e-Teaching Assistant
A Social Intelligent Platform Supporting Teachers in the Collaborative Creation of Courses

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Abstract: With the ambition of providing teachers with a concrete tool for worldwide exploiting didactic contents to feature their courses, we face the problem of creating a social platform with adequate functionalities to satisfy the teacher expectations. Starting with a well designed architecture we endow it with three key functionalities that become the stakeholders of the emerging social network: 1) a quality system ensuring the value of the materials the users put in the platform repository as their contribution to the social business, 2) a recommender system based on computational intelligence techniques constituting the principal tool to guide teachers along the assembling of materials into courses, and 3) a gamification system, root of the no-profit business plan of the platform, to involve teachers in the social network. As a result we delineate an ecosystem where teachers exploit contents of a repository to which contribute by themselves. They are encouraged in exploiting and contributing because the contents are of high quality; they are wisely assisted in the exploration of the repository by platform services yet under their full control; and they are variously reworded by this involvement.

1 INTRODUCTION

In the last few years we have observed the proliferation of platforms (like Merlot, Connexions, OpenLearn, ARIADNE, MACE, Share.TEC) that make available to teachers didactic materials that can be used for teaching. Moreover, multimedia representation models like Learning Object – LO (Wiley, 2000), Open Educational Resources – OER (Atkins et al., 2007), and SCORM (ADL - Advances Distributed Learning, 2004), have been proposed for enhancing the interoperability of platforms in representing and exchanging didactic resources. By means of these platforms/models and also the materials made available on the Web by Schools and Universities, a huge amount of didactic materials is available that could be adopted (or acquired when subjected to fees) for the preparation of single lessons or entire courses. In this overwhelming of information, however, it is not easy to discover the right materials that meet the preparation and expectation of the class students. Moreover, the quality of the resources is not always the same, the level of detail of the treated topics ranges differently from elementary to very detailed and advanced presentations, and the requirements for effectively attending to the materials are not always clear. Therefore, teachers wishing to reuse already developed materials spend hours in the retrieval of adequate lectures, exercises and projects for their classes, succeeding only seldomly in finding the right ones.

In this paper we wish to detail the characteristics of a tool, named *e-Teaching Assistant*, specifically tailored for helping and supporting teachers in the process of preparation and sharing of didactic resources (either single materials or entire courses). This tool is designed by considering teachers as "demanding-users", namely individuals that, accustomed to produce educational materials and having clear ideas on the topics to be taught according to the level of preparation of the class to which they are intended, do not expect to receive "pre-defined" instructions on how to create and organize their courses; rather, they demand to both interact with the system and discuss and collaborate with domain experts. A key characteristic of e-Teaching Assistant is that users can formally or informally collaborate for the realization of courses by means of a social network (SN) specifically tailored for this context. Moreover, intelligent services, denoted as "meta-services", are devised for our demanding users, supporting them in the preparation, retrieval and exchange of materials. Among them, we point out: the reviewing service for improving the quality

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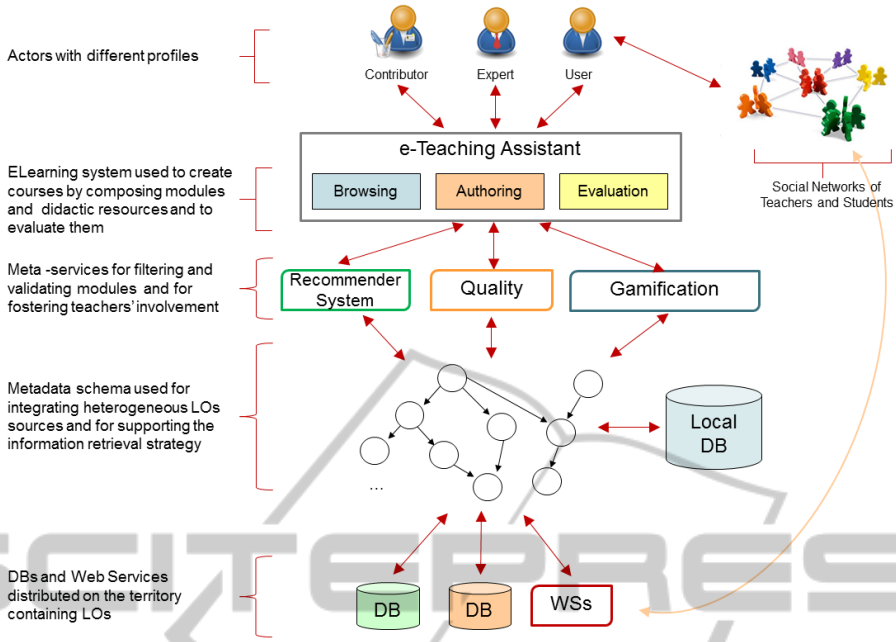

Figure 1: e-Teaching Assistant Architecture.

of the published materials by taking into account the characteristics of the students to which they are devoted (language, age, student backgrounds, and objectives); the recommendation service for the identification of suitable materials; composition services to generate new courses by reusing materials developed by other colleagues, still keeping the provenance of the materials; gamification services for encouraging teachers in proactively participating to the platform.

This paper presents our thoughts on how these meta-services should be integrated to forecast a social intelligent learning management system for demanding users. We start with an overview of the whole architecture, giving prominence to the enhancements w.r.t. state-of-the-art e-learning platforms. Then, we highlight the features of the proposed recommendation and gamification systems, in order to face the distinctive peculiarity of the afforded task.

We are currently experimenting this new paradigm in the framework of the NETT European project (nett-project.eu), where these services aim to help teachers to improve the provision of courses for improving the entrepreneurship (Valtolina et al., 2014). This discipline is crucial in the education of young generations, yet not well assessed as a corpus of basic lessons and those orienting the learner to a given specialization. We face this immaturity by a cognitive recommendation system, as for advanced service, and a gamification system, as for gathering community members and their evaluations at the basis of the former. In this short note we will discuss these tools from a methodological perspective, having our experience in NETT as a workbench.

2 ARCHITECTURE AND QUALITY OF THE MATERIALS

In recent years many e-learning platforms have been devised, like Merlot, Connexions, OpenLearn, ARIADNE, MACE and Share.TEC, mainly focused on handling single resources (like powerpoint presentations, pdf files, exercises and so on). In Merlot and Share.TEC the architecture relies on the definition of ontological structures to support the sharing of digital content. In particular, Share.TEC proposes an ontology called TEO (Teacher Education Ontology) (Ivino et al., 2009) to provide a powerful tool for cataloging and classifying materials capable to provide personalized access to didactic resources, based on the actual users needs, their cultural context, and their professional profile. Even though these systems provide some SN capabilities, they are quite limited and not well integrated in the entire process of production and use of the developed resources.

The architecture to be devised for e-Teaching Assistant should meet the following requirements:

- Didactic materials should be handled at different levels of aggregation, ranging from single resources to modules and courses, where a module is an aggregation of single resources and a course

is an aggregation of modules. In this way, teachers can have a more complete overview of how the course and other ancillary materials (like articles, exercises, discussion) associated to a module or an entire course are organized by other colleagues.

- Each course, module or single resource is associated with a set of metadata that describes the didactic materials and give meaning to them. By starting from the standard LOM (IEEE, 2006) we consider a small subset that aptly conform to the context under consideration. Note that: the metadata for modules (and in turn those for courses) can be automatically extracted from the annexed resources; and, multiple values can be specified for the same property (e.g. the language of the module is the union of those used in its contents).
- Exploiting the result of the Merlot and Share.TEC projects, we extend and integrate our metadata structure using the OAI-PMH protocol for the selective gathering of metadata describing learning objects[1]. Through this protocol, our metadata structure is extended in an ontology able to allow personalized access to the educational materials and to offer an effective strategy for integrating different didactic content sources.
- The didactic materials are not forced to be stored within e-Teaching Assistant. Materials can be present in other platforms or made available through web services. However, their metadata are locally stored and exploited by the metaservices. External materials might also be subjected to the payment of royalties to their authors or to the platforms where they are stored.
- A SN should be deeply integrated in the system in order to offer social metaservices for the creation of communities around the topics covered by e-Teaching Assistant and the support of peers in all the phases of the creation, revision, audit and publication of didactic materials as well. The actors of the SN are classified in Visitors, Contributors, Masters (leaders in given topics), and Experts (contributors with large experiences). These roles will dynamically change, according to the level of participation to the network.
- Levels of reputations of the SN members, levels of appreciations of the developed materials, provenance of the developed materials, and their reuse will be associated to the actors and materials handled by the system, maintained up-to-date and exploited by the available metaservices as well.

[1]OAI-PMH is the Open Archives Initiative Protocol for Metadata Harvesting (http://www.openarchives.org/pmh/) whose aim is to create an independent interoperability framework based on metadata harvesting.

At any level of the education system, an e-learning platform needs to face issues concerning the quality of didactic materials offered to students. In Merlot a reviewing system similar to the one adopted in the context of publication of journal papers is used. Moreover, all the cited platforms support the grading of the materials using different scaling (either from 0 to 5 or from 0 to 10): an information that is only used for ranking the materials when they are retrieved.

In e-Teaching Assistant we will adopt the aforementioned solutions to guarantee the quality of the developed materials, enhancing them by:

- integrating the reviewing activities with comments and ideas coming from the SN. The SN should thus become a mean for exchanging ideas, comments and solutions for better facing the learning issues of students. Both formal and informal communications will be granted to teachers belonging to the same community;
- linking the quality of the developed materials with the respectability of the teachers producing them. In this way, teachers are encouraged to produce high quality materials to improve their respectability in the community. The use of levels of respectability has also the advantage of identifying masters of given topics and experts that can help the former in the reviewing processes.

3 COMPOSITION OF COURSES

The core business of e-Teaching Assistant is the composition of new courses. To this aim teachers are guided to both organize courses as a wise sequence of modules and to fill up modules with resources that comply with their didactic goals and cultural preferences. Thus, besides the traditional tools for retrieving didactic materials based on keywords and metadata matchings, the intelligence of e-Teaching Assistant is represented by a computationally intelligent recommendation system based on both metadata and user consensuses variously collected through the common social tools of the SN.

Actually, Recommendation System (RS) is a relevant component of every modern SN in most disparate fields, ranging from movies, music, books, to financial services. Usually implemented as a web application, it constitutes a class of algorithms aimed at predicting user responses to options, by generating meaningful recommendations to a collection of users for items that might interest them.

In e-Teaching Assistant, RS will focus primarily on the exploitation of didactic materials available in already developed platforms that take into account the characteristics of both teachers and students in terms of backgrounds, competences, language, and level of instruction. Moreover, in order to recommend materials with high quality, it will exploit social aspects such as the interaction between teachers and students, their reputation, and the respectability they have gained in the network. Such social context well embraces the proliferation of open educational resources (OERs) released under Creative Commons licenses, and the variability of the characteristics of the community of users involved in the educational process as well. On the one hand the heterogeneity of the on-line material, developed in different languages and with different quality for a variety of target students in different contexts of learning, complicates the realization of useful RSs. On the other hand, teachers are rarely satisfied by predefined and non-flexible recommendations when they exploit materials developed by other colleagues. Moreover, students having different background, culture and level of instruction need specific recommendations to support the discovery of suitable materials according to their aims, interests, and didactic needs. Finally, both teachers and students are tightly connected by means of SNs through which they can chat, exchange materials, and give evaluations on the resources available in a recommendation. Traditionally, RS are classified as:

- *Collaborative Filtering (CF) Systems*, where predictions about the interests of a user are inferred on the basis of people having similar interests and preferences. They are based on k-nearest neighbor (kNN) methods (Breese et al., 1998) as for Neighborhood-based approach and parametric estimation techniques as for Model-based approach (Bell et al., 2009).
- *Content-Based (CB) Systems*, where recommendations rely on the user's preference and the items' descriptions. They are based on query and relevance/similarity scores as for IR approaches (Mooney and Roy, 2000), and on classifiers of ⟨content, user-rating⟩ pairs, such as Naive Bayes (Pazzani and Billsus, 1997) and kNN classifiers, decision trees, and neural networks (Melville et al., 2002) as for Classifier.
- *Hybrid Recommendation Systems*, combining the above approaches in order to mitigate the associated limitations, for instance via boosting techniques (Schein et al., 2002) or generative models (Kim and Ahn, 2012).

Recent studies have attempted to use techniques for studying social relationships in terms of network theory, the Social Network Analysis (SNA), in combination with RSs. In (Brusilovsky, 1996) the authors got encouraging results by assigning weights to the content-based attributes used for recommendations as a function of their importance for users. In the e-learning context, several RSs have been developed to propose courses, materials, and relevant topics in forums (Brusilovsky, 2012). Although increasingly popular, so far only few studies such as (Frias-Martinez et al., 2006; Mulwa et al., 2010) have been addressed to suggest collaborative learning resources.

These methods are not sufficient to make satisfactory suggestions, mainly for the following reasons:

1. The inability to treat the uncertainty of both the ratings/suggestions and the resource description proposed by the SN members. In fact, judgments collected from a plethora of users with different habits and cultures may produce contradictions which in turn result in data having a high degree of ambiguity. This calls for a granular interpretation of the information provided by such crisp attributes, for instance in terms of fuzzy sets, rough and interval sets, and so on (Apolloni et al., 2008).
2. The lack of interpretability of the recommendation model and, as a consequence, of the recommendation policy.
3. The lack of user interaction. With the advancement of computational techniques, we have the unprecedented ability to allow machines to assist users in completing their tasks. Thus, fully automatic suggestions may not be entirely appreciated by the active user, which risks to get frustrated in using the RS platform whenever its recommendations prove to be erroneous.
4. The inability of current RSs to highlight the social relationships between users. This is especially important within a SN where each user will certainly appreciate receiving recommendations from those considered "closest" to her (classmates, teachers, etc.) (Shinha and Swearingen, 2001).

We expect e-Teaching Assistant to overcome these limitations by embedding computational intelligence into a hybrid system through the following features:

i) a Rule-Based System (RBS), to provide the user with an interpretable recommendation policy. We focus on a special instance of a decision tree algorithm, exploiting the one-to-one correspondence between decision trees and RBSs.

ii) Granular Computing techniques (Apolloni et al., 2008), which are essential to handle non crisp judgments. By fuzzifying the sets constituting an-

tecedents and consequents of the RBS, we will introduce a fuzzy reasoning based on fuzzy entropic criteria and expressed in terms of fuzzy decision trees. To avoid injecting inconsistencies in the final rule set, the tree construction will be compliant with the multivalued attributes characterizing modules and contents of our repository.

iii) Interactive Machine Learning techniques, to allow the user to interactively participate in the development of the final recommendation. The development of a RS guided by the user intervention translates in dynamic modifications, backtracking included, of the rule set on the basis of the user input. In turn, the system will provide the most valuable suggestions satisfying the (explicit and implicit) constraints introduced by the user, such as presence of introductory courses, constraint on the course duration, and so on.

iv) Social Network Analysis (SNA), to capture social relationships among users. We will work on *ad hoc* clustering techniques for finding groups within the SN members. In this way, we will replace the concept of proximity of the typical CF algorithm with the corresponding SNA one, introducing weights on the preferences of the users, so that well-reputed members of the SN will have a higher influence in the whole process.

4 TEACHERS' INVOLVEMENT STRATEGIES

The SN life is made up of social activities, by definition. This implies that a SN may survive the initial enthusiastic period where the network is designed and its mockup is implemented only if the platform is populated by a community of users who have concrete motivations for interacting and sharing knowledge. Having decided for an open platform that is not rooted on a profit business model, we identified gamification as a relevant tool for fostering the user interest. Gamification indeed is a familiar context in the teaching framework for two reasons:

1. Students are in a continuous competition as a natural status of their job. It is a competition which is primarily toward themselves: they try improving themselves everyday, hence compete and overwhelm their own abilities. Actually several types of games are used in classroom activities (eLearn Magazine Staff and Contributors, 2011; Muntean, 2011; Raymer, 2011) based on typical game elements like time, accuracy, point systems integrated into training programs.
2. Teachers are in continuous competition (Nah et al., 2013) toward three frontlines: 1) themselves as former students, 2) students, to whom they can never yield, and 3) colleagues for both immaterial (pride) and material (carrier) reasons.

We plan leveraging on this competition for engaging teachers in creating and sharing materials. This type of metaservice is designed as an incentive system based on a set of rules that encourage teachers to explore and learn the properties of their possibility space. We adapt the common strategies (Deterding et al., 2011) to the above competition line in terms of:

- Frontline n°1
  1. *A layering mechanism* which allows teachers to learn new skills incrementally, and then practice those skills before demonstrating their mastery in creating new materials. Hence they are incrementally challenged to featuring contents, modules and finally entire courses.
  2. *A character upgrade scenario* which provides feedback to teachers for warning about how much progress they have made in creating a course. They gather virtual goods and assets to change the character in the way they like.
- Frontline n°2
  1. *Private or closed community groups*, which provide their agreement on the material produced by teachers according to their acquired competencies and rules. In fact, the overwhelming success and influence of social media in modern society corroborates the power of other people's opinion.
  2. *Objective indexes* such as number of downloads of the single contents by students, cumulated scores expressed by them, etc, which are a direct way of acknowledging the teachers work.
- Frontline n°3
  1. *Keeping the authorship* of the developed materials and the acknowledgment of the work done, that is very relevant for teachers. A contributor can integrate a module developed by another teacher and decide to keep it "as is" or to modify it (by adding or removing content). The system keeps track of the fact that the module is duplicated from an existing one, and the compliance (or not) with the original form. This feature is useful for maintaining the provenance of the material and to ensure the author' royalties and for incrementing his/her reputation.
  2. *Making teachers talking to one another*, which gives them common goals and rewards, especially if that reward is predicated on group par-

ticipation. Teacher's peers see when they collect these rewards. These extrinsic rewards are much more effective if people can use them for bragging rights, rather than just having some extra trophy graphic that nobody else will see.

A final remark on the game design concerns the whole presentation of the metaservices. The design, the look and feel, the interaction style and the communication process of the e-learning environment need a specific care and an incremental production of mock-ups anytime that new users requirements appear. Moreover, it is import to test our prototype as early as possible. One of the most repeated mistake is to make assumptions about how the target audience will use the product. The only way the designers can understand it is to put the system in front of them, watch them use it, and to document the experience in order to pay attention to how long it takes to make the correct input, and to watch through teachers' eyes for seeing where they look first on the screen mockups.

5 CONCLUDING REMARKS

The main goal of the *e-Teaching Assistant* is to offer a new opportunity for supporting teachers by exploiting the contributions of a SN able to enhance and enrich didactic contents proposed by their members. To this aim, the paper proposes a social oriented solution based on three metaservices for exchanging high quality didactic materials, retrieving content through a computationally intelligent recommendation service and stimulating the teachers involvement through gamification strategies. Other metaservices are under design for offering a semi-automatic combination of modules according to the requirements and skills characterizing them and by fitting the teachers' expectation according to their profile and background.

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