ISSN 1870-4069

# Prototype of a Recommendation System of Educative Resources for Students with Visual and Hearing Disability

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**Abstract.** The purpose of this article is to present the design of a recommendation system of educative resources for the students with visual or hearing disability to support the learning in the subjects of the Human Formation area. The recommendation is based in the perception of the utility of the educative resource through a vote using collaborative filtering and the K-nearest neighbor algorithm. For the implementation was integrated to a platform using PHP, MySQL, JavaScript and the library Mahout Apache. Finally, are presented the results obtained of the tests realized to a focal group of students with disability and the evaluation of the system.

**Keywords.** Usability, semantic web, inclusive learning, learning objects repository.

## 1 Introduction

The recommendation systems are applied in various areas such as the marketing, medicine, technology and education. In these systems the user realizes an object or item selection based on his or her needs and preferences, giving recommendations even to others. The design of adaptive recommendation systems to support the education and especially to users from different modalities as on-site or e-learning actually require of digital resources that allow uphold the learning processes according to their academic preferences and requirements of the students even with any disability.

Which entails to promote materials and digital resources that underpin the learning process in the programs that are offered in the distinct modalities, where it seeks to intensify the learning strategies and auto learning in order to obtain better results in the academic performance of the students. As well as an inclusive approach for people with disabilities.

This investigation has as purpose the design of a recommendation system of accessible learning resources like learning objects or digital resources designed to support the students with disabilities learning in Human Formation area.

The Recommendation System (RS-OLR) uses the collaborative filtering technique and the K-nearest neighbor algorithm, and to find the similarity between users with the objective to find a major quantity of resources in tune with their needs. The system is a search and recommendation tool of accessible learning resources to the subjects of the university human formation in the learning programs of BUAP in on-site or e-learning modality.

The article is organized as is indicated next: In the section 2, are presented the foundation and theoretical review of the research work. In the section 3, is defined the methodology for the analysis and the recommendation system design. In the section 4, are shown the results of the pilot test of the focal group of students with disability. Finally, are presented the conclusions and future work of the research.

## 2 Related Work

In this section are reviewed the topics of open learning resources, the learning objects, repositories and the recommendation systems that give support this research.

### 2.1 Open Learning Resources, Learning Objects and Repositories

The Open Learning Resources (OLR), are designated as materials for the teaching-learning, since 2002 the UNESCO [1], pronounced in favor of the generation of these resources, which include:

- Learning contents: Complete courses, materials for courses, modules, contents, learning objects, etc., which are didactic.
- Tools: Software for the creation, delivery, use and improvement of the open learning content, including searching and organization of the content, learning management systems (LMS), tools of content development, and communities of e-learning.
- Resources of implementation: Copyright licenses that promote the open publication of materials, design principles and local adjustment of content.

All of this also entails an inclusion process therefore the subjects must be accessible for all people and achieving a universal design, but still require to work on accessible materials.

According to IEEE "A Learning Object (LO) is any entity, digital, which can be used, re-used or referenced during technology supported learning" [2]. Such objects are utilized in e-learning, interactive and collaborative environments. Examples of LO include a lesson, multimedia contents, a video, simulations, and animations.

The Learning Objects are used as a digital learning resource that seeks to favor the access to learning contents and facilitate the learning to the specific development of the disciplinary competence.

They are composed of two part: the content and on the other the metadata, being esencial to be able to integrate to a repository of LO, that is to say a LOR.

The Learning Objects have as functional requisites: accessibility, reutilization and interoperability. In addition, they possess advantages over other digital learning resources such as manageability, durability and scalability [3].

The Learning Objects possess metadata that describe and identify the learning resources and facilitate their searching and recovery. Currently, exist various standards of metadata, which look to easy the exchange and accessibility of the learning objects amid the most used are the IEEE-LOM, DublinCore, Can Core y OBAA. The LO require an instructional design to guarantee to promote the learning by the dimensions: pedagogical, didactic and technological [4]. Concerning the Learning Objects Repositories are specialized digital libraries, that lodge multiple types of educative resources of learning objects and/or its metadata, which are used in different e-learning environments that help the teaching-learning process [5]

The LOR arise to establish a solution that would allow the users find easily digital resources oriented to education, solving the problems of content management and can establish norms for the quality of its resources, also must offer facilities to the creation, management of the metadata and stored resources [6].

### 2.2 Recommendation Systems

The Recommendation Systems (RS) emerged in the middle of '90s (Li, 2010) with the objective of toast the users those results of searches of information near to their necessities [7].

For Chesani [8] defines a recommendation system as "that one able to realize predictions starting from the fact that a user likes or do not an item, object, mean, or information that would access". A RS is associated with a group of items, where I = i1,...,in and its objective is to recommend to the users items of I that can be of their interest. The system is able to treat each user individually, bias a product or service to attend the necessities, is a priority form to improve the quality of the searches.

The recommendation systems are the allies of the personalization of computational systems, principally in the web, by its ability to identify preferences and suggest relevant items for every user: for which is needed of profiles that store the information and preferences of every user [9]. Such is the case of the open learning resources as the LO s that have associated metadata to be able to identify and classify. According to [10] the recommendation systems are classified in: RS Based on the Content, Collaborative RS, and Hybrid RS.

**Recommendation Systems based in Collaborative Filtering** The collaborative RS (C-RS) have two classifications: based on memory (employ similarity metrics to determine the similarity between a pair of users and calculate the items that have been voted for both users and compare such votes to calculate the similarity) and based on models (utilize the matrix of votes to create a model

through which establish a group of similar users to the active user) and other classifiers for this category are the Bayesian, clustering and based in regressions models.

The algorithms that often are used to implement the collaborative filtering techniques based on memory, are methods based on neighborhood (K-nearest neighbor algorithm). These function selecting an appropriated group of users, according the similarity of the same regarding the active user, and use the values of such users to generate the values of the active user.

**User Profile and Student Model** In the case of a user profile of a software system, this can comprehend both personal data, behavior patrons, personal interests and preferences [11]. The profiles created explicit or implicit, regarding to understand how such characteristics of the student that are relevant in the educative process, and the interrelation within these, as they are the level of comprehension of a topic, learning styles, users likes, stratum, psychological characteristics like state of mind, the goals and at least their environment or context. All this characteristics related between them form what is called the student model, which allows to construct a profile and model the system to the user needs.

### 2.3 Related Works

The different contributions about the recommendation systems of learning objects in repositories, such as:

In the National University of Colombia [12], give an input about the development of adaptive smart courses, using a tutorial system and proposing a model of seven modules to search, recover and recommend learning objects, to support the learning virtual environments.

Likewise, there exist the works based on the recovery of thematic content and of the defined context [13] in the different repositories, which have permeate in support the education at distance.

Another investigation of Colombia [14] has applied the collaborative filtering technique to value the perception of the use of learning objects by the students as a support to their activities and the results favor the recommendations by an adaptation of the K-nearest neighbor algorithm.

The contribution of recovery systems of LO in repositories [15] have attached to the use of learning styles, the processing of natural language, ontologies and the hybrid recommendation systems have facilitated the management of the LO, but lack of the description of the real use of users.

According to Cechinel et al. [16] in the RS developing utilizing the library Apache Mahout to calculate recommendations of learning resources generated by different algorithms of collaborative filtering based in memory applied over sets of obtained data of the MERLOT repository, where more than 3500 resources available for the e-learning.

## 3 Methodology

The methodology in this research is exploratory with a qualitative approach, for what was applied the model of prototypes and design centered in the user for the proposal of the recommendation system.

### 3.1 Analysis and Design of the Proposed Recommendation System

The architecture client-server of three layers to integrate LMS Moodle and the system of recommendation called "SR-Recursos Educativos Accesibles Universitario" (SR-REAU). The objective of the proposal is to develop a recommendation system of digital accessible learning resources like are the LO or other resource, according to the student with disability profile and learning results. The recommendation system has at least two main tasks: prediction and recommendation. In Figure 1, is showed the architecture of the system and regarding the design of RS is based on:

- The representation of the recommendations: through the evaluation of the contents by a unique value (like or do not) and the Likert scale 1 to 5, regarding to the utility to learn.
- Regarding the evaluation are added over the items to generate and classify the recommendations and finally is showed an ordered list, according to the profile of the student with disability, with the data: tuition, name, last name, user, code, e-mail and career. Likewise level or degree of visual or hearing disability.

### 3.2 Development of the Recommendation System

For the implementation it was used the collaborative filtering technique and the K-nearest neighbor algorithm through the Mahout Apache library. The recommendation system was developed in PHP, HTML, Javascript and the database MySQL, in a Linux server with Apache. The database stores information of the educative resources which can be digital resources: pdf files, documents, videos, LO or any digital educative resource, where the principal objective is to store a valuation of the resource (see Figure 2).

For which, the four steps that were implemented to achieve the recommendations in the system of collaborative filtering are the following:

1. Calculate the similarity between users: In first place, is inserted the user profile: id_student, disability, id_resource and the valuation that gave the student, this will allow to determine through the metrics, the similarity between a pair of users.
2. Calculate the K-neighbors of the active user: Making use of the selected metric of similarity, in the case of the API of Apache Mahout counts with: Pearson correlation similarity, Euclidean distance similarity, among others, what is calculated is the similarity between pair of users, the occupied metric

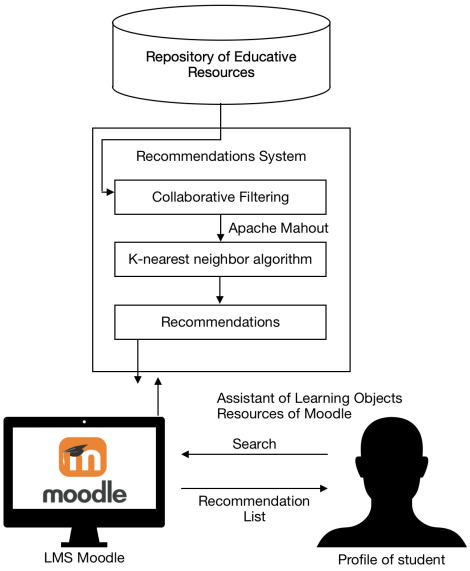


**Fig. 1.** Architecture of the recommendation system SR-REAU in three layers.

was the coefficient of Pearson coefficient similarity. So that are obtained the k users more similar to the active user. These users are called as the k-neighbors of the active user.

3. Calculate the predictions of the items: Selecting the subset of users which valuations are going to be used and, so will have influence in the generation of the prediction for the active user. From the k-neighbors of the active user, are determined the possible valuations that the active user would do about the items not yet voted, that is to say, is predicted how the user would value that items, for which in Apache Mahout it has various algorithms to calculate the neighbors closer to the active user where was selected the k-nearest neighbors methods, being this the one who reduces the effect of noise in the classification, but creates limits between similar classes.
4. Show N better recommendations: Behind the calculation of the predictions, is chosen N items more suitable to be recommended to the user, that is to say, the higher, more voted predictions, held.

In Figure 3, it is visualized the options of the Recommendation System of University Accessible Educative Resources where the user registers, searches educative resources for the subject and subsequently evaluates. Likewise consults the retting list of the recommended resources.

In Figure 4, is showed the list of the results of the search and after the selection of an educative resource for people with disability, the recommendation system will allow the user to order them according to the criteria: use and evaluation.

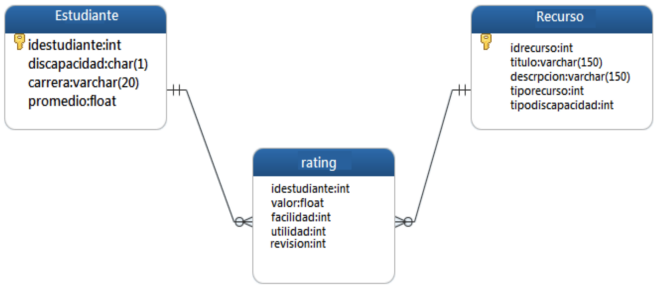


**Fig. 2.** Relation of the database for the vocation of educative resources.


**Fig. 3.** Prototype of the Recommendation System-REAU.

In order to evaluate, in Figure 5, users cast their vote according to three criteria, in a Likert scale of 1 to 5, where 1 is "Nothing", 2 is "Little", 3 is "Regular", 4 is "Quite" and 5 is "Totally": spacing

- Value, which represents a general grade of the resource.
- Academic relevance, if it was useful for the learning.
- Ease of use, refers to the usability in general to navigate and use.

## 4 Tests and Results

### 4.1 Pilot Test

For the test of the system, it was applied the technique of inspection and inquiry with the user. The participants of the test were selected according to three


**Fig. 4.** List of recommendations of the system.

criteria: a) be a student, b) have some hearing or visual disability and c) be in a course of the area of university human formation.

For which, it was conformed a focal group of 6 users with visual and hearing disability: two students with medium hearing disability, as well as three with deafness, from the Degree in Graphic Designing and one student with blindness from the Degree in Law. Regarding the functionality tests, were presented two possible scenarios for the final users, hereunder, are described:

- Situation 1: To the user was given a brief explanation of the use of the system and was accompanied in every activity actively.
- Situation 2: To the user was explained the use of the system and only was accompanied in the beginning of a selected activity and only in a much needed case.

For every situation the users must accomplish certain tasks as are:

- Task 1. Register as user of the system and find the navigation menu and select an option.
- Task 2: Realize a search and select the item of the interest of the user and value the educative resource
- Task 3. Consult the list of recommendations and value again.

The results demonstrate that the usability of the recommendation system to support people with disability is intuitive and easy to manage, achieving to interact according to their disability, because is included a plug-in “webkit-speechrecognition" which allows to listen and interact with the system to the users with visual disability.


**Fig. 5.** Review for the value of the educative resource (item).

**Table 1.** Obtained results of the pilot test.

| Tasks | Situation 1 | Situation 2 |
|---|---|---|
| No. 1 | 100% | 95% |
| No. 2 | 100% | 95% |
| No. 3 | 95% | 90% |
| Average | 98.33% | 91.6% |

### 4.2 Evaluation of Metrics

The metrics of accuracy or decision, evaluate the certainty of the prediction system and value if the recommendations are appreciable and effective for the user.

According to Cleverdon [17], there are five metrics to be considered:

1. Delay. Period of time passed since is done the demand until is given the answer.
2. Presentation. The physic format of the output of the system.
3. Exhaustiveness. Capacity of the system to present the relevant items.
4. Precision. Capacity of the system to hide items which are not relevant.

For this test, only was used two metrics that help to measure the effectiveness regarding the list of recommendations as Precision (P) and Recall (R). These are calculated from the table of contingency which classifies the items regarding to the necessities of information distinguishing two groups: relevant o no relevant of a total of 237 educative resources in the system.

In addition, also the items are classified according to how they have been recommended to the user (selected) or not (not selected). For which was taken the data of the six users U= u1, u2, u3, u4, u5, u6 with their values of 1 to

5 that are assigned to the educative resources in different sessions during the scholar semester. Hereunder, is presented the Table of contingency (Table 2), which shows the proportion of selected relevant items (Nrs=178) regarding to the total of selected items (Ns=200), that is to say, measures the probability that a selected item would be relevant. Moreover, the exhaustiveness or recall, use the proportion of selected relevant items (Nrs=178) regarding to the total Nr =190:

$$P = \frac{Nrs}{Nr} = 0.89. \tag{1}$$

**Table 2.** Table of contingency of precision and recall of the system.

| | Selected | Not selected | Total |
|---|---|---|---|
| Relevant | 178 | 12 | 190 |
| Irrelevant | 22 | 25 | 47 |
| Total | 200 | 37 | 237 |

In (1), it is indicated that the probability of the system to recommend an educative resource would be relevant is of 8% for the student meanwhile that the exhaustiveness (2) os of 0.93, the probability that the system presents the relevant items recommended to the user:

$$R = \frac{Nrs}{Nr} = 0.93. \tag{2}$$

## 5 Conclusions and Future Work

One of the principle contributions was the design and development of the recommendation systems applying the technique of collaborative filtering using the API Apache Mahout, PHP, Ajax, JavaScript, HTML5, achieving to apply the K-nearest neighbor algorithm and calculate the similarity measures to ease the searches and processes of recovery of information with major precision to deliver or recommend trustable educative resources and useful for the learning of the students according to the hearing or visual disability, achieving to strengthen digital abilities and promote relevant and significant searches that allow to support the subjects of Human Formation and the disciplinary competences with accessible digital materials so that the student with disability has access to the resources according to the profile and utility that perceives for the learning, giving a valuation to the resource, and by this way to strengthen the learning processes in face-to-face or distance learning.

The work to future, is to amplify the sample and incorporate other algorithms and strategies of evaluation to improve the recommendations and predictions with major depth in the system. Finally, the trend of the recommendation systems is total and immerse in the educative systems in all the modalities as a tool to support the quality of the didactic digital resources and materials,

for which is demanded websites or repositories that generate recommendations more conscious and complete to support the education with new strategies and scenarios in the high level.

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