Learning Object Recommendations based on Quality and Item Response Theory

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***Abstract* — Nowadays, teachers and students continue to face the problem to find high quality learning objects for learning and teaching. The purpose of this paper is to introduce an innovative approach, which considers Item Response Theory (IRT) for recommending to students or teachers Learning Objects (LOs) of high quality in the context of the Learning Objects Economy, which is a marketplace for sharing and reuse of LOs. Recommendations provide to teachers or students the needed support for finding high quality learning objects taking advantage of the previous quality evaluations carry out by peers. An evaluation of our approach was carried out in a real scenario which allowed us to verify the applicability of the process for generating good recommendations.**

***Index Terms*— Item response theory, learning objects, recommendations.**

I. Introduction

OVER the years, the concept of Learning Objects (LOs) has been thought and re-thought by many diverse and qualified people. The IEEE Learning Technology Standards Committee (LTSC) [1], in its work about the Learning Object Metadata Standard [2], defines a LO as "any object, digital or non-digital, that may be used for learning, education or training". According to Polsani [3], a LO needs to be accessible, reusable and interoperable, but also a LO needs to be wrapped in a learning intention. **

In the academic context, the problem of how to recommend the best LOs to users according to varied criteria becomes relevant. Different metrics that could be indicators for the positive relation between the LOs and users characteristics (relevance) have been seriously studied [4]. However, the quality of the LOs as well as how this quality could be used for generating recommendations of LOs is an issue that looms large. In this sense, relevance could be a good indicator for quality but might be not enough as a quality measure.

The purpose of this paper is to introduce an approach for recommendation of LOs based on definition of quality measures in the context of Learning Objects Repositories (LORs) using the Item Response Theory (IRT) as fundamental. Potential users could be a learner looking for the best LOs for a learning purpose but also a teacher looking for the best LOs to be cloned for offering to his/her students in a particular learning and teaching process.

In section 2, an explanation is provided about what quality is and a model is described for representing a quality evaluation process. Section 3 introduces ITR and presents how IRT is used in order to generate recommendations of LOs. In section 4 an evaluation scenario is described and finally in section 5 some conclusion and future directions are described.

II. Learning Objects Quality

There are many definitions of quality, but in general it is well accepted that quality is referred to as the set of inner properties of a product or service which enables to meet the design specifications [5]. Then, a quality evaluation process is defined as "the systematic examination of the extent to which an entity (part, product, service or organisation) is capable of meeting specified requirements" [6].

Most LOs definitions indicate that a LO consist of least two components: educational resources and metadata. In this manner, the Learning Object Quality is strongly related with the quality of its metadata as well as the associated educational resources [7], e.g. if there is not metadata, some features of the LOs are deficient as its ability to be found. In addition, there are other important aspects of LOs which need to be considered when a quality evaluation takes place, for example, the LOR where the object is stored.

A LOs quality evaluation process needs to be a systematic process which considers the several Components, Dimensions and Categories of evaluation that could be defined in order to cover the complexity of this construct. Based on a literature review [8][9], we can summarize in Figure 1 the main elements of a quality evaluation process of LOs.

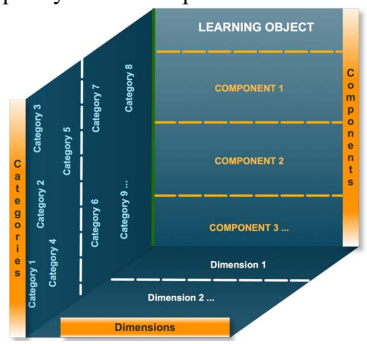

Fig. 1. Quality evaluation process elements

In Figure 1, Components are refereed to constituent elements of the object which should be evaluated, Dimensions indicates the different perspectives from which a LOs should be evaluated and finally the Categories represent the specific quality metrics to from each component according with each dimension.

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III. LEARNING OBJECTS CHARACTERISTIC CURVE

A. Item Response Theory

Item Response Theory (IRT) is a system of models that defines one way of establishing the correspondence between latent variables and their manifestations. IRT is a theory of statistical estimation which use latent characterization of individuals and items as predictors of observed response [10] [11] [12]. In this study, we use IRT in order to establish the correspondence between Learning Object Quality (latent variables) and Evaluation Categories Items (Manifestations) as an indicator for generating recommendations to users in the context of LORs. The most general and accepted IRT model, named IRT Three Parameters Model, is shown in Equation 1:

$$P(\theta) = c_i + (1 - c_i)\frac{e^{1.7a_i(\theta - b_i)}}{1+e^{1.7a_i(\theta - b_i)_p}} \qquad \textbf{(1)}$$

In an assessment process, this model defines the probability a particular item *i* has to be correctly answered given a proficiency level θ using a logistic function. The model assumes that the relation between item performance and ability is given by a logistic function described by one-, two-, or three parameters. Parameter *a*, tells us how the item can discriminate between highly proficient students and less proficient students; parameter *b*, indicates the difficulty level of the item; and parameter *c* indicates how likely the examinees are to obtain the correct answer by guessing.

This paper aims at presenting a quantitative model for quality evaluation of LOs, considering quality as a latent variable which cannot be measured completely in a direct way. In this manner, IRT offers a possibility to measure Learning Object Quality considering indirect measures available about the LOs, and therefore makes it possible to generate recommendations considering these measures.

B. From IRT to Object Quality Theory

Let us consider a set of learning objects LO = {lo_1, lo_2, … lo_m}, a set of users U = {u_1, u_2, u_3, … , u_n} interacting with LOs through a LOR and a Learning Object Quality Matrix Q (U, LO) = {q_{11}, q_{12}, … $q_{n,m}$} which represents the implicit and explicit quality of each LO.

A quality measure of a LO for each different defined category (e.g. Presentation Design, Accessibility, Adaptation Capabilities, Capacity of Reuse, etc.) could be represented in a dichotomous manner. The meaning of *q* depends on the dimensions and categories considered in the quality evaluation process definition, e.g., if Presentation Design exists as a category, for measuring the quality of the design of visual and auditory information, then:

$$q = \begin{cases} 1: \textit{if a user considers the LO has a high quality of Presentation Design} \\ 0: \textit{in other case} \end{cases}$$

Table 2 shows the Perceived Quality per LO (*qlo*) as well as the User Perceived Quality (*qu*) where *qlo* = {qlo_1, qlo_2, …, qlo_m} represents the average of the quality perceived for the users for each LO, and *uq* = {uq_1, uq_2, …, uq_n} represents the average perceived quality of each user for the complete set of considered LOs.

TABLE 1. INFERRING QLO AND UQ

	lo_1	lo_2	…	lo_m	uq
u_1	$q_{1,1}$=1 or 0	$q_{1,2}$=1 or 0			uq_1
…					uq_3
u_n	$q_{n,1}$=1 or 0	$q_{n,2}$=1 or 0		$q_{n,m}$=1 or 0	uq_n
qlo	loa_1	loa_2		loa_m	

C. LO probability to be high quality perceived

The *uq* over the general set of LOs as well as the *qlo* for a set of users permits us to define the probability of a particular LO to be perceived as high quality by a specific user given a specific *uq*. Using the logistic function presented previously (Equation 1), which corresponds with the IRT One Parameter model when c=0, this probability is defined as:

$$P(uq) = \frac{e^{1.7(uq-qlo)}}{1+e^{1.7(uq-qlo)}} \qquad \textbf{(2)}$$

where *uq* is the User Perceived Quality of one over the all LOs and *qlo* is a specific LO Perceived quality for all users.

Figure 2 presents the representation of this probability through ten-level scale and is called Learning Object Characteristic Curve (LOCC). This curve shows the probability that, given a User Perceived Quality (*uq*) over all LOs, a LO in particular could be considered as a High Perceived Quality LO by a user.

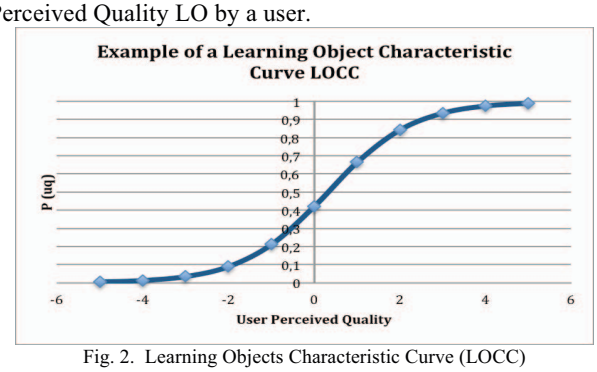

Fig. 2. Learning Objects Characteristic Curve (LOCC)

In this way, and following with the IRT fundamentals, the process of recommendation of LOs could be based on the Object Information Function (OIF) which is a mathematical way to compute how much information each LOCC can tell us. LOs to be recommended are those with the Maxim OIF [11].

$$OIF_i(uq) = 1.7^2(1 - P(uq)_i)(P(uq)_i) \qquad \textbf{(3)}$$

IV. EVALUATION

The purpose of the evaluation is to validate the model presented in the previous section in a real scenario with real users and LOs, verifying the capacity of the model to support recommendations of LOs.

A. Evaluation scenario and methodology

The environment selected to evaluate the model was the Colombian Learning Objects Repositories Federation which is a federation developed in the context of the Colombian project called ROAC [13].

The data set for the evaluation of the model comes from 19

individuals (teachers and students from National University of Colombia (Manizales Brach)) who interacted with five LO stored in FROAC.

As described in the above section, the methodology used to evaluate the model consists of four steps: 1) LOs Quality Evaluation, 2) The User Perceived Quality (uq) and Perceived Quality per LO (qlo) Calculation, 3) the Generation of the Learning Objects Characteristics Curve, and 4) the application of the recommendation model.

B. Results

The Quality Evaluation Process for LOs evaluation from FROAC is inspired on Learning Object Review Instrument (LORI) [8]. FROAC Quality Evaluation Process is an instance of the model presented in section 1. The quality of the LO is developed over two LO Components: the Educational Resources and the LO Metadata. Two dimensions of evaluation have been considered: Evaluation from Users and an Automatic Evaluation. Each dimension of evaluation considers different categories of evaluation. The FROAC Evaluation from Users is developed over the Educational Resources using some LORI [8] categories, in particular: Reusability, Interaction Usability, Content Quality, Motivation, Presentation Design and Standards Compliance. For each category a set of questions are presented to the users. The FROAC Automatic Evaluation dimension is developed over the LO metadata using the following criteria: 1) Completeness, 2) Consistency and 3) Coherence [14].

Considering the evaluation developed by the 19 individuals and following the methodology, the LOCC and the OIF for all of the LOs was obtained. Figure 3 and Figure 4 show the LOCC and the OIF for the lo1 and lo2 respectively.

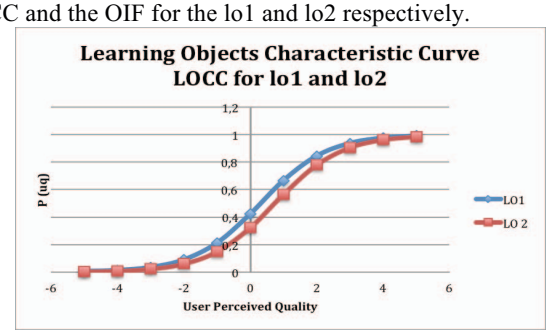

Fig. 3. Learning Object Characteristic Curve for lo1 and lo2

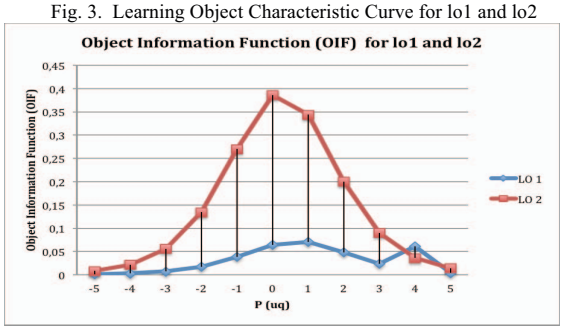

Fig. 4. Object Information Function for lo1 and lo2.

According to IRT, the best objects to be recommended are the ones with the Maximum Object Information Function (MOIF). Object Information Function (OIF) quantifies the information regarding quality available about each LO as a function of the demonstrated perceived quality by the users.

Considering the results, *lo2* should be only recommended if analyzed *uq* over all LOs is not equal to 4, because OIF2(us) > OIF1(us) for all us, except for us = 4.

V. Conclusions and Future Work

LOs quality is one of the most important issues to be considered in the management of a LOR. Quality is referred to as the set of inner properties of a product or service which enables to meet the requirement specifications. In this paper, a model for representing the quality of learning objects is presented as well as a model for recommending learning objects based on IRT. An evaluation process was developed in the context of FROAC considering users of this LOR federation. The evaluation show promising results and another experiment with a larger sample of LOs and users is planned.

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