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Student-oriented planning of e-learning contents for Moodle

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ABSTRACT

We present a way to automatically plan student-oriented learning contents in Moodle. Rather than offering the same contents for all students, we provide personalized contents according to the students' background and learning objectives. Although curriculum personalization can be faced in several ways, we focus on artificial intelligence (AI) planning as a very useful formalism for mapping actions, i.e. learning contents, in terms of preconditions (precedence relationships) and causal effects to find plans, i.e. learning paths that best fit the needs of each student. A key feature is that the learning path is generated and shown in Moodle in a seamless way for both the teacher and student, respectively. We also include some experimental results to demonstrate the scalability and viability of our approach.
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1. Introduction

E-learning is increasingly widespread in the educational world by taking advantage of information, computing and telecommunication technology, together with a wide range of electronic multimedia uses. The validity of online assessment methods has already been demonstrated in Hewson (2012). Furthermore, the application of multimedia tools have a great impact on education, training and, in general, on curricula considerations. These tools support (and facilitate) learning, and their usage within e-learning makes the learning process friendly to students, who interact with teachers in a better way than in traditional classroom teaching (Martín-Blas and Serrano-Fernández, 2009). In fact, e-learning permits us to remove the barriers of time and space, which are characteristic of traditional teaching worldwide, because the access to a course is now possible by a simple connection to Internet. In addition, e-learning makes it possible better monitor the learning progress of the students. This is very valuable for students and teachers because they can realize students' learning state in a very easy way.

1.1. Learning Management Systems

E-learning requires two kinds of activities: communication activities (e-mail, forums, conferences, on-line blogs, etc.), and exploration activities (mainly navigation of contents). These activities usually take place on a Learning Management System (LMS). A LMS is a platform for administrating, documenting and delivering e-learning contents, which offers the enrolled students a vast number of courses with highly customizable capabilities. Many of these platforms, such as Moodle, Sakai, Docebo, Atutor, Ilias, LRN, etc., are increasingly being used in schools and universities as a powerful support and improvement for teaching activities. Although LMSs are a fraction of educational ecosystems where different platforms (LMSs, e-portfolios, assessment systems, curricula management systems, etc.) live together and collectively support e-learning, the great risk here is not to exploit LMSs up to their full potential. On the contrary, LMSs are traditionally used simply as mere "repositories" of learning contents. For the best use of these contents, it is fundamental not to consider them in an isolated way (and, consequently, not to consider a LMS just as a simple database), but as part of a much larger system in which contents are aggregated for the construction of courses that can be fully personalized. Intuitively, the underlying idea is to build student-oriented learning paths by combining appropriate learning contents, where a learning path is a set of activities that a student needs to perform to achieve a certain level of knowledge.

It is important to note that each student has his/her own characteristics (profile, learning style, prior background and learning objectives). These individual traits are very useful to provide each student the most adequate learning path to attain his/her learning outcomes (Garrido and Onaindia, 2013; Papanikolaoum et al., 2002). In other words, it is not enough to plan a general learning path for all students but to personalize as much as possible each learning path. Therefore, what is essential for a LMS is, first, to identify a specific learning path for each student, and second, to provide the maximum possible autonomy to

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him/her. Thus, learning paths should be student-oriented, and planned to meet the individual characteristics of each student.

1.2. Motivation

We motivate the necessity of personalization by using a simple example. Let us imagine that two students, Paul and Kate, enroll on an Italian course. The course consists of three sequential modules (corresponding to three different learning levels): "Elementary module", "Intermediate module" and "Advanced module"; and it is possible for a student to take the entire course or just a part of it. Let us suppose that Paul has sufficient knowledge of Italian and only wants to improve his grammar. Kate, however, has already a good level of Italian but wants to speak more fluently. Certainly, it makes no sense to design the same learning path for both students. It is necessary to plan for Paul a path that only includes the "Intermediate module" and for Kate a path that includes the "Advanced module". Starting from these considerations, it is necessary to find (and to put it into practice within a LMS) the best learning path so that each student achieves his/her learning objective, starting from his/her initial characteristics.

Although the sequence of the Italian course's activities may seem unique, we consider the portions of the course assigned to Paul and Kate as two different learning paths. More generally, we can consider a course where the sequence of activities may be (or not) unique, but this does not necessarily mean the sequence of learning activities is the same because different students can skip parts of the course and take different learning paths according to their specific needs. For example, in a course composed by n activities, we can have learning paths of n, $n-1$, $n-2\ldots$ 1 activities, and in different orderings. And the personalization can be even more flexible. If two activities achieve the same learning outcome (e.g. by means of a multimedia document and by reading a paper, respectively), one student could take the former and another student the latter. In other words, it is possible to find learning paths that involve, for example, the same number of learning activities but in a different sequence (in line with the course's constraints of causality) or different sets of activities, depending on the specific learning outcomes and students' profiles/learning styles.

Consequently, we need planning to select the best sequence of learning activities (and in the right order), from the entire set of activities defined by the teacher, to satisfy each student's learning goals. It is necessary to plan the steps to reach one or more goals because the steps cannot be a simple, arbitrary sequence of learning activities but what the student needs to do/learn in an adequate causal ordering. Also, although a student can tick some parts that she/he already knows, we still need planning. Perhaps in a long sequence of activities the student has a background on some parts, but this does not mean that we do not need to plan the remaining part of the sequence. In other words, the planner needs to plan the remaining part of the path to satisfy all the learning goals, and this can be significantly different from one student to another.

Additionally, a good planning activity should be accompanied by a good monitoring activity of the learning paths. In fact, though a student is following a certain learning path, that path could eventually need to change, because of discrepancies between expected and real results, updates on the learning objectives, etc., and a re-planning of the path, in part or whole, may be necessary.

1.3. Related work

The need for systems that automatically build student-oriented learning paths by combining appropriate learning contents has become more and more intense in the last years (Baylari and Montazer, 2009; Chen, 2008; Garrido and Onaindia, 2013; Kontopoulos et al., 2008; Papanikolaoum et al., 2002). Generally speaking, literature abounds with works to exploit techniques on nearly all aspects of e-learning.

There are a variety of studies that face the problem of curriculum personalization in different ways, without focusing on a specific LMS. For example, Dorça et al. (2013) show three different strategies to automatically detect and exactly adjust students' learning styles, by taking into account students' performance. In another approach, Thyagharajan and Nayak (2007) suggest to address the automatic selection and integration of adequate learning materials for a student by using Web services based on student's features as initial knowledge, objectives, preferences, etc. More generally, Thyagharajan and Anbumani (2009) propose a model to help teachers build an interactive courseware, without being experts in multimedia programming and Web technologies, to get the adaptive presentation of multimedia elements through streaming to the students by considering their specific needs.

Laurillard et al. (2013) highlight that the use of digital technology in teaching is not always optimized and suggest the Learning Design Support Environment project as a way to enable the teachers to develop and test their learning ideas in terms of effective learning design. Chang and Ke (2013), Chang et al. (2010) and Tan et al. (2012) apply a genetic algorithm approach to customize and personalize course generation. The results of these works are promising but their application to standard LMSs can be difficult.

From a perspective based on the design, analysis and scoring of tests, the personalization of e-learning systems has been approached by using the item response theory (PEL-IRT) which, by considering the difficulty of the learning materials to be provided and the ability of the students, finds personalized learning paths (Chen et al., 2005). Another work based on the students' results of pre-tests, has led to a genetic-based customized e-learning system which conducts to a personalized curriculum sequencing (Chen, 2008). Also, a real-time assessment of students' productivity and interest in learning by using a Recommender System has been considered in Kaklauskas et al. (2013). Other authors combine a personalized multi-agent e-learning system based on item response theory with artificial neural networks and soft computing methods (Baylari and Montazer, 2009; Brusilovsky and Vassileva, 2003; Idris et al., 2009).

Like in our case, several works use AI methods in order to identify student-oriented learning contents. In particular, the prediction of the students' behavior to help in the decision-making teaching procedures in open and distance education has been considered by using Bayesian networks (Xenos, 2004). Such a work takes into consideration general students' behavior without focusing on specific learning contents. On the other hand, similarly to our idea, intelligent planning has been used for learning paths' personalization (Kontopoulos et al., 2008). That work focuses on creating a new planning ontology from the e-learning information and use standard planners to solve the problem. On the contrary, we do not create any new ontology, but we perform a knowledge engineering-based mapping from Module Object-Oriented Dynamic Learning Environment (Moodle) to standard Planning Domain Definition Language (PDDL) to make our compilation ready for any of the PDDL planners that are publicly available.

Moodle has been considered by previous works such as Romero et al. (2008), which used data mining techniques in order to improve the course management (i.e. statistics, clustering, classification, visualization, etc.), without focusing on a real-time planning activity. Additionally, some other papers such as Martín-Blas and Serrano-Fernández (2009) just focus on Moodle's characteristics and consider this platform as a valid tool in order to perform learning/teaching activities. That kind of work is oriented to a specific course but does not focus on the possibility of a learning path's planning activity in real-time.

In the line proposed by Garrido et al. (2013), there are tools that use IMS structures such as SCORM or Learning Design in order to get

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