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Describing Learning Features of Reusable Resources: A Proposal

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***Abstract*—**One of the main advantages of the LO paradigm is to allow the availability of good quality, shareable learning material through the Web. The effectiveness of the retrieval process requires a formal description of the resources (metadata) that closely fits the user's search criteria; in spite of the huge international efforts in this field, educational metadata schemata often fail to fulfil this requirement. This work aims to improve the situation, by the definition of a metadata model capturing specific didactic features of shareable learning resources. It classifies LOs into "teacher-oriented" and "student-oriented" categories, in order to describe the role a LO is to play when it is integrated into the educational process. This article describes the model and a first experimental validation process that has been carried out in a controlled environment.

***Keywords*—**Learning object, pedagogical metadata, experimental validation.

I. Introduction

AS it is well known, learning object (LO) technology [20] allows the building of repositories that constitute a kind of specialised digital libraries, available via web, where high quality re-usable materials can be selected by students and teachers on the basis of a description of their content (metadata) [21]. This possibility, at least in principle, helps to exploit the opportunities offered by the web to education. Autonomous learners, in fact, are supported by a choice of self-consistent, inter-related and organized educational modules. Teachers can share materials and experiences on a wide basis; they can form virtual communities of practice, whose members can work on common material and modify it.

A relevant role in the realisation of this potential is played by the identification of LO descriptors that allow for effective searching of repositories of reusable material. Accordingly, much effort has been devoted to define standards for cataloguing LOs [4]. Just as an example we recall here the Learning Object Metadata (LOM) scheme [13] that, promoted by IEEE Learning Object Standards Committee, resulted from the joint effort of several initiatives in the field. It was approved as IEEE-SA standard in June 2002 (http://standards.ieee.org/).

The work carried out and the increasing interest for the LO technology pointed out the limited capacity of present metadata standards to express the pedagogical features of learning resources according to the view of the education world. For example, the educational affordances of IEEE LOM are controversial [8]. Moreover, the expressive power of the proposed metadata models is often unsatisfactory with respect to the underlying educational paradigm: it has been observed that metadata models lack of a learning-related vocabulary to help users describe type of learning, objective and context [24]. In addition, in LOM based application profiles pedagogical metadata elements are almost never mandatory, thus they are rarely filled in [11].

To these problems, that mostly derive from the fact that the LO technology was conceived and developed in a technologically oriented cultural context, we have to add the difficulty, due to the variety of views that occur in digital educational resources, to individuate a standard set of metadata apt to balance essentiality needs (to limit the effort of the production) with precision requirements (to facilitate the retrieval of a resource) [7]. Finally, standards defined at international level make it difficult to take into account the specificity of national systems [10].

These issues form the basis of the studies that analyse educational metadata according to a pedagogical point of view. Among the theoretical studies, we recall for example the proposal of Jonassen & Churchill [16], who formulate indications, on the basis of the psychology of learning, about possible types of LOs and ways to expand metadata in order to support meaningful learning [17]. Another example is constituted by the work of Mwanza & Engestrom [23], who investigate the potential contribution that specific learning theories can offer to produce both pedagogically meaningful and contextually relevant content descriptions.

Among the studies oriented to the education practice, we recall, for example, the work of Suthers et al [27] who, focusing on the need of describing educational resources in a way 'understandable' to educationalists, propose some modifications to LOM.

Simon & Quemada [26] suggest an approach to the choice of metadata based on user attitudes. The educational requirements of metadata for exchanging learning resources

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are analysed by using a reference scenario. The identified user needs are translated into requirements of the metadata model, which is assessed asking the potential users to 'virtually' describe their learning resources.

Metadata application profiles including pedagogical descriptors that meet the needs of educators have also been proposed. We recall for example the Gateway to Educational Materials project (GEM, http://thegateway.org), an initiative of the US Department of Education based on the Dublin Core Metadata Standard (http://dublincore.org/). GEM introduces a metadata application profile for describing educational resources in a semantically rich way and with an accompanying set of controlled vocabularies [25]. Gem's guiding principles and metadata form the basis for the proposal formulated by EdNA (Education Network Australia, http://www.edna.edu.au/), a network of the Australian education and training community.

These works produced very valuable results. From the point of view of the education practice, however, two aspects need further investigation:

1. Teachers, in their work, make use not only of material to be employed directly with students, but also of schemata, scripts, meta-models that support them in devising educational proposals [3]. Material of this type, oriented to plan activities such as for example a web-based discussion between peers, or a collaborative project, is a very valuable reusable educational resource, as it constitutes a sort of guide to carry out innovative classroom activities. Pedagogical metadata, as a consequence, should help the teacher to efficiently select LOs that are representative of two kinds of material: resources, oriented to students, aimed at being used directly in the education practice; and resources, oriented to teachers, aimed at organising it.

2. A standardised language in the education field is hardly to be found. The terminology is often inherently ambiguous, or it is interpreted with different meanings by the different professional figures involved in the design of LOs. For examples, the expressions 'problem based learning' and 'project based learning', which denote different pedagogical strategies, are often used as synonyms by teachers. In particular, the majority of teachers, at least in the Italian situation, are not familiar with the language used by instructional designers for indicating web-based pedagogical approaches. For example the expression Web-quest strategy is not acknowledged by the whole teacher community, although this strategy is widely used. Metadata and vocabularies, on the contrary, should avoid as much as possible ambiguities, and should use a terminology that is generally shared by the education community and corresponds to the approach usually adopted in school practice to define the characteristic features of a proposal.

These considerations form the basis of our work. In particular, we devised a proposal for pedagogical metadata, aimed at describing resources included in repositories that are mainly oriented to high schools, higher education and life-long learning, with particular reference to the Italian realm. Our work also includes a glossary of terms that supports both the indexing and the searching for LOs.

The characteristic features of our proposal are: 1) the introduction of a specific metadata element to describe the role that a LO has to play when it is integrated into the educational process; 2) alternative sets of metadata descriptors depending on the role of the LO.

As it focuses on the pedagogical dimension, the model is not intended to describe content-related aspects, for which we refer to international standard schemata.

An initial version of the proposal has been experimentally validated with a number of potential users with different backgrounds. This validation process showed the suitability of our approach. At the same time, it suggested us to introduce a number of modifications apt to improve the adherence of the model to the user needs.

Our work is presented in the following sections. At first, we illustrate the conceptual premises of our proposal and the current version of the model (Section II). Then, we describe the approach we followed in the validation process (Section III) and discuss the results (Section IV). The modifications and the evolution of our model are further illustrated in Section V. Some remarks about future work conclude the paper (Section VI).

II. Pedagogical Description of LOs

Table I outlines our proposal (both the initial and the present version) for describing LOs from a pedagogical point of view. Differences between the two versions are highlighted in grey. For the sake of space, we do not indicate the sets of values nor the number of possible values for each element. They will be explicitly illustrated in the following text, when functional to the discussion. For an in-depth presentation of the proposal we refer to [2].

The proposal integrates descriptors from the main international metadata standards, in particular IEEE-LOM, GEM and EDNA, with new ones aimed at identifying the context of use, educational features, structure and learning approach of the resource.

Category General includes two descriptors, *Material language* and *User language* that identify the language of the resource and that of the intended user. They correspond to the LOM descriptors *1.3 General.Language* and *5.11 Educational.Language* respectively [13].

TABLE I
Metadata Elements of our Proposal (Before and after Experimental Validation)

Category	Elements (Initial version)	Elements (Present version)
General	▪ Material language ▪ User language	▪ Material language ▪ User language
Audience	▪ Sector ▪ Level ▪ Content prerequisites ▪ Previous general competences	▪ Sector ▪ Level ▪ Content prerequisites ▪ Previous general competences
Educational Features	▪ Estimated required time ▪ Interactivity type ▪ Cognitive level	▪ Estimated required time ▪ Fruition mode ▪ Interactivity type ▪ Cognitive level

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Category	Elements (Initial version)	Elements (Present version)
Pedagogical Model	▪ Type [mandatory] Case: Functional Resource type Structured Subtype Didactic strategy Activity/Assignment available Assessment available Learning design Suggested didactic strategies Hints for activity/assignment Hints for assessment	▪ Type [mandatory] Case: Functional Resource type Structured Subtype Didactic strategy Activity/Assignment available Activity Type Assessment available Units of learning Hints for activity/assignment Hints for assessment Learning mode Standard compliance Pedagogical design and the like Suggested didactic strategies Hints for activity/assignment Hints for assessment Learning mode Lesson plan Suggested didactic strategies Hints for activity/assignment Hints for assessment Learning mode Reference material available
Annotation	▪ Entity ▪ Date ▪ Description	▪ Entity ▪ Date ▪ Description

Category Pedagogical Model constitutes the characteristic feature of our proposal. It aims to describe the main pedagogical approach adopted by a LO. Our choices for its elements started from the observation that there are two kinds of LOs: teacher-oriented resources (that we call *Learning design LOs*), devoted to guide the teacher in the design of learning activities; and student-oriented material (that we call *Structured LOs* and *Functional LOs*), to be used directly by students (with or without the teacher's mediation) (see Fig. 1).

In the current version of our proposal the descriptors for teacher-oriented resources that support the LO pedagogical design are further differentiated (*Units of learning*, *Pedagogical design patterns and the like*, *Lesson plans*), depending on the type of help offered to teachers, on the level of abstraction from the context and on the level of formalization. *Lesson plans* are illustrations of proposals in terms of objectives, strategies, supporting tools, resources, possible uses and so on; they are formulated in plain natural language, and no constraint is imposed on their structure. Lesson plans are instantiated in a specific knowledge domain and are aimed at a particular target population, although they can be endowed with indications for reuse in different contexts.

The solution of a specific educational problem is supported by tools like *Pedagogical design patterns* and similar schemata [22], [1] that model a particular strategy or technique in order to make good practices transferable: these patterns are not instantiated in a specific knowledge domain, and are therefore more general than lesson plans. Although still formulated in natural language, design patterns observe precise structural prescriptions.

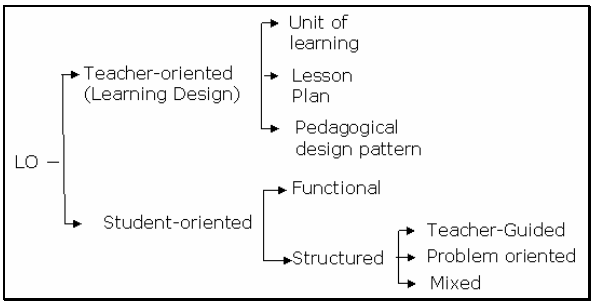


Fig. 1 Taxonomy of LOs

The building of environments centred on an active approach to learning is facilitated by the use of suitable *Units of Learning* [18], [19] that are described using formal languages (EML – Educational Modelling Languages; see for instance the IMS Learning Design specification [14]) and are therefore interpretable also by automated environments (Learning Management Systems).

As we already discussed in [6], learner-oriented resources can be classified depending on the role they are intended to play in the learning process. This consideration is based on the observation that teachers, planning an educational proposal, organise the overall path in a number of modules, each focusing on a specific aspect and providing the setting for a particular learning experience. Thus, these modules include a well-identified educational objective and a pedagogical approach to it. They moreover can make use of auxiliary material (report forms, FAQs, bibliographies,) which does not include a specific pedagogical orientation but has a general-purpose or context-related function. Accordingly, we distinguish between *Structured LOs*, representing educational modules, and *Functional LOs*, referring to auxiliary material.

These ideas lead us to introduce a descriptor *Type* that differentiates LOs according to the above classification (see Fig. 1). This element is mandatory and for any given LO it can assume only one of the values constituting its vocabulary.

As to the other elements of the *Pedagogical Model* category, a single set of pedagogical descriptors can hardly characterize all types of LO. For example, the didactic strategy is a key-element in describing a *Structured LO*. Its expressiveness, however, is limited for *Functional LOs* that can be better described by the type of the resource (e.g., set of data, graph, etc.). The *Pedagogical Model* category, therefore, includes different sets of descriptor, to be used in alternative depending on the actual value of the *Type* element:

- *Structured* LOs are described on the basis of the pedagogical orientation (*Subtype)*, the didactic strategy (*Didactic strategy*), the existence and type of the activity proposed to students (respectively *Activity/Assignment available* and *Activity Type*), and the existence of (self)-assessment material (*Assessment available*). The *Subtype* element relies on a single-choice set of values: *Guided*, if the educational resource aims to introduce the student into a new topic under a planned guidance; *Problem*, if it proposes a problem situation to be explored autonomously by students; *Mixed*, if it integrates the two approaches (see Fig. 1) [6]. For the *Didactic strategy* element a vocabulary of thirteen multiple-choice values is

provided (see Hata! Başvuru kaynağı bulunamadı.II). The terms in the vocabulary are quite familiar to Italian teachers and their meanings are generally shared.

TABLE II
VOCABULARY OF ADMISSIBLE VALUES FOR THE *DIDACTIC STRATEGY* ELEMENT

auditory / visual / tactile or kinaesthetic learning
case based teaching and learning
critical incident-based learning
demonstrations
drill & practice
exploratory learning
goal-based [scenario-based] learning
learning by designing
problem based learning
resource based teaching and learning
tutorial
discussion groups
role-play simulation

- *Functional* LOs are described on the basis of the typology of resource, by means of the element *Resource type*. Allowed values for this descriptor include, for instance, *FAQ list, game, movie, computer simulation* etc.
- *Teacher-oriented* LOs (*Lesson plans*, *Learning design patterns and the like*, *Units of Learning)* are described similarly to *Structured LOs*. In this case, however, descriptors refer to activities, lessons, didactic units or modules which the *Learning design* LO proposes.

Category Audience describes the characteristics of the intended user of a LO (in case of teacher-oriented LOs this is the final user, i.e. the student). The *Sector* and *Level* elements are similar in their meanings to analogous descriptors of other proposals (e.g. in EDNA.Audience the *edna-sector* and *edna-userlevel* element refinements), but they take different values. In our case, these elements rely on vocabularies that fit the Italian context and the educational level our work focuses on. Two distinct elements for the prerequisites are also included: one referring to content, the other to the general abilities and the metacognitive capabilities that should be mastered to successfully deal with the LO (*Content prerequisites* and *Previous general competences* elements respectively).

Category Educational Features includes some educational characteristics of a LO, partly present in other proposals. For example, the element *Estimated Required Time* takes the same meaning and values as the LOM 5.9 *Typical learning time* element. The element *Cognitive level* relies on Bloom's taxonomy [5] as a vocabulary for its values: this is suggested also in [12] and in [28]. The cognitive level is an important parameter for identifying the difficulty level of learning material; thus we chose to take into account the context and the target population, by associating the complexity of the resource to the typology of cognitive objectives the LO is aimed at.

The *Interactivity type* element, differently from other proposals, aims to describe the nature of the interaction (*Minimal, with content, with teacher, with peers*) that is to be activated by a LO.

Category Annotation corresponds to the LOM *Annotation* category. We suggest to include comments on the LO and indications about the authors of the comments to capture, for instance, problematic aspects that emerged from previous experiences in using the resource.

III. EXPERIMENTAL VALIDATION OF THE PROPOSAL

A preliminary validation of our ideas was carried out by experimenting the initial model with a group of 14 prospective users with different backgrounds (foreign languages, scientific subjects, etc.) and various levels of expertise in e-learning: in particular, the group was composed by 3 instructional designers, 5 teachers and 6 technologists. The validation activity was mainly focused on the elements whose values are specified in a closed vocabulary.

The experimenters were asked to use the model elements and glossary for indexing some LOs, to write down the problems they met and to report their opinions by a questionnaire administered via individual interviews.

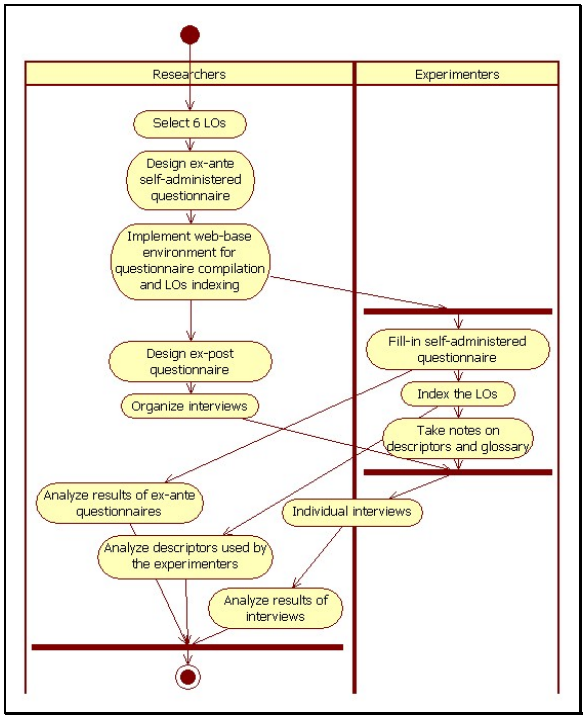


Fig. 2 Structure of the validation process

The experiment phases are illustrated in Fig. 2. We selected six LOs and we proposed four of them to each participant by means of a web-based tool we designed and implemented. Three LOs referred to topics of general interest (history, basic physics, multiculturalism) and one referred to a specific topic (math, French and English as second language), selected on the basis of the experimenter competences. S/he was asked to index each of them writing down notes about the descriptors and the glossary. Preliminarily, each participant had to fill-in a self-administered, ex-ante, electronic questionnaire. We designed it to obtain precise profiles of the experimenters with respect to their expertise in specific e-learning aspects and in their mastery of the LO paradigm.

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After indexing the LOs, each participant was individually interviewed: in order to limit misinterpretations, the interviews were carried out by two researchers (one with the role of observer) and they were audio-recorded.

The data analysis (Section IV) of this experimental validation process focuses on the results of the self-administered questionnaire, the results of the interviews and the descriptors used by the experimenters to index the LOs.

IV. Results of the Experimentation

The limited number of users involved in the experiment makes it quite difficult to generalise the results. However, we obtained some useful indications on the usability of our proposal and on the required changes.

A. Observations on the Self-Administered Questionnaire

Experimenters had to self-assess their competence and to produce a personal definition of the LO concept. On the basis of the answers we identified three groups of users characterized by low (2), medium (10) and high (2) knowledge about LOs. By detecting the profiles of the experimenters as to LO competence helps us to highlight the possible relationship between profiles and opinions about the proposal. Moreover, it would allow comparisons with any other future experimentation.

B. Observations on the Results of the Interviews

Ex-post interviews were guided by a questionnaire that was aimed at exploring: 1) the suitability, completeness and non-redundancy of categories, descriptors and vocabularies; 2) the clarity and coherence of the names chosen for the categories, the metadata elements and the items of the vocabularies; 3) the appreciation of the glossary.

The results of the interviews confirm the difficulties of clearly describing the pedagogical aspects of LOs. They also seem to indicate that our proposal is a valuable step in this direction: category and element names and meanings were quite easily understandable for all the experimenters. The majority of them (11), moreover, declared that our proposal quite effectively captures the educational features of a LO. Some aspects to be improved were also suggested, with particular reference to the *Pedagogical Model* category.

A relevant remark about the *Pedagogical Model.type* element emerged. All technologists and 2 instructional designers (out of 3) appreciated our attempt to simplify LOs' descriptions by identifying three mutually exclusive typologies (each one tied to specific sub-descriptors). Conversely, 6 experimenters, including all the teachers, observed that the constraint of choosing only one value for the pedagogical type of a LO is often too restrictive: in several cases the same LO can include both a *Functiona*l and a *Structured* component; in other cases there are LOs that include both teacher-oriented and student-oriented parts. The availability of the *Pedagogical Model.Didactic strategy* element was particularly appreciated. However, the experimenters reported partial overlapping of some items of the vocabulary.

C. Descriptors used by the Experimenters

For each LO, the set of descriptors chosen by the various experimenters are quite similar as regards the elements of the categories *General, Audience*, *Educational Features* and the descriptors of the category *Pedagogical model* (i.e. *Activity/Assignment available*, *Assessment available*). In particular, regarding the *Educational Features.Cognitive level* element (that allowed for more than one value) we observed that almost all experimenters made the same choices in the same order, thus confirming, at least to some extent, that this element has a clear and shared meaning.

The choices regarding the *Pedagogical Model.Type* and the *Pedagogical Model.Didactic strategy* elements show more heterogeneity. Regarding the element *Type*, all experimenters selected the same value for two LOs (one representing the plan of a lesson and the other a collection of English language exercises). As for the other LOs, the same value was indicated by 2/3 of the experimenters, except in the case of the LO devoted to the learning of math. For this LO, the choices of the experimenters are equally distributed between the values *Structured* and *Functional*. This fact corresponds to the observations made by the experimenters during the interviews. In our view, it indicates that the distinction between teacher-oriented LOs (*Learning design*) and student oriented ones (*Functional* and *Structured*) is quite easily understandable and shared. On the contrary, the distinction between *Functional* and *Structured* LOs is more difficult to individuate, as some material, depending on the situation, can be used with different pedagogical objectives, or it can include both components.

As to the element *Didactic strategy*, we recall that more than one value is admitted. In almost all cases the experimenters identified a large number of strategies for the same LO, thus confirming the difficulty of clearly distinguish among different strategies that are inspired by the same view of learning. As to the *Subtype* element, in three cases (the LOs on history, basic physics and English language) the choices of the experimenters coincide. These are well-defined LOs from the point of view of the learning theories. In the other cases, which refer to LOs where a teaching component is integrated with a problem oriented approach, the choices are almost equally partitioned between the values *Mixed* and *Problem oriented*. We hypothesise that this difference is mainly due to fact that some users tend to emphasise the problem oriented approach of a didactic resource, while others give more relevance to the opportunity it offers to integrate constructivism in the didactic practice.

Finally, the descriptions proposed by the experimenters do not seem to be related with their previous knowledge on LO technology, thus confirming the need of reflecting on pedagogical metadata by starting from the observation of teacher attitudes towards educational material to identify valuable pedagogical descriptions.

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V. Evolution of the Model

The results of this first experimentation suggested some modifications to our model, involving both the shared semantics of descriptors and vocabularies, and some issues at a more conceptual level. As to the former aspect, we improved the glossary and included in the indexing tool further support for the teacher/indexer.

As to the conceptual issues, they mainly refer to the type of a LO and to the *didactic strategy* it includes, if any. In particular:

- we modified the vocabulary of the *Pedagogical Model.Type* element to reflect a classification of the *Learning design* LOs based on the kind of support offered to teachers (as already discussed in Section II);
- we introduced the possibility of providing more than one description for any given LO, to take into account that it is sometimes difficult to identify a single *Pedagogical Model type.* This amendment should allow to describe quite clearly the pedagogical features of *Structured* LOs that integrate relevant *Functional* components. Moreover, it simplifies the description of LOs of this kind, and it increases their reusability by giving evidence to all their educational characteristics. The possibility of expressing more than one description to a LO, furthermore, allows to take into account the usefulness of teacher-oriented LOs also for students. For example, *Lessons Plans* LOs can include resources that can act as *Functional LOs*;
- we modified the *Didactic strategy* vocabulary by generalising some terms, so to reduce their number and limit the chances of misunderstanding. For example, we now avoid to include in the name explicit reference to the learning mode (collaborative or individual) or to the fruition mode (presence, distance, blended);
- we also added two new descriptors: 1) *Pedagogical Model.Learning Mode*, to be used with LOs of types *Structured, Unit of learning, Lesson Plan, Pedagogical Design Pattern*. Possible values for this element include: *collaborative, individual*. This element allows to refine the meaning of a specific didactic strategy avoiding redundancy. For example, strategies inspired to socio-constructivism [15] are expressed by selecting a constructivist strategy (i.e. problem solving) and the value *collaborative* for the element *Learning Mode*. 2) *Educational Features.Fruition Mode* that allows to specify if the LO can be reused in a presence, distance or blended learning path.

VI. Conclusion and Future Perspectives

The starting point of our work has been the classification of educational resources into two main categories: material oriented to the teacher (so called *Learning design LOs*) and to the student (so called *Structured* and *Functional LOs*). On the basis of this distinction we identified a set of pedagogical descriptors and defined related vocabularies (list of values) and glossaries (the definitions we assigned to values).

To efficiently support resource description and retrieval, a vocabulary has to be semantically shared among designers and (re)users [9]: thus, the intended users of a description model play a central role in the validation of the model itself. Accordingly, we decided to try out our proposal in a number of controlled tests with a variety of users.

The initial version of the model was validated by a number of e-learning experts with different backgrounds; the results of the preliminary experimentation seem to confirm the effectiveness of our approach; at the same time a number of suggestions and user needs emerged. Therefore, a further step of our work was the refinement of the initial set of metadata.

At present, we are conducing other validation activities for our model with two different target groups: 20 M. S. students and 10 insurance working persons, with the aim of analysing similarities and possible inconsistencies with the results of the first experimentation.

Although we have still to finalize these validation processes and to reflect upon results, we can already report that it is paradoxically difficult to express clearly and without ambiguity the conceptual meaning of terms that are frequently adopted in everyday didactic practice. Moreover, the experimenters' observations underline the difficulty of precisely identifying and clearly describing pedagogical characteristic of LOs.

However, the results of the preliminary experimentation reveal that the majority of users share the semantic and pragmatic values of our descriptors and agree with the premises of our work, showing a critical and constructive attitude towards the possibility of capturing part of their experience and their tacit knowledge in the description of learning resources.

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