains students'cognitive abilities and leads to low learning efficiency.

The specific features that need to be considered in the process of implementing adaptive e-learning are:

- the learners'level of knowledge and skills, as both the initial level and the current state are essential when conducting interim tests;
- the individual rate of assimilation (working capacity) and level of cognitive and practical autonomy;
- the nature of the thought processes of the different groups of learners, etc.

Conclusions

Each learner has individual needs and characteristics such as basic knowledge, learning style, motivation, etc. These differences affect the effectiveness of the learning process and are a prerequisite for some learners to easily master the learning material of an e-course, whereas others to encounter significant difficulties.

The main goal of the functioning of the system for adaptive learning is to increase the efficiency of learning by reducing the time for access to the necessary learning information, selecting a sufficient amount of learning resources to achieve the set learning goals, providing different learning styles and content accessibility, stimulating self-control and self-learning, motivating students through active forms of education and so on.

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