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THE LIBE PROJECT DISTANCE LEARNING PLATFORM – EVALUATING AN ADAPTIVE E-LEARNING SOLUTION

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Adaptive Learning to Personalized Education

Technological innovations have made it feasible for humankind to customize how to shop, to accomplish banking tasks and how to interact one with each other, nevertheless the traditional classroom model, or most part of it, continues to be based on a "one size fits all" paradigm. This could guarantee a high level of efficiency, but it does not consider individual students' strengths and weaknesses as it should (Reiser, 1987).

In the field of education, existing technological solutions provide a good implementation of the traditional classroom model, at distance or not, but they also lead to a monolithic interpretation of the learning process. To guarantee a high level of learning experience for students it is necessary to allow users to take choices in order to regulate the learning processes. At the same time, these choices are anticipated by the system considering the evolution of the processes themselves, and so on (Park & Lee, 2003).

Recently, the growing need to support a new model of personalized education has motivated experimental pedagogy research combined with the information and computer science in order to achieve new technological solutions to tailor the learning experience onto student's previous experiences, actual perceptions and future needs. Nowadays, with the introduction of newly developed tools for e-learning is possible to reach a new, higher level of customization both in distance and in face-to-face education.

In literature, adaptive learning is commonly described as an educational methodology which combines different techniques and strategies for instruction and resource utilization to allow students to take various itineraries to, and different amounts of time for, reaching the same educational goal ("mono-itinerary model") or a range of comparable goals ("multi-itinerary model") (Wang & Lindvall, 1984; Park & Lee, 2003).

Another way to define the meaning of adaptive learning is to highlight the differences between other terms commonly used nowadays in the field of educational technology like differentiated, personalized and adaptive learning in a digital environment. Differentiated learning is when there are different paths that learners can choose within a learning environment, but these paths are pre-organized as pre-set categories. Personalized learning is

when there is a different learning path for each individual student, usually obtained by the system through a rule-based algorithm (e.g. a decision tree). Usually as first step learners take a pre-test that will be used to define the individual's path and didactic materials. At last, adaptive learning is when there is not any pre-set path, but an algorithm data-driven constantly obtains students' data from the system, analyse them and adapts students' learning path in order to better define student profile and to improve its own rules and routines over time.

These three concepts are not to be intended as a succession of steps, but they are more like to be interpreted as different possibilities to achieve personalization in education. It is important to stress that they are not mutually exclusive, on the opposite it is essentially preferred to achieve all of them simultaneously.

Nevertheless, this categorization implies the assumption that the machine should make the learning path selection for the students. Currently, this approach has been overtaken by a more comprehensive idea of smart tutoring the student. Hence, there are other effective approaches to educational technology which foster algorithms relying on the idea of empowering the learner in selecting his/her own path – as either a pre-set category or even to create his/her own path that adjusts over time based on the learning process and interactions with other learners.

From a historical overview, the adaptive educational systems could be categorized mainly into four different approaches based on the theoretical model used to achieve the adaptation, in other words, on which educational elements are adapted in order to match the learner's needs: the macro-level approach, the aptitude-treatment approach, the micro-level educational approach and the constructivist-collaborative approach (Park & Lee, 2003; Mödritscher et al., 2004).

The first approach focuses on goals, depth of the course and delivery systems, in this approach educational alternatives are chosen based on the student's educational objectives, abilities and achievement level in the course structure. The second one focuses on adapting the educational procedures and strategies in order to match the student's individualities for the education and the selection of educational plans that ease the learning progress of the student/students with the same qualities. The third one analyses the student's learning necessities throughout the education and offer educational indications according to his/her needs. The fourth approach is related to modern aspects about how an e-learning system can be employed within the learning process following the constructivist pedagogical approach.

It is about two decades that the educational research is mainly focused onto Web-based educational systems (Kahn, 1997). There are different kinds of adaptive Web-based systems, which can be divided into three groups, summarized as follows (Brusilovsky et al., 1998):

- *Adaptive Information Systems* (AIF) which serve personalized information online.

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- *Adaptive Filtering Systems* (AFS) which help user to find relevant information in the Internet.
- *Adaptive Educational Systems* (AES) which aims to adequate its relation with the student according to a predefined but updatable model of the user that reflects his objectives, preferences, knowledge and competences.

The latest group is the most investigated: the most part (about more than half) of the existing adaptive Web-based systems could be categorized as AES. The reason for this to happen is that the first two groups could be considered, in certain conditions, as subgroups of the third. In other words, the three groups are not so distinct between them. For example, an on-line information system can be classified as an AES depending to what audience it is referred to. A second reason is that systems in the AES group are considered as more multipurpose and adaptable type of system than the others in the other group. This is a strong motivation for researchers coming from different areas to stay focused and work mostly on AES group. In the end, from the technical point of view, developing technologies for an AES is more feasible since developers can rely on components already used and tested in earlier smaller projects (like standalone Intelligent Tutoring System (ITS) or Adaptive Hypermedia (AH) systems). For example the Web-based AES CALAT, or ELM-ART, or WITS have been created pre-existent ITS.

Since the Web is the most viable mean for distance and blended learning, this document will focus specifically on Web-based Adaptive Educational Systems (Web AES), analysing them according to applied adaptation technologies. For the LIBE project purposes, it is convenient to categorize the available technological solution based on the technique used for obtaining the adaptation and their availability.

As stated before, all kinds of adaptation technologies used in Web AES are implemented starting from either the ITS area or the AH area (Brusilovsky et al., 1998). For the ITS source, there are the following approaches: curriculum sequencing, interactive problem solving support, intelligent analysis of student's solutions, adaptive collaboration support, and example-based problem solving support; for the AH: adaptive presentation, adaptive navigation support and user modelling.

Both of the approaches are discussed in the next paragraphs.

Current Approaches to Adaptive Learning

This paragraph provides a concise review of existing research on adaptive Web-based educational systems. To categorize the different approaches has been taken in into consideration one main aspect of the systems: what is adapted. As stated in the paragraph before, in this review are considered two major groups of AES, the ones coming from ITS area and the other coming from AH area. Nevertheless, it is expected that in a near future new adaptive technologies will be developed as for example, adaptive translation of voice and text materials.

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Hereafter it is reported the list of reviewed approaches, the first five could be categorized as originating from ITS field of study, the other from AH field:

- **Curriculum sequencing techniques**: this is the more aged and, at the moment, the most common technology for Web-based AES. These techniques are divided into high-level sequencing or *knowledge sequencing* (determines next concept or topic to be taught) and low-level sequencing or *task sequencing* (determines next learning task – problem, example, test within current topic) (Brusilovsky, 1992). Sometime these techniques are mentioned also as *instructional planning technology*. The principal aim of curriculum sequencing is to deliver to the student the most appropriate individually calculated sequence of learning units and tasks to study with. In this case the system assists the student in order to obtain the "optimal path" through the learning material.
- **Interactive problem solving support**: this approach implements an algorithm to support the student during each step of problem solving, providing him/her an intelligent help that varies from the simpler task of giving a hint to the more complex task of executing the whole next step for the student. Usually a system that adopts this kind of approach registers all the actions of the student, try to recognize them, and use this information to help the student and to adapt the student model. This technology is widely used in teaching programming, one of the most common examples is the LISP-TUTOR software from Anderson & Reiser.
- **Intelligent analysis of student solutions**: this kind of technologies considers exclusively students' final answers to educational problems (from a question to a programming task) and do not analyse how these answer were acquired. Nevertheless, intelligent analysers can provide other information than whether the answer is correct: what exactly was wrong (or incomplete) and to what knowledge these errors were related. As before, intelligent analysers provide extensive error feedback to the student and can adapt the student model. Systems providing intelligent analysis of solutions are very suitable in the context of slow networks since they need only one interaction between browser and server for a complete iteration.
- **Example-based problem solving**: this kind of approach is not so widely adopted. It consists of a system that provides the student with help examples from their own earlier experience in solving new problems. In other words, an ITS recommends to the students the most relevant cases (for example problems already explained or solved). One benefit of this approach is that it does not require an extensive client-server interaction.
- **Adaptive collaboration support**: this approach is not related to the single student, but it is adopted to deal with a group of student in a collaborative learning environment. A system which uses this technology has stored all the user's history in relation to well defined user models in order to arrange a matching collaborating group. It could also provide the most suitable peer to answer to a particular question, or create the group in the proper moment of time to answer to a specific collaborative problem situation.
- **Adaptive presentation**: a system with adaptive presentation try to adapt the content of the text learning material (e.g. a hypermedia page) to the student's objectives,

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knowledge and other information stored in the user profile. In this kind of approaches, the material provided are not static, but dynamically adapted, newly generated or assembled from pre-existent materials, for each user. For example, an adaptive presentation system could adapt reading material giving to expert students more exhaustive and specified information, while to novices additional explanation. This kind of adaptive approach is crucial in Web-based AES because the same material could be automatically tailored to a large number of different students.

- **Adaptive navigation support (ANS)**: these kind of techniques are particularly related to the Web navigation: an adaptive navigation system supports the user in hyperspace orientation adjusting dynamically the appearance of links on the page. In other words, it is possible to adaptively hide or annotate links or to dynamically sort them to help in the choice of the next link to read. Logically, this technology could act as an application of curriculum sequencing technology into hypermedia contexts. As for the curriculum sequencing, it is aimed to provide suggestions to students in order to obtain the "optimal path" through the learning material (in this case hypertexts). One big difference is that the ASN provides to the students a wide range of links among which to choose, leaving the choice to the students, instead of pointing the student to the next learning task.
- **User Modelling**: nowadays, the creation of user model has become a challenge. It is a prime application of standard machine learning techniques. The ability to create tailored environments depends mainly on the amount and accuracy of information stored in each user model. Past user's behaviour could be used as training examples by a machine learning system. The need for large labelled data sets could be faced through the use of modern data mining techniques in order to handle large amounts of data. Actually, these solutions are explored by researchers and are object of modern educational and informational research.

It is a proven fact that adaptive technologies can enhance the learning experience from a pedagogical point of view to a more practical one: adaptive presentation increases the usability of learning material; ANS and adaptive sequencing are recommended for overall course adaptation and to provide student with suggestion to highest relevant materials; with their interactivity and intelligent feedback, intelligent solution analysis and problem solving support considerably improve the feasibility of assignments; machine learning and data mining techniques are the most advanced solution to create a more detailed and reliable user model. At last, but not least, adaptive collaboration is a relatively recent technology devoted to a specific pedagogical approach providing new opportunities for communication and cooperation. The most part of these technologies is in a research phase, providing results only in their respective fields, nevertheless it is already possible to reuse some of their implementation in a working learning environment.

The following table presents a first draft of the evaluated AES, detailed following the approaches and characteristics described above.

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Table 1: Inventory of personalized solution for e-learning

AES	Hypertext component	Adaptive sequencing	ANS	Problem solving	Intelligent analysis	Adaptive presentation	Developed	Integration
OrbisDictus	Y	N	N	N	N	Y (text materials)	Y	N
LAMS	Y	Y	N	Y	Y	N	Y	Y
Xerte	Y	Y	Y	Y	Y	Some	Y	Y
Desire2Learn	Y	Y	N	N	N	Y	Y	Y
TAO	Y	Y	N	N	Y	Y	Y	Y
KNewton	Y	Y	?	?	Y	?	Y	?
CALAT	Some	Y	N	N	N	N	Y	N
ELM-ART	Y	Y (course, text)	Annotation	N	Y	Some	Y	N
AST	Y	Y	Annotation	N	N	Some	Y	N
InterBook	Y	Y	Annotation	N	N	Some	Y	N
Medtec	Y	Y (tasks)	N	N	N	Some	-	N
C-Book	Y	N	N	N	N	Y	Y	N
PAT - InterBook	Y	Y	Annotation	Y (server)	Y	Some	Y	N
DCG	Y	Y	N	N	N	N	Y	N
De Bra's	Y	N	Disabling	N	N	Y	Y	N
WEST-KBNS	Y	N	Annotation	N	N	N	Y	N
PAT	Y	N	N	N	N	N	Y	N
WITS	N	N	N	N	N	Y	Y	N
Belvedere	N	N	N	Y (java)	N	N	Y	N
ADIS	N	N	N	Y (java)	N	N	Y	N
D3-WWW-Trainer	Y	N	N	Y (java)	N	N	Y	N
Manic	Y	Some	N	N	N	N	Y	N

Towards A LIBE Adaptive Learning System

Currently, the presented list is an attempt to evaluate as more as possible solutions to be used in the LIBE Project in order to achieve personalization of learning experience. Since pre-existent and commonly used LMSs (e.g. Moodle, Canvas, Blackboard) offer only a partial personalization of learning experience, some researchers agreed to resort to add-on applications in order to extend them with adaptivity features. In literature, it was observed that, even if these LMSs are universally used to provide teachers with tools to build and manage online and face-to-face courses, they do not offer to the student a complete personalized learning experience (Peter et al., 2010). It is a shared opinion between academics that further researches on designing and developing add-on applications to extend LMSs adaptivity features are needed since commonly adaptivity is widely used in activities not strictly related to education (e.g. social media) and should be revised in order for being used for educational purposes (Bachari et al., 2011; Wen et al., 2007).

Some of the software applications listed in the previous paragraph could be assimilated to traditional micro-adaptive educational systems: they are adaptive but not adaptable to every learning condition, in other words the "intelligence" of the software is system-dependent and it is not transparently available to the user (Brown et al., 2005). Conversely, each type of software can be more successful than the other based on what types of learning conditions or learners are present in the final scenario. It was argued that adaptive educational systems should be controllable by the teacher or by the student him/herself because sometimes they cannot be smart enough to adapt in a suitable way in all possible situations (Triantafillou

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et al., 2004), therefore, it is reasonable to apply for a system with more available functions (e.g. ANS and adaptive sequencing) instead of focusing on only one type of functions (Park & Lee, 2003).

Nowadays, it sounds realistic that more studies are needed to support the standardization and the optimization of the findings and implementations obtained from educational research into AEH systems. Nevertheless, from the list proposed in the previous paragraph, it seems reasonable to identify at least three most feasible tools to be used in the LIBE project to achieve a good level of personalisation and adaptivity. They are the following:

- **Xerte**: The Xerte Project provides an authoring tool for learning object. It is open-source , free to use, and allows to export created learning objects in the most common format (SCORM 1.2 and 2.0). It has a strong developers and content authors community producing interactive learning materials. The Xerte community platform allows also to find already prepared learning objects.
- **LAMS**: LAMS is relative new software for designing, managing and delivering online collaborative learning activities. It has a highly intuitive visual interface that allows teachers to create rapidly complex scenarios in their learning objects. It is also provided in a module version ready to be used in the Moodle platform.
- **Desire2Learn**: Desire2Learn LeaP is an adaptive learning platform that adjusts to student's needs, returning a personalized study path and accelerating the learning process. Desire2Learn integrates and substitutes the formerly known Knowillage LeaP. This software uses a semantic engine to map learning materials to the knowledge objectives, then automatically selects relevant content from the existing materials, and the tutor can then adjust the learning path. It is only available as a commercial product. Nevertheless, it is possible to integrate its functionalities into Moodle platform.

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