Development and System Assessment of Learning Object Recommendation based on Competency
RecOAComp

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Abstract: This article describes the development and evaluation of a learning objects (LOs) recommendation system based on competences called RecOAComp. For such, the multidisciplinary team was composed by educators, programmers and designers. Its purpose is to make recommendations based on the user profile. Thus, it works by filtering and suggesting LOs that can support the subject in the construction of competences according to her/his needs. RecOAComp was used in stricto sensu graduate courses on Education and Informatics in Education between 2011 and 2015, involving more than 150 subjects. The obtained results derived in system reprogramming, interface improving, student/teacher profile characterization and usability parameters implementing; besides inserting new competences and LOs in the databank. Currently, the project is aimed at implementation of collaborative filtering, with which students evaluate the relevance of the indicated LOs, adding this information to the recommendation. In addition, RecOAComp will be made available in plug-in format for Distance Education environments. Therefore, this study aims to provide a LOs recommendation system in different educational modalities, supported on the needs of each student in order to collaborate with her/his competence-building processes.

1 INTRODUCTION

With Web 2.0, ordinary users can elaborate and make available content. Thus, space was opened for the production of materials for education, among them learning objects (LOs). Defined as all modular digital resource used to support classroom or distance learning, they can still be reusable and approach different media, supporting different students profiles.

However, when users use search engines for access to contents they are faced with a great diversity and quantity of retrieved materials and information. In the area of Education, this quest requires a management to avoid excessive work of the teacher during the selection of relevant materials; or that the student spend a lot of time until finding a suitable material to support her/his needs.

Thus, in order to store and organize LOs, repositories have been created, aiming at the easing of their selection from the knowledge areas, themes and types (video, simulation, hypertext etc.). On the other hand, it is observed that these repositories, when consulted, still end up returning a lot of content that is irrelevant to the subject's needs, causing an overload of information.

This study deals with the construction and evaluation process of a recommendation system called RecOAComp (Learning Object Recommender based on Competences, *Recomendador de Objetos de Aprendizagem baseado em Competências* in Portuguese), which allows filtering of Learning Objects, according to the competences that the user needs to build or rebuild from her/his profile. The intention is to make available to the academic community in general a technology that can assist teachers and students in the competence-building process.

The article is organized as follows: at first the concept of competences in the context of education

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is discussed (section 2). In section 3 takes place a reflection on the recommendation systems and their relevance in assisting students and teachers access to learning objects relevant to competences construction. Then, in the course of sections 4 and 5, the prototype in question is described, as well as the process of elaboration and evaluation of the recommendation system RecOAComp. In section 6 the analysis of data collected is presented with the focus on the last validation and evaluation cycle carried out in 2015. After that, the conclusions identified up to the present stage of this study are displayed.

2 COMPETENCES: AN EDUCATION VIEW

The term 'competence' was first used in the legal field, employment given still today as 'competence to judge something'. Its use has been expanded to the Administrative and Educational areas. In the latter, its implementation started in professional education, but was soon included in the educational reforms in several countries with a perspective, many times, behaviorist. In the late 1990s and early 2000s, the term was also earning a constructivist bias, due especially to the works of Perrenoud (1999; 2002).

The latter theoretical view about competences has potential to contribute to a comprehensive student training, as it goes beyond the simple content memorization practice. It is understood this way, since its elements are composed of **K**nowledge, but also **A**bilities and **A**ttitudes, abbreviated in the KAA acronym. They can be related to the four pillars of the 21st. century Education. (Delors, 1996): learning to know (knowledge), learning to do (ability), learning to live with others and learning to be (attitudes).

When building the KAA, along with its mobilization in situations according to Le Boterf (2004), one can put her/his competences into action. Perrenoud (2004) adds that mobilization is, especially, adaptation, generalization or specification for orchestration and coordination of the elements of the competences. When using a competence, there is a number of procedures from the identification of the problem, the means and resources to solve it, to the evaluation, the making of adjustments and documentation of actions (Perrenoud, 1999).

Thus, in front of a scenario in which individuals are faced constantly with scientific and technological novelties, new socio-cultural and economic pathways as well as great content production, building competences becomes necessary. In this sense, learning objects can collaborate in the (re)construction of part of KAA or of the competence in its entirety as they seek to work with some of its elements in particular or in whole. In this regard, in order to assist individuals to achieve appropriate choices on reliable materials and according to their needs, recommendation systems were developed, which will be addressed in the next section.

3 OBJECTS OF LEARNING AND RECOMMENDATION SYSTEMS

Learning objects (LOs) are content modules or units aiming at learning with support of digital technologies (IEEE 2002, p.5 *apud* Coll and Monereo, 2010, p.252). They have as characteristics the possibility of being adapted and reused, and besides being affordable, durable, they can be used in different platforms (Fabre et al., 2003 apud Tarouco et al., 2004). Haughey and Muirhead (2005) note that "[...] LOs have no value or utility out of teaching contexts, its value lies in its application to the classroom and online environments where teachers may or may not be present".

In order to aggregate these materials in a common space, repositories of learning objects were developed, which are databanks that store them, with the aim to facilitate their access and organization. Repositories allow indexing of these objects through metadata filling, or, in other words, a set of information that characterizes each LO registered, with the objective to favor its search.

Recommendation Systems (RS) become, thus, a strong ally to this educational context, as they are applications that are intended to achieve the appropriate combination between users expectations (profile) and items to be recommended, i.e., to define this interests relationship. According to Cazella et al., (2010), RS use the repositories of LOs coupled to users preference data to direct content with potential interests.

In the educational context, they emerge as a tool able to relate, more efficiently, educational resources to students' training needs. This is due to the types of filtering providing, therefore, a personalized recommendation with a reduced number of

irrelevant indications. Thus, it is understood that the greater the diversity of filterings implemented in the system, more refined will be its materials screening.

In general, there are seven types of filtering recommendation systems, being: (1) Collaborative Filtering; (2) Content-based Filtering; (3) Demographic Filtering; (4) Knowledge-based Filtering; (5) Utility-based Filtering; (6) Filtering based in Other Contexts and (7) Hybrid Filtering. In the case of RecOAComp, it has as filterings: Collaborative, Content-based and Hybrid.

Below, RecOAComp prototype is detailed, which uses the competences as one of the materials filtering possibilities.

4 RecOAComp PROTOTYPE

The Learning Objects Recommender based on competences (RecOAComp) is available at http://www.recomendadorcomp.ufrgs.br/, shows the login screen.

The technologies used in prototyping process were: Java Server Faces - JSF (in the *view* layer), Prime Faces, Java Persistence API - JPA with Hibernate (*persistence* layer) and MySQL. At this stage of the research project to which the system is linked, collaborative filtering is already inserted, but knowledge-based filterings and filterings with hybridism variations are being implemented. The following describes the system operation logic in educational context.

The teacher of a course first registers her/his discipline in RecOAComp informing the competences that may be built by students coursing it and to what degree (1-5). Then, she/he links those competences to learning objects (already inserted in the system or registering new ones), as well as tells which of these competences they can help to build and to what degree, from the deepening of their content and activities.

The student, in her/his turn, when registers her/himself in the discipline, tells the system the degree of construction (0-5) which she/he has, given the competences linked to it. This will be the profile of the student in the prototype.

After these procedures, a recommendation can be requested, which is the indication to the student of learning objects from the crossing between: the degree of each competency addressed by the discipline; how much the subject in question has built each competence of the discipline based on her/his perception; and the degree of contribution of the learning object registered by the teacher for the construction of competences related to it. The goal is to assist them in the process of creation or improvement of competences.

If the student understands that she/he built or improved one or more competences with the use of the indicated LOs, she/he can return to her/his profile and change it, which will modify the next recommendations. Similarly, after the use of learning objects, students can provide feedback to the system, evaluating them in a ranking (Likert scale with 5 points represented visually by a set of stars) according to their satisfaction with the recommendation. As the Recommender is being used and evaluated, recommendations will be ordained again, using, also, in addition to competences-based filtering, collaborative filtering (arising from the evaluation carried out by users on the relevance of each suggested recommendation).

The RecOAComp prototype was evaluated through its use in some graduate disciplines. The experiments are reported in section 5 that follows.

5 RecOAComp IMPLEMENTATION AND EVALUATION EXPERIENCES

This research follows an exploratory nature, with a qualitative and quantitative approach. The methodology involves the research of literature, system prototyping and evaluation.

The project began in 2011, when the prototype was built only with the competences-based filtering. In this phase, the group performed its first validation. From then, until the first half of 2015, the system was used, validated and evaluated by more than 150 participating subjects, who are students from different areas of knowledge who attended *stricto sensu* graduate disciplines on Education and Informatics in Education. In the following sections, this methodological pathway will be detailed, by presenting the RecOAComp model and the system validation process.

In order to evaluate the performance of the RecOAComp recommendation system prototype, applications were made in two graduate programs disciplines from 2011 to 2015/1 (convenience sample).

In the **first stage** of the research, which began in 2011, the recommender prototype was developed, then the first system evaluation was promoted. It took place in a discipline entitled 'Competences for Distance Education and the use of learning objects',

involving 32 students. The registered learning objects are part of the collection developed by the research group, with the purpose to make recommendations viable to users and to carry out the first tests. Through feedback from students and teachers who used RecOAComp, the need to create and enhance features in order to refine and perfect the prototype was verified.

In the **second stage**, which began in 2012, prototype architecture was perfected with Java and MySQL applications. The LOs evaluation by users was refined through Likert scale. A tutorial video was also incorporated into the tool in order to facilitate its usability. The prototype had new validation with the reissue of discipline, totaling 29 students participating. New LOs were added to those already registered, this time with the inclusion of those made available by repositories that are external to the research group, allowing greater diversification. It was found that the recommendation system attended satisfactorily to the needs of students, i.e., information filtering was carried out correctly, showing a LOs base sufficiently formed already. From the feedback received, the need to enhance the existing features, such as user profile and LOs evaluation, was found.

In 2013, characterizing the **third step**, data to be filled in the profile, such as KAA detailing on the form, were improved. Also, a new application was created so that the user could indicate whether she/he used or not the recommended object. Administrator, to qualify prototype management, and teacher profiles were also developed. The latter can register disciplines/courses and indicate which competences she/he wants her/his students to construct. Furthermore, interface improvement began, however, the need to improve some usability issues was understood. A new validation was performed, through the discipline 'Pedagogical Models and Competences in Distance Education', with the total of 35 students. In this application, the students could also register learning objects from different repositories in RecOAComp, contributing even more to the diversification of its databank.

In the **fourth stage**, which took place in 2014, the system has undergone a makeover in its PHP databank, which aimed to rewrite the code and perform refactoring, aiming to prepare it for the incorporation of new tools. This modification requested a restructuring of the whole interface design, project that was initiated at this stage and continued in 2015. Also, changes were made in the profile filling form programming, reducing the scope of KAA degrees from a limit of 10 to 5 points. The prototype had the validation performed with 30 students of the discipline 'Competences and Learning Object Recommendation', when registration of learning objects activities and competences-based recommendations were carried out. In addition, through an online questionnaire, with questions relating to operation, interface and usability, it was possible to assess the contributions of RecOAComp in the competences-based recommendation and to identify necessary improvements to the prototype. With this information, significant changes and adjustments were made, particularly regarding the drafting of the new interface, at that time under development.

These validations, occurred between 2011 and 2014, used the following methodological procedures:

1) **Student's Registration in the System by Filling in a Form on the Definition of Profiles Related with the Competences:** The questionnaire involved questions about 'Teaching Experience in E-learning' (options 'yes' or 'no'), assessment competences based on built or not knowledge, ability and/or attitudes. Information about competences that the students believed they had not developed yet guided the filtering procedure because it was possible to link the profile of these students to learning objects that could assist them in building these still incipient competences.
2) **Registration of Learning Objects:** Once their registration is done, students had to insert objects into a form based on metadata from a repository developed at the research participant University. This insertion characterized a teamwork. When inserting the selected LO, the team informed the system its General Category (ID information), Life Category (creation description), Technical Category (information to allow use), Educational Category (educational description), and Rights Category (use restrictions or not). After that, students of the groups assessed whether registered LOs supported (yes or no) the construction of some specific competences related to Distance Education. Thus, for each LO, the group analyzed a series of 14 competences, which are also presented in the profile. Thus, it was possible to have a good basis for LOs recommendation.
3) **Learning Objects Classification:** After the process of LOs registration and association with the competences, the groups evaluated the classification performed between them. This step

was fundamental to identify some small distortions and to assess the filling process provided by the prototype.

4) **Recommendation Evaluation:** The next step was to start evaluating the use of RecOAComp recommender. For each LO recommendation made by the system, feedback was requested on a Likert scale (a number scale of 5 points), being the extremes: 'horrible' - when the suggested LO was unrelated to the competences that the student needed to build (indicated in her/his profile) and 'excellent' when the LO indicated was related to the competences that the student needed to build.

In the **fifth stage**, which began in 2015 and, thus, in development process, continuity was given to the implementation of the new system interface, based on usability issues and implementation of new functionalities identified as necessary. A collaborative system filtering was also implemented. To date, the user evaluated the relevance of the LO recommended, but the system did not use these data in the content recommendation process; they served only for a system evaluation. With the implementation of collaborative filtering, the student tells how relevant the recommended LO was to her/his needs. The prototype collects this data and incorporates them in the process of the forthcoming recommendations, along with content filtering, which was already used before.

The application of this new version of RecOAComp was held on the discipline 'Competences in Distance Education and Recommendation of Learning Objects' of the Graduate Program in Education and Informatics in Education, with 24 students. Again we used an online questionnaire, in order to collect data about the new interface and the operation, as well as the relevance of the prototype as a whole. Regarding the methodological pathway used in this RecOAComp application, there were some changes due to improvements made in the system. This time the students, organized in groups, initially inserted learning objects, informing the KAA of the competences that each of them enabled to build and to what degree (0-5). The same was done in relation to the created discipline. In a second moment, students individually accessed the system and requested their enrollment in the disciplines created by the other groups. Entering the disciplines for the first time, each student reported how much (0-5) she/he thought she/he already has developed the KAA competences addressed by the discipline through a form provided by the system. Then, already inserted in the discipline, they requested a recommendation of learning objects, analyzing if the recommended contents were relevant to their real needs, as shown in their profiles. This reevaluation was conducted in 2015/1, by using the system at the graduate course already mentioned and attented by students in master's and doctorate, continuing the data collection method that had been applied.

In section 6 data collected focusing in the latter application-evaluation cycle are analyzed.

6 DISCUSSION AND DATA ANALYSIS

The prototype was used and evaluated by students in a graduate discipline in 2015/1. To register the evaluation, we used a questionnaire which was answered by 11 students. The results of this last evaluation are described and analyzed below.

The group considered the system as highly relevant for education (63.6%), with high writing and editing quality (72.7%), promoting interdisciplinary use (63.6%). They also concluded that the RecOAComp, through the recommended LOs, enables the student to be challenged in activities that give the opportunity for raising hypotheses, the interaction, the reflection, the exchange and the construction of knowledge, with which they strongly (45.5%) or at least in part (54.5%) agreed. In the same line, participants answered that it favors the ability to elaborate and create knowledge from the action-reflection-action in 45.5% for both options. At the same time they considered that it instigates the search for other information on different sources of research, as 45.5% strongly and 54.5% partially agreed. Thus, it was possible to observe that the participants identified the RecOAComp recommendation system as a possible ally of the teacher and of the students in the teaching-learning process.

As for usability and design of recommender interface, they considered it clear and concise, fully (42.9%) or partially (50%), easy to use, with information location presented in an intuitive way. There was little disagreement on the aspects 'clear instructions' (9.1%), 'interactivity' (9.1%), 'easy and consistent navigation' (9.1%), 'well organized on-screen images' (18.2 %) and 'instructions provided in a clear and objective way' (18.2%). In this sense, they point to the need for some improvements, such as: inclusion of help icons, updated tutorial provision, statements review and navigation hierarchy insertion.

In the categories ‘colors adequacy’ and ‘fonts size and pleasant style’, 9.1% had no opinion; the remaining respondents agreed fully or in part, adding 90.9% respectively for both options in these statements. The same percentage of responses was identified stating that the system is ‘engaging/motivating’. The topics ‘visually attractive’, ‘flexible and reusable’, ‘high quality graphic project (page design)’, ‘enough help resources and usage tutorial’ had similar percentages of disagreement and doubt in the positioning of research participants, which were around 50%.

Regarding the learning objects registered in RecOAComp, they were evaluated favorably. Thus, the group of students considered fully or in part that the recommended LOs presented concepts clearly. There was disagreement of 9.1% in the categories ‘accurate and current information presentation’ and ‘inclusion of appropriate amount of material’. This points to the requirement of registration with a higher number of objects in the system.

Regarding the ‘good use of multimedia resources (sound, pictures and video)’, some disagreement or doubt (9.1%) arose. Also, for the ‘good use of animations and simulations’ 18.2% did not know how to answer and 9.1% disagreed. Such responses demonstrate the need for inclusion of new LOs that include greater interactivity and/or multimedia resources diversity.

RecOAComp has been constantly improved from the validations performed. These experiments indicate its relevance for education supported in digital resources in classroom or at distance modalities. The intent, therefore, is that the RecOAComp recommendation system can support the building and improvement of competences, in favor of a comprehensive and quality education.

7 CONCLUSIONS

This article presented the prototype development process of the educational recommendation system called RecOAComp, as well as its validations and evaluations. It allows, through an Educational Recommendation System (ERS), filtering learning objects based on competences in order to help students to build them according to what is understood as necessary in a discipline.

As future works, we conjecture about the insertion of a new functionality in the prototype. This refers to the implementation of knowledge-based filtering. This filtering technique proposes specialized knowledge modeling (human specialist) to assist in LOs recommendation. This modeling will use domain ontology, refining filtering process and, therefore, recommendation. For example, if different teachers name the same competence as ‘Databank Model’ and ‘Databank Modeling’, the agent will identify these similarities and rewrite the competence title as "Databank Modeling". This is a way to integrate content and meaning. Domain Ontology application aims to work on this integration problem.

Equally, we aim to elaborate a questionnaire as a test to be presented to the student when she/he enrolls in a discipline. This test is important in helping the teacher to analyze if the KAA of the students were undersized or oversized by the student in relation to the degree of competences for the level of discipline (for example: introductory, intermediate, advanced).

Finally, it is expected that this work will assist researches on the subject, given the relevance of the contributions that recommendation systems can offer to education.

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