Why do Standards in the Field of E-Learning not fully support Learner-centred Aspects of Adaptivity?

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Abstract: As a pre-study for *AdeLE (Adaptive e-Learning with Eye Tracking)*, a research project with the aim to develop and implement a solution framework for personalized adaptive e-learning based on real-time user behaviour, this paper examines the learner-centred aspects of adaptive e-learning and their support in e-learning standards. For this purpose, indicators for adaptation criteria are derived from the learner's characteristics and exemplary adaptive methods for an e-learning environment are introduced. On the basis of these indicators and because of the importance of standardization, the paper points out requirements on e-learning standards to support learner-centred adaptivity. According to these requirements two well-established standards - *SCORM* and *IMS* - are examined in order to evaluate its applicability to the *AdeLE* solution approach.

Introduction

E-learning was identified as one of the emerging areas in the last few years as shown by means of concrete numbers in an IDC study (IDC 2003). About 934 Mio USD were invested in e-learning worldwide in the year 2003 and the European market is meant to be the best one. Nevertheless, (Baumgartner 2003) reports about a lot of failures and only a few - in most cases locally restricted - success stories. Knowledge transfer itself can be improved by technology, as described in (ADL 2001), but the e-learning contents have to be adapted to the learner to compensate problematic areas like weaknesses and even disabilities of learners (see IMS 2003) or other disadvantages of technology-based learning as treated in (Dietinger 2003).

From the technical point of view - and taking into account that the learning process may be enhanced through automatic mechanisms for customised information delivery - an e-learning environment has to provide personalisation and adaptivity. These aspects of customisation may include an enhanced user profiler - e.g. by means of real-time eye-tracking as presented in (Garcia et al. 2004) - as well as extended, high-quality contents, which have to be created by experts using professional tools. Indeed, these facts cause much more costs to introduce e-learning solutions. Due to this critical financial aspect it is important to consider interoperability issues like transferability and reusability of content as well as the usage of learning object repositories (see also Qu et al. 2002). In particular, standards for describing and exchanging e-learning content are established as pointed out in (Dietinger 2003). But do these standards fully support learner-centred aspects of adaptivity?

AdeLE, a two-year research project carried out by the Department of Information Design at the University of Applied Sciences (FH JOANNEUM) and the Institute for Information Systems and Computer Media (IICM) at the University of Technology in Graz, Austria, aims to research on adaptivity in the field of e-learning and to develop an innovative framework for personalized adaptive e-learning. The *AdeLE* framework itself will not be treated closer here, but in context of the research project this paper stipulates some relevant learner-specific indicators and adaptive methods for e-learning and tries to point out if and to which extent well-established standard specifications can be used for an adaptive e-learning system. We try to answer the critical question, how learner-centred adaptivity influences e-learning by pointing out requirements for standards in the field of e-learning and by examining standards which are interesting for AdeLE on these requirements.

Indicators and Methods for learner-centred Adaptivity

The main focus of this paper is set to the learner-centred point of view in terms of asymmetric learning (see Jain et al. 2002). Thus, didactics and other topics, which are relevant for teachers, will not be treated here and can be found e.g. in (Specht 1997). As shown in figure 1, the learner interacts with the learning management system (LMS) by passing the user profiler, which can provide relevant indicators to the system in order to undertake personalisation adaptation tasks. Because of the focus on the learner and due to the utilisation of an enhanced user profiler, these indicators can be derived from the characteristics of the learner.

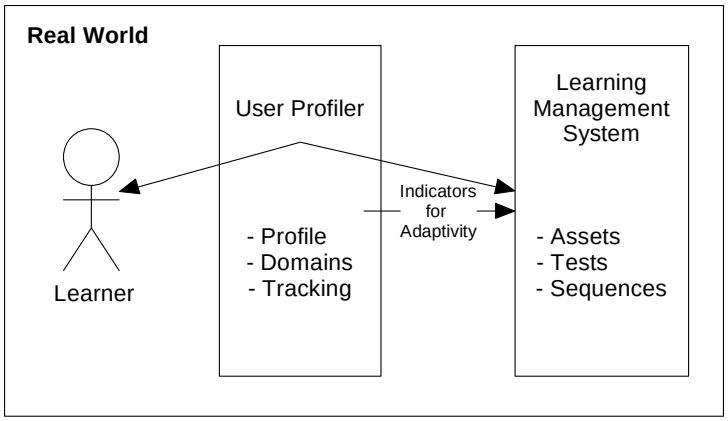

Figure 1: Adaptive, learner-centred e-learning

According to (Brusilovski 1996) the characteristics about learners can be categorized in six classes of indicators to adapt to: (1) background knowledge, (2) domain-specific knowledge, (3) cognitive and affective abilities, (4) constitutional attributes, (5) preferences as well as (6) interests and learning targets. Furthermore, the indicators can be divided into two categories: On the one side there are static or slowly changing attributes, on the other side there are attributes which are highly dependent on the situation and the user behaviour - this kind of indicators can alter within hours or even minutes.

Following the insights stated in the last paragraph, an adaptive e-learning environment has to consider and manage static and dynamic indicators of all six classes. This can be carried out by working with a user model of the learner (see also Koch 2000) and by analysing the user behaviour in real-time, e.g. by exploiting eye-tracking as described in (Garcia et al. 2004). According to the definitions of adaptivity and adaptability (see Oppermann 1994) it has to be mentioned, that slowly changing indicators could be handled by an adaptable system, but, in fact, it is also possible that the e-learning environment adapts to these attributes within an initializing phase.

In case of learner's characteristics changing during the learning process, the system can provide methods to adapt to the newly retrieved indicators as discussed below.

Background knowledge

Background knowledge of learners comprises language skills, experiences with computers and the e-learning environment, general knowledge, etc. If the e-learning environment detects that the learner does not understand a phrase or word, this fact could have been the result of a lack of general knowledge or language skills (see Felder et

al. 1995). According to the language level registered in the user profile (representing the user's language ability in some weighted form), the system could present an explanation or translation for the problematic words. Besides, the e-learning environment could provide graded background knowledge expertise modes for novice, normal and expert users to be able to adapt to the learner's experiences.

Domain-specific knowledge

Domain-specific knowledge defines the knowledge about the content domain, which a learner has to study. Therefore, the e-learning environment has to support the possibility to present the content in different levels of detail. In case of a high reading rate and a lot of skipped passages the system can perform adaptation tasks in terms of the levels of detail. Besides, the e-learning environment should offer navigational elements to step over content or go on with the questionnaire if this is necessary for a lecture. It is important to remark, that the user must be able to override the suggestions, because the system may not patronise the learner.

Cognitive and affective abilities

Cognitive and affective abilities - like the user's intellect, learning speed, spatial cognition, the ability to concentrate, or the motivation to learn - do have a strong influence on the learning process itself. This class of indicators may be mapped and reduced to the seven types of "Multiple Intelligence" described in (Gardner 1993). One the one side, an e-learning environment could adapt to the learner's intelligences - which have to be assessed somehow and may represent the learner's competences and qualifications for a certain subject - by providing different ways to present the content, different paths through the course as well as different types of questionnaires. Furthermore, providing the accurate level of detail to treat the content and high-lightening of relevant terms could be necessary to allow adaptation in terms of learning speed as shown for domain-specific knowledge already. On the other side, the system also has to consider attributes concerning the ambient circumstances - like brightness or noise level in the room - and the learner's abilities to learn under the influence of these external parameters.

Constitutional attributes

Constitutional attributes describe on the one hand physical properties of the body like disability, age, and so forth. On the other hand, these indicators also cover constitutional states of the learner like tiredness, concentration, and the like. An adaptive e-learning environment has to be able to cover both kinds of attributes, e.g. in order to adapt the courseware delivery and present the content as Braille or auditory for blind people, or enlarge the font size for partially sighted persons. Furthermore, the system can analyse the user's behaviour and suggest pauses if a learner is tired or not concentrated. With respect to didactical models, and according to (Nelson 2001), children and young adults should learn in terms of cognitivism - e.g. because they need more guidance to develop their cognitive and affective abilities and to gain background knowledge -, while adults are rather used to explore topics on their own by the means of constructivism. Besides, certain contents are more appropriate for a certain age level. Therefore and because of the strong relation to the learner's intelligences, the system has to provide the same methods as pointed out for cognitive and affective abilities.

Preferences

The learner's preferences include attributes like the preferred presentation of contents, the favourite way to navigate through a course and the like (see also Tsandilas et al. 2003). Preferences cover everything "a learner wants to use" and they are partially dependent on cognitive and affective abilities as well as on constitutional attributes, which both describe "what the learner is able to do". Together with cognitive abilities this class of indicators may include common learning style definitions, as for example the Felder-Silverman Learning Style Model (see Felder et al. 1998), which classifies students as sensing, visual, inductive, active and sequential learners. Therefore, the e-learning system has to provide methods for adapting content representation, learning path and navigation elements according to these modelling alternatives. From the technical point of view, preferences also could be used to adapt the content to the output device or to the bandwidth the learner is connected to the system, so the system could ignore multimedia content, which takes a long time to load or cannot be displayed on the screen, and deliver appropriate media types.

Interests and personal targets

Interests and personal targets are important attributes in terms of adaptive e-learning, because this class encapsulates the tasks from the learner-centred point of view. It is important to analyse if the user intends to just pass a lesson or if he wants to specialize on this area. According to the learner's intention the system may present the

content on different levels of detail as well as provide background knowledge for certain topics, e.g. by generating additional hyperlinks using a dynamic background library.

Requirements on Standards supporting adaptive E-Learning

According to the above depicted six classes of indicators, we suggest that adaptivity has to be supported by the standards in the field of e-learning on three different levels. First of all, the standard has to enable user' profiling to store, organize, model and interpret information about the learner. Secondly, it must be possible to adapt the contents - in particular e-learning assets, which can be raw media files such as text, images, sound, Web pages, assessment objects or other pieces of data - in terms of semantics and presentation. Finally, it is important to offer different types of learning instructions and different ways to assemble the content-assets. Referring to these three aspects and in context of the research project *AdeLE* the requirements on e-learning standards will be discussion in the following sections.

Requirements on User Profiling
A standard in the field of adaptive e-learning needs to enable user profiling - at least - in the following ways:

- Supporting static and dynamic information attributes about a learner to create a user model within the e-learning environment
- Modelling knowledge domains - i.e. supporting modelling mechanisms for concepts and concept relations - to describe the background and domain knowledge of the learner
- Supporting management (like storage, deletion or update) of attributes in real-time, e.g. the actual constitution
- Tracking the learning progress, the paths through the courses, the viewed content elements and the constitution of the learner to enable evaluation of the system and of the contents as well as to research adaptivity in the field of e-learning

Requirements on Content
Towards the aspects of e-learning content the standard has to provide the following features:

- Considering characteristics about the target group for the asset (language, age, etc.)
- Defining different levels of detail to cover the learner's interests and targets
- Offering background knowledge to an asset
- Enabling the use of parallel defined, different media-formats for one asset (text, image, audio, Braille, etc.)
- Mapping assets to knowledge domains to be able to react to background knowledge
- Separating content and presentation

Requirements on Instructions and Sequencing
In terms of learning instructions and assets' sequencing an e-learning standard has to fulfil the following requirements:

- Providing different types of instructions, like displaying an asset, repeating a lection, performing a questionnaire, suggesting a pause, etc.
- Defining different kind of assessment objects to adapt to the learning style or paradigm
- Enabling the possibility of defining additional information pages about the content, e.g. to extract and show only the definition sections of an asset, the non-understood words or phrases, etc.
- Allowing the learner to choose an own way through the course (constructivism)
- Suggesting and optimizing the best path through the course (cognitivism)
- Defining dependencies between assets to ensure required knowledge

Inspection of Standards towards learner-centred Adaptivity

As already stated in section 1 of this paper, standards within the field of e-learning can be seen as essential criteria for transferability and reusability of content (see also Qu et al. 2002). In this section, two exemplary and well-established standards are examined on basis of the requirements considered in the previous chapter to point out to which extent the standard could be used for implementing the *AdeLE* solution framework.

The *Advanced Distributed Learning Initiative* (see ADL 2004) was established by the *US Department of Defense (DoD)* in 1997 to develop a strategy for using information technologies to modernize education and training and to promote cooperation between government, industry and academia to develop e-learning standardization. Currently the standard specifications are summarized within the *Sharable Content Object Reference Model*, abbreviated as *SCORM*. *SCORM* is a collection of specifications adapted from multiple sources to provide a comprehensive suite of e-learning capabilities that enable interoperability, accessibility and reusability of Web-based learning content. Because the actual version of the standard, *SCORM 2004*, is still part of the development process of the standard, there are some aspects towards learner-centred adaptivity missing.

SCORM supports a detailed description of assets and content objects using the *IEEE LTSC* metadata specification *Learning Object Metadata (LOM)* with *IMS* metadata elements. Using this specification *SCORM* allows defining assets for different aggregation levels and formats, languages and language levels, operating systems and platforms, interactivity types, semantic densities, intended end user roles, typical age ranges, difficulties, relations, and so forth. In spite of all these attributes, accurate and up-to-date background knowledge can only be offered using dynamically created links to external sources, e.g. as static links to a separate known library or in terms of search queries pointing to dynamically retrieved resources (see also Garcia et al. 2004). Besides, knowledge domains are not considered at all within *SCORM*, so the system cannot cross reference from a content object to one or more knowledge domains.

In terms of learning instructions and sequencing *SCORM* includes the *IMS Simple Sequencing* specification, which allows the definition of dependencies between content objects as well as more complex structures of the content. Although questionnaire is implemented in a very prototypical way within the exemplary runtime environment of *ADL*, there exist no specifications for assessment objects, user profiles or knowledge domains - these areas are evaluated now or will be treated in the closer future. Thus, our requirements on *SCORM* towards user profiling and learning instructions are not or only partially fulfilled.

As already pointed out, *SCORM* uses some specifications of the *IMS Global Learning Consortium* (see IMS 2003). *IMS* is developing and promoting open specifications for facilitating e-learning activities such as locating, using and sequencing educational content. These specifications support didactical models, tracking and reporting learner progress and performance, exchanging student records between different systems and making e-learning accessible by people with disabilities. This standard follows a more global approach and covers more aspects of e-learning than storing and distributing e-learning contents as seen in the *SCORM* specification.

User Profiling is covered by the *IMS Learner Information Package (LIP)*, which allows storing the learner's attributes as well as tracking the learning process. Besides, it is possible to assign and update competencies of a learner according to the specification *IMS Reusable Definition of Competency or Educational Objective (RDCEO)*. Towards content and sequencing, *IMS* offers the possibilities of *SCORM*, because both are based on *IEEE LOM* extended by *IMS*. Finally, the *IMS Question & Test Interoperability Specification (QTI)* allows describing tests and questions. The specification has a powerful set of features that enables it to exchange a wide range of question types plus a number of extension facilities.

Overall it can be said, that the *IMS* specifications considers all essential aspects for e-learning and, therefore, better fulfils our requirements on adaptive e-learning in terms of the indicators previously stipulated in this paper. Nevertheless, *SCORM* is more practical oriented - *AD*L even offers an open *J2EE*-based runtime environment - while it is more expensive to develop an e-learning system based on the very complex *IMS* specifications.

Conclusions and Future Work

As pointed out through the previous sections, the standards in the field of e-learning considered in this paper do partially include aspects of learner-centred adaptivity. Especially on the level of content creation and presentation as well as sequencing the assets the evaluated standards fulfil most of the requirements on adaptive e-learning. Furthermore, *IMS* supports also central aspects of assessment, user profiling and knowledge domains. Nevertheless, real-time tracking of learner's behaviour and states, certain kind of learning instructions, support of background knowledge and the dynamic generation of information pages about content objects represent important issues that are not included within the evaluated e-learning standards.

In the context of the research project *AdeLE*, it can be concluded that the usage of a well-established e-learning standard is meaningful, but that it is necessary to extend the chosen standard in terms of adaptivity. Similar approaches can be already found in literature and in praxis, e.g. in the *KOD* project (see KOD 2002). We want to emphasise that an adaptive e-learning environment has to support real-time tracking mechanisms as well as enhanced user profiling including describing and tracking domain and background knowledge. Furthermore, we are conscious of the fact that it is not enough to focus on learner-centred adaptivity. In this area it is a critical factor that

the e-learning environment provides methods to adapt to the learner also in terms of didactics (e.g. different learning paradigms) and the teaching process (e.g. different teaching styles).

For future work the aspects of the teaching process have to be researched to provide a holistic theoretical model for adaptive e-learning. Combining the perceptions of learner- and teacher-centred adaptivity a standard in the field of e-learning has to be extended in terms of the missing requirements. The resulting specifications can be used as basis for the learning object repository and the adaptive e-learning environment itself.

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