# Looking for Contextualized Learning Objects to support Semi-automatic Learning Design Generation

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*Abstract*— **Learning object economy are marketplaces for the sharing and reuse of Learning Objects (LO). There are many motivations for stimulating the development of the LO economy, but maybe the main of them is the possibility to provide just the right content, to just the right learner, at just the right time, in the context of a long-life learning process, according with adequate quality standards. In fact, this is the main objective of education [1]. As well as it is necessary to orient some barriers for the development of LO economy such as the granularity and editability of the LO [2], some enablers must be promoted in order to develop learning object economy: Learning Design generation and the Standards promotion.**

**Learning design is the term coined to a movement for more consistent approaches in describing and documenting teaching practice to facilitate communication and sharing, but also importantly to facilitate the improvement of teaching practice. Ironically, there is currently no standard definition for learning design[3].**

**The main purpose of this paper is to improve our proposal of standardized and adapted learning design generation for integrating distributed learning objects repositories (DLOR) as sources of LO to be located in the generated learning design. The proposed solution orients two main issues: the Distributed LO Searching Process through a multi-agent Platform and the Micro-Context based Location Process using disambiguation techniques in order to place the LO into the most adequate learning design micro-context.**

**To relieve the teachers' design work, for offering them the possibility of reuse LO from different source into a semiautomatic generated learning design without the necessity to leave of their virtual environment, is the main contribution of our approach.**

***Keywords-learning style; learning design; learning objects economy; word sense disambiguation, micro-context***

## I. INTRODUCTION TO BASIC CONCEPTS OF LEARNING OBJECTS ECONOMY

Through the years, the concept of learning object has been thought and re- thought for many, diverse and qualified people. The IEEE Learning Technology Standards Committee (LTSC) [4], in its work over the Learning Object

Metadata Standard [5] defines a learning object as any, digital or non-digital, that may be used for learning, education or training. This definition covers almost anything as a learning object, but not any available thing is a learning object. According to Polsani [6], LO need to be accessible, reusable and interoperable, but also a learning object need to be wrapped in a learning intention.

Wile [7] reinforces the concept of reuse introducing the term of "object" from the Object Oriented Programming paradigm of computer science, where one "object" is understood as a component that can be reused in multiple contexts. In this way, a learning object is presented as a small instructional component that can be reused in different learning contexts, when required. This remark is important to us because our proposal is based in the idea of the learning object economy [2], where reuse is the key.

Learning object economy are marketplaces for the sharing and reuse of LO. As in any economy, different actors play different roles in the learning object economy. Ochoa in [8] identifies the following eight actors: Market-Makers, Authors, Resellers, Publishers, Teachers, End Users, Assemblers and Regulators. *Market-Makers* provide support to interchange LO among them, some examples are Learning Object Repositories (LOR), Open Courseware sites, Learning Object Technologies researchers and trainers. *Authors* are LO creators, as teachers or learning designers. *Resellers* are those who have acquired the right to exploitation of LO, as universities or private companies. *Publishers* are those who have the publication right of the LO. *Teachers,* usually are Authors or End-Users. *End-Users* use the LO for learning. *Assemblers* reuse small LO to construct other most complex ones. Finally, *Regulators* set the rules by which the sharing takes place.

Offering a learning process for all is the main motivation for stimulating the development of the learning object economy. However, to ensure that this necessity becomes a reality it is necessary to overcome some barriers in the learning object economy as is shown in [2]. We are going to focus the discussion only on two major categories of barriers: technical and pedagogical.

There are two main *technical barriers* for reuse: granularity and editability. Granularity is referred to how big should a learning object be. In this sense, Wile in [7] introduces two different points of views for facing the decision: efficiency and instructional point of view. Author indicates, from the efficiency point of view, the decision regarding learning object granularity can be viewed as a trade-off between the possible benefits of reuse and the expense of cataloguing, in contrast with the instructional point of view where the major issues to be consider are the

scope and sequence.

With respect to editability, it is possible to change any aspect of a learning object if it is available in a suitable form. Editability produces that the LO granularity could be changed. There are many distribute LO not editable, in fact, this is one of the most common excuse for no reuse provide by teachers.

Count with editable and open LO require the agreement among the LO economy actors. In particular, referred to the right author management, which would increase the creator confidence. On the other hand, the implementation of author tools to support LO editability, which addressing the accessibility issues in the content is one of the most important issues in this economy.

*Barriers from pedagogical view* are related basically to the LO context. According to [9] context could be defined as any information that can be used to characterize the situation of an entity, in our case the LO. Yet context in education is essential. But, practically, context in LO inhibits reuse. Addressing the context allows to use LO in different scenarios. Small granularity facilities to drive the context issues and LO editability could permit to teachers contextualize the LO according with learners necessities.

As well as the barriers, some enablers must be promoted in order to develop learning object economy: Learning Design generation and Standards promotion.

*Learning Design generation.* "Learning design" is the term coined to a movement for more consistent approaches in describing and documenting teaching practice to facilitate communication and sharing, but also importantly to facilitate the improvement of teaching practice. But, there is currently no standard definition for learning design[3]. A well-accepted definition for an instructional design process is the following: the process that should be followed by teachers in order to plan and to prepare the instruction [10]. This process should address, in an integral way, the people's needs, such as cognitive, emotional, social, and physical. Given that LO are just content, to have a real learning experiences those contents need to be administered in order to achieve a pedagogically and adequate sequence. The adequate pedagogical theories and techniques need to be in place in order to assure that LO have real impact [8].

Automatic learning design generation is an important topic in the research areas of adaptive learning systems as well as technology enhanced learning in general. Some approaches [11], [12], [13], [14] have been proposed in order to help teachers in the generation process of learning designs adjusted to user characteristics (i.e., learning styles and competences) which is not an easy problem, in particular for the teachers. Actually, this problem implies that teachers need to know the different instructional theories, they also need to control the different user variables to consider in the learning design construction such as users' learning styles and competences, among others and furthermore, teachers need to know how to develop standardized learning designs for the specific learning platform they use.

*Standards promotion.* If a global learning object economy is the goal, there must be common-agreed standards that enable the sharing of LO between heterogeneous systems [8]. Important organizations/groups such as The IEEE Learning Technology Standards Committee (LTSC) [4], IMS Global Learning Consortium [10], Dublin Core Metadata Initiative [11], among others, have been concerned in proposing approaches for learning object standardization. Almost all elements, actors and process of the learning process have been objects of standardization. In [13] we present a resumes of the analysis develop about different standards and organizations involved in their creation which has been accepted and validated in the international scope.

The research presented in this paper is based on an approach for standardized and adapted learning design generation [28],[29] and aims at improving this approach by stimulating the learning object reuse through accessing distributed learning objects repositories (DLOR) as sources of LO with diversity granularity, which are elements in the generated learning design. Our proposal consists of two differentiated parts, the Distributed Learning Objects Metadata Searching Process and the Micro-Context based Location Process.

Distributed Learning Objects Metadata Searching, was conceived as a mechanism to promote a reuse-oriented approach. This process is supported by agent technologies and its main purpose is looking for external LO, not developed by the teachers, which could be used for our solution as inputs in the learning designs generation process.

Micro-Context based Location Process proposes the analysis of the learning objects' metadata and the current Micro-Context (in the LOR it live) considering disambiguation techniques in order to establish the LO relevance for a specific micro-context in a learning design and thus helps in placing the object in its correct context.

The rest of the document is structured as follow. In section II the Distributed Learning Objects Metadata Searching Process is introduced. Section III describes the Micro-Context based Location Process. Section IV shows some initial evaluation results and finally in the section V some conclusions and remarked future works are introduced.

## II. LORSE: META-SEARCHER OF LEARNING OBJECTS OVER DISTRIBUTED LEARNING REPOSITORIES BASED ON INTELLIGENT AGENTS

In order to address the Distributed Learning Objects Metadata Searching Process, we have developed a learning object repositories searcher (LORSE), which stands for Distributed Learning Objects Metadata Searcher, as a mechanism to promote a reuse-oriented approach. LORSE

multi-agent system [26] has been modelled as an independent set of JADE intelligent agents that collaborate to support the users in the LO searching process. LORSE consists of two different types of agents: the Directory Facilitator Agent and the Specific Searchers Agents. The main purpose of this multi-agent platform (Figure 1) is to deliver to the most suitable LO according to the parameters provided by the user in a specific query. The Directory Facilitator Agent maintains a directory of tuples, where each of them relates one specific searching service over a LOR with one specific agent called Specific Searcher Agent. Each Specific Searcher Agent develops the task of registering a new service into the Directory Facilitator Agent and of processing the services requested. When an external process needs to request for a particular service in the platform, the external process must communicates with the Directory Facilitator Agent to request the identifier of the agent in charge of a specific service. Specific Searchers Agents implement particulars web clients through behaviours for requesting search services over particulars repositories. In [26] we introduce an example of application with three repositories (Merlot, Conexions and UdG), now we have added more (DalSpace, Deep Blue and DLESE) three as is shown in figure 1.

When the Merlot Agent (Specific Searcher Agent in charge to the integration of Merlot Repository) is born, the Merlot searching service is registered to the Directory Facilitator Agent in order to allow other agents or processes to locate and send requests to this agent. The Merlot agent is activated when a request for searching is sent to it. Merlot's agent counts with a particular behaviour, which is a client for the RESTful web service, offered by Merlot repository. When a request is sent to the agent and according with the terms and conditions of the query, the agent performs a connection with the service, sending the parameters. The same behaviour gets the response, which is an XML document (metadata).

The implementation of Connexions and UDG Agent is similar to the Merlot agent, they have behaviours designed to interact with the RESTful web service offered by this applications.

For the integration of DalSpace digital repository, Deep Blue Repository at the University of Michigan and DLESE Repository into the multi-agent platform, we have created an intelligent agent for each of them with a indexer behaviour, which using the OAI-PMH harvester protocol index the categories (catalogues) and records into each categories (resources) of each particular repository. Each resource metadata are stored in a database as a tree. In this way the information is available for searching.

In order to test LORSE, we have integrated our proposed platform upon OpenACS/.LRN learning environment. For the integration process it was necessary to implement the LORSE Client package in this platform, which implements a web service client upon dotLRN in order to send requests to the LORSE Multi-agent Platform and process its responses. This package offers an interface to user that provides functionalities in order to search over several repositories in a transparent way. Therefore, when teachers use the learning environment they are able to search LO from those repositories to enhance the activities designed in the platform without necessity of leave to the learning environment.

## III. MICRO-CONTEXT BASED LOCATION PROCESS

The main purpose in this section is to explain our proposed approach to enrich our learning design generation process considering external and distributed LO, which are stored in LOR.

To achieve this objective two different sources of information are available: 1) the information prevenient from LOR, in particular, the catalogue or indexed mechanism of the LO and the LO metadata and 2) the available information provided by the teacher in the competence definition which permits to define appropriate performances that should be demonstrated by a person on a specific context. The competence definition consists of four categories of information: Competence General Information which provides general data about the competence; Competence Elements which are smaller learning purposes and means more specific and concrete learning process outcomes; Didactical Guidelines and the Competence Context of application.

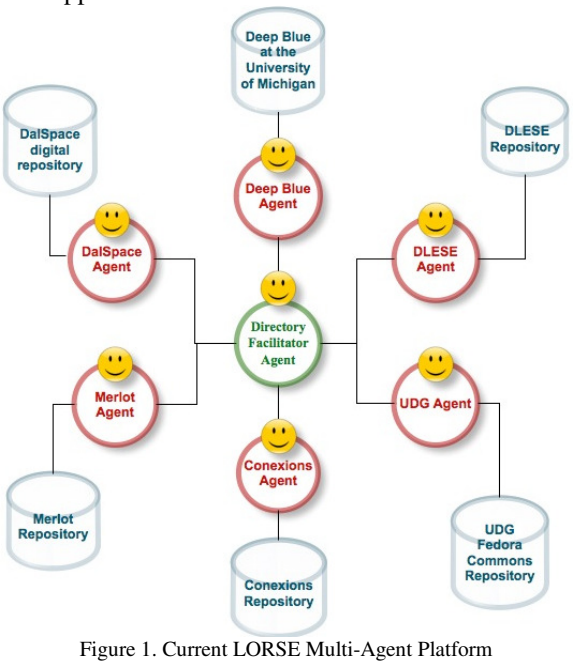


Figure 1. Current LORSE Multi-Agent Platform

Competence Elements in turn describe the Essential Knowledge which the student should mobilize in a specific context to demonstrate the acquisition of the competence and the Competence Evidence as the mechanism to measure the level of achievement of each particular competence

element. These available evidences are evaluated according with [27]. Schum's evidential reasoning approach explains how the evidence coming from different sources can be evaluated. In our case, the analysis of the evidence is related with its relevance, the relevance of the learning object for addressing what the teacher is looking for.

*A. Learning objects relevance*

Borlund in [28] mentioned three central conclusions from the nature of relevance and its role in information behavior from [29]:

- Relevance is a multidimensional cognitive concept whose meaning is largely dependent on users' perceptions of information and their own information need situations;
- Relevance is a dynamic concept that depends on users' judgements of quality of the relationship between information and information need at a certain point in time;
- Relevance is a complex but systematic and measurable concept if approached conceptually and operationally from the user's perspective.

Saracevic [30] distinguishes between five basic types of relevance: (1) System or algorithmic relevance, which describes the relation between the query (terms) and the collection of information objects expressed by the retrieved information object(s); (2) a topical-like type, associated with aboutness; (3) pertinence or cognitive relevance, related to the information need as perceived by the user; (4) situational relevance, depending on the task interpretation; and (5) motivational and affective, which is goal-oriented.

Ochoa in [8] use an modified Saracevic categorization (eliminating motivational and affective dimension) as the base to define a set of complete metrics for LO relevance identification. These metrics are shown in table I.

TABLE I. RESUME OF FEATURES ABOUT CREATED METRICS

| TYPE | METRIC | DESCRIPTION | INPUTS |
|---|---|---|---|
| Topical Relevance | Basic Topical Relevance (BT) | Number of times the object has been previous selected from the result list when the same (or similar) query terms have been used | Queries of which the system keeps record. |
| | Course-Similarity Topical Relevance (CST) | Number of time that LO in the list have been used in the universe of courses. | Courses |
| | Internal Topical Relevance (IT) | The sum of the hub value of the courses where it has been used. | Courses |
| Personal Relevance | Basic Personal Relevance Ranking (BP) | Analyse the characteristics of the LO used previously, in particular the relative frequencies for the different metadata field values. | Metadata from the Learning object used for a particular user. |
| | User-Similarity Personal Relevance Ranking (USP) | Numbers of time similar users have reused the objects in the result list. | Information about Learning object use and its metadata. |
| Situational Relevance Ranking Metrics | Basic Situational Relevance Ranking (BS) | Cosine distance between the TF-IDF vector of contextual keywords and the TF-IDF vector of word in the text field of the metadata. | Description of the course, lesson or activity and the learning object metadata. |
| | Context Similarity Situational Relevance Ranking (CSS) | Analyses of objects that already have been used under similar conditions. Frequencies for different fields in the LO metadata. | Information about Learning object use and its metadata. |

*B. Learning objects relevance through the Micro-Context*

The automatic disambiguation of word senses (WSD) has been an interest and concern since the earliest days of computer treatment of language in the 1950's and it involves the association of a given word in a text or discourse with a definition or meaning (sense) which is distinguishable from other meanings potentially attributable to that word [31].

All disambiguation work involves matching the context of the instance of the word to be disambiguated with either information from an external knowledge source (knowledge driven WSD), or information about the contexts of previously disambiguated instances of the word derived from corpora (data-driven or corpus-based WSD).

The assignment of words to senses is accomplished by reliance on two major sources of information:

- The context of the word to be disambiguated in the broad sense: this includes information contained within the text or discourse in which the word appears, together with extra-linguistic information about the text.
- External knowledge sources, including lexical, encyclopedic, etc. resources, as well as hand-devised knowledge sources, which provide data useful to associate words with senses.

Most disambiguation works use the local context of a word occurrence as a primary information source for WSD. Local or "micro" context is generally considered to be some small window of words surrounding a word occurrence in a text or discourse, from a few words of context to the entire sentence in which the target word appears.

We are going to consider the micro-context of a learning object as a part of the curricular structure where the learning object should live (learning design to be generated). Let us present the follow example. Consider the following curricular structure (Table II) belonging to a course of Unified Modelling Language (UML), generated based in the competence definition provide by a teacher:

TABLE II. PART OF A CURRICULAR STRUCTURE OF UML COURSE

| Unified Modelling Language |
|---|
| • Introduction to UML |
| o *Concept* |
| o *Diagrams* |
| o *Relation of UML with the Unified Process of Development* |
| • The models |
| o Use cases diagrams |
| o *Actors* |
| o *Use Case* |
| o *Relations* |
| o *Class diagrams* |
| o *Sequence diagrams* |
| o *Activity diagrams* |

We need to locate the LO which are results of a preliminary search based in the simples mechanism provided by the LOR, or according with the metrics described in table I in the below structure.

Our proposal is the analysis of two different possible micro-contexts, the micro-context of the LO in the repository structure (catalogue) where it live and the micro-context of the LO in the curricular structure where it will live. Comparing this possible micro-context we could take a decision about the location of the learning object where it will live, in the learning design.

Then, the first step is to derivate the micro-context of each learning object (LO) to be located and also the possible micro-context in the curricular structure.

Given a LO its micro-context which live in a catalogue in a LOR its micro-context is:

$$loMicroContext(LO,C) = SuperCategories(LO,C) U SubCategories(LO,C)$$

Where, LO is learning object; C is the catalogue in the LOR; in this way loMicroContext define the LO Micro-Context in a particular LOR catalogue.

Table III shown the loMicroContext of one LO, "Introduction to OMG's Unified Modelling Language".

TABLE III. INTRODUCTION TO OMG'S UML" FROM HTTP://WWW.MERLOT.ORG/MERLOT/VIEWMATERIAL.HTM?ID=78769)

| Science and Technology |
|---|
| • Computer Science |
| o Programming Languages |
| o **LO Introduction to OMG's Unified Modelling Language** |

In the Curricular Structure (CS) provided by the teacher, the possible micro-context could be:

$$csMicroContext = \sum_{1}^{N} cuMicroContext(\text{leaves})$$

The number of leaves in the CS defines the possible micro-context in the curricular structure. Three of the nine possible micro-contexts (cursive word in table II) in the CS presented below are shown in the table IV.

Now, the second step is to calculate the similarity among the different CS Micro-Context and the LO Micro-Context in order to locate the LO in the structure.

TABLE IV. POSSIBLE MICRO-CONTEXT IN THE UML COURSE

| First possible Micro-Context in the Learning Design |
|---|
| Unified Modelling Language<br>Introduction to UML<br>Concept |
| **Second possible Micro-Context in the Learning Design** |
| Unified Modelling Language<br>The models<br>Use cases diagrams<br>Actors |
| **Third possible Micro-Context in the Learning Design** |
| Unified Modelling Language<br>The models<br>Class diagrams |

For this step we propose to use different existed metrics to calculate the similarity among the TF-IDF (Term Frequency, Inverse Document Frequency) vectors inferred through the analyzed Micro-Context (CS and LO). Some of these metrics could be Dice coefficient or Cosine Distance.

Dice coefficient qualify the similarity between two vectors (Q and D) from 0 to 1, where 1 indicate identical vectors and 0 orthogonal vectors.

$$s = \frac{2|Q \cap D|}{|Q| + |D|}$$

Cosine Distance varies between -1 and 1, where $-1$ meaning exactly opposite, to 1 meaning exactly the same, with 0 usually indicating independence, and in-between values indicating intermediate similarity or dissimilarity.

$$s = \frac{Q.D}{|Q||D|} = \cos(\theta), \text{ where } \theta \text{ is the angle between Q \& D}$$

Based on the results of the algorithms for metrics implementation, the LO will then be located in the most similar Micro-Context in the CS with respect to the Micro-Context of the LO in the repository structure (catalogue) where it live.

## IV. RESULTS

After implementing the proposed approaches for searching and locating LO, an initial evaluation of our developments has been conducted. The analysis was based on interviews with teachers in which the application of a Service Quality Model (SERVQUAL) instrument [32] was developed. SERVQUAL explains the difference between the clients expectative and the satisfaction that they really obtain from the offered service.

We have developed a particular instrument (a survey)

to measure the user satisfaction in four aspects of our proposal:

- The satisfaction with the searching process (SEQ1), it means the possibility to search over different distributed repositories in a unique environment.
- The usability of the tool developed upon dotLRN platform (SEQ2) to integrate LORSE.
- The satisfaction with the results offered by the searching process (SEQ3).
- And the satisfaction with the possible location of LO into a curricular structure available for testing (SEQ4).

The instrument was applied to six teachers in the University of Girona, Spain, as a part of descriptive research in which the teachers had the opportunity to test our proposed application. The results presented in figure 2 shown a very close relationship between the importance perceived for the users referred to the evaluated issues and the satisfaction with the solution.

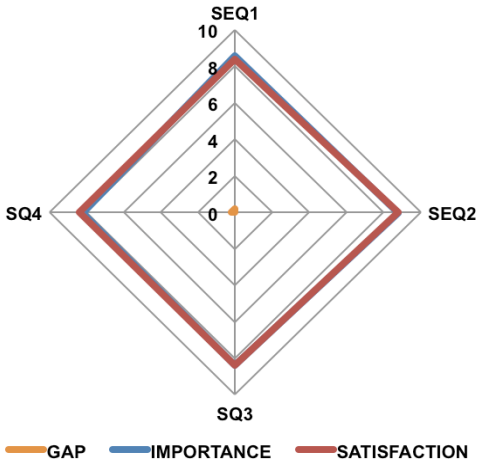


Figure 2. Graphics of Initial Results

Some other conclusions from the interview process could be highlighted:

- All Teachers think the reuse of learning objects as a possibility to improve virtual learning process for uniting the efforts of teachers from the different universities.
- All Teachers emphasis in the necessity of guaranteeing the quality of the selected learning objects, which is an important issue in the learning object economy, in particular, for the learning design generation process. The process for selecting learning object should be contextualized to the teachers and students necessities and it must guarantees the learning design quality.

## V. CONCLUSIONS AND FUTURE WORK

Main purpose of this paper is to improve our approach for standardized and adapted learning design generation [28] and [29] stimulating the learning object reuse by accessing DLOR. Proposed solution introduce two differentiated process: the Distributed Learning Objects Metadata Searching Process and the Micro-Context based Location Process, which were introduced in the document body.

Results developed with teacher from University of Girona are promising and it stimulates the development os evaluation scenarios when the main issues will be testing the LO relevance and the effectivenessit's of its location in the curricular structure in a more rigorous way.

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