WikiLOR: a Collaborative Approach to Improve Learning Object Metadata

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Abstract. *The quality of metadata in learning object repositories is frequently low; metadata records are incomplete, inaccurate, and out of date. This paper introduces a collaborative, metadata editing approach to improve metadata quality and completion by the community's effort. WikiLOR is a wiki that acts as both: a learning object repository and a collaborative metadata editor. WikiLOR proposes a wiki-way for editing both a learning object's content and its metadata. WikiLOR encourages collaborative editing, promotes discussion, helps in conflict resolution and supports version management. The paper additionally documents an experiment that reveals the qualities of WikiLOR and compares it to other benchmark applications.*

1. Introduction

One of the main motivations of learning objects (LO) and learning objects repositories (LOR) is to enable the reuse of educational resources by as many people as possible. Reuse is a common practice among teachers who are collecting learning resources to share in their classes. Reusing educational content saves effort, improves content quality (through various cycles of reusing), and promotes collaboration between educators, content creators, and students. To foster reuse, educational content must be packaged and augmented with additional information such as subject matter, intended audience, copyright, level of difficulty, etc. Chiappe and colleagues define LO as "a digital self-contained and reusable entity, with a clear educational purpose, with at least three internal and editable components: content, learning activities, and elements of context. The learning objects must have an external structure of information to facilitate their identification, storage and retrieval: *the metadata*" [Chiappe et al. 2007].

Learning Object Repositories (LORs) are systems that support the storage, search, and retrieval of LOs. LORs like Agrega[1] and Merlot[2], and federations of repositories like GLOBE[3] or FLOR[4] to name a few, publish an increasingly larger amount of LOs. This large volume of information overwhelms students and teachers when they are looking for a particular resource. Metadata is useful to address this issue.

Metadata enable the authors to classify their contents in a universal manner, shared by most repositories. A complete and accurate metadata in LOs is essential to share, search and find relevant LOs between the myriad of existent published LOs.

[1] http://agrega2.red.es/visualizadorcontenidos2/Portada/Portada.do (last accessed May 28, 2015)
[2] http://www.merlot.org/merlot/index.htm (last accessed May 28, 2015)
[3] http://globe-info.org (last accessed May 28, 2015)
[4] http://laflor.laclo.org (last accessed May 28, 2015)

LOM (Learning Object Metadata), a commonly used standard for LO metadata proposed by IEEE [IEEE 2003], defines over 60 attributes to describe a LO. Despite its advantages, metadata generation is a tedious and complex task. For this reason, it is often ignored, underestimated or users do not have the skills to carry it out. This leads to incomplete, inaccurate, or incorrect metadata, and thus the potential of the learning objects cannot be materialized. In this article we propose a collaborative approach to edit LO´s metadata.

Collaborative editing is a group practice to produce work through individual contributions, pursuing a common goal. Working in collaboration reduces the effort to perform the task, since the result is achieved by the contributions of several people, rather than a single individual [Lowry et al. 2004]. Particularly, we adopt a "wiki-way" [Leuf and Cunningham 2001] to create, complete and fix metadata's records in a wiki behaving as a LOR. In the same manner that Wikipedia allows users to create, complete or correct encyclopedic articles by the community effort; we propose a collaborative LOR where both LOs´ content and metadata are collaborative produced.

In this paper, WikiLOR is introduced as a semantic wiki that maps a LOR to a wiki. Each LO is mapped to a wiki article and metadata to semantic categories and properties. It is supported by the *Semantic MediaWiki* [Krötzsch et al. 2007] engine and uses various *Semantic MediaWiki* services (like template, and forms) to ease editing of LO metadata. WikiLOR also includes a set of tools that help users identify a LO with incomplete metadata and encourages to complete them. It is also able to automatically complete some metadata. WikiLOR was tested in different situations, in order to verify that it simplifies LO's metadata generation, thus improving metadata quality.

The rest of the article is organized as follows. Section 2 briefly presents the state of the art and background of the work. The section 3 provides details of how WikiLOR was designed as a LOR and presents the functionalities that support the collaborative editing of the metadata. Section 4 presents evaluations results. We finally provide conclusion and discuss future work.

2. Related Work

Greenberg and Robertson [Greenberg & Robertson 2002] learned that metadata authors welcome collaboration, particularly to receive assistance and training from expert cataloguers. Bauer and colleagues [Bauer et al. 2007] conducted a review of automated and collaborative approaches to metadata generation. They concluded that a hybrid approach provides the best results. A hybrid approach handles automatically the more technical attributes (such as title, language, author, format, size). In addition, collaborative tagging is used generate the elements that typically need more interpretation (e.g., level of difficulty). The approach we follow in the design of WikiLOR is consistent with these findings.

The most similar approach to ours is FreeLOms [Gentile'06]. It is a LOR whose goal is to support reusing and repurposing of LO through versioning and composition. It uses Scorm as its metadata schema and the Alfresco CMS[5] as the underlying technology. It implements LO publishing workflows and allows multiple users to edit metadata. FreeLOms does not implement mechanisms to foster user's participation or to

[5] https://www.alfresco.com, last accessed May 1st, 2015.

manage crowdsourcing of the various curation tasks commonly required in repositories (e.g., metadata completion).

3. WikiLOR: the learning object repository

WikiLOR[6] is a customized Semantic MediaWiki[7] (SMW) for learning resources. A SMW is an extension that adds semantic support to the MediaWiki[8] (MW) engine. This extension adds an underlying model for the semantic of the wiki content. It is not only an editable semantic hypertext, but also queryable knowledge repository. Wiki articles are tagged with *categories* to indicate the types of the article (e.g., City, Country). Categories are the mechanism that SMW provides in order to index and catalogue articles according to a criterion. Implicitly, categories define a relation among the articles within a category. Articles are also connected by *semantic properties* (e.g., Paris *isCapitalOf* France). Semantic properties define semantic data and represent an attribute or relationship. The domain of the property is always a wiki article while the value can be a literal (Paris *population* 2,211,000) or a wiki article (e.g., Paris *belongsToCountry* France). Properties have a name and are typed. The syntax to define a property within an article is *[[propertyName::value]]*. This expression creates a semantic relation between the article and the value.

The main difference with a traditional wiki is that WikiLOR behaves as a LOR. Within WikiLOR, LOs are represented as wiki articles and their metadata by means of semantic relations. The implementation of WikiLOR takes advantage of the semantic functionalities of SMW, like semantic properties, template, forms and searches. Figure 1.a shows the WikiLOR homepage where are listed the stored LOs. Following sections detail the main features of WikiLOR.

In WikiLOR, any LO is represented as wiki article. To distinguish LO from other wiki articles (such as indexes or meeting reports) WikiLOR uses the *LearningObject* category that groups all LO articles. The line *[[Category:LearningObject]]* in any wiki article turns it into a *learning objet article*.

LO metadata is created by means of SMW *semantic properties*. Wikilor adopts LOM-ES[9], the Spanish profile of the LOM standard. For instance, we can add the sentence *[[LOM_General_AgregationLevel::1]]* in a learning object article to set the value of LOM *Agregation Level* attribute to 1. In the following it is detailed how WikiLOR represents LOM standard in terms of wikis.

Some LOM attributes only admit a set of predefined terms; for instance “atomic”, “collection”, “hierarchical” and “linear” are predefined terms for the *General.Structure* attribute. LOM predefined terms are represented in WikiLOR as articles that belong to the *LomTerm* namespace. For instance a LO article can have defined the property: [[*LOM_General_Description*:: *LomTerm*:*Atomic]]*. Articles in the *LomTerm* namespace determine a controlled vocabulary.

As there are some LOM attributes that are multiples for the same LO, in WikiLOR a LO could establish both 1:1 and 1:n relationship between the LO and the

[6] http://remar.lifia.info.unlp.edu.ar/wikilor/index.php
[7] https://semantic-mediawiki.org/ (last accessed July 16, 2015)
[8] https://www.mediawiki.org (last accessed July 16, 2015)
[9] http://educalab.es/recursos/lom-es (last accessed May 28, 2015)

corresponding category. For instance, the *General*, *LifeCycle*, *MetaMetadata* and *Technical* categories define 1:1 relations between the LO and the metadata (e.g. General.Title). However, *Educational*, *Relation*, *Annotation* and *Classification* categories imply 1:n relationships. 1:n relationships are defined by means of Semantic Internal Object[10] (SIO), which are "internal objects" semantically related to any article. Thus, it is possible to implement a 1:n relationship between one LO and a category.

Because the code to establish relationships between LO articles and the LOM attributes must be present in all LOs by issues of reusability and modularity, WikiLOR provides with one semantic template for each LOM category. Therefore, we have defined the templates General, LifeCycle, MetaMetadata, Technical, Educational, Relation, and Classification.

3.1 Metadata Creation and Editing

The mechanism for metadata instantiation is based on the use of *Semantic Forms*[11]. Semantic forms are an extension to MediaWiki that provides simple forms to create and edit articles, presenting a user-friendly interface. A semantic form gives the faculty to specify entities or values for the semantics relations of an article. Each of the fields in the semantic form is associated with a semantic property and then, when an article is created or edited, a semantic relation of the concrete property will be created between the article and the value entered at the corresponding field. WikiLOR predefines a semantic form associated with the *LearningObject* category, and therefore this form is used every time a LO is either created or edited (Figure 1.b). This form gives a simpler and intuitive way to complete semantic relation, encouraging metadata completion.

WikiLOR also supports automatic metadata generation. There are several fields of the LOM standard that are completed automatically, saving user effort and avoiding mistakes or omissions. Some LOM attributes are created automatically with a non-editable default value defined with a semantic relation between a LO and these values. There are over 25 fields to be completed automatically, from simple ones like *General.Title* (which is completed with the wiki article's name), to more complex ones as *LifeCycle.Contribute.Entity* (completed with the logged-in user vCard) or *LifeCycle.Contribute.Role* (completed as Editor, by LOMv1.0).

3.2 WikiLOR Semantic Search

WikiLOR provides a semantic search tool to perform queries over the semantic data defined by the semantic relations between LOs and LOM attributes. Semantic searches use the semantic relations between entities instead of plain text, given more accurate results to the user. To perform a semantic search in WikiLOR is necessary to define semantic queries in wiki code. To obtain the LOs whose *General.Keyword* value is "Smalltalk", it is necessary to perform a query like the following one:

```
{{ #ask:
      [[Category:LearningObject]]
      [[Lom_General_keyword::Smalltalk]]
}}
```

[10] http://www.mediawiki.org/wiki/Extension:Semantic_Internal_Objects
[11] http://www.mediawiki.org/wiki/Extension:Semantic_Forms/en

This kind of queries tends to increase their complexity as the desirable values grow. To simplify this situation, WikiLOR provides with a semantic form called "*LearningObjectQuery*". (Figure 1.b)

3.3 Encouraging metadata edition

The more the repository grows; there is more possibility of incomplete metadata in the repository, and therefore less chance of finding resources with low levels of completed metadata. To solve this situation WikiLOR provides a set of tools that help the detection and edition of incomplete metadata. WikiLOR defines two different indicators of missing attributes, the *incomplete attribute indicator* and the *incomplete category indicator*. The *incomplete attribute indicator* acts at individual attribute's level, and is visualized at the LO interface. Every incomplete attribute has attached the "Complete It!" hyperlink (see Figure 1.a, right column). When clicked, the link will take the user directly to the metadata editing form. The *incomplete category indicator* appears at category level. It is considered that a category is incomplete if at least one of its attributes is incomplete. The indicators consist in a three color range to communicate the completeness of the category attributes: red for categories with less than 30% of it metadata fields completed, yellow for those categories whose metadata fields are completed between the 30% and 70%, and finally green for those LO's categories with more than 70% of their fields complete. Figure 2 shows an example of colored boxes according to its completeness. At the WikiLOR main page, there is also an index of LOs with incomplete categories (Figure 1.a). This index groups incomplete LOs by categories with a direct link to the corresponding metadata editing form (Figure 1.b).

3.4 The Collaborative Method

WikiLOR supports a collaborative method for LOs creation, search and edition. The concepts stated below are the basis of a LO definition within a wiki, but this is not enough to define a collaborative environment for LO edition, publication, searching and reusing. A collaborative LOR, as a collaborative environment, should expose a collaborative method that defines a strategy to coordinate users in the LO creation and edition [Lowry et al. 2004].

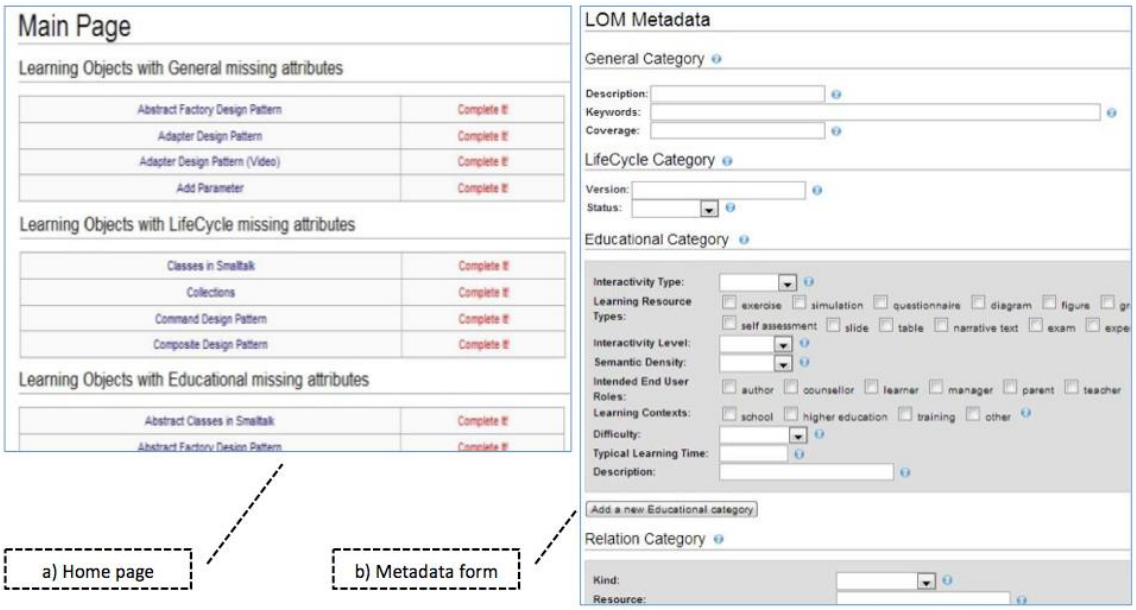

Figure 1. WikiLOR's home page (a) and its metadata edit and search form (b)

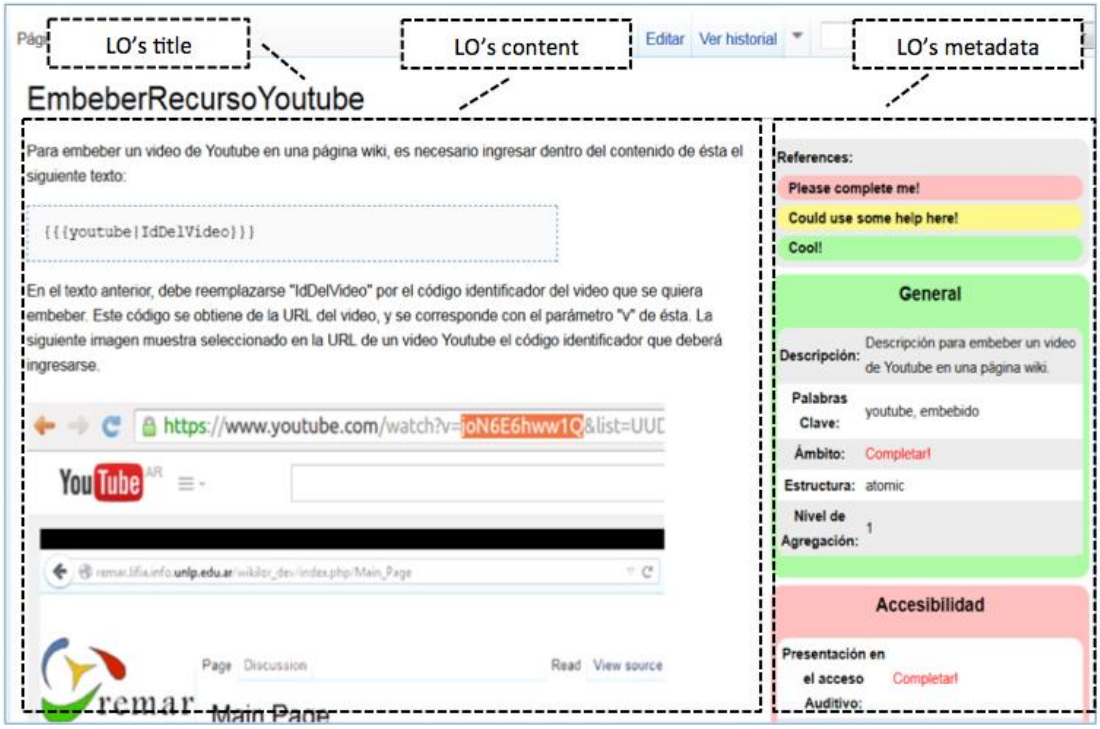

Figure 2. A LO in WikiLOR – Title, Content and Metadata

As in WikiLOR, LOs' content and its metadata are differentiated; the collaborative method must take this issue into consideration. The collaborative creation and edition of the content doesn't differ from the collaborative edition and creation of a wiki article. Therefore, there is no need to define further concepts for a collaborative method involving a LO's content, it is already provided by the MediaWiki engine. On the other hand, the metadata creation and edition process presents other issues that, although similar to the content, need to be included in a differentiated collaborative process. WikiLOR proposes a four steps process that establishes a consensual interaction among coworkers at the creation and edition of LO's metadata:

1. **Identification of LOs with incomplete metadata.** They are identified by means of WikiLOR incomplete attributes indicators.
2. **Metadata record creatio**n. When a LO lacks of a metadata record, it is necessary to create a new metadata record. This record may start as an empty record, or partially complete, not necessary begins as fully complete metadata information. It will be complete thanks to the collaborative metadata edition carried out by the users collective.
3. **Metadata discussion.** This is a key step in the collaborative process; it involves communication and interaction between individuals, and this is where the real contribution of the expertise of each of the people involved in the work is reflected. This step covers the entire LO life cycle because of they are evolutionary. Collaborative metadata edition could involve a debate of different ideas and proposals about a LO metadata. Discussion of metadata take place during the metadata edition. In the *edition with form* interface, there is the "Comment" tab to attach an *annotation* about the LO. An annotation looks like a

user review of the LO metadata. A LO has as many annotations as users reviews. Annotations are also part of the LO´s metadata.

4. **Metadata Edition.** Finally, after reaching a consensus, the metadata record should be edited. This step presents the basis of a collaborative method. It is also necessary to define a strategy to encourage the edition. This process is not a step per se, but a functionality provided by the repository that aims to facilitate the finding of missing or invalid metadata fields. WikiLOR provides with metadata's edition and creation form.

3.5 Support for the Collaborative Metadata Edition

WikiLOR has all the features and benefits provided by wikis, very useful for the collaborative metadata edition. Among these features are:

- *Mechanisms for call for user participation and encouraging metadata edition.* WikiLOR uses "incomplete indicators" for attributes and categories.
- *Discussion mechanism for metadata improvement.* WikiLOR provides with the "Discussion" article for each LO article, which is the key for the implementation of the collaborative process described in Section 3.5.
- *Conflict management in metadata editing.* WikiLOR supports the two different simultaneous edition scenarios: the edition of disjoint attributes and the edition of the same attribute. In both cases, WikiLOR provides mechanisms for conflict resolution. For the first scenario, it is enough with an automatic merging of different versions of metadata. For the second scenario, it is not possible to make an automatic merge. In these cases, WikiLOR shows the current edited attribute values along with the already stored attribute values; then, the user is able to perform the merge manually.
- *Versioning and change history.* WikiLOR persists the differences between distant editions of the metadata of a LO article. In turn, it presents the user the possibility to compare changes between versions and *rollback* to a previous version. The management of versions is done through the "Revision History" view of a LO article, accessible from the display, using the tab "View History".

4. Evaluation

We have conducted an evaluation in order to assess WikiLOR capabilities. This evaluation took into account two dimensions: WikiLOR as a LOR and WikiLOR usability for metadata edition and publication. Although this was a preliminary evaluation, it was useful to useful to glimpse promising results.

4.1 – WikiLOR as a LOR

In order to determine the use of WikiLOR as LOR, we conducted an experiment dealing with LO publication and metadata annotation. An instance of WikiLOR[12] was used to support educational resources used in the Object Oriented Programming (OOP) course of the Computer Science School of the University of La Plata, Argentina. In this experiment three volunteer teachers of the OOP course worked collaboratively publishing 175 LOs and completing their metadata. Notice that teachers were not forced

[12] http://moodle.lifia.info.unlp.edu.ar/_wikilor/index.php

to complete the metadata. Finished the experiment, a quantitative analysis about the LOs and the used LOM attributes was performed. These results were compared with the results about the use of metadata done in Globe [Ochoa et al. 2011], which is widely recognized in the field of learning objects.

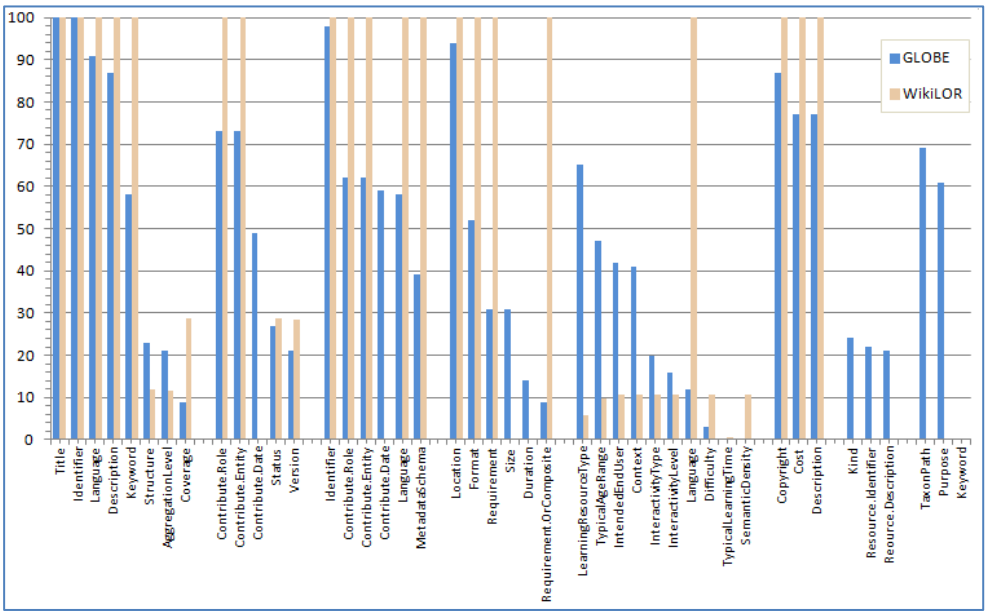

Figure 3. Completion comparison: Globe vs WikiLOR

Regarding the metadata, in Figure 3 can be observed that most of the attributes that Globe has strengths (with percentages greater than 80%), WikiLOR does too, and even some of them are exceeded, such as "General.Language" attribute. However, other relevant attributes, such as those related to the educational field, WikiLOR presents low percentages of completion, which was expected because metadata completing was not encouraged. However, the 175 LOs has a record of metadata with minimal information required for “harvesting” services, ensuring the ability to export the metadata of all objects in the repository. This is due to WikiLOR supports “automatic attributes generation”. Thus it is that the attributes "General.Title" "General.Identifier" "LifeCycle.Contribute" "MetaMetadata.Identifier" and "MetaMetadata.Contribute", among others, were completed for 175 LOs. On the other hand, the collaborative metadata edition contributed to complete remain attributes (i.e. attributes: "General.Description" (100%) and "General.Keyword" (100%)).

4.2 Interaction and ease of use for metadata edition and publication

This experiment aimed to measure the effort for LO metadata edition and publishing in WikiLOR. It was compared the usability of the mechanism for this purpose, against a benchmark alternative mechanism proposed by the "LOM-Editor"[13] tool, used for metadata instantiation in REPOSITORY, a complement of ARIADNE infrastructure. Three volunteer users participate in the experiment and were previously trained on the use of both tools. They also were instructed on the attribute values to be used in order to only relieve the effort in editing and publishing metadata and avoid the effort in find out

[13] IEEE LOM Editor: http://dbis.rwth-aachen.de/cms/projects/LOMEditor. Last access: May 2015.

the attribute values. After volunteers publish the metadata in both tools, a comparative analysis was done. This analysis focused on the time required for metadata editing and the number of steps for metadata publishing. The experiment reveals that: the time consumed for the metadata edition in WikiLOR was substantially shorter than the consumed in LOM-EDITOR editor. Table 1 shows the time required by each participant at each tool. The advantage of WikiLOR is due to the "automatic attributes generation" mechanism which help to automatically complete the attributes "LifeCycle.Contribute" and "MetaMetadata.Contribute". In addition, the three participants agreed that WikiLOR provides an interface for faster attribute values edition; the checkboxes and drop-down lists present in the form for editing most of the attributes do not require writing time, in contrast to LOM-EDITOR that requires entering data manually by the keyboard.

Regarding the metadata publishing, the three participants agreed that the WikiLOR mechanism is simpler. This is because WikiLOR is not just an editor, but also a repository of LOs; therefore, the publication of metadata is integrated. On the other hand, the LOM-Editor tool is simply a metadata editor thus to submit metadata is a necessary one more step, to upload to the repository where the metadata will be stored.

5. Conclusions and Further Works

The quality of metadata in LOR is frequently low. Bad or missing metadata limits the usefulness of repositories and hinders learning object reuse. Wikis, through a right combination of functionalities and collaboration dynamics, achieve high productivity and acceptable quality of on-line content. We have built WikiLOR, a hybrid between a Semantic Wiki and a Learning Object Repository. It combines the collaborative editing features and dynamics of wikis, with the benefits of the Semantic Web to model LO object's metadata following the LOM-ES standard. We evaluated it in a real usage scenario and observed that: a) it contributes to improve metadata completion and quality, b) it simplifies the process of editing and publishing LO, and c) it effectively supports collaboration in metadata editing.

Currently, WikiLOR will be used in the context of the REMAR[14] project. In this project, teachers will be trained in the use of metadata for accessibility for open learning resources. According the nature of WikiLOR, it will be easy extended to consider new metadata. Besides, this opportunity will be profit to do a deeper evaluation.

The Semantic Web has much to offer in relation to LORs. We are particularly interested in exploring how a repository can benefit from using Linked Open Data as the values of metadata properties.

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[14] https://proyectoremar.wordpress.com/

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