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Personalized Web Learning: Merging Open Educational Resources into Adaptive Courses for Higher Education

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Abstract. In this paper, educational and technical challenges for applying learning pathways in Massive(ly) Open Online Courses in higher education are outlined. We argue that quality issues and didactical concerns may be overcome by (1) reverting to small Open Educational Resources that are (2) adaptively joined into concise courses by considering (3) predefined learning pathways with proper semantic annotations and (4) the observation of learner behaviour. Such a merger does not only require conceptual work and corresponding support tools, but also a new meta data format and an engine which interprets the semantic annotations as well as the measures of learner's actions. These factors are then turned into didactically meaningful recommendations for the next learning steps, thereby creating a personalized learning pathway for each learner. The EU FP7 project INTUITEL is introduced, which has already contributed to the conceptual work and is currently developing the software to achieve these tasks.

1 Introduction

Massive(ly) Open Online Courses (MOOCs) involving thousands of learners via internet are currently a major topic in technology enhanced learning (TEL). With this new approach, inquisitive learners from all over the world can participate in the lectures of proven experts. As formulated enthusiastically in the New York Times: *"...even in a remote developing country like Mongolia [...] you can find high-school students tuning into courses from American universities like M.I.T., Harvard and Berkeley"* [1]. If one follows the UNESCO [2], Open Educational Resources (OER) could even provide a solution to the world's educational problems.

Although there is a lot of praise, there is also a lot of critique. One aspect that is often discussed concerns the high dropouts rates MOOCs usually suffer from, which according to selected studies (e.g. [3–5]) amount up to 90%. However, this number has to be analyzed critically, as it is questionable whether this is an appropriate measure (cf. [6]). While 10% of thousands of students is still a large number, students also have varying motivations to enlist in a MOOC and some never actually planned to finish a course—and, to our knowledge, one contributing factor is the rigidity of MOOC learning. The relevant question thus is how to give those learners the best support, who actually planned but did not finish a course.

In this context, the different cultural and educational backgrounds of the students make the provision of knowledge in a one-size-fits-all manner questionable. Consider e.g. that *"Chinese classrooms tend to be more structured and authoritarian than classrooms in the West, [...] American schools try to encourage critical thinking skills and student interaction with teachers"* [7]. When applying these different cultural challenges to the creation of MOOCs, two fundamentally different courses will result. If different (culturally motivated) learning styles are integrated into the course directly, the students' time and effort to adjust is reduced, individual learners can be better supported and learning satisfaction is likely to increase. We believe that personalization of learning content is a very promising approach to achieve this. In this paper, we therefore investigate a technical solution given by the EU project INTUITEL[5] on how MOOC learning can be made more individual, human-centered and interactive.

Such a development also appears useful to overcome the problem of interaction between students and teaching staff in MOOCs, which is almost impossible for sheer numerical reasons: a higher learning satisfaction does lead to a lesser demand for personal interaction[6].

MOOCs also have the disadvantage that full-fledged courses with high quality content are expensive to produce, difficult to maintain and almost impossible to adapt to individual needs. Conversely, in the past few years, a large number of "small information pieces" have shown up on the internet, providing excellent free content covering almost any subject. We call these artifacts *Small Open Educational Resources (SOER)* (cf. [8, 9]). The second aspect of this work therefore elaborates on how SOER can be effectively orchestrated along predefined learning pathways in order to create a MOOC-like course.

2 Technical approach of INTUITEL

In the following, we assume that the learning content for a TEL course consists of a set of *knowledge objects* (KOs). They may be accessed separately and in different order according to some predefined sequence we call a *learning pathway* (LP). The desired personalization then consists of selecting an order of the knowledge objects based on considering all the aforementioned aspects for an individual learner - but in contrast to other approaches, INTUITEL avoids *enforcing* such an order. Even more, at any stage the learner is given full freedom to chose his preferred KO. We consider this freedom to be one of the main advantages of self-paced learning, not to be dropped in favour of a more or less "programmed" learning for reasons of efficiency and speed.

[5] INTUITEL = Intelligent Tutorial Interface for Technology Enhanced Learning, http://www.intuitel.eu, is funded in the 7th framework programme of the European Union (FP7-ICT-2011.8, Challenge 8.1) under grant no. 318496

[6] This experience has been gained by one of the authors (P.A.H.) in a long standing involvement in the Virtual University of Bavaria in Germany with more than 25.000 enrolled students in the fall of 2013, see http://www.vhb.org

The INTUITEL system then tries to give a non-intrusive guidance, much in the way a caring and responsible teacher would do on the basis of his deep pedagogical knowledge and respecting the fact that all learners are different [10]. This task is addressed for five different leading eLearning platforms (eXact LCMS[7], Clix[8], Crayons[9], ILIAS[10] and Moodle[11]).

While these are typical Learning Management Systems (LMSs) and not MOOC platforms, the underlying concept of personalizing the learning process is identical[12].

The INTUITEL system has been designed in a way that decouples the presentation of content from the provided service to act independently from the used "front-end". This allows it to evaluate the added value in a smaller context before applying it to large scale settings. Expanding the service to MOOC-style courses is then an issue of scalability and optimization rather than a conceptual one. In the following, we introduce the main components and give an overview of the proposed system.

Extension of the hosting platform: The enhanced learning software interacts with INTUITEL via a lightweight web service, which gives access to its data and user interface:

1. General services to, for instance, pre-load metadata for the enhancement of learning material.
2. User score extraction (USE) to acquire learner-specific data.
3. Tutorial guidance (TUG) to exchange information with the learner.
4. Learning object recommendation (LORE) to suggest the most suitable learning material.

The specification is open and can be applied to every type of LMS, furthermore the concrete implementations for ILIAS and Moodle are open source and usable as blueprints for other systems.

Hierarchy of ontologies: A set of static and dynamic ontologies build on one another to represent learner- and course-specific data as well as adaption strategies (cf. user, domain and teaching model [11]). The basis of this hierarchy, the pedagogical ontology (PO), is founded on Meder's web didactics [12] and insights gained from the L3 project [13]. It contains the vocabulary and relations necessary for enhancing learning content with didactical and technical metadata [14]. The Semantic Learning Object Model (SLOM) describes how learning material needs to be enhanced in order to be interpretable by the INTUITEL system. Software to comfortably edit metadata and learning pathways with a graphical user interface is currently in development. In the optimal scenario, teachers will only be required to interrelate content with LPs, while the remaining data is determined automatically. INTUITEL therefore also provides a rather

[7] cf. http://www.exact-learning.com/
[8] cf. http://www.im-c.de/en/
[9] cf. http://www.iosb.fraunhofer.de/servlet/is/4525/#
[10] cf. http://www.ilias.de/
[11] cf. http://moodle.com/
[12] We want to emphasize at this point, that a commercial partner of the INTUITEL project very successfully provides MOOCs to industrial customers and now actively integrates INTUITEL features in their commercial system.

complete tool suite for non-technical target groups, attempting to provide innovation as well.

Back-end: Apart from aggregating the required information, the INTUITEL back-end creates learning recommendations and feedback with a combination of modules using Java and OWL reasoners. For each learning step, the respective data is at first pre-processed in the Learning Progress Model (LPM), then analyzed in the INTUITEL Engine and post-processed in a block called Recommendation Rewriter.

Communication layer: To enable an efficient message exchange, the INTUITEL communication layer (CL) interconnects the previously described components and manages message distribution. Since all exchanged data is based on XML, the data transmission is relatively simple. Two types of messages transmission technologies are available, HTTP and XMPP. Nevertheless, questions of scalability need to be considered.

3 Creating Personalized Learning Recommendations

Within the INTUITEL project the learning process is analyzed by considering the learning pathway of a learner through a course and by gathering additional data. The system may draw these data from four different sources: (i) *the learning content*, i.e. what has to be learned? (ii) *the learner history*, i.e. what has already been learned? (iii) *the learning environment*, i.e. what are the temporal, spatial and physical parameters? (iv) *the learner*, i.e. what are the characteristics of this person?

In the context of INTUITEL, we extract from these sources so called *didactic factors* that are symbolic statements with each of them having a distinct meaning for the learning process. They are defined statically, but calculated for each learner individually. By combining them with the learning pathway information, it is possible to deduce that a certain knowledge object is better suited for the learner than another one. Moreover, it also is possible to state *why* this is the case (e.g. because it is age-appropriate, has a suitable difficulty level, etc). This enables self-reflection of the learners and thus increases their metacognitive skills.

This personalized recommendation and feedback creation process is started at the moment when a learner begins a new learning step. The relevant situational and learner-specific data is requested from the learning platform and also the domain and content information is retrieved from the corresponding SLOM repository. With this and the previously stored data (e.g. past recommendations and beforehand requested information), the most suitable learning pathways and the didactic factors are determined in a first pre-processing step.

INTUITEL takes two approaches for finding optimal learning pathways for a learner, an interactive and a technological one. Firstly, it may carry out an interactive dialogue with each learner. For this case, teachers can add notes and describe for whom a particular pathway is most suitable. This makes it possible for learners to make an informed choice, but one has to keep in mind that self-assessments are commonly qualitatively limited [15]. INTUITEL therefore also implements a data-driven approach that allows evaluating choices algorithmically [16, 17]. With this method, the system can automatically come to conclusions whether the current selection is optimal, or if the learner's behavior indicates that another learning pathway would be more suitable.

The basic definitions of the didactic factors and their value ranges are present as a separate ontology, which is interpreted by the LPM. This allows it to incorporate various soft aspects into eLearning, like e.g. motivation or other emotions [18].

All these data are then forwarded to the INTUITEL Engine. This component is a combination of a set of Java modules and standard OWL-reasoners (like e.g. FaCT++ or HermiT). Its task is to analyze the provided ontologies in order to identify the most suitable knowledge objects with regard to the most suitable learning pathways and the current situation as expressed by the didactic factors. It therefore generates semantic queries and starts the most efficient reasoners for the specific query. INTUITEL thereby builds on the results and insights of the THESEUS project [19] and in particular the HERAKLES Reasoning Broker [20]. Not only does this allow to exchange the reasoner, but the scalability of the reasoning process necessary for a large number of participants is also provided. The output of this procedure is then interpreted in a post-processing step in order to create the final learning recommendations and also generates natural language messages for the learner, if appropriate.

This multi-layered procedure allows a high level of personalization, which is based on sound didactical models. The learning progress of each learner is evaluated gradually in respect to multiple aspects. This not only allows to select the most suitable learning pathway for each student, but also to determine which of the routes on these pathways fits the individual cultural and educational needs of the learner. In this process the didactic factors can furthermore be used to guide learners in regard to fine-granular aspects and thus consider the given individual boundary conditions.

Let us note, that while this recommendation process of course follows the well-known reference model for Adaptive Learning Environments [11], it is rather different from existing implementations of this model by keeping the learner's freedom of choice in every moment and therefore acting as a non-intrusive guide.

4 Personalized Web Learning

Apart from providing a manageable adaptive system, the INTUITEL approach also allows to overcome the second deficiency of MOOCs pointed out in the introduction. This may be attributed to the fact that learning material is extended with SLOM data externally, i.e. the content remains as is. Introducing additional elements in the material is not necessary. Course authors are thus not restricted in their choices of what learning material they provide and in which style they do it. They just need to add further information to it in a subsequently following step—and in principle this material can reside anywhere on the internet. An effectively personalized course, consisting only of the content relevant for a certain learner, but nevertheless following a well-defined didactical model, will be the result.

This approach preserves the high level of freedom for course creation currently demanded by authors, but allows the reuse of their content in a novel way. Given that this is extended to a (possibly decentralized P2P-) network of SLOM repositories, renowned authors from all over the world can link their Small OER via URIs and provide their learners with a huge knowledge space. It is conceivable that such a knowledge space can attract as much learners as one of the current MOOCs—but more flexibly so and with an almost unlimited individuality. We leave it open whether one should call this a "MOOC" then.

A course designer—or many of them—can contribute to this knowledge space not only by adding new learning content. They can also contribute a new Cognitive Content Map (CCM), which defines new learning pathways through this knowledge space. Cultural adaptation is only one of the possibilities such opened. Another possibility is to keep such a course up to date: one may add the actuality of a knowledge object to the set of didactical factors and then automatically receive recommendations to use more recent learning content with higher priority. At the same time, this creates an innovative learning pathway: adding new learning content while keeping the old one also allows learning about the history of a knowledge domain. Last but not least, we mention two further options: (i) creating an international federation of eLearning content providers and (ii) finding similar learning material via its SLOM properties.

5 Summary

In this paper, we outlined a way to make MOOCs more suitable for a greater variability of learning needs, by semantically annotating their parts and running them in a semantically enhanced learning platform. Such a platform is not necessarily a LMS, but could also be a future version of current MOOC platforms. As pointed out above, the INTUITEL project generalizes this semantic approach to be independent of the technical details of the front end, and is currently also integrated into a successful MOOC platform.

INTUITEL therefore contributes to key aspects of MOOCs, e.g. how to create online courses in a didactically meaningful way, how to add semantic interoperability and how learning platforms can assist in that. Such a semantic reconstruction of current MOOCs will, in our estimate, contribute to resolve their current problems.

We furthermore outlined how complex large courses may be constructed from Small OER, thereby resolving the problems maintainability and adaptability of current MOOCs. The INTUITEL system here serves as the "glue" integrating various learning content into a greater knowledge space.

Let us furthermore emphasize again that our approach, while of course implementing the well-known reference model for Adaptive Learning Environments [11], does so in a fashion which is rather different from previous implementations [16, 17]. Preserving the freedom of choice for each learner is targeted to remove the observed rigidity in present MOOC learning.

By providing the information on the learning process in a suitable format, and by delivering the necessary interfaces, INTUITEL also opens the doors for implementing other technologies like learning analytics and data mining directly into the learning platforms[13]. With the insights that can be gained from a data driven perspective, this could result in new didactical approaches and thus enhance education in general.

[13] cf. APPLYTEL project proposal by the INTUITEL consortium

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