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ARTICLE

Ascertaining the Relevance of Open Educational Resources by Integrating Various Quality Indicators

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Abstract

The aim of the open educational resource (OER) development movement is to provide free access to high-quality educational materials in repositories. However, having access to a large amount of educational materials does not provide any assurance of their quality, and the mechanisms so far used to recommend educational resources have shown themselves to be lacking for a variety of reasons. Most evaluation systems are based on a costly manual inspection, which does not allow all materials to be evaluated. Moreover, it is often the case that other useful pieces of information are ignored, such as the use that users make of the materials, the evaluations that users perform on

them and the metadata used to describe them. To try and improve this situation, this article presents the shortcomings of existing proposals and identifies every possible quality indicator that is able to provide the necessary information to enable materials to be recommended to users. By studying a significant set of materials contained in the MERLOT repository, the relationships among various, currently available quality indicators were analysed and numerous correlations among them were established. On the basis of that analysis, a measure of relevance is proposed, which integrates all existing quality indicators. Thus, the explicit evaluations made by users or experts, the descriptive information obtained from metadata and the data obtained from the use of the latter are employed in order to increase the reliability of recommendations by integrating various quality aspects. In addition, this measure is sustainable because it can be calculated automatically and does not require human intervention; this will allow all educational materials located in repositories to be rated.

Keywords

relevance, open educational resources, MERLOT, e-learning

Determinando la relevancia de los recursos educativos abiertos a través de la integración de diferentes indicadores de calidad

Resumen

El propósito del movimiento de desarrollo de recursos educativos abiertos es proporcionar libre acceso a materiales educativos de alta calidad disponibles en repositorios. Sin embargo, tener acceso a una gran cantidad de materiales educativos no garantiza que estos sean de calidad, y los mecanismos empleados para recomendar los recursos educativos utilizados hasta la fecha se han mostrado insuficientes por diferentes motivos. La mayoría de los sistemas de evaluación están basados en una costosa inspección manual que no permite tener evaluados todos los materiales; además, muchas veces no se tienen en cuenta otras informaciones útiles como la utilización que hacen los usuarios de los materiales, las evaluaciones hechas por los usuarios y los metadatos que describen el material educativo. Para intentar mejorar esta situación, en este documento se exponen las carencias de las propuestas existentes y se identifican todos los posibles indicadores de calidad que pueden aportar información sobre qué materiales recomendar a los usuarios. A través del estudio de un conjunto significativo de materiales del repositorio Merlot se analizan las relaciones existentes entre los distintos indicadores de calidad disponibles, para constatar que existen numerosas correlaciones entre ellos. Posteriormente y a partir de este análisis, se propone una medida de relevancia que integre todos los indicadores de calidad existentes. De esta manera se utilizarán las evaluaciones explícitas realizadas por usuarios o expertos, la información descriptiva proveniente de los metadatos y los datos que proceden del uso de estos, para lograr aumentar la fiabilidad de las recomendaciones al integrar diferentes perspectivas de la calidad. Además, como esta medida se puede calcular de forma automática se garantizará su sostenibilidad, ya que no necesitará de la intervención humana para su cálculo, lo que permitirá que todos los materiales educativos ubicados en repositorios estén valorados.

Palabras clave

relevancia, recursos educativos abiertos, Merlot, *e-learning*

1. Introduction

Our knowledge society demands competencies and skills that require the use of new educational practices, such as the use of open educational resources (OERs) available on the Internet (Schaffert & Geser). In a similar way to open software development, with projects such as Linux or Apache, the world of education is trying to develop high-quality OERs with rights that allow users to reuse them and adapt them to suit their respective contexts (Kelty et al.). However, as is frequently the case for any resource searching task, most searches in repositories return a vast number of materials, thus making it difficult for users to decide which of them are best suited to their needs. Without a formalised process that allows an algorithm to calculate the relative importance of the resources, most materials searches will be lacking and their usefulness limited (Brownfield & Oliver). To try and overcome this problem, most repositories have used expert and user evaluations of educational materials. Specifically, Tzikopoulos et al. identified that, of the 59 repositories contemplated in their study, 23 offered various mechanisms for evaluating educational materials. However, the evaluation system used so far is lacking (Kelty et al.) for a variety of reasons.

The task of manually reviewing materials is costly, and the amount of educational materials is enormous and growing by the day. For example, at the time of the study (October 2009), there were 21,399 materials in the MERLOT repository, of which just 2,867 (13%) had been peer reviewed. Consequently, unevaluated materials appear at the end of search results, as if they were poor-quality resources. This situation has arisen because existing evaluation initiatives use a costly inspection of the materials as the main source of information. But, as Ochoa and Duval point out, for a measure of OER quality to be useful, it needs to be calculated automatically. Furthermore, when analysing the reliability of these explicit evaluations, we find that there are a number of problems. Most expert evaluations are performed individually, which represents a limitation on their validity. To overcome this limitation in part, it would be necessary to develop collaborative evaluation processes in the repositories, and this would increase the cost of evaluating resources even more (Boskic). Regarding user reviews, we also find that there are severe limitations on them for a variety of reasons, such as the lack of user training, the potential subjectivity of tastes, etc. (Han). Moreover, only a small number of users provide these evaluations and, as a result, their evaluations may not be representative of the opinions of all users as a whole (Kay & Knaack). Along similar lines, Akpinar performed a validation study on certain evaluation areas of the Learning Object Review Instrument (LORI). The study compared evaluations with student and lecturer surveys and concluded that LORI evaluations were not sufficient to predict the educational benefits that might be obtained from OERs.

In addition, while there are various initiatives that allow a search to be performed across several repositories, such as the EduSource project (McGreal et al.), we find that repositories have different evaluation systems, thus making it difficult to sort the results returned for several repositories. In a similar way to the various metadata application profiles, it is crucial to develop strategies that allow different repository evaluation systems to be integrated (Li et al.).

Moreover, Kelty et al. assert that educational resources are being evaluated statically, just like

traditional educational materials used to be. To overcome this deficiency, they propose that evaluations should not only focus on content, but also contemplate potential contexts of use.

In any event, the availability of large databases of data with evaluations has opened up new opportunities for developing indicators that could complement existing evaluation techniques based on an enormous effort of manually inspecting materials. Indeed, such evaluation techniques could be replaced by other measures that are automatically calculated, thus facilitating an indicator of the quality of educational materials in a less costly way (García-Barriocanal & Sicilia).

A potential improvement that Kelty et al. propose is to use systems similar to the lens mechanism that the Connexions repository uses, in which each lens is created by applying an evaluation criterion to materials, including peer reviews, popularity, number of re-uses, number of times they are linked, etc.; the application of one lens or a combination of lenses allows educational materials to be filtered.

In a similar way, Han indicates that the current systems for recommending educational materials lack a weighting mechanism that would otherwise allow the evaluative data from various sources to be taken into account, since each one provides information differently. Consequently, he proposes an integrated quality indicator that combines explicit expert and user evaluations, anonymous evaluations and implicit indicators (favourites and retrievals).

Drawing our inspiration from the last two proposals, the aim of this study is to formulate a relevance indicator that: can be calculated automatically; ensures that all resources are rated; and encompasses available quality indicators, which can be classified into three categories:

- Evaluative. This encompasses all explicit expert and user evaluations.
- Empirical. This refers to information on materials usage, as obtained from their implicit data, such as retrievals, the number of users who bookmark them in their favourite materials lists, etc.
- Characteristic. This refers to descriptive information on the characteristics of the materials, as obtained from their metadata.

The rest of this article is structured as follows: in sections 2, 3 and 4, the quality indicators are identified and grouped under the categories referred to earlier; in section 5, an analysis of the relationships among the quality indicators is performed by studying a significant set of materials in the MERLOT repository; in chapter 6, a measure of relevance is proposed and applied to the set of materials under investigation; and finally, in chapter 7, the conclusions are drawn.

2. Evaluative Quality Indicators

There are many studies on how to evaluate OERs, such as those proposed by Kay and Knaack and by Kurilovas and Dagiene; the evaluations that have been put into practice are those implemented in the various repositories.

In the MERLOT repository, materials are evaluated by a peer-review process that focuses on three aspects: content quality, ease of use and potential effectiveness as a teaching-learning tool; each aspect is rated from 1 to 5 (poor to excellent). The weighted mean of the three aspects becomes the educational resource's final evaluation value. Registered users can also evaluate and comment on resources.

The eLera repository allows users to evaluate materials by using LORI, which focuses on nine aspects: content quality, learning goal alignment, feedback and adaptation, motivation, presentation design, interaction usability, accessibility, reusability and standards compliance. In a similar way to MERLOT, each aspect is rated on a scale from 1 to 5. Worthy of note is that collaborative evaluation initiatives have been developed through eLera, in which groups of experts participate. When this approach is taken, materials are first evaluated individually and asynchronously, and then the evaluations are discussed prior to agreeing on a final rating.

Finally, the Connexions repository proposes a quality evaluation by using a lens mechanism; the application of one lens or a combination of lenses allows users to filter materials to obtain the most suitable ones. Among potential lens types are those based on peer reviews and those elaborated by users (Baraniuk).

3. Empirical Quality Indicators

When it comes to recommending resources, the use of implicit data resulting from usage is an idea that has already been applied to Web page selection. Along these lines, Claypool et al. show that it is worthwhile using implicit data obtained from user behaviour for sorting search results. These measures have been used to improve searches on the Web, since they reflect the users' interests and degrees of satisfaction, and are less costly than explicit evaluations (Fox et al.).

In the particular case of OERs, implicit information about resource retrieval or bookmarking in favourites is available in the MERLOT repository. In Connexions, lenses for recommending materials can be created automatically on the basis of data such as popularity, number of re-uses, number of times they are linked, etc. (Baraniuk). Building on this idea, Kumar et al. propose that, besides the evaluations available in the repositories, data on materials usage could be used to supplement information on the quality of educational materials. Similarly, Yen et al. propose using information on references to educational materials so as to sort them using the Page Rank algorithm that Google uses to return search results.

Likewise, in this section we could include social tagging systems, which are a basic way of adding descriptive metadata to educational content. While social tagging tools have received a great deal of criticism due to their terminological imprecision (Cueva & Rodríguez), there are some proposals that suggest using this information to build a recommendation metric like, for example, counting each tag as a vote for the educational resource (Yen et al.).

4. Characteristic Quality Indicators

The characteristic category encompasses indicators based on metadata, which can take advantage of the potential of information describing an educational resource. Along these lines, various authors have proposed their own indicators: Ochoa and Duval propose using metadata to sort the search results for educational materials and to be able to recommend the most suitable ones. Specifically, they propose a set of relevance metrics for educational materials, applying the same ideas used to classify Web pages, scientific articles, etc. Knowing which materials are the most relevant from different viewpoints would make it easier to choose an educational resource for re-use. The information for estimating these relevance metrics is obtained from data on users' retrieval of educational materials, the metadata on the materials, registers of materials usage and information on the context. Zimmermann et al. remind us that, in order to reuse an educational resource designed for a specific context, it is often necessary to adapt it to the new context in which it will be used. Consequently, they propose evaluating the adaptation effort required in order to reuse it. Adaptation to a new learning context may involve such tasks as: adapting materials to a new learning objective or a new group of students (different from the target group for which they were originally designed); extracting part of the content from the resource; and combining the resource with other educational materials. When faced with the question about how to find learning materials that can be adapted to a new context in the least costly way, Zimmermann et al. propose measuring metadata similarities to ascertain adaptation needs. Finally, Sanz et al. propose metadata-based reusability metrics – the calculation of which can be automated – that measure aspects such as consistency and educational and technological reusability, thus allowing materials with greater potential for re-use to be chosen.

5. Analysis of the Correlations among the Various Quality Indicators

Once the various quality indicators have been identified and grouped under the categories referred to earlier, the relationships among them can be analysed. It should be stipulated that the study was conducted on a set of 141 materials selected from MERLOT, the repository from which we were able to obtain indicators for all the categories. This set of materials was retrieved on 1 October 2009. It included all materials added to the repository between 2005 and 2008 that had been evaluated by experts and had received comments from users. Table 1 shows the indicators chosen for the study: Personal Collections indicates the number of times a resource has been bookmarked in favourites; Exercises are teaching proposals that link to one or several materials; and Used in Classroom indicates whether a resource has been used in the classroom by the user evaluating it. Regarding the indicator based on metadata, the Reusability indicator proposed by Sanz et al. was used.

Table 1. Quality indicators studied

Evaluative	Empirical	Characteristic
Overall Rating Content Quality Effectiveness Ease of Use Comments	Personal Collections Exercises Used in Classroom	Reusability

Then the correlations among the indicators of the various categories were studied. Table 2 shows that there is a strong correlation among the explicit ratings given by experts. However, there is hardly any correlation among the ratings given by users. Only ease of use is correlated with the ratings given by experts. This may be due to the fact that users do not have the necessary knowledge to evaluate the resource they are analysing, perhaps because it falls within an area or level beyond their scope. It may also be due to the fact that users place greater importance on ease of use in their overall evaluation of educational materials. In this respect, Han points out that it is difficult to place a numeric value on users' tastes in a quality evaluation. For example, if users prefer certain types of literature, they are more likely to rate educational materials dealing with them more highly.

Table 2. Kendall's Tau correlation among explicit ratings

	Overall Rating	Content Quality	Effectiveness	Ease of Use	Comments
Overall Rating	1	0.776**	0.718**	0.663**	0.096
Content Quality	0.776**	1	0.724**	0.615**	0.107
Effectiveness	0.718**	0.724**	1	0.507**	0.126
Ease of Use	0.663**	0.615**	0.507**	1	0.172*
Comments	0.096	0.107	0.126	0.172*	1

** Correlation is significant at 0.01 * Correlation is significant at 0.05

Table 3 illustrates the correlations among indicators in the Evaluative and Empirical categories, and shows a correlation between the materials in Personal Collections and expert evaluations.

Table 3. Kendall's Tau correlation between explicit and empirical ratings

	Personal Collections	Exercises	Used in Classroom
Overall Rating	0.171**	0.033	0.045
Content Quality	0.145*	-0.014	0.034
Effectiveness	0.224**	0.047	0.123
Ease of Use	0.146*	0.036	0.071
Comments	0.046	-0.007	0.049

** Correlation is significant at 0.01 * Correlation is significant at 0.05

Table 4 shows the correlations among the indicators in the Empirical category.

Table 4. Kendall's Tau correlation among empirical ratings

	Personal Collections	Exercises	Used in Classroom
Personal Collections	1	0.227**	0.105
Exercises	0.227**	1	0.298**
Used in Classroom	0.105	0.298**	1

** Correlation is significant at 0.01 * Correlation is significant at 0.05

Finally, Table 5 shows the correlations with the metadata-based Reusability indicator.

Table 5. Kendall's Tau correlations with the metadata-based Reusability indicator

	Reusability
Personal Collections	0.240**
Exercises	0.062
Used in Classroom	0.092
Overall Rating	0.287**
Content Quality	0.301**
Effectiveness	0.300**
Ease of Use	0.279**
Comments	0.031

** Correlation is significant at 0.01

The correlations found among the indicators of the various categories support the idea that they are all measures of quality obtained from different viewpoints, and that they can be complemented to obtain an indicator that rates the relevance of an OER.

6. Integrating Quality Indicators into a Measure of Relevance

The measure of relevance combines all information on the quality of a resource. Consequently, if a quality indicator is missing, a measure of relevance can be obtained from existing indicators and calculated automatically. This will solve the current problem whereby materials without expert evaluations appear at the end of any search, automatically ruling them out. It will also increase the reliability of recommendations. The relevance of a learning resource called *o* is described in (1).

$$\text{Relevance}\ (o) = \sum_{i=1}^{n} a_i \text{Evaluative}_i(o) + \sum_{j=1}^{m} b_j \text{Characteristic}_j(o) + \sum_{k=1}^{l} g_k \text{Empirical}_k(o) \quad (1)$$

Here, a_i, b_j, g_k represent the weights of the various Evaluative, Characteristic and Empirical relevances, and *n*, *m* and *l* indicate the number of indicators in each quality category. In addition, all the relevances are normalised in a range of values from 0 to 5, which is the scale used for MERLOT's evaluative indicators, and their mean values are obtained when several data are available. If one of the data is missing, the weights are adjusted so as not to penalise its absence from the calculation of relevance, and the equation described in (2) will always be fulfilled:

$$\sum_{i=1}^{n} a_i + \sum_{j=1}^{m} b_j + \sum_{k=1}^{l} g_k = 1. \quad (2)$$

Adapting the generic formula to the specific case of the MERLOT repository study, it is possible to explain how a_1, a_2 are the weights of the two Evaluative indicators (overall rating and comments) and $\text{Evaluative}_1(o), \text{Evaluative}_2(o)$ are the mean values of the two Evaluative indicators of learning resource o.

To ascertain the weights, two sources of information were used. First, the weights proposed by Han for integrating the various measures of quality into the rating of educational materials, and second, information obtained in the previous section on the studies of correlations among quality indicators. By combining both sources of information, the resulting final model is expressed in Table 6.

Table 6. Weightings of the quality indicators studied

	Indicator	Weight
Evaluative	Overall Rating Comments	0.3 0.1
Empirical	Personal Collections Exercises Used in Classroom	0.15 0.1 0.05
Characteristic	Reusability	0.3

To explain the use of the relevance indicator, we studied the Graph Theory Lessons educational resource available in the MERLOT repository. Table 7 shows the values of the quality indicators obtained at the time the study was conducted.

To integrate all of these values into the final formula, we had to perform a transformation of the usage indicators (Personal Collections, Exercises and Used in Classroom).

First, we had to normalise them, taking account of the amount of time the resource had been available in the repository. In this instance, the resource had been available since 24 September 2005. Obviously, a resource that has been available for a longer period of time may have been used

more often, hence the need to normalise this value. In addition, the Empirical indicators had to be normalised on the reference scale used (0 to 5). This indicated that materials with a relevance value closer to 5 are more relevant.

Table 7. Quality indicator values for the Graph Theory Lessons educational resource

	Graph Theory Lessons
Personal Collections	9
Exercises	0
Used in Classroom	3
Overall Rating	5
Comments	4
Reusability	4.49

Second, the relevance indicator was applied to the set of materials obtained from the Merlot repository and studied. Figure 1 shows the statistical distribution of the measure of relevance compared to a normal distribution. This graph allows us to illustrate that the measure of relevance has a distribution in which a minority of materials had low or very low ratings, and the majority had intermediate values. This behaviour may correspond to the one that is expected in a process of educational materials evaluation.

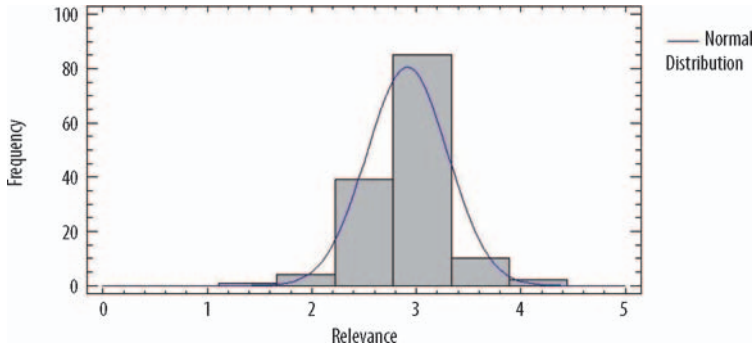

Figure 1. Relevance indicator histogram

7. Conclusions

The correlations found among the indicators of the various categories support the idea that they are all measures of quality obtained from different viewpoints and that they can be complemented to obtain an indicator that rates the relevance of an educational resource. The use of this measure of relevance may offer several advantages when it comes to selecting quality educational materials.

First, the main advantage is that will help the end-user select educational materials.

Another advantage is that it will improve the reliability of evaluations, since it encompasses all existing and relevant information: expert and user evaluations, usage data and information contained in their metadata. Given the large number of educational materials available in repositories, being able to provide a quality indicator that encompasses very diverse aspects – ratings by users with different profiles, resource usage data and resource characteristics described in metadata – will help to locate quality educational materials for re-use.

Finally, worthy of note is the advantage offered by the sustainability of the indicator's calculation. As the measure of relevance can be calculated automatically, it will allow all educational materials available in repositories to have a rating, even when one of the quality indicators is missing. For example, when a resource has been evaluated by users but not by experts, and data on their usage and characteristics are available, the measure of relevance can be calculated automatically, thus providing a recommendation to help users in the process of selecting materials.

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