Multi-agent System for Expert Evaluation of Learning Objects from Repository

Valentina Tabares [1], Néstor Duque[1], Demetrio Ovalle[2]

[1]Universidad Nacional de Colombia Sede Manizales
{ndduqueme, vtabaresm}@unal.edu.co
[2]Universidad Nacional de Colombia Sede Medellín
dovalle@unal.edu.co

Abstract.

Regarding the educational contexts based on e-learning, Learning Objects (LOs) have arisen as a new conceptual model to organize the content. Thus, it is necessary to analyze the potential impact of LOs on knowledge appropriation processes using the quality concept. In this case, quality is understood as the level of relevance of the educational resources in the teaching-learning process, associated to educational goal and other characteristics. The level of significance can be determined by evaluating the characteristics of the object by a group of experts; however, this process is not an easy task because different criteria should be considered, such as teaching, interoperability, scalability and reusability. On the other hand, a factor to solve is the selection of experts. This paper presents different dimensions and metrics to evaluate, and an automatic mechanism for the correct selection of the experts. The validation is done through the development a multi-agent system.

Keywords: Learning objects, expert evaluation , quality evaluation, metrics, multi-agent systems.

1 Introduction

E-learning today has become one of the major schemes of education, changing the traditional teaching-learning process and providing numerous pedagogical and access advantages . This scheme generates new needs such as the development and improvement of educational materials, where Learning Objects (LOs) are distinguished from other resources by their possibility to be reused in multiple contexts, in addition to their availability in different environments. LOs are stored in digital libraries that are accessible via a network without prior knowledge of the structure to facilitate its search and retrieval, called Learning Objects Repositories (LORs) [1].

Due to the large number of LOs that are stored in the LORs which do not meet minimum quality according to the context where they areintended to be used, it is necessary to generate initiatives to evaluate LOs in a dynamic way, considering different aspects in order to provide the user only with the best resources [2].

The evaluation of LOs can be approached from different perspectives and considering different dimensions. In this paper, we present a model based on expert's evaluation and the developed tool for the allocation of the experts and for assessment of LOs. For any evaluation by experts, it is essential to define the dimensions to evaluate, the metrics to qualify the object, and the instrument used to obtain such qualification, but it is also very important the proper selection of the experts who will conduct the assessment. The definition of the category of experts and their classification is a subject that attracts attention in different areas, as of this choice depends the quality of the evaluation.

Exploiting the advantages of Multi-Agent Systems (MAS), this paper proposes a system that supports the evaluation of LOs from the point of view of expert's review. The system covers the process of evaluation by experts, defining the necessary conditions to evaluate LOs, capturing information of LOs to be evaluated, and defining the profiles of experts that perform the evaluations. Based on this information, the system automatically assigns the LOs to experts. Evaluations are followed by the use of the collected information in order to apply previously established metrics.

The paper is organized as follows: Section 2 presents de basic concepts and Section 3 shows some works related. Section 4 presents the MAS proposed model, which allows review of LOs by experts. Section 5 shows prototype evaluation with a case study, and finally, Section 6 presents conclusions and future work.

2 Basic Concepts

Learning Objects (LOs): Wiley (2000) defines a LO as "any digital resource that can be reused to support learning". People who incorporate LOs can collaborate and benefit immediately from new versions. The potential impact of LOs is highlighted by Hodgins: They represent a completely new conceptual model for the mass of content used in the context of learning. LOs are destined to change permanently the form of learning, and in so doing, it is anticipated that they will also usher in an unprecedented efficiency of learning content design, development, and delivery. However, their most significant promise is to increase and improve human learning and performance [3]. Moreover, a remarcable feature of LOs is the possibility to be described by metadata, facilitating search and retrieval; they must also meet the needs of students for which they were designed.

Learning Objects Repositories (LORs): A digital repository is "any collection of resources that are accessible without prior knowledge of the structure" [4]. LORs are electronic databases that accommodate a collection of small units of educational information or activities that can be accessed for retrieval and use. LORs enable the organization of LOs, improve efficiencies, enhance LO reuse and collaboration, and support learning opportunities [5]. A further aspect of great importance is the fact that many people can contribute to the content to be shared with a community [6]. However, this

creates the need for assessment processes that ensure the quality of the content to be delivered to users.

Quality of LOs: The Oxford dictionary defines quality as the standard of something as measured against other things of a similar kind. For Williams (2000), evaluation must assemble all the standards associated with objects, learners, instructional theories, and other stakeholder values. He also emphasizes the need to include evaluation as an integral part of any design process [7]. In the domain of LOs, quality is understood as a set of criteria for assessing the educational resources and determining their level of relevance in the teaching-learning process [1]. This degree of relevance of LO is measured in educational and technical terms. There are several criteria to evaluate the quality of LOs through metrics -some of them take advantage of product-centric approach and other in the process [8]. Despite its recognized importance, currently no consensus has been reached of all the elements involved in measuring quality of LOs.

3 Related Work

Today, LO evaluation is understood as a necessitythat aims at solving problems caused by the growth of LORs and seeks to ensure the effective use of these resources designed to support teaching-learning processes. In this section, some jobs that have to do with the issues addressed are collected: Approaches, dimensions and metrics to qualify the object to be evaluated, and how the experts that undertake the assessment are selected. Several authors agree that concerns about quality normally focus on different criteria: accuracy, appropriateness to intended audience, effective design, aesthetics, functionality and quality of metadata [9], [10], [11], [12], [13].

Cechinel, in his doctoral thesis, recognizes that the creators of objects have a cumbersome task, which leads to the time of publication and the digital resource metadata not being incorporated or being done carelessly, which results in bad description and leads to difficulties for its recovery. To avoid this, the evaluation is required to be done manually or automatically [11].

For Cechinel and Ochoa, assessing quality of LOs is a difficult and complex task that normally revolves around multiple and different aspects that need to be addressed. Nowadays, quality assessment of LOs inside repositories is based on the information provided by the same community of users and experts that use such platforms [14].

The work [8] presents a proposal for implementation of a quality model for LOs based on ISO 9126 international standard for the evaluation of software quality. The proposed implementation is based on tools for gathering expert's opinion and analysis of metadata using Semantic Web technologies.

In [1], a methodology is suggested to assess the quality of the LOs considering pedagogical and usability issues. These criteria are formalized in a tool that guides experts during the review of LOs and the allocation of a numeric value to each element within a predefined range, which will be averaged to obtain a single value that reflects the

quality of the resource. A MAS for searching and cataloging LOs is proposed, which provides the user with the resources according to specific characteristics.

The work presented in [15] defines a recognized instrument, called Learning Object Review Instrument (LORI), for the evaluation of LOs by experts, individually or collaboratively, allowing the assessment of nine dimensions. Each criterion is evaluated on a scale of five levels. Leacock and Nesbit provide some explanations about each one of the nine dimensions of LORI and how they should be interpreted to evaluate LOs. In addition to defining what should be evaluated, in the specific case of this work, it is necessary to determine the experts to evaluate the resources and how LOs are assigned to each expert. For Farrel and Nielsen, "how do I get a user experience career?" is the key question in the assessment process [16].

Botella et al. propose a classification of evaluators based on the university degree obtained or the number of hours of practice gathered in this field. This is why it is important to collect other attributes of each user such as domains, skills or projects to determine their expertise [17].

Returning to these elements, a model is proposed using a Multi-agent system that determines the dimensions and metrics to evaluate and also relies on an expert system for the selection of experts, the allocation of LOs that can be evaluated and presented according to their specific expertise.

4 Proposal of Multi-agent Architecture for LO Evaluation

To ensure the quality of the LOs and enhance the experience of users in the use of these resources, different evaluation strategies have been proposed. In previous works, we proposed strategies for automatic metadata evaluation calculating metrics [18], [19], using these metrics to support the processes of management repositories [20], and taking advantage of user perception can set the level of LOs quality[21]. In this article is presented a proposal that allows quality evaluation of LOs according to reviews by experts with different profiles. The evaluation is based on a set of metrics to determine the quality of resources and whether they can be published or continue visible to users, or require revisions and corrections.

The proposal supports the peer-review of LOs, similarly to assessing a scientific paper by critical examination of third parties that are experts in the area, and requests a group of experts to review it in order to obtain advice about whether or not the article must be accepted for publishing.

Specifically, this proposal uses MAS in the process of quality evaluation of LOs by experts, taking advantages that allow the disintegration into functional blocks, without losing the systemic point of view, which leads to distributing the solution in diverse entities that require specific knowledge, processing and communication between each other.

The architecture presented in Fig 1 is proposed from the analysis and design made of MAS, where are the agents that interact within the system and the communication established among them. The system manages the evaluation process, which begins

with the registration of each repository. The LOR administrator must select the metrics to be used, the weights for each metric, and the update mechanism of the information of the LOs. After the process of building the profile of experts is done, and using this information, a set of LOs is assigned to the experts for them to evaluate. Finally, using the answers given by the experts, metrics that will define the level of overall compliance with the quality indicators are calculated.

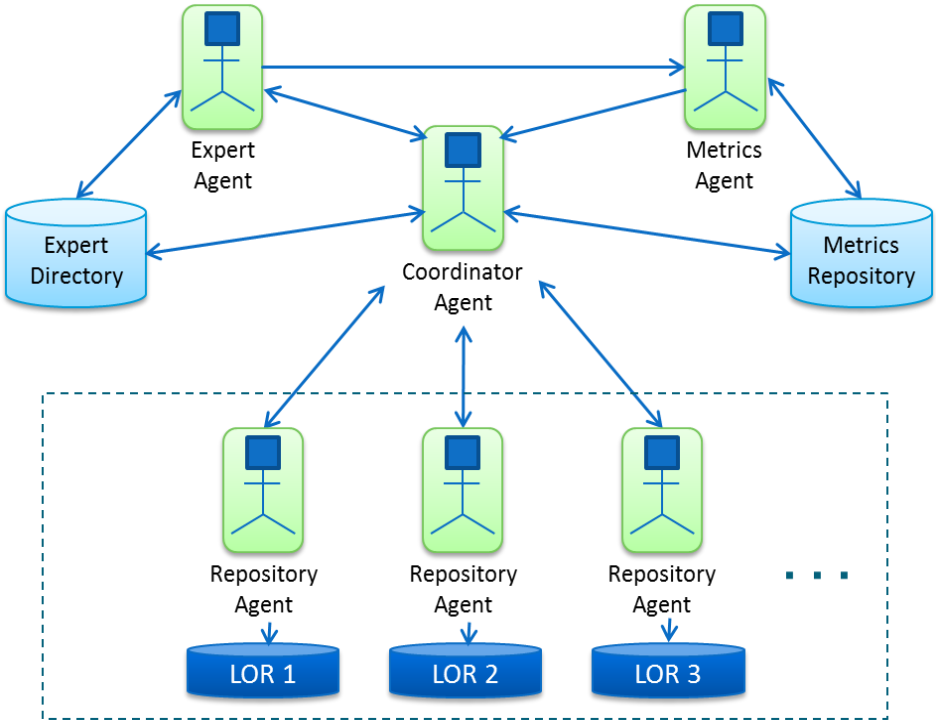

Fig. 1. Multi-agent System Architecture Diagram

Repository Agent: This agent knows all the information associated with the repository to provide LOs to be evaluated and represents the LOR within the system. This agent is in charge of the initial configuration of the evaluation process, defining what metrics will be used to evaluate the LOs and their respective weights. This agent will also define the communication mechanism between the system and the LOR. They must continually update the metadata of LOs to be evaluated, so update mechanisms are available through the OAI-PMH protocol or XML files. Each Repository Agent sends this information to the Coordinator Agent.

Expert Agent: An expert is a person who has a set of skills and a level of experience that allows performing analysis of LOs and making judgments about them. The evaluation process should be realized confidentially, objectively and consensually. As not all experts have the same degree of expertise and knowledge, a process of defining the

profile for each expert is performed. This process is based on information requested through questions to identify characteristics of each expert.

The dimensions and information sets in which the profile is based are presented below:

Personal Information: This is the basic information of the expert; it is used to identify and locate the expert. ***Preferences Information:*** In this part, the expert must specify topics and areas of academic and research interest. This information allows an association between the themes of LOs and the expert. ***Educational Dimension:*** This dimension allows identifying the level of expertise on issues related to the teaching-learning process. This experience allows the expert to analyze whether the material actually has an educational orientation, it is well constructed pedagogically and is of interest to prospective students. ***Content Dimension:*** The expert is asked their level of education, field of education and interest to establish the possibility of analyzing thematic and disciplinary aspects. ***Aesthetic Dimension:*** **It** defines whether the expert has training related to aspects of visual design. ***Functional Dimension:*** **It** determines whether the expert is familiar with technical aspects related with performance, availability and access of LOs. ***Metadata Dimension:*** Due to the great importance of metadata, it is necessary to determine knowledge about appropriate use of metadata and standards-compliance. ***Relation Information:*** To ensure that the evaluation process is objective, this information allows determining whether the expert is part of a group of managers of a specific LOR, thus preventing the allocation process to deliver LOs from this repository. ***Experience Information:*** This information is updated as the expert interacts with the system, as having a history of evaluations made is essential in the process of resource allocation.

When an expert is registered in the system, several questions for each dimension are carried out. The answers are processed by the agent to determine a Level of Expertise (LE) of each dimension. These numeric values are used in the metrics calculation. All expert profile information is stored in the Experts Directory, which will be consulted by the Coordinator Agent for assigning LOs evaluated. This Agent also receives assignment news and is responsible for returning response of acceptance or rejection. He also handles the subsequent capture of evaluations provided by human experts and provide this information to the Metrics Agent.

Metrics Agent: This agent is responsible for calculating the metrics to determine the quality of each LO. An assessment instrument with questions that can determine the level of compliance with desirable characteristics of LOs is proposed. For processing the answers given by the expert a set of 8 metric which belong to one of the dimensions are defined. These metrics are defined based on the review of the state of art and previous work experience. These are presented in Table 1.

Table 1. Metrics Description

Dimension	Metric	Description
Educational	**Potential Effectiveness**	It determines the level of validity that can have an OA as a tool for teaching and learning.
Content	**Relevance and Rigor**	It analyzes whether the LO has problems with content that may confuse the student or any discriminatory information is presented.
Aesthetic	**Visual Design**	It evaluates that the resource presents an appearance that does not interfere with the learning process and comes to potentiate this.
Functional	**Reusability**	It determines whether it can be used in different contexts, analyzing whether it may be independent or requires changes to be reused.
	Facility of Use	It analyzes whether the presentation of the contents is given so that students can navigate it intuitively.
	Facility of Access	It defines the facility to open and use the LO, or if it requires specialized software for viewing.
Metadata	**Completeness**	It analyzes whether the metadata have valid values and the information presented is sufficient to understand the content of the object.
	Precision	A comparison is made to determine whether the metadata describes the associated content accurately.

A questionnaire with questions related to each metric is presented to each expert. The answers given by the experts and Expertise Levels (LE) defined in the profiles correspond to a numeric value between 0-5 and 1-5 respectively. An equation is usued to calculate each metric (1), where: n is the number of questions associated with the metric, k is the number of responses to question i, E_{ij} is the answer to the question i given by the expert j, and LE_j is the level of expertise in the dimension associated to the expert's profile j. After the metrics are calculated, they are stored in the Repository Metrics, which are reviewed by the Coordinator Agent.

$$Metric = \left(\sum_{i=1}^{n} \frac{\sum_{j=1}^{k} (E_{ij} \times LE_j)}{\sum_{j=1}^{k} LE_j} \right) \quad (1)$$

Coordinator Agent: This is the agent responsible for making major decisions in the process of evaluation by experts. It is the agent with greater responsibilities within the system. The Coordinator Agent receives information from the Repository Agent related

to the LOs to be evaluated and the metrics to be calculated, that are of interest by the LOR administrator. One of the main roles of this agent is the process of assigning LOs to be evaluated by each expert. This behavior is based on Expert System that executes rules from associated experts profile information and LO metadata to be assigned.

In the Expert System, the role of Coordinator Agent has the following guidelines or rules:

1. Discarding experts who have some relationship with the repository that owns the LO.
2. Performing a comparison of similarity between the themes selected for the expert (Preferences Information) and title, description and keywords fields. These values are arranged in descending order and 6 with a higher similarity are selected.
3. The Ranking experts selected according to the amount of LOs evaluated (Experience Information).
4. Executing rules to compare the LE of the three experts with more experience and the three with less experience. The goal is to select the two experts (one from each sub-group) with higher LE in different dimensions.

If the execution of the rules of paragraph 4 do not generate difference between the experts, it is proceeded to conflict with a resolution algorithm inference engine. The strategy is to select those experts in each sub-group having the highest level of similarity to the object. If this value coincides with experts who have already evaluated some objects of that repository, and if ultimately there is no difference, they are selected randomly.

After selecting the experts to assign the LO, the Coordinator Agent sends the Expert Agent a notification that needs to be answered by indicating that the expert accepts the evaluation of the resource. Once the experts have performed the evaluation of LOs and the Metric Agent has calculated the values of the metrics, the Coordinator Agent calculates a final value for each LO following the equation (2). where: n is the number of experts that evaluated this LO, k is the number of metrics evaluated by expert i, M_j is the metric value j by expert i, and W_j is the weigh by metric j.

$$LO\_Index = \sum_{i=1}^{n} \left(\sum_{j=1}^{k} (M_j * W_j) \right) \Big/ n \qquad (2)$$

The Coordinator Agent is responsible for analyzing whether the allocation of an expert is needed to make a new evaluation of LOs. If the LO gets a weight equal to or greater than 4 points, it means that the resource is approved for publication, if the result is between 3 and 3.9 a new evaluator is assigned and if the weight is less than or equal to 2.9, it is reported that the LO must go through a process of improvement and is not suitable for publication.

Repository, Expert an Metrics Agents are mainly used by the possibility that the tasks may have to be divided into functional blocks, while the coordinator agent uses an expert system based on rules for the process of decision making regarding the allocation of experts for each LO.

5 Experimental Work

The proposed MAS was implemented using the JADE platform (Java Agent Development Framework). The experimental work aims to validate the possibility of implementation and use of the system, and this is not directed to evaluate system performance.

A case study was conducted in which the proposed model was used to evaluate 46 LOs of FROAC for issues related to software, algorithm, and system audit. FROAC is a model used in Colombia for the establishment of a set of LORs that allow sharing these resources through the definition of policies, methodological foundations and processes of construction and administration of LOs [22].

For this case study, the work was carried out with a group of 15 experts, professors and postgradu-ate students of the Universidad Nacional de Colombia-Sede Manizales. This group had specific expertise in the subject of LOs, in the area of education, and in issues related to metadata and functionality of LOs. The allocation process was done following the rules of the Coordinator Agent and, on average, each expert reviewed 6 LOs. The results of the evaluation process are shown in Fig. 2.

As observed in Fig 2, it was possible through the proposed system to establish what resources met the conditions defined and may be published, the resources that needed substantial changes were rejected and the objects that required placement in a new expert's area to enrich the results of the evaluation. The figure above shows the average score for each object and the graph below shows the summary; in our case, 43% approved, 22% rejected, and 35% for review .

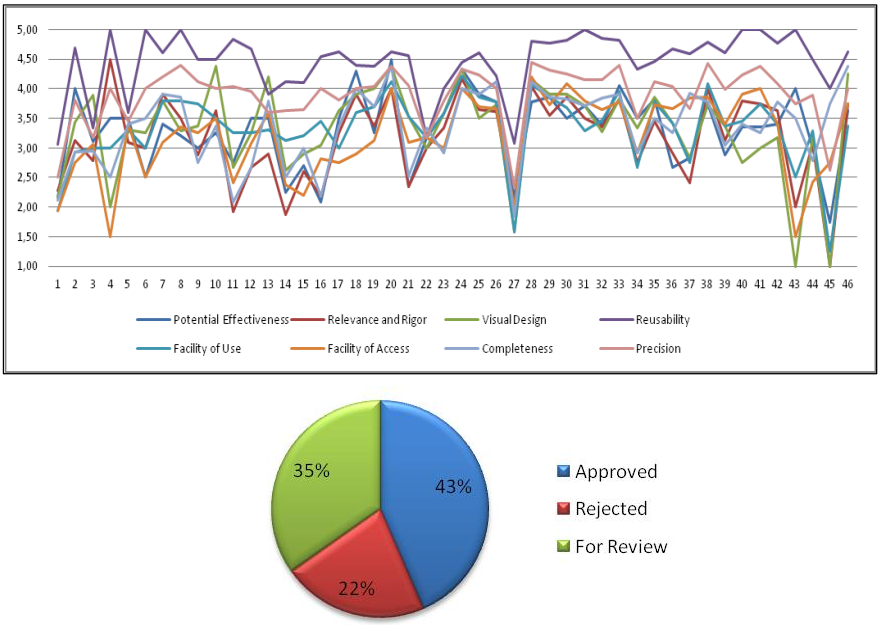

Fig. 2. Results of the case study

6 Conclusions and Future Work

The main purpose of this paper is to introduce our research for the evaluation process of LOs from the vision of the expert, as well as the modeling by means of MAS.

Our approach includes the definition of the expert profiles, the selection of experts for an specific LO to evaluate, the definition of our metrics for diverse dimensions and the integration of values calculated in the assessment of each LO.

An expert system is proposed for the automatic selection of experts to evaluate the different objects. The rules and inferences are related to their level of expertise and previous work performed. Other tools allow manual assignment of experts for evaluation, which would mean extra work for Repository Managers.

The development of a dimensional model and MAS approach allows organizing the assessment, conditionally determining the assigning of the experts and calculating the metrics independently and obtaining the result for each learning object. This proposal is versatile, as it is possible to determine what metrics are evaluated, as well as to add new ones.

Currently, our research interest is focused on some of the different open issues identified in our research: Integration of previous works in evaluation of Learning Objects in a single model, validation of the metrics proposed and the improved process of assigning LOs to experts. We also hope expects to make a full assessment of system performance.

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