Supporting Students to Find Relevant Learning Resources through Social Bookmarking and Recommendations

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***Abstract*— The abundance of educational resources available on the Web leads to information overload for the students and the difficulty in finding useful and relevant resources for a specific learning context. The solution that we propose in this paper is a platform called Edu3R (Educational Resources Retrieval and Recommendation), which relies on community filtering: students enrolled in the same course can perform collaborative search through various learning object repositories, bookmark the resources of interest, rate them and share them with peers. The rationale is that resources found and selected by peers are likely to be relevant since the learning community is centered around the same course and the same learning tasks and is relatively homogeneous (classmates generally having common learning backgrounds and completing the same curriculum). Edu3R also relies on social tagging, through which learners annotate resources with meaningful terms that reflect the educational context, provide a personalized classification and facilitate subsequent retrieval. Finally, Edu3R also integrates a collaborative filtering mechanism for recommending learning resources based on student similarity. The paper provides an overview of the system architecture, functionalities and pedagogical rationale, as well as a comparison with similar platforms.**

Keywords—learning objects, educational resource retrieval, social bookmarking, social tagging, collaborative filtering

I. INTRODUCTION

The amount of educational resources available on the Web is vast and continuously increasing, making it difficult for learners to use them effectively [7]. There has also been a proliferation of systems that store such resources [19], which are referred to as learning object repositories (LORs). A learning object (LO) is a "common format for developing and sharing educational content" [18], being defined as "any type of digital resource that can be reused to support learning" [20]. LOs can include "video and audio lectures (podcasts), references and readings, workbooks and textbooks, multimedia animations, simulations, experiments and demonstrations, as well as teachers' guides and lesson plans" [16]. LORs facilitate the sharing, search and reuse of these educational resources, together with their associated metadata (i.e., descriptors which characterize an LO from a technical and pedagogical view). Examples of such LORs, from different subject domains and educational sectors, include: ARIADNE, LRE, COSMOS, AMSER (large LORs, with hundreds of thousands of LOs), MERLOT, OER Commons, Connexions (medium LORs, with tens of thousands of LOs), Open Science Resources, ATLAS@CERN (small LORs, with thousands of LOs) [18].

With this abundance of LOs, the discovery and recall of useful, relevant and reliable resources for a specific learner and a specific learning context become a very complex issue [7], [9]. Community filtering could be a solution to this problem, by encouraging learners who take the same course to do some form of collaborative search, share their search results and bookmark the resources of interest for further use.

In this context, we propose a platform called Edu3R (**Edu**cational **R**esources **R**etrieval and **R**ecommendation), aimed to help students from a specific learning community (e.g, a class, a group of students enrolled in the same course) to find relevant and useful resources for their learning. With Edu3R, students can automatically search through many different LORs simultaneously, bookmark the resources of interest, share them with peers, as well as rate and tag them. Subsequently, students have the possibility to search also through the locally saved bookmarks, i.e., those resources which have been previously found by classmates and passed their quality filter. This local search is of course faster than the search through all external repositories and its results can be more relevant to the student, since they reflect the preference of his peers. This is due to the fact that the learning community is relatively homogeneous (classmates generally having similar learning backgrounds and completing the same curriculum) and is centered around the same course and the same learning tasks.

For example, the usefulness of one LO on the topic of Web programming will be evaluated quite differently by a highschool student looking for an introductory tutorial on HTML and a master student looking for an advanced Web services tutorial. At the same time, a self-taught learner will generally need a detailed, step by step tutorial, while a student who simply searches for some clarifications to a previously attended lab session will likely expect a brief and more targeted content. Furthermore, students attending similar courses taught by different instructors or following different textbooks will need different additional resources to complement the instructors' lectures. While in large LORs the LO ratings (if present) are averaged from a very heterogeneous student population, in Edu3R resources are assessed and filtered by a small but more homogenous learning community. This is in line with the local voting approach proposed in [5], "since local

votes represent the opinion of fellow coursemates, and hence are likely made from a course perspective".

Edu3R also relies on social tagging, i.e., collaborative annotation of the resources with student-defined keywords. Tags help label and categorize resources, facilitating collaborative indexation and improved access [12]. According to [8] and [10], social tagging can stimulate cognitive and social learning processes and can be used as "a support for enhancing the learning experience and fostering the group dynamics in collaborative activities" [12]. Students can add tags which are meaningful and relevant to the learning community, reflecting the specific educational context [9].

Finally, Edu3R also includes a recommender system component, aimed at suggesting resources of interest to the students, based on the similarity between learners (i.e., collaborative filtering approach). This is motivated not only by the popularity of recommender systems in e-commerce settings [1], but also by their successful transfer into educational contexts [14]. So far, various recommendation algorithms have been tested on LOs collected from different LORs (MERLOT [3], CELEBRATE [13]), leading to accurate and useful results.

The rest of the paper is structured as follows: the next section provides an overview of related works, outlining the novelty features of our system. Section 3 describes the functionalities of Edu3R and their underlying pedagogical rationale; some details regarding the system design, architecture and implementation are subsequently presented. The paper ends with some conclusions and future research directions.

II. Related Work

Edu3R is at the intersection between LO search and sharing, social bookmarking, social tagging, educational recommender systems and personal learning environments. Hence, the related approaches come from different categories of systems.

A somewhat similar approach was proposed in [5]. The authors devised a system used for language learning, in which links of potential interest are retrieved from social bookmarking sites (currently Digg and xMarks). Teachers associate keywords to each learning activity and the system automatically searches through the social bookmarking services for those keywords, every time a learner accesses the learning activity; a filtered list of 10-15 links is shown to the learner. Students can vote for each of the retrieved links (through like / dislike icons) and these votes are subsequently used to filter the results (i.e., links with negative peer evaluations are no longer shown to the learners). There are several differences between this system and Edu3R: i) the search takes place in social bookmarking sites rather than in educational resource repositories; ii) the search is done based on predefined keywords specified by the teacher, rather than on students' defined keywords; iii) the system is specifically conceived for the language learning scenario, rather than for a more generic approach; iv) it does not offer students the possibility to add new bookmarks (found by the student through external searches), add new tags, save or share links of interest; v) there is no recommendation process taking place, just a filtering of the bookmarks based on popularity (number of like / dislike votes received).

Another related system is ASK-LOST 2.0, a social tagging tool for educational resources [9]. The main functionalities provided by ASK-LOST 2.0 are: i) submit and tag learning objects (beyond predefined metadata schema); ii) browse educational resources via tag clouds created by all the users; iii) create a personal collection of educational resources, including resources uploaded by any user and corresponding tags; iv) search, rate and comment educational resources; v) social networking support: the user can add other users to her watchlist and receive updates through RSS feeds of all the tags and educational resources created by them. In contrast to Edu3R, the focus in ASK-LOST 2.0 is mainly on the tags and there is no recommendation process involved. Furthermore, the educational resources in ASK-LOST 2.0 are submitted by the students, instead of being found automatically by the system, by searching through various LORs (as is the case with Edu3R).

A system which does include recommendations is ReMashed [6], which retrieves resources from Web 2.0 services (Flickr, Delicious, Blogs and Slideshare). Students can rate this content, and based on these ratings the system applies collaborative filtering techniques for generating recommendations (just like in Edu3R). The main difference between ReMashed and Edu3R consists in the content source (students' personal accounts on Web 2.0 services vs. LORs), but also in the fact that there is no search capability included in ReMashed and no personal resource collections of the students (i.e., no saved bookmarks).

Edu3R also bears some similarity with Personal Learning Environments, such as PLEM [4] or LearnWeb2.0 [15]. PLEM is a "Web 2.0 driven service for personal learning management that acts as a Long Tail aggregator and filter for learning" [4]. Its aim is to help students find niche learning resources of good quality. It provides a federated search engine, which retrieves resources from different services, including both open courseware (such as MIT OCW, OpenER) and Web 2.0 tools (such as Blogger, Technorati, YouTube, Flickr, Slideshare etc.). Students can create personalized learning resource collections, in which they can aggregate, tag, rate and share these resources. Furthermore, the resources are filtered according to their popularity, as reflected in the number of comments, links, saves, likes, ratings, votes, views, shares, trackbacks etc. (that they received both within PLEM and in the external services). By contrast, Edu3R takes into account only the ratings given by peers in the system and then computes recommendations based on learner similarity; this can be considered a more targeted filtering, relying on more relevant preferences, coming from more relevant peers.

In a similar vein, LearnWeb2.0 [15] offers students the possibility to search resources through various Web 2.0 services (such as YouTube, SlideShare, Blogger, Delicious, Flickr etc.). Once retrieved and stored in the internal repository, resources can be bookmarked, tagged, rated, commented, shared, aggregated and organized in folders. Furthermore, the research queries can be shared with peers and notifications can be received for new resources matching a

query (i.e., by subscribing to a query RSS). Moreover, learners can create groups of interest, in which they could gather resources belonging to the same subject. Thus LearnWeb2.0 has a higher focus on collaborative learning, social searching and sensemaking [17], while Edu3R includes also a collaborative filtering recommendation of the learning resources. Furthermore, LearnWeb2.0 retrieves resources from generic Web 2.0 services, not specifically from LORs as in case of Edu3R.

III. Edu3R Prototype

A. Functionalities and Pedagogical Rationale

Edu3R is an educational support system, conceived to help students find quality learning resources and share them with peers; an initial version of this platform was described in [2]. As mentioned in the introduction, the proliferation of educational resource repositories and the abundance of available learning objects make it difficult for students to choose the most appropriate content for their specific learning needs. We therefore aim to provide a personalized filtering and recommendation of the educational resources, based on the learning context. This is done by creating a learning community at course (class) level, in which students can search for LOs from different repositories, bookmark the LOs of interest, rate them and share them with peers. The rationale is that resources selected by coursemates are likely more relevant, since they reflect the current course context, with the specific tasks and teaching approach. Furthermore, the community is somewhat homogeneous, since classmates generally have similar learning backgrounds, with common curriculum and learning experiences.

One of the main functionalities provided by Edu3R is the retrieval of educational content from various repositories. The student can specify the keywords of his choice and the system automatically searches through all the available repositories (such as: Ariadne, comPADRE, Connexions, LORNET, Merlot, OCW, OER etc.). The list of results includes the highest rated LOs in each repository; the students can visualize their title, short description and original URL. Fig. 1 illustrates such a search result for the query "Java". After analyzing the content, students can decide to "Recommend" the LO, i.e., save its URL to the local database, together with some additional information (title, description, tags, keywords used for searching it). Subsequently, students can choose to "Bookmark" the LO, i.e., save the LO to their personal collection of educational resources; Fig. 2 shows an excerpt from such a personal bookmark collection. By recommending an LO, students effectively choose to share it with their peers, since it will become available to the whole Edu3R learning community. At the same time, students can also choose to share the resources from their own collection through their personal social networks (by using the dedicated Twitter, Google+ and Facebook buttons).

Another important functionality offered to the students is to search through the local database, i.e., through the educational resources already found and bookmarked by their peers (as shown in Fig. 3). This bookmarking action is a first quality filter, since students only save resources that they consider interesting and useful for their learning. Thus students can take advantage of peers' searches and their assessment of the educational resources, harnessing "the wisdom of the community".

Furthermore, students can also add other LOs to the system, beside those automatically retrieved from the LORs; thus, if students find any external resource of interest, they can share it with peers and bookmark it to their personal collection for further use (without being limited by the integrated LORs). Fig. 4 illustrates this process, in which students have to specify the URL, title and short description of the resource to be added to Edu3R local database.

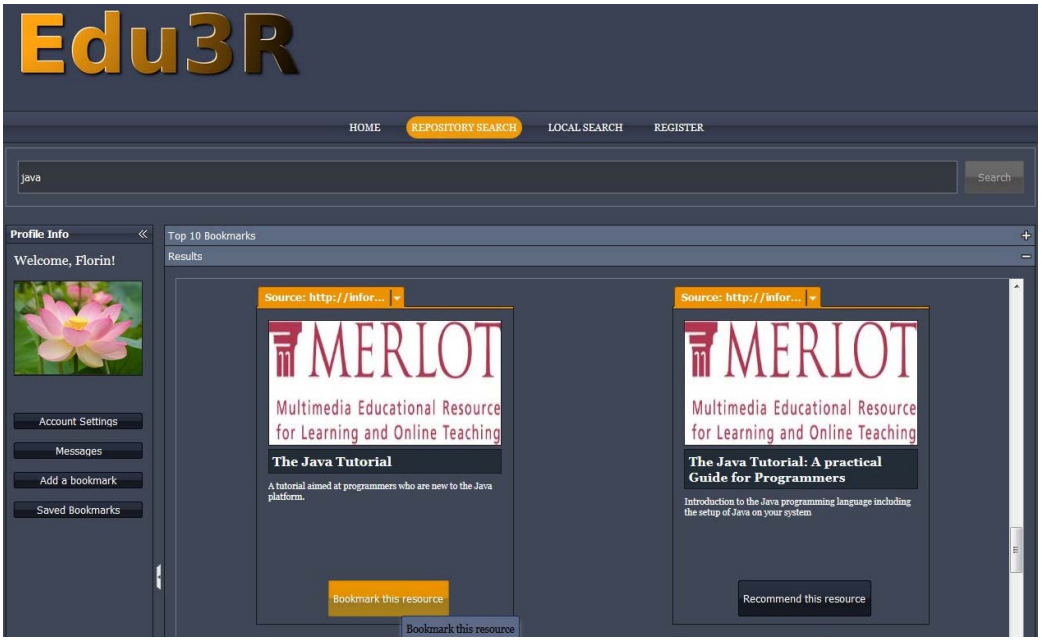

Fig. 1. Edu3R – Repository search results for the query "Java"

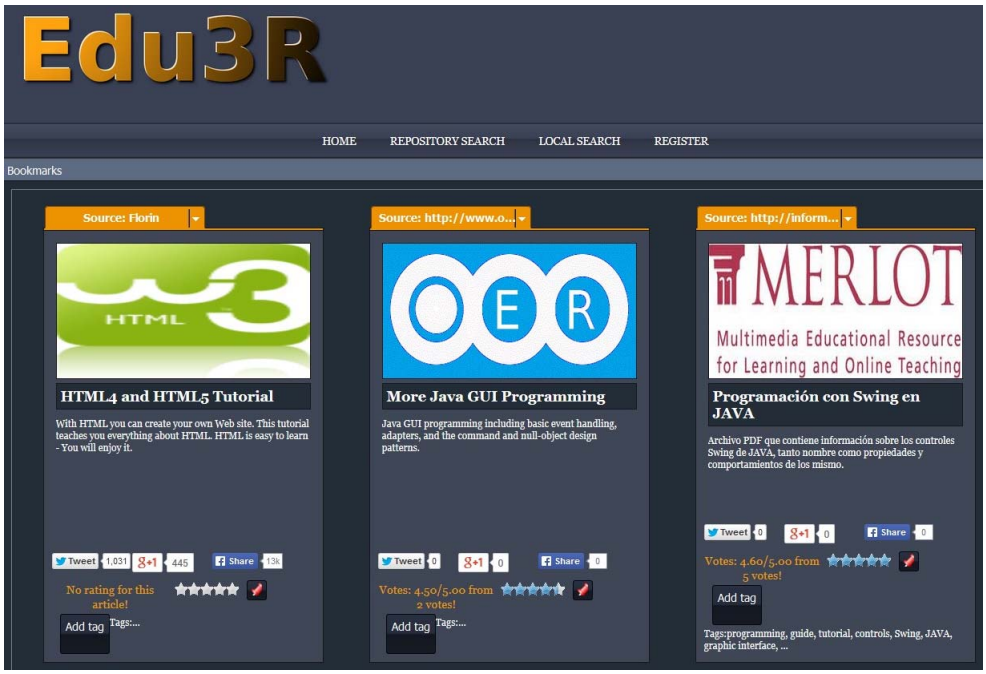

Fig. 2. Edu3R – Personal bookmark collection. For each LO we can visualize the source LOR, title, short description, average rating and tag list; a resource can be shared (through Twitter, Google+ and Facebook), it can be rated (through the 5-star voting model) and tagged; furthermore, it can be removed from the collection (by clicking the red pin).

Fig. 3. Edu3R - Local search results for the query "Java"

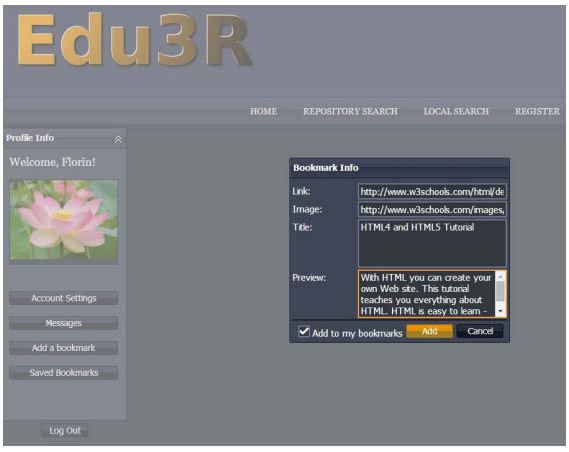

Fig. 4. Edu3R – Adding an external learning resource

Next, students can also tag the resources, adding meaningful terms that facilitate subsequent retrieval, as can be seen in Fig. 5. Tagging provides a personalized classification, which reflects the educational context, the interests and the expertise of the learners. Since tags are shared with peers, students act as a "human filter" for each other; furthermore, social tagging can "enrich peer interaction and peer awareness around educational content" [9]. The popularity of the tags is reflected in the order they are displayed in. Tags also play an important role in searching: if the keywords are found among the tags, then those LOs are ranked higher in the result list.

Students can also assess the quality of the resources and rate them on a 1 to 5 scale. An average mark is computed by the system, which is then used to order LOs in the local search results. Thus, poor quality resources as well as those irrelevant for the community are filtered out with time.

Based on these ratings, Edu3R also makes recommendations to the learners, suggesting additional resources of potential interest. Only the ratings of the most similar peers to the current student are taken into account for these recommendations. Two students who rate resources in like manner, can be said to have similar learning preferences; therefore, if an LO is rated highly by one of them and not yet rated by the other, the system assumes the LO could be of interest to the second learner as well and consequently recommends it to her. These recommendations are included in the dedicated tab "Your peers also liked", as can be seen in Fig. 6. Therefore, learners have an incentive for rating LOs: giving thoughtful ratings for numerous resources is a prerequisite for getting adequate and useful recommendations.

Fig. 5. Edu3R – Tagging a learning resource

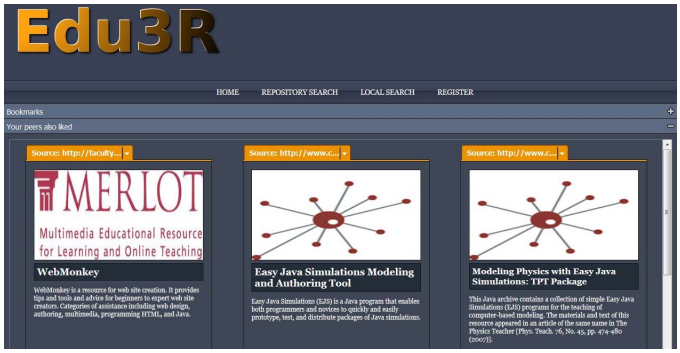

Fig. 6. Edu3R – List of recommended resources

Another functionality offered by Edu3R is the visualization of the most popular resources in the system, based on the overall ratings received from the entire community. These can prove useful in addition to the personalized recommendations, offering students a snapshot of the current learning preferences of the peers and raising their curiosity for additional resources. Finally, Edu3R also integrates an asynchronous messaging tool, in order to offer support for student communication and encourage peer interaction.

To sum up, the main role of Edu3R is to provide quality learning resources to the students, relevant to the current course and tasks and help them manage and organize their personal resource collection. The system was conceived for a blended learning scenario, as a complement to traditional face-to-face instruction; the resources are to be used in addition to the lectures provided by the teacher, expanding the reading list offered in the classroom. Additionally, Edu3R is aimed at increasing student participation and involvement with the learning community, through the share and recommendation functionalities. Stimulating critical thinking is also envisaged, by encouraging students to annotate LOs, assess their quality and express their opinions.

B. *Architecture and Implementation Overview*

A schematic architecture of Edu3R prototype is included in Fig. 7.

The main system components are:

- *External search module* – retrieves LOs from various resource repositories. 11 sources are currently included (Ariadne, comPADRE, Connexions, LORNET, Merlot, MIT, NSDL, OCW, OER, OrangeGrove, OUJ), but the list could be extended. Dedicated web scrapers are built for each LOR, based on jsoup HTML parser (http://jsoup.org/). The wrappers parse the search results returned by each LOR and display them to the learner in a common format (including a picture, a title and a short description).
- *Local search and filtering module* – queries the local database for the resources already bookmarked by the students. The filtering algorithm takes into account the location of the keywords in the LOs (title, tags, description, original search keywords used for retrieving the LO from the external repository) and orders the results accordingly (with tags given by students having the highest priority). The average ratings of the LOs are subsequently used for sorting them, based on overall popularity.
- *Recommender module* – suggests resources of potential interest to the current student. A collaborative recommendation algorithm is used [1], by which the student will be recommended LOs that peers with similar learning preferences liked (i.e., rated highly) in the past. Pearson correlation metric is employed for computing similarity between learners, based on ratings given to the LOs.
- *Bookmark manager module* – saves LO bookmarks to the local database, in the internal required format (including the URL, title, description, picture and original search keywords). It also stores the external resources individually found by the students and manages the students' personal resource collections (allowing for bookmark removal, tagging, rating etc.).
- *Communication module* – provides asynchronous communication facility between the students (through a simple messaging system).

As far as implementation is concerned, Edu3R was built using Java EE Web application technologies, in conjunction with HTML, CSS, JavaScript and AJAX; Apache Tomcat is used as servlet container and MySQL as DBMS.

IV. Conclusion

Edu3R is a platform aimed to help students from a specific learning community to find relevant and useful educational resources. An initial small scale testing of the prototype revealed a successful retrieval of LOs from the various integrated LORs. The next step will be to evaluate the platform in a real course context, empirically assessing the students' satisfaction with the system and its effect on learning.

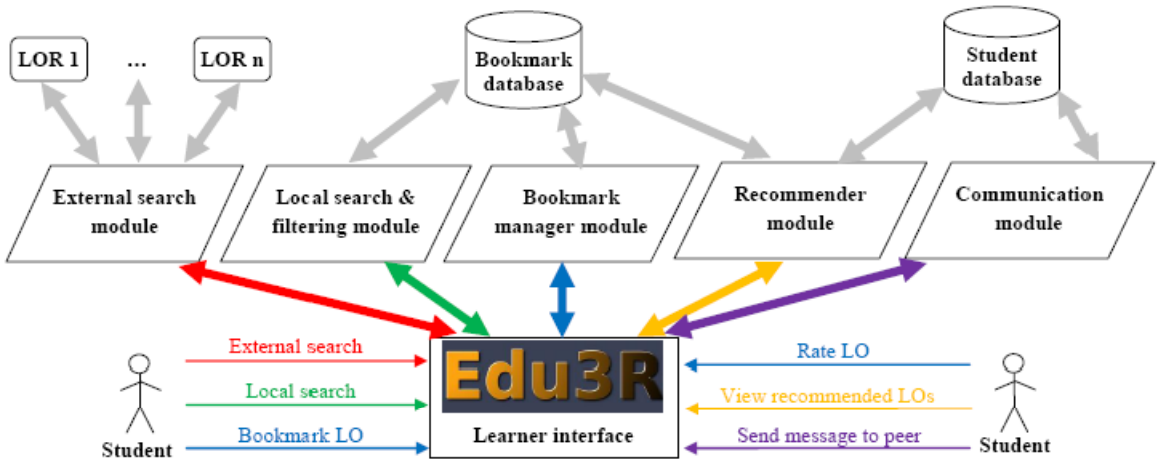

Fig. 7. Edu3R – Schematic system architecture and sample functionalities

Future development of the prototype will be focused on extending the recommender module by: i) including several rating criteria, such as difficulty level, content quality, presentation quality etc., in conjunction with multi-attribute collaborative filtering; ii) diversifying and improving the recommendation algorithms, taking into account pedagogical issues (as envisioned in [7]); iii) adding recommendations based not only on ratings but also on collaborative tagging (as suggested in [11]). The social tagging features could also be extended, by providing suggestive visualizations of tag clouds and community-created folksonomies.

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