From Content Objects to Learning Objects: 
Adding Instructional Information to Educational Meta-Data

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Abstract

This paper presents the work of the KOD European project for maintaining instructional information in learning objects meta-data, so that they can be easily reused for the manual and automatic construction of courses.

1. Learning Objects and Learning Objects Meta-Data

Learning objects currently lead other candidates for the position of choice in the next generation of instructional design, development and delivery, due to their potential for reusability, generativity, adaptivity, and scalability. They can be thought of as a new type of computer-based instruction, grounded in the object-oriented paradigm of computer science.

A working definition by LTSC (the IEEE Learning Technology Standards Committee, ltsc.ieee.org) defines learning objects as any entity, digital or non-digital, which can be used, re-used or referenced during technology supported learning. Examples of learning objects are digital exercises, study texts, cases, media assets, courses, study programmes, etc. The basic idea is that a learning object can stand on its own and may be reused. In practice, this means that learning objects are mostly smaller objects – smaller than courses – which can be re-used in different courses. For the purposes of this paper, we adopt Wiley definition, which narrows learning objects to any digital resources that can be reused to support learning.

Reusability of learning objects requires that they are described in a common format, so that they can be easily searched, retrieved and reused for the (manual or automatic) construction of courses (i.e. collections of learning objects, as opposed to atomic learning units). In this context, a number of international efforts have been initiated during the past few years, for defining common educational meta-data standards. That is, meta-data sets which go beyond existing meta-data specifications (such as the Dublin Core meta-data set, dublincore.org), aiming to support the common description of content objects (i.e. as opposed to learning objects).

The current IEEE LTSC Learning Objects Metadata (LOM) specification for the description of learning objects includes the following fields:

1. general: general information that describes the learning object as a whole;
2. lifecycle: features related to the history and current state of this learning object and those who have affected this learning object during its evolution;
3. meta-metadata: information about the metadata instance itself (rather than the learning object that the metadata instance describes);
4. technical: technical requirements and technical characteristics of the learning object;
5. educational: educational and pedagogic characteristics of the learning object;
6. rights: intellectual property rights and conditions of use for the learning object;
7. relation: features that define the relationship between the learning object and other related learning objects;
8. annotation: provides comments on the educational use of the learning object and provides information on when and by whom the comments were created;
9. classification: describes this learning object in relation to a particular classification system.

As it is evident from the above description, the current version of LOM does not include instructional information. That is, learning objects are described rather as content objects, since their instructional “value” is not included in their description.

This fact may compromise the value of learning
objects, since it may be difficult to manually or automatically bind them together for the development of courses which are coherent, from an instructional point of view.

2. Related Work

A number of efforts have been recently initiated for overcoming the above problem, and add instructional information in the meta-data description of learning objects. The CANDLE European project 0, for example, includes in the meta-data description of learning objects their “position” according to Reeves pedagogical dimensions shown below 0:

- epistemology: from objectivism to constructivism;
- pedagogical philosophy: from instructivist to constructivist;
- underlying psychology: from behavioural to cognitive;
- goal orientation: from sharply-focused to cognitive;
- experiential value: from abstract to concrete;
- teacher role: from didactic to facilitative;
- program flexibility: from teacher-proof to easily modifiable;
- value of errors: from errorless learning to learning from experience;
- motivation: from extrinsic to intrinsic;
- accommodation of individual differences: from non-existent to multi-faceted;
- learner control: from non-existent to unrestricted;
- user activity: from mathemagenic to generative;
- co-operative learning: from unsupported to integral;
- cultural sensitivity: from non-existent to integral.

Wiley, on the other hand, proposes the following taxonomy for characterising learning objects, to be included in their meta-data description 0:

- fundamental: for example, a jpeg of a hand playing a chord on a piano keyboard;
- combined-closed: for example, a video of a hand playing an arpeggiated chord on a piano keyboard with accompanying audio;
- combined-open: for example, a web page dynamically combining the previously mentioned jpeg and quicktime file, together with textual material on the fly;
- generative-presentation: for example, a java applet capable of graphically generating a set of staff, clef, and notes, and then positioning them appropriately to present a chord identification problem to a student;
- generative-instructional: for example, an execute instructional transaction shell, which both instructs and provides practice for any type of procedure, for example the process of chord root, quality and inversion identification.

However, it may be difficult for learning material authors (who may not be experts in instructional design theories and models) to characterise their learning objects according to the above dimensions. Moreover, even if learning objects meta-data maintain the above information, it may be still difficult to manually or automatically construct courses from learning objects.

3. The KOD Approach

The KOD European project (see acknowledgements section) aims to develop a vertical learning portal (VLP), which can support learning material authors, tutors, publishers, etc, to design, develop, modify, publish, search, retrieve, broker, interchange and re-use adaptive educational e-content; and learners to access educational e-content in a personalised way. The KOD technical solution is based on the knowledge packaging (KP) format, i.e. an extension of the IMS content packaging specification 0, for facilitating the common description of knowledge packages, i.e. collections of learning objects, together with adaptation rules which determine which learning objects should be selected for different learner profiles 0.

The first step in the development of a knowledge package involves the definition of a knowledge map, comprising the domain concepts addressed by the knowledge package. This knowledge map can be published in the KOD VLP, so that it can be re-used for the development of alternative knowledge packages in the same domain. When the KOD Packager (the KOD authoring tool for developing knowledge packages, see Figure 1) imports a knowledge map XML file, it automatically creates a number of organizations (similar to IMS CP organizations, i.e. containers of learning objects), one for each knowledge map unit.

Each knowledge map unit can, in turn, be communicated through a number of instructional strategies. That is, learning material authors can define specific instructional strategies for communicating each concept in their domain; or, alternatively, they can select to adopt an instructional strategy among those which are supported by the current version of the KOD system:

- Nine events of instruction, by Gagne 0, 0;
- CDT – Component Display Theory, by Merill 0, 0;
- CLE – Constructivist Learning Environments, by Jonassen 0;
- SOI – Constructivist Model of Learning, by Mayer 0, 0;
- Situated Learning through web-based environments, by Herrington and Oliver 0, 0; and
- LODAS – Learning Object Design And Sequencing theory, by Wiley 0.

Practically, when authors select a specific instructional
strategy for one knowledge map unit, the KOD Packager automatically creates a number of knowledge objects (containers of learning objects), which reflect the steps of the respective instructional strategy. Then, authors can import learning objects to each knowledge object of each organization, i.e. for implementing each step of the instructional strategy selected for communicating each knowledge map unit.

Finally, authors can define adaptation rules determining which:
− knowledge map units,
− instructional strategies, and/or
− learning objects
should be selected for different learner profiles.

As a result, when the KOD e-learning system (or any LMS compliant with the KP format) imports a knowledge package, it can disaggregate it, interpret the rules included in it, match them with the learner profile, and select the learning material which is appropriate for the individual learner requirements, skills, preferences, etc.

3.1. Re-usability in KOD

The KOD VLP aims to assist the interchange and re-use of adaptive educational e-content. That is, the knowledge packages that are created through the process and tools described in the previous section can be published in the KOD VLP, so that they can be searched, retrieved and accessed by learners in a personalised way; or re-used by authors for the creation of new knowledge packages. In addition, the KOD VLP facilitates the re-use of the “building blocks” of the knowledge packages. For example, as mentioned above, authors can publish knowledge maps, so that they can be searched, retrieved and accessed by learners in a personalised way; or re-used by authors for the creation of new knowledge packages.

![Figure 1. The KOD Packager for Developing knowledge packages in the KOD VLP.](image)

1. list of learning objects in the domain, which are available to be included in the knowledge map
2. one new organization is automatically created for each knowledge map unit
3. a number of knowledge objects are automatically created, reflecting the instructional strategy selected for the communication of each knowledge map unit
4. a number of learning objects are selected, for implementing each instructional strategy, for communicating each knowledge map unit
5. rules which determine which instructional strategies and/or learning objects should be selected, according to different learner profiles
6. preview and editing of learning objects
packages which follow a specific instructional strategy
information necessary for the construction of knowledge
addition to a number of other elements) the element of the IEEE LOM specification) include (in
These meta-data (maintained within the “relation” element of the IEEE LOM specification) include (in addition to a number of other elements) the instructional information necessary for the construction of knowledge packages which follow a specific instructional strategy.
retained and transfer
retrieved and re-used by other authors in the creation of new knowledge packages; authors can also search and retrieve adaptation rules, both at the level of knowledge map units, as well as at the level of instructional strategies and learning objects.
Similarly, authors can search in the KOD VLP, to retrieve learning objects which are related to the domain of the knowledge package. For example, one author can search for learning objects which are available for the “definitions of tele-radiology” knowledge map unit.
Moreover, authors can also search learning objects based on their “instructional value”. That is, for example, authors can search for learning objects which “gain attention” (i.e. Gagne’s first instructional event) for the “introduction to tele-radiology” knowledge map unit.
In order for the KOD Packager to be capable of retrieving this information (or possibly making similar suggestions), the learning objects maintained within the KOD VLP are described through educational meta-data. These meta-data (maintained within the “relation” element of the IEEE LOM specification) include (in addition to a number of other elements) the instructional information necessary for the construction of knowledge packages which follow a specific instructional strategy.
The meta-data maintained for this purpose are shown in Table 1, and are based on the steps suggested by the instructional strategies supported in the current version of the KOD system (see above).

### 4. Discussion

The innovation of the KOD project is that both (i) the learning objects comprising a “course” (knowledge package), as well as (ii) the adaptation rules which determine how they should be adapted for different learner profiles, are described in a common format. As a result, adaptive educational e-content defined within the KOD VLP can be easily interchanged and re-used: after developing a knowledge package, one author can publish it in the KOD VLP repository; since the knowledge package is described in a common format, it can be easily searched and retrieved by another author, for the development of alternative knowledge packages in the same domain.

The KOD project proposes that learning objects meta-data maintain which are the “steps” related to each learning object, with respect to a number of instructional strategies. As a result, we can achieve re-usability of learning material, both at the domain level (i.e. re-use learning objects in a specific domain), as well as at the instructional level (i.e. re-use learning objects according to their instructional value).

Moreover, our approach seems to be more natural – we expect that authors would find it easier to describe learning material in this way, especially, if they are assisted by a detailed help system. However, this can only be verified during the demonstration and assessment of the KOD project, where a large number of authors are expected to be involved. In fact, KOD aims to provide a test-bed for investigating the use of instructional information in learning objects meta-data. In this context, the KOD project is currently developing three demonstrator knowledge packages in the domains of tele-medicine, knowledge management and e-business. A number of authors are involved in the development of

### Table 1. Instructional information maintained within the meta-data description of learning objects available in the KOD VLP

<table>
<thead>
<tr>
<th>Gagne</th>
<th>CDT</th>
<th>SOI</th>
<th>CLE</th>
<th>Situated Learning</th>
<th>LODAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>• gain attention</td>
<td>• rule</td>
<td>• select relevant information</td>
<td>• question, case, problem, project</td>
<td>• authentic context</td>
<td></td>
</tr>
<tr>
<td>• inform learner about learning objectives</td>
<td>• example</td>
<td>• organise incoming information</td>
<td>• related case or worked example</td>
<td>• authentic activity</td>
<td></td>
</tr>
<tr>
<td>• stimulate recall of prior knowledge</td>
<td>• recall</td>
<td>• information resource</td>
<td>• information</td>
<td>• expert performance</td>
<td></td>
</tr>
<tr>
<td>• present the material</td>
<td>• practice</td>
<td>• cognitive (construction) tool</td>
<td>• related case or worked example</td>
<td>• multiple perspectives</td>
<td></td>
</tr>
<tr>
<td>• provide guidance for learning</td>
<td>• prerequisite</td>
<td>• conversation &amp; collaboration tool</td>
<td>• information</td>
<td>• collaboration</td>
<td></td>
</tr>
<tr>
<td>• elicit performance</td>
<td>• objective</td>
<td>• social – contextual support</td>
<td>• resource</td>
<td>• reflection</td>
<td></td>
</tr>
<tr>
<td>• provide feedback</td>
<td>• help</td>
<td>• guided practice</td>
<td>• coaching and collaboration</td>
<td>• articulation</td>
<td></td>
</tr>
<tr>
<td>• access performance</td>
<td>• mnemonic</td>
<td>• recall</td>
<td>• authentic assessment</td>
<td>• rule or concept</td>
<td></td>
</tr>
<tr>
<td>• enhance retention and transfer</td>
<td>• feedback</td>
<td>• stimulated recall</td>
<td>• worked example case type</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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each knowledge package, who are using the KOD VLP for retrieving learning objects for the domain of their interest, and according to specific instructional strategies.

Finally, it should be noted that instructional design theories and models are rather descriptive in nature, in the sense that they offer guidelines as to what methods to use to best attain a given goal. However, they are not usually prescriptive in the sense of spelling out in great detail exactly what must be done and allowing no variation: “prescription only applies to deterministic or positivist theories, which are almost nonexistent in the social sciences” 0. In this context, the steps shown in Table 1 (which constitute the “instructional value” maintained for each learning object available in the KOD VLP) are the result of an “interpretation” of the literature on the respective instructional design theories and models, which is also currently under verification, through the demonstration and assessment phase of the project.

5. Acknowledgements

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6. References


