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A Framework for the Conceptualization of Approaches to "Create-by-Reuse" of Learning Design Solutions

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Abstract: IMS Learning Design (IMS LD) is an interoperable and standardized language that enables the computational representation of Units of Learning (UoLs). However, its adoption and extensive use in real practice largely depends on the extent to which teachers can design and author their own UoLs according to the requirements of their educational situations. Many of the proposed design processes for facilitating the creation of UoLs are based on the reuse of complete or non-complete learning design solutions at different levels of granularity. This paper introduces a comparison framework that conceptually analyzes and classifies reusable learning design solutions and processes that drive the creation of ready-to-run UoLs. The framework provides a comprehensible representation of such processes and units of reuse over two dimensions, namely granularity and completeness. It also offers a frame for discussing issues, such as the proper level of reuse, of existing and forthcoming proposals. Finally, it opens the path to other strands for future research such as providing language independence of learning designs or proposing approaches for the selection of the reusable solutions.

Keywords: Reusable Units of Learning, Educational Modelling Languages, Learning Design Processes, Interoperability, Conceptual Framework
Categories: D.2.12, D.2.13, H.1.0, K.3.1

1 Introduction

Educational Modelling Languages (EMLs) reflect a change in emphasis away from using the computer to deliver educational content towards using the computer to facilitate the teaching-learning processes [Rawlings et al. 2002]. IMS Learning

Design (IMS LD or LD), realised by IMS Global Consortium (one of the major bodies developing interoperability specifications for e-Learning) in 2003, is currently the most established EML [Koper and Tattersall 2005]. Nevertheless, the adoption of LD by teachers in real educational practice greatly depends on the availability of tools and processes capable of facilitating the creation of computer-interpretable Units of Learning (UoLs) [Griffiths and Blat 2005]. These tools and processes should consider a broad range of types of teachers with different pedagogical and technical backgrounds as well as diverse didactical contexts (e.g. institutions, communities of practices, etc.).

The main problem refers to the fact that technical formalism (XML) and LD concepts are not familiar to the majority of the teachers. In this sense, the current trend in the development of LD editors is to hide the LD details by using concepts (and their representations) closer to the teachers' concepts. This type of editors is classified as high level or distant from the specification authoring tools [Koper and Tattersall 2005; Burgos and Griffiths 2005].

Different approaches are being considered for providing concepts that are significant to teachers in the process of authoring LDs:

- Educational *taxonomies*, such as the taxonomy of learning activities used in [Conole and Fill 2005]. Other candidate taxonomies are the well-known Bloom's taxonomy [Bloom and Krathwohl 1984] or the classification of learning activities proposed in [Shuell 1992].
- *Primitives* or events that do not necessarily embody a particular pedagogical view of learning and teaching but which reflect the real situation in the classrooms. Examples of primitives are "discuss this text" or "research this topic on the web" [Griffiths and Blat 2005].
- Pedagogical design *patterns*, which besides providing a conceptual common ground are a way of communicating educational expertise. Examples are the CLFPs (Collaborative Learning Flow Patterns), which capture the essence of well-known techniques for structuring the flow of learning activities [Hernández-Leo et al. 2006a].
- *Frameworks* for the description of specific types of LDs with special pedagogical affordances. The framework for the specification of collaboration scripts proposed in [Kobbe et al. 2005] is an example.

On the other hand, the teacher-friendly creation of UoLs can be achieved by reusing pre-existing learning design solutions at different levels of granularity (e.g. an LD activity vs. the whole flow of activities included in an LD) and completeness (e.g. a complete UoL vs. the bare bone structure of the flow of the activities of the LD), so that they can be incorporated into the creation of new LDs. To facilitate the understanding of the solutions before their actual reuse, they are presented to teachers using some of the aforementioned conceptual approaches as well as different types of graphical representations. Moreover, the diverse types of learning design solutions afford different types of design processes for their reuse and customization (assembly vs. refinement processes).

This paper introduces a *create-by-reuse framework* that elucidates different approaches for the creation of UoLs via the reuse of learning design solutions at different level of granularity and completeness. This framework is intended to provide criteria for comparing and classifying existing and yet-to-come proposals for creating

UoLs, as well as their associated design processes based on a certain level of reusability. In addition, the framework provides a "tool" for discussing the proper level of reuse for user-friendly creation of UoLs according to teachers' contexts and backgrounds.

The structure of this paper is as follows. Section 2 reviews and classifies the different types of reusable solutions that have been proposed for creating UoLs. The types of design processes that can be applied in the creation of these UoLs are discussed in section 3. Section 4 is devoted to discuss a challenging example illustrating a design process that conforms to the framework. The example includes learning design solutions formalized with different EMLs. Finally, conclusions can be found in section 5.

2 Reuse of Learning Design Solutions

Several proposals have been identified for creating UoLs by reusing pre-existing learning design solutions at different levels of granularity and completeness. The two dimensions *granularity* and *completeness* that we propose in our conceptualization provide an interesting way of classifying and comparing some of those relevant proposals [see Figure 1]. Furthermore, this two-dimensional space provides a way of grouping the existing and forthcoming proposals into four general sets:

- *Exemplars* are ready-to-run (complete) UoLs [LN4LD 2006; Griffiths 2005]. These UoLs may range from a one-activity session to a whole course. (i.e. finer or coarser-grained exemplars). In fact, the final goal of any design process carried out by a learning designer is obtaining an exemplar that fulfils the teaching-learning requirements. In other words, an exemplar contains all the information required to be enacted by an LD-compliant LMS (Learning Management System).
- *Templates* are partly completed exemplars [Griffiths 2005]. They consider all the elements of an exemplar, but these elements needs to be refined (completed) in order to be fully operational. There may be also templates at different levels of granularity as well as at different degrees of completeness. [Figure 1] shows, as an example for illustration, that a template that represents a CLFP (e.g. the templates implemented in the COLLAGE authoring tool [Hernández-Leo et al. 2006a]) is more incomplete than the template that results from particularizing the pattern into an LD (i.e. the pattern plus the specification of the group size limits but still without the resources that are needed in order to achieve a ready-to-run UoL). Accordingly, the LearningMapR initiative aims at enabling the selection of templates and exemplars to be reused and customized as necessary or desired [Buzza et al. 2005]. Though without considering compliance with LD, the objectives of the AUTC project fit well with the presented orientation [AUTC 2003]: the project seeks for the identification of learning design exemplars considered as having the potential of fostering high quality learning so that they could be redeveloped in generic templates.
- UoL *chunks* are portions of exemplars. The granularity of the chunks may range from a ready-to-use (complete) activity structure (including the

activities, environments, resources it references) to a learning object (smaller grain size). In contrast to exemplars, chunks are not "playable" on their own. The "lego metaphor" is used in [Berlanga and García 2005] in order to explain their approach to enable reusability and exchangeability of UoL chunks when supporting adaptive learning design. A similar approach (not LD compliant) is the proposal of [Haake and Pfister 2007] who distinguish between atomic scripts (i.e. chunks), which support a specific collaborative learning activity, and composite scripts (i.e. exemplars), which support complex learning tasks through sequences of atomic or composite scripts.

- *Building blocks* or *components* are partly completed UoL chunks at different levels of granularity and diverse degrees of completeness. [Figure 1] includes as an example "an abstraction of a pedagogic activity type", which may be similar to the predefined activity tools that LAMS (Learning Activity Management System) [LAMS 2006] offers to users as components that can be graphically dragged and dropped to describe a sequence of activities.

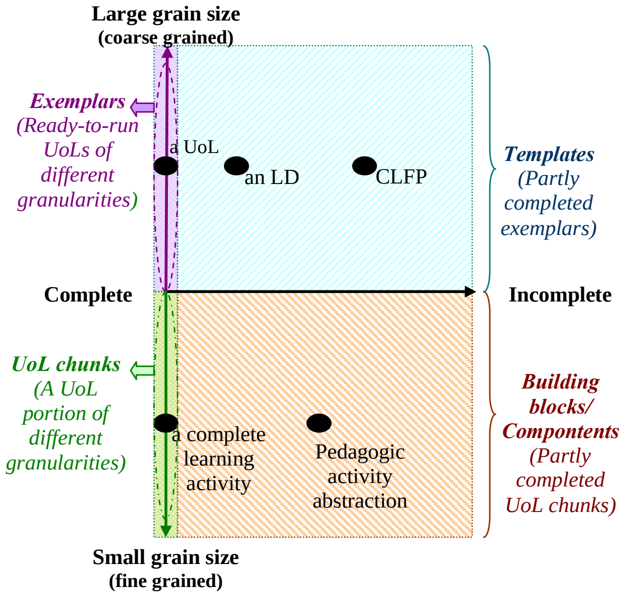

Figure 1: Dimensions of the create-by-reuse framework: reusable learning design solutions at different level of granularity and completeness

Nevertheless, the design processes for reusing the learning design solutions in order to create UoLs are even more important than the reusable solutions themselves. Hence, further topics arise: What kind of design processes can be applied? To which extent do the processes depend on the type of reusable solution?

3 Design processes for creating Units of Learning

When creating a UoL, the pre-existence of re-usable parts of learning processes is a prerequisite. Yet, the challenging task is for the learning designer how to integrate these half-baked parts into a full-fledged learning design. This section discusses different ways of achieving this and conceptualizes the design processes for the creation of UoLs that are supported by existing LD approaches and tools.

As defined in the previous section we consider templates, exemplars, components and chunks as the basic constituents for the creation of full Learning Designs. Because of their different nature we get a first separation of the creation process according to the activities needed to move forth to ready-to-run UoLs:

1. *Refinement*: this activity is needed to reduce the abstraction level of constituents by adding concrete information about numbers of participants, roles, activity descriptions, resources, etc. This is the basic activity to move from templates to constituents that are closer to an automatically executable representation, and may take several steps of abstraction reduction.
2. *Assembly*: this activity is needed to complement a constituent by combining several together or integrating them into a coarser grained process structure. This activity is especially suited for UoL chunks, which are not "playable" on their own but have to be integrated into other structures to be operational. While the mere sequencing of activities without dependencies between them is relatively unproblematic, more complex learning processes, that require interrelations between artefacts flowing through several activities or consistency of roles through phases, are more demanding. These relations have been discussed with proposed solutions in [Hernández-Leo et al. 2006b; Harrer 2006].
3. *Modification*: this activity may take place orthogonally to the other two. It usually reduces neither abstraction nor incompleteness, but changes some information inside the constituent. E.g. in exemplars the creation of a new UoL can be achieved by keeping the process structure, while exchanging the concrete resources to move to another subject of learning.

[Figure 2] shows these types of processes for creating complete UoLs. From right to left a refinement process moving from abstract (incomplete) to less abstract (more complete) constituents and from bottom to top an assembly process, which creates a larger scope structure from fine grained constituents. A modification usually would keep the position with respect to both abstraction and completeness.

Refinement and assembly design processes highlight the basic, stereotypical techniques to move towards complete UoLs. In practice it is very well imaginable and ―from the perspective of a learning designer― highly desirable to have the option of mixing both approaches within one design process. To show the usefulness of our classification of design processes, we apply this conceptualization to the design processes underlying two representative tools, Collage and LAMS (although LAMS models are not completely compatible with LD), based on the idea of creating by reusing design solutions.

As can be seen in the top right section of [Figure 1] CLFPs are highly abstract and thus incomplete representations of learning scenarios. Consequently refinement steps are necessary to create a complete UoL, such as customizing the pattern for the concrete scenario and binding the activities to specific tools and resources [Bote-Lorenzo et al. 2004]. The first refinement step produces an LD, while the second results in a UoL, ready to be played in an LD engine. This can be seen as a pure "horizontal" design process with refinement steps. On the contrary, the typical design process supported by LAMS is the assembly of LAMS building blocks (activity tools) into a process sequence by graphically linking the activity tools. This type of design process can be considered the "vertical" assembly design process of [Figure 2].

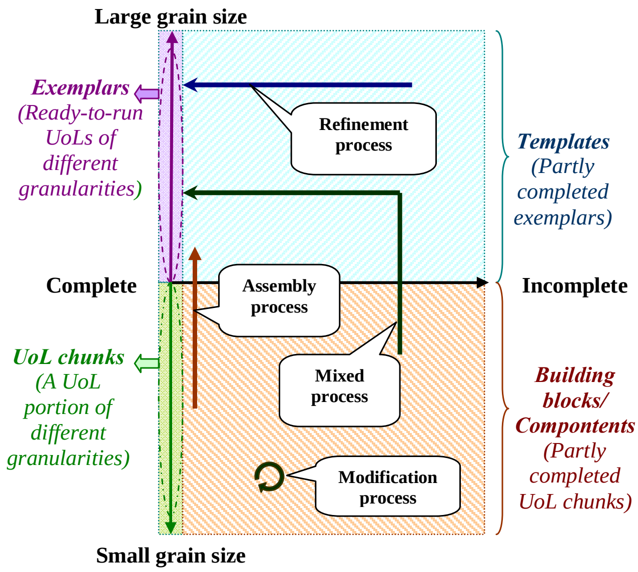

Figure 2: Design processes for creating UoLs by assembling, refining and modifying learning design solutions

Collage also has the potential to use a "mixed" design process, by assembling different templates based on CLFPs into a more complex learning structure and then refining it by adding concrete information. As an example, a pattern (e.g. Jigsaw CLFP) can be combined/assembled with another pattern (e.g. Pyramid CLFP), so that one of the phases of the Jigsaw is structured according to the Pyramid [Hernández-Leo et al. 2006a]. This integrated template has to be refined in the usual procedure of Collage to produce a fully operational UoL. This mixed process can be seen as an instance of the angular design process in [Figure 2].

Learning objects are considered in the framework as the finest grained chunks, which need to be assembled with other components of different granularity (e.g. an activity building block) in order to reuse them when creating a UoL. In this case, the result of the assembly is actually a refinement of the component: the learning object (e.g. a document) completes the component (e.g. an activity building block). "Refinement by assembly" can thus be understood as a type of mixed design processes.

4 A Challenging Create-by-Reuse Example

The proposed framework envisages an interesting challenge: the integration of learning design solutions formalized with different languages (e.g. the formalisms used in LAMS and IMS QTI for questionnaires) so that they can be assembled in order to generate an LD-compliant UoL (or eventually other type of UoLs using a different formalism). Therefore, the problem that design processes should address is not trivial. Not only do we need to assemble and refine learning design solutions at different level of granularity and completeness but we also need to transform formalizations [Dodero et al. 2007] to achieve a uniform notational level that can be interpreted by an EML engine. These ideas are illustrated with the following ad-hoc design process example, which is represented in [Figure 3].

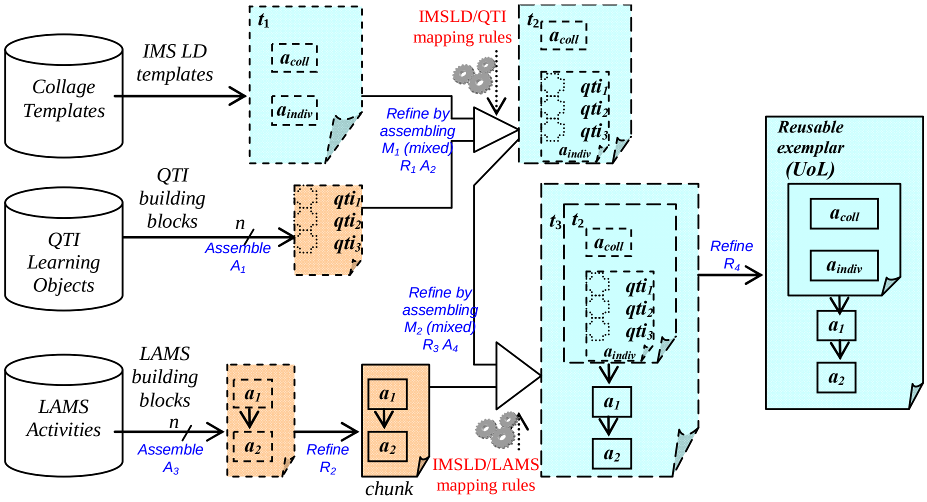

Figure 3: Example design process in which various learning design solutions are integrated into refinement, assembly and mixed processes

The process starts by a teacher searching Collage templates and selecting the pre-defined Pyramid CLFP-based LD template (t_1), which consists of two incomplete activities (an individual, a_{indiv}, and a collaborative activity, a_{coll}). Then she proceeds to the selection of three QTI items, which are assembled (A_1) forming a questionnaire. The template is refined (R_1) into t_2 by assembling the questionnaire: the individual activity will consist of answering a questionnaire. In addition, two LAMS activities (which include the supporting tools) are assembled (A_3) and subsequently refined (R_2) with the necessary text that particularizes each activity. Activity a_1 encourages the students to share resources and a_2 provides a forum for discussing. To particularize a_2 the title, the instructions and the topics of the forum must be typed. The resulting chunk is assembled (A_4) with t_2 as additional activities according to the rules used to map LAMS activities into the coarser grained LD template. The outcome is the template t_3, which still needs to be refined (R_4) in order to be ready-to-run. Once the activities of the template t_2 are set up by adding the necessary text (i.e. the task of the collaborative activity, the grades related to each question of the questionnaire, etc.), a complete exemplar is achieved. This exemplar can be delivered as a UoL or, according to the designer's criteria, be reviewed and modified. The complete process is graphically depicted in [Figure 4] according to the create-by-reuse framework.

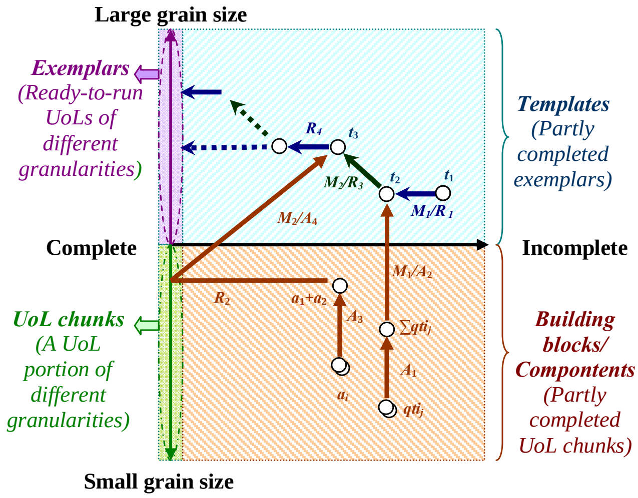

Figure 4: Schema of the example design process that integrates assembly, refinement and mixed processes, in accordance with the create-by-reuse framework

In the figure, point t_1 is the entry LD template that represents a coarse-grain LD abstraction (e.g. a CLFP) that is used as a starting point for transformations. Since t_1 indicates all the elements that need to be refined in order to be a ready-to-run exemplar, it is situated above the horizontal axis. At the same time, selected learning objects and activities are composed by means of assembly transformations on the vertical dimension (*A*). The addition of item qti_1 does not increase the granularity on M_1 mixed process: assemble by refining (R_1/A_2) step, since it is used to fill in a gap on the t_1 template, so that t_2 is generated. t_3 results from the assemblage (M_2 with refinement R_3 by assembly A_4) of t_2 and the chunk consisting of two already assembled (A_3) and refined (R_2) building blocks (a_1 and a_2). That entails increasing the grain size with respect to t_2 as it can be seen in [Figure 4].

5 Conclusions

Reusing learning design solutions with the aim of facilitating the creation of UoLs is expected to foster the adoption of the IMS LD specification. Several approaches discussed within the LD community consider as reusable elements many different types of learning design solutions that can be assembled, refined or modified in order to generate customized UoLs. The main objective of the create-by-reuse framework proposed in this paper is to organize such approaches so that they can be compared and classified. On the one hand, it distinguishes and classifies the reusable solutions according to their level of granularity and completeness. On the other hand, the framework illustrates the basic types of design processes and their combinations, used to integrate the reusable solutions. In addition, it provides a conceptual frame to discuss several related issues, such as: what is the proper level of reuse for teacher-friendly creation of LDs depending on the institution, community, etc? Which types of learning design solutions are potentially more reusable, the coarser and/or the more incomplete? How can a proper understanding of the solutions before their actual reuse be facilitated? Furthermore, the paper envisages emergent approaches for creating learning designs when elements from more than one specification, formalism or model have to be combined in a single UoL, or they have to be transformed before being delivered to a specific non IMS LD-compliant LMS.

Future work includes extending the proposed framework with new dimensions: different computer-interpretable EMLs, types of pedagogically-based formulations behind the reusable solutions (namely patterns, taxonomies, etc. as discussed in the introduction); other strands for future research are approaches for the selection of reusable learning design solutions (from the use of metadata to the use of ontologies [see Knight et al. 2006]) and types of notations or representations used to present the solutions to the teachers (from textual to visual notations [Botturi and Stubbs 2007]).

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