QUALITY EVALUATION MODEL FOR LEARNING OBJECTS FROM PEDAGOGICAL PERSPECTIVE. A CASE OF STUDY

Y. Eguigure[1], A. Zapata [2], V. Menendez[3], M. Prieto[3]

[1] Universidad Pedagógica Nacional "Francisco Morazán" (Honduras)
[2] Universidad Autónoma de Yucatán (México)
[3] Universidad de Castilla-La Mancha (España)
yeguigure@upnfm.edu.hn, zgonzal@uady.mx, mdoming@uady.mx, manuel.prieto@uclm.es

Abstract

In modern e-learning, Learning Objects Management Systems (LOMS) are a new key piece for the interchange of resources. LOMS are repositories specialized in search and recovery of learning objects (LO). LO is a particular instructional resource that can be used as basic unit of information and interchange between e-learning applications. However, quality in LO is a problematic present in many of LOMS management activities. In this work a Quality Evaluation Model for Learning Objects (MECOA, from a Spanish acronym that means it) is presented. MECOA proposes a model to evaluate the learning objects from a pedagogical perspective, using indicators collections grouped in six categories and it defines a linguistic label set for each one of indicators. An instrument for MECOA was implemented into an own LOMS called AGORA (from a Spanish acronym that means Help for the Management of Reusable Learning Objects). The obtained data is source of important pedagogical information, especially in the learning object management process; due that, this quality evaluation information is added to the metadata of the object and could be retrieved along with the OA within LOMS. As example of this, a rule set was obtained by means a knowledge extraction methodology. The generated rules are IF-THEN type and can be used for improvement some learning object related task like search, tagging and sequencing from recommending perspective.

Keywords: Learning Objects, Data Mining, knowledge extraction, Quality

1. Introduction

The determination of the quality of learning objects is a major challenge for the different actors in the process of teaching and learning. Currently, there are thousands of repositories and learning objects on various subjects available on the network. However, the quality of these resources varies and their selection may not be an easy task.

In this sense, there are many studies and proposal about Learning Objects Quality as LORI [1,2], it defines rating scale and rubrics for items grouped in nine areas: content quality, learning goal alignment, feedback and adaptation, motivation, presentation design, interaction usability, accessibility, reusability, standards compliance or ACOAM-LOM [3,4] that extends the IEEE-LOM standard and includes new elements as ergonomic and aesthetic.

To achieve the establishment of a mechanism for granting a measure of quality for a learning object, we propose a Model for Quality Evaluation of Learning Objects (MECOA), which can be applied perspective of different actors teaching and learning process. The mechanism proposed on the model may be an additional element of a learning object repository where users not only obtain or supply the metadata of the object but also that the user can, from their position of teacher, student, specialist or teacher, evaluate the quality of the learning object form a pedagogical perspective.

In this case, the repository stores information on the quality of teaching provided with the object of both his recovery and eventual reuse. Therefore, the proposed mechanism offers evaluate educational value of the resources stored, from a series of educational criteria present in the LO and from the perspective of various actors in the educational process. Considering the premise that human beings do when evaluating the qualitatively and not quantitatively.

The challenge plans this mechanism is the use of fuzzy logic to establish the valuation of quality traits in the MECOA.

The structure of the article is described next, initiating with a description of the MECOA's characteristics, specially the indicators on the pedagogical quality. In the section 3, AGORA project is presented, a Learning Objects Management System oriented to instructional design of learning objects using recommending; the model's implementation is shown in this section. In the section 4, a case of use for knowledge discovery using MECOA is presented, that's includes the methodology's description and results gained. The conclusion and future works are presented in the section 5.

2. Quality Evaluation Model for Learning Objects (MECOA)

On the Web there area a big amount of learning objects and repositories for LOs, some they are well designed or developed and there are many standards proposed to assure the quality process while they area built. In the literature it is common to find information and standards regarding to regulations and methodologies on how to design LO of quality. The quality of the learning objects is a topic that it has been defined in many researches.

To achieve the establishment of a mechanism for granting a measure of quality for a learning object some iberoamerican institution on the context of a cooperation program called A8172 "Methodology and tools for quality assessment of e-learning resources for teachers in training." as a result of the collaborative activities it had been established a product named MECOA which stands for Quality Evaluation Model of Learning Object. The aim of the model is to define a set of indicators to evaluate the quality of learning objects from a pedagogical perspective. The MECOA is designed by taking as its starting point the following processes [5]:

- Recognition of the needs and the corresponding capabilities of the teachers education characterized by a predominance of discipline, in which there is a predominance of teaching assignments in impairment of learning and a marked resistance to curricular changes and little or nonexistent training in the use of communications technology, resources and information.

- The definition of pedagogical principles or values of teacher training. This axiological dimension identifies four pedagogical principles that are set to cross in the formulation of indicators. These values include self-management, creativity, meaning and participation. From this perspective we consider the competition principle and property of subjects for which elements will be subject at the time of building the evaluation model.

- The definition of dimensions and features of the e-learning resources. These are defined considering the above processes and evaluated from the perspective structure, competence and status process.

- Integration of a scheme of measurement and indicators of learning resources with their corresponding e-learning features.

MECOA is conceived as a methodological proposal for the construction of quality indicators for quality evaluation of LOs from a pedagogical perspective that includes six indicators: content, performance, competition, self-management, meaning and creativity contained in the object. Each of these indicators is itself made up of a number of features, which can be evaluated by four actors: teacher, student, teacher or expert depending on the domain and domain-level aspect of assessing LO.

Even though it is difficult to generate an integrated proposal for evaluating the quality of such resources, defining features of the above processes and the definition of features that can automatically or through an interaction be established by one or more teachers with the aim of establishing a measure in the evaluation process of the LO from a pedagogical perspective.

These indicators have different application aspects, and specialists who can evaluate a type of test to determine a more specialized field in which the resources might complete a pedagogical and educational function. This measure could allow educators to define the quality of teaching resources in the school where they are made or used.

Fig. 1 shows an outline of articulation of indicators of model quality assessment of OA. The model includes the combination of six indicators, which can articulate manner to evaluate objects available in any Learning Object Repository, particularly as it is applied in another attribute AGORA platform [13]. Each indicator has features which characteristics are defined through a set of linguistic labels, so that it is possible to obtain a valuation for its educational potential of the object [7].
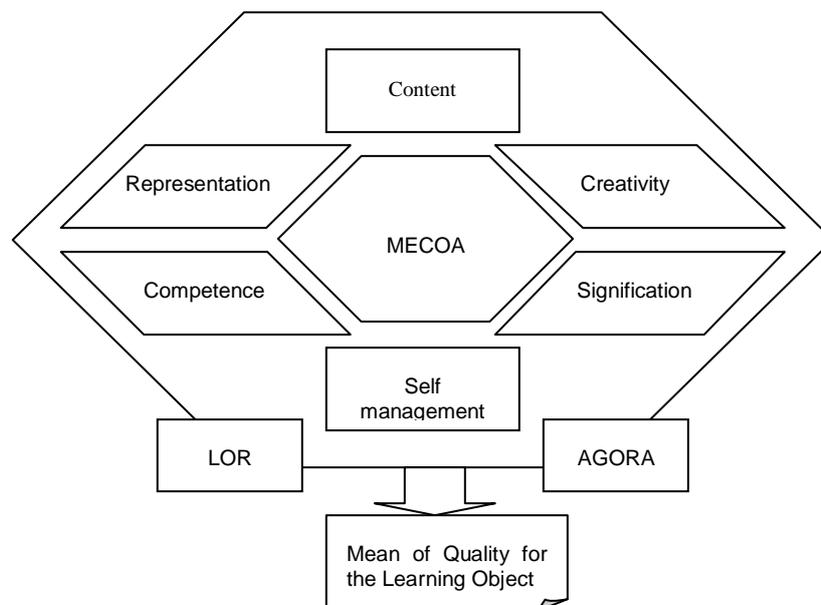

Fig. 1. General composition and interaction of the MECOA

The model presented is oriented to define a measure of quality to determine the degree of membership found that certain characteristic that are "identified with a linguistic label", has with respect to a particular feature. The operative model promotes a strategy oriented to enable the four identified users (learners, teachers, expert and pedagogues), to establish the educational potential of learning object. This information will be incorporated within the metadata of the LO at the time of storage in a repository, or may be available as a recommendation to the teacher when choosing a LO in the construction of a course.

2.1. Indicators on the Pedagogical Quality of MECOA

The quality of the learning objects includes a set of observable and desirable characteristics that could be established [6]; i.e., speaks about metadata in learning objects have. The metadata could be defined as the quantity of information that could be defined within the object. If there is a little or non-existing metadata about those resources, it is almost impossible to think on task such as seeking, recovering or utilization of these. The efforts

done toward the standardization for metadata on learning objects are oriented to determine if the task such as seek or recover could be possible and easy [7].

The model states that the indicators defined should be taken on count once the object is uploaded or recovered form the LO repository as a part of the metadata. The main purpose is that the quality evaluation of the object itself is stored on the metadata of the learning object. For this model there had been defined linguistic labels for a fuzzy set that are presented but they have not been implemented on the actual case of study. Additionally, it is possible identify the potential actors that could participate in the evaluation process as well as the kind of scope in which the feature is pertinent t which area not detailed in this document because it is out of this case of study. In the same way, each of the indicators and features are described on the following [7].

A. Content

The content indicator includes information related to the learning objective of the LO, the typology of the content, the balance among the communication means used on the design process of the object, the quality of the information, the actuality of the information and the support of the bibliographical reference as elements to acquire certain competence. Table 1 shows the main features, definition and some recommendations about the way they might be evaluated.

Table 1. Features of the Content indicator

Feature	Definition	How to evaluate it
Information about the objective	Level of specification of the level of assessment on learning terms of the execution objective	Does the interface contains explicitly references of the competence toward is oriented?
Typology	The content could be made by concepts or exercises of procedures or show attitudes.	Does the interface include the type of content that will be developed?
Mass media balance	The use of different languages: graphic, visual, audio, animation, schematic, is what gives the media diversification and expressive.	Is it a balance between the number and arrangement of means in the object?
Learning objective	Makes explicit the purpose of the object in terms of type and level of the learning to be achieved.	Is there correspondence between the object and the activities to be developed?
Information quality	Visible qualities on the information for their further valuation	Is it consistent information within the object?
Timeliness of information	Relevance of information due to its actuality	Is it updated the information presented in the object?
References	Makes explicit the sources en bibliographical references	What is the level of detail of the bibliographic sources?

B. Representation

The representation indicator includes features such as the interrelationship among components as elements of a unit, iconicity in the concretion level of representation of the LO, the object shape indicating its appreciation and aesthetic achievement. Table 2 presents the details for how to define and evaluate each feature.

Table 2. Features of the Representation indicator

Feature	Definition	How to evaluate it
Articulation components	Integration of the different elements of the object in a unit.	In which manner are elements integrated on the object?
Iconicity	Grade on which the object achieves the appearance of real object by the realization of its essential attributes.	How much closeness or relationships do exist between representation and the nature of the object?
Form	Ease of recognition of the represented object and aesthetic achievement	What are the characteristics that define the abstraction represented in the object?

C. Competence

The indicator named Competition includes among other features level of achievement or difficulty for a particular competition, the outcome of competition is achieved in order to exercise the cognitive process of the learning process with the object and contributes to pedagogical mediation can be achieved in the interaction with the object. The table below (Table 3) shows the features; a definition and questions about the way of evaluate them.

Table 3. Features of the Content indicator

Feature	Definition	How to evaluate it
Level of achievement	Difficulty level that the object have for the kina of competence that the LO promote	Graduation of the learning shown as the objective is being accomplished?
Results	Predominant attribute that it LO contribute to acquire the competence.	To which predominant attribute contribute this LO?
Cognitive process	Type of process o r dimension of learning toward	In which grade the competence had been acquired?
Development of competence on pedagogical	Offer exercises that allow the development of the vision and capability of mediation in learning situations.	What kind of activities could evidence the mediation strategy?

D. Self management

The self management as one of the indicators of the model, includes as a part of its features the security as the feeling of satisfaction of a subject that surf in the object; as well as, the possibility of generate a initiative on the learner achievement who interact with the object. Table 4 shows the corresponding detail on the self management indicator.

Table 4. Features of the Self management indicator

Feature	Definition	How to evaluate it
Security	Feeling of the user when interact to an LO results form the easy navigation and clever instructions.	Are the instructions clear and navigation easily within the object?
Initiative	Components of the resource lead different levels of learner initiative	In what way the design offers the learner control?

E. Signification

Within MECOA, the indicator called the significance is determined by several features such as motivation and problem definition as a cognitive conflict that motivates the user to learn, the existence of a recognizable conceptual structure of the way information is organized within the object, generalization evidenced by the possibility that the object present situations that are transferable to other situations, the cognitive challenge as the presentation of a graduation of tasks based on student needs. The table 5 below presents in detail the way in which the features are suggested to evaluate the linguistic labels defined on each possible evaluation and evaluator.

Table 5. Features of the Signification indicator

Feature	Definition	How to evaluate it
Motivation	The initial interrogation allow the user to identify his scares or unknowledgeable and motivate him to learn.	Are the questions provocative or motivational?
Recognizable conceptual structure	The LO includes a map or any kind of conceptual organizer that show the object structure on terms of the information organization that contains it..	Is there any conceptual organizer specified on the object?
Generalization	The goal gives the examples and/or application cases that enable the concept/ideas transference to a variety of situations.	How is the knowledge transference being done?
Cognitive challenge	The resource contains a increasing difficult degree and/or need adaptabilities that the user could establish.	Are the objective defined on the way that they could be achieved and theirs level of complexity is also included?

F. Creativy

The sixth indicator defined in the MECOA is the creativity. This indicator is evidenced by features such as self-knowledge as the existence of elements within the object tot enables the individual to learn to recognize their interests and potentials. In this indicator, it is also show, the feature of choice among alternatives in solving problem that arise within the LO. Table 6 shows the definition of the features and ways to evaluate the throughout the model proposed.

Table 6. Features of the Creativity indicator

Feature	Definition	How to evaluate it
Self-knowledge	The resource contains activities and tools for the user to recognize their own interests and potential.	Which actions could be defined to achieve the self-knowledge?
Choice among alternatives on solving problems	Level on which the resource makes troubleshooting, allowing the choice of alternatives.	What could be done to answer to a problem?

The indicators and their corresponding features had been broadly defined in terms of educational aspects; however, for evaluation within an LO linguistic labels have been defined that will be measured by fuzzy arithmetic. So, the quality evaluation establishes that within the parameters based on which they are valued the degree of pertinence of a particular tag within a feature set for any of the indicators.

Given the importance of the process of interaction between the teacher who does an object or that he recovers and the repository should allow a way to interact with the attendant evaluation according to their role in the valuation process of LO (as a pedagogue, teacher, expert or learner) to determine how it's going to qualify each of the features and how these will be presented to the assessor once the evaluation process [7].

An important aspect to take into account when making an evaluation of the quality of the LOs, is the selection of weighting criteria, since they must be issued in a range that reflects the quality within an objective scale which in our case is unclear. Considering the evaluation criteria can turn the meaning of it, towards what you want to know about the object. Due that they seek to determine what are features from a pedagogical view on purely quantitative evaluation is not a possibility because such valuations are not possible to assess the quality of a certain material. Therefore, looking to make a subjective assessment of qualitative aspects in the assessment of the features of each indicator is done by linguistic labels for establishing the degree of membership to each of the labels that make a particular feature. That is why the collection mechanisms for assessment measures of the object considered a series of questions to assign a measure, in this case diffuse the LO to undergo an evaluation of quality. For the case of study using AGORA it is had been defined to use discrete evaluation in order to define a quality measure for an object learning. Since the implantation of the MECOA in AGORA using discrete tags gives important pedagogical information, it is possible to obtain even more detailed information on the fuzzy tags implementation.

Achieving the appropriation process model is not spontaneous or automatic which requires the development of various activities to the socialization of the indicators and features, as well as daily use in the preparation and documentation of the LOs. This is what trough the implementation through AGORA we are pretending to achieve [5].

3. AGORA Platform

As consequence of the current importance for e-learning, repositories that motivate collect, access and interchange of educational resources are required. A Learning Object Repository is a repository specialized in storage, management, classification, search and recovery of this type of digital contents [14]. It offers flexible mechanisms for metadata and resources access that are part of LO. It allows the development of solutions that integrate LO to architectures and e-Learning systems existing.

3.1. Description and Architecture

The platform AGORA (Help for Managing Reusable Learning Objects in spanish) is a proposed management system, specializing in construction and reuse of Learning Objects [13]. It is a project involving several institutions in Latin America.

AGORA is an integrated environment that provides recommendations to the teacher in the task of developing a quality instructional resource. For these, the project considers factors such as instructional design, knowledge management, the teacher profiles, action history.

AGORA provides an environment where all activities and tasks associated with management of the learning objects are interconnected, thus facilitating its monitoring and enforcement. Doing so has created a set of technological principles for the design of the project:

- Implement a software architecture based on layers that is independent of the platform, the storage format and use.

- Use standards and protocols accepted by the educational community as SCORM 2004 and IEEE-LOM.

- Develop a service-based interface and communication standards that allow interoperability with other applications (Web Services, REST, AJAX, etc.).

- Generate a distributed storage model of Learning Objects.

- Develop a component model and extensions for easy scalability.

- Design a flexible representation of knowledge to implement rules, conditions, parameters.

The model considers construction, recovering and storing of information and rules concerning Instructional Design using learning objects. The architecture contains five elements (Fig. 1), each one specialized in part of the process.
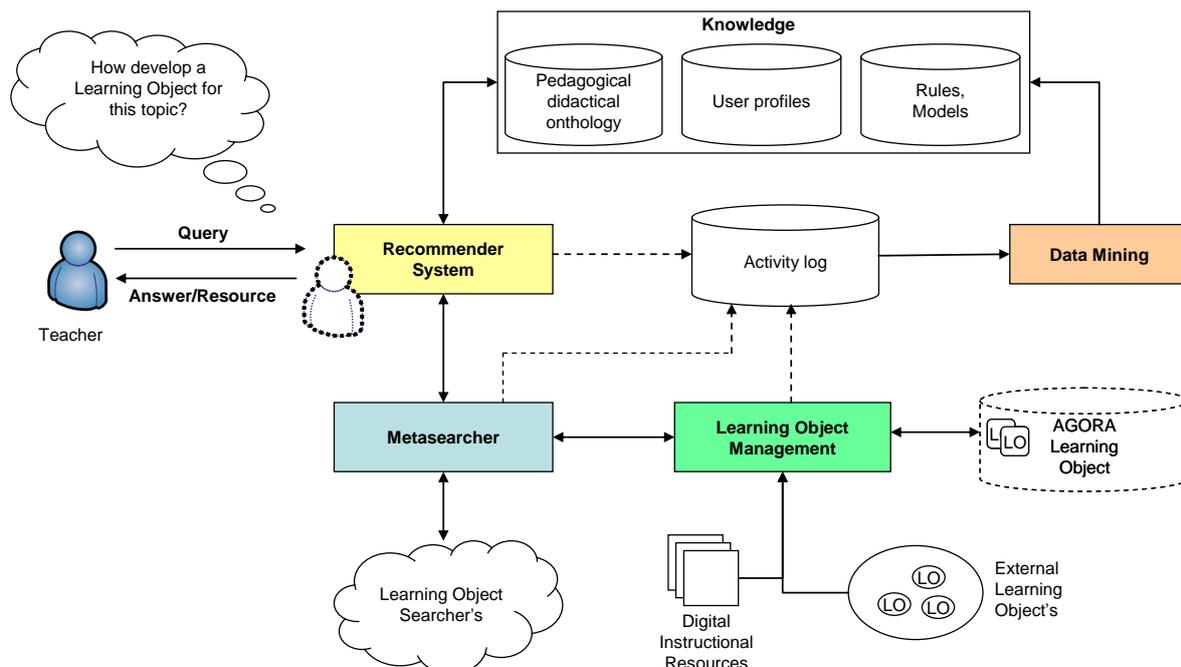
Fig. 2. General composition and interaction of the MECOA

AGORA proposes the use of an Instructional Design ontology that represents the knowledge that is needed for the correct application of Instructional Design methods. This information is used for search and recommending more adequate Learning Objects for declared specific learning objectives. All actions of users into AGORA are stored in activity log for a subsequent analysis using data mining and extract new knowledge that improves rules, profiles and ontologies.

3.2. Implementing MECOA in AGORA

In the platform, the Learning Object Management Module is the element responsible for the incorporation, transformation, storage and recovery of Learning Objects for AGORA. The users have a workspace where they can interact with others using communication tools (forum, instant messaging, mail). This area has tools for create learning objects, edit its metadata in a manual or assisted way (Fig. 3a.), includes a searcher for users and learning objects.

The MECOA was implemented in this area as an additional tool available for any person (AGORA's user or not). For any learning resource published in AGORA, a quest is available

for evaluate it using a simplified version of MECOA dimensions (Fig. 3b). Any user can express his opinion about any Learning Object and see the results of all evaluations, they can write comments and suggestion about use and improvements of a Learning Object.

Fig 3. (A) AGORA's user workspace. (B) MECOA's quest

4. Knowledge Extraction from the Quality Assessment

In this section we present how the responses of the MECOA-based tool described were used as an information source into a methodology for extracting knowledge from digital resources for learning [8].

4.1. Collect data

The information used for the study is obtained from the AGORA platform log files. In AGORA, teachers evaluate the Learning Objects. Examples of the values recorded into the system are media balance, initiative, typology, cognitive process etc. All these data are a rich source of knowledge about recommendations, preferences and teachers opinions about a LO.

4.2. Preprocess the Data

It is important to adapt data during preprocessing stage, considering the nature of the available information about Learning Objects. This contains major differences of this method with regard to preceding ones.

The details of all four preprocessing activities and our tests are here presented:

- *Select data*, for the study we used data obtained from a set sample of 400 Learning Objects assessments from a total of 1100 stored objects. These objects were published in the AGORA platform by 80 teachers of public and private universities of Mexico. Learning Objects were selected taking in consideration their biggest amount of attribute data available.

- *Create summarization tables*, for the quality evaluation table, the attributes were based on the MECOA quality assessment method, including indicators for LOs evaluation from a pedagogic perspective and some computational attributes not included in metadata.

- *Data discretization*, in the instrument based from MECOA, their values are labeling by default. These labels facilitate the field edition. They also help in the later interpretation of results.

4.3. Data Transformation

Data table it's transformed into dataset, which were exported to ARFF format (Attribute-Relation File Format), allowing a best portability for the application of Data Mining algorithms. These data are now described in detail:

For the dataset, the information generated from LO evaluations was used. For this set, 15 attributes were established; all of them based in the MECOA model and 400 LO instances.

4.4. Apply Data Mining and Interpret Results

For this stage, we used WEKA [9] (Waikato Environment for Knowledge) that provides Data Mining algorithms for classification and association. In this section, for each algorithm used in the study, the test characteristic and results obtained are shown. These results can be presented by the form of tables.

A. Classification Algorithms

This is achieved using ID3 [10] (Induction Decision Trees) and J48 [11] algorithms. These tests are intended to verify the effectiveness in the classification rules generation from both systems and thus provide corroboration if rules are similar.

Various tests were verified with ID3 and J48 algorithms with the already mentioned datasets. two attributes were selected as classification elements:

- Media balance, whose labels are: null, deficient, regular, adequate, saturated
- Result, whose labels are: knowledge, skills, attitudes, values, mixed

We obtain a set of IF-THEN-ELSE rules from the algorithms. After an analysis, we eliminate those rules that were with irrelevant information. The table 7 and table 8 show some of the best rules obtained for each algorithm used.

Table 7. Some of the best rules obtained with the ID3 algorithm

Considering the Media balance as classification attribute	
Rule-generated	Rule interpretation
initiative = navigation path; joint components = sequenced; problematic = introduction to problem => regular	The LO has a *regular media balance* if it does fulfill the next requirements: the design allows the navigational path, their components are integrated and contain the introduction to a problematic.
initiative = programmed answers; result = skills; conceptual structure = graph => adequate	The LO has an *adequate media balance* if it does fulfill the next requirements: the design allows the programmed answers, contains exercises and graphs.
knowledge transfer = examples; conceptual structure = none; result = knowledge; typology = conceptual; joint components = sequenced => adequate	The LO has an *adequate media balance* if it does fulfill the next requirements: the knowledge transfer is given by means of examples and contains a structure based on concepts sequenced.

Table 8. Some of the best rules obtained with the J48 algorithm

Considering the Media balance as classification attribute	
Rule-generated	Rule interpretation
cognitive process = processing; self-knowledge = proposes challenges; typology = concept => mixed (10.0/1.0)	The LO has *knowledge and skills transfer* if it does fulfill the next requirements: preprocessed information, proposes challenges and contains concepts.
cognitive process = processing; typology = concept => knowledge (17.0/6.0)	The LO has *knowledge transfer* if it does fulfill the next requirements: preprocessed information and contains concepts.
cognitive process = processing; typology = processes => skills (14.0/4.0)	The LO has a *skill transfer* if it does fulfill the next requirements: preprocessed information and contains processes.

B. Association Algorithms

For the association rules generation we have executed the A priori [12] algorithm. For this algorithm, we determined the generation of 100 rules, which have a minimum support of 0.3 and minimum confidence of 0.9 as parameters.

We obtain a set of IF-THEN rules from the algorithms. After an analysis, we eliminate those rules that were with irrelevant information. The table 9 shows some of the best rules obtained.

Table 9. Some of the best rules obtained with the A Priori algorithm

Considering the A Priori algorithm			
No.	Reliability	Rule-generated	Rule interpretation
37	0.98815	initiative = navigation path; problematic = none => media balance = adequate	If the LO consists of navigation path and not contain problematic then the media balance is adequate.
46	0.98742	joint components = sequenced; problematic =none => media balance = adequate	If the LO consists of sequenced components and not contains problematic then adequate the media balance is.
61	0.98496	cognitive process = access to information; initiative = navigation path; problematic =none => result= Knowledge	If the LO consists of access to information, navigation path and not contain problematic then knowledge transfer.

All this rules can improve many tasks, like edition, creation or search of learning objects. This knowledge can be used to get a better recommendation and suggest values or actions that the user can do.

5. Conclusions

Quality in learning object is a problematic present in many management activities. There are works related to establishment evaluation methods and techniques to define the learning object quality. Many of these works are focused to technological features leave out the didactic point of view for the learning objects.

In this work a Quality Evaluation Model for Learning Objects (MECOA, from a Spanish acronym that means it) is presented. The MECOA is a collaboration product between some Iberoamerican institutions. Its goal is to define a proposed evaluation for learning objects from a pedagogical perspective. MECOA uses indicators collections grouped in six categories: content, representations, competence, self- management, signification and creativity. MECOA defines a linguistic label set for each one of indicators.

An instrument for evaluation was designed to implement MECOA. This instrument is easy to answering for learning object evaluators. The obtained test was incorporated into AGORA platform. This LOMS offers services to recommendation and assistance for facilitate the learning object development.

The information generated from the instrument was integrated with others information sources and applied it data mining techniques. The results obtained offers new knowledge about learning object's characteristics that can be used to improve many management task for instructional design.

Acknowledgements

References

[1] Elera, **About LORI 1.5.** http://elera.net/eLera/Home/About%20%20LORI/. Last access may 2009

[2] Akapinar, Y. 2008. **Validation of a Learning Object Review Instrument: Relationship between Ratings of Learning Objects and Actual Learning Outcomes**. Interdisciplinary Journal of E-Learning and Learning Objects, 4, 291-302. Retrieved from http://ijklo.org/Volume4/IJELLOv4p291-302Akpinar.pdf

[3] Velásquez, C., Muñoz, J., Álvarez, F. 2007. **Aspectos de la Calidad de objetos de aprendizaje en el Metadato de LOM**. Virtual Educa, Brasil. Retrieved from http://ihm.ccadet.unam.mx/virtualeduca2007/pdf/214-CVA.pdf

[4] Ruiz, R., et al. 2006. **Formato para la Determinación de la calidad en los objetos de aprendizaje**. Consultado en Julio. Conferencia Latinoamericana de Objetos de Aprendizaje (LACLO) 2006.

[5] Eguigure, Y., Prieto, M. 2009. **Evaluación de la Calidad Pedagógica de OAs utilizando Etiquetas Lingüísticas Difusas. Recursos Digitales para el Aprendizaje**. Prieto, M.E., Sanchez-Alonso, S., Pech, S., Ochoa, X. S. Editorial UADY, México. ISBN 9876077573173

[6] Vidal, C., Segura, A., Prieto, M. 2008. **Calidad en Objetos de Aprendizaje**. V Simposio Pluridisciplinar sobre Diseño y Evaluación de Contenidos Educativos Reutilizables, SPEDECE 08. Oct 20, Salamanca, España.

[7] Eguigure, Y. 2008 **MECOA -Evaluación de la Calidad Pedagógica de OAs**. In Proyecto AECI A/8172/07: Metodología y herramientas para la evaluación de la calidad de los recursos para tele-aprendizaje en la formación de profesores, Prieto E. Agencia Española de Cooperación Internacional para el Desarrollo, Rep.Int.

[8] Zapata, A. Menéndez, V., Prieto, M.E. 2009. **Aplicación de Minería de Datos para la extracción de reglas en Objetos de Aprendizaje**. Recursos Digitales para el Aprendizaje. Prieto, M.E., Sanchez-Alonso, S., Pech, S., Ochoa, X. S. Editorial UADY, México. ISBN 9876077573173

[9] Witten, I. H., Frank, E. 2005. **Data mining: Practical machine learning tools and techniques**, New Zealand: Morgan Kaufman Publishers inc.

[10]   Quinlan, J. R. 1986. **Induction to Decision Trees**. Machine Learning, 1(1), p. 81-106

[11]   Ye, P., Baldwin, T. **Semantic Role Labeling of prepositional Phrases**. 2005. The 2nd International Joint Conference on Natural Language Processing, Jeju Island, Korea,. p. 779-791.

[12]   Agarwal, R., Imielinski, T., Swami, A. 1993. **Mining association rules between sets of items in large databases**. Proceedings of the 1993 ACM SIGMOD International conference on management of data, p. 207–216.

[13]   Prieto, M., Menendez, V., Segura, A., Vidal, C. 2008. **A Recommender System Architecture for Instructional Engineering**, in Lecture Notes in Computer Science, S.B. Heidelberg, Editor. p. 314-321.

[14]   ADL. **Emerging and Enabling Technologies for the design of Learning Object Repositories**,   http://xml.coverpages.org/ADLRepositoryTIR.pdf. (acessed April 2009)