Towards IMS-LD Extensions to Actually Support Heterogeneous Learning Designs. A Pattern-based Approach

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Abstract

The objective of the IMS Learning Design (IMS-LD) Specification is to provide a containment framework of elements that can describe any design of a teaching-learning in a formal way. It does not impose any learning approach and is pedagogical independent. In this way, learning designers can precisely prescribe the instructional and teaching strategies. The problem is how common teachers can develop appropriate IMS-LD contents. This paper presents an adequate design approach based on design patterns. Design patterns are being proposed in learning to facilitate the design activities from non expert users. We find these proposals valuable, but consider that additional efforts are required. We propose a language of design patterns for learning, hierarchical structured in several aggregation layers. In addition, we consider generative design issues to obtain IMS-LD materials.

1. Introduction

The purpose of Educational Modelling Languages (EMLs) [1] and the current IMS Learning Design (IMS-LD) specification [2] is to support the crafting of diverse learning experiences, embodying different kind of activities and in different contexts. The IMS-LD proposal is a meta-language that allows to codify the pedagogic values as units-of-study (e.g. courses, course components, programs of study), associating each element of content (e.g. texts, tasks, tests, assignments) with information describing its instructional strategy (e.g., roles, relations, interactions and activities of students and teachers), that is, the activities that have to be carried out in order to produce valuable learning.

The work on IMS-LD is the most important initiative to date aiming to integrate Instructional Design issues in the international standards process [3]. But, it is concerned with modeling and description. Little attention has been paid to learning theories and instructional design principles in order to achieve the design of sound IMS-LD materials [4]. Learning theories and instructional design principles are valuable resources. But they are difficult to use. It is hard for teachers to apply these ideas.

To solve these problems design patterns are being proposed as mechanisms for capturing pedagogical strategies and design practices. The use of patterns for learning and instructional design is gaining an increasingly popularity. These proposals are isolated and existing patterns are not related. To gain truly advantage, patterns should be properly organized.

In this paper we propose to organize a language of design patterns for learning in a hierarchy of abstraction layers. Our idea is to facilitate the composition of valuable IMS-LD materials according to good instructional design principles, maintaining IMS-LD pedagogic flexibility. Our pattern language guides the labor of learning designers through the different abstraction layers, in a top-down sequence.

In the next section we introduce patterns for instructional design and our language proposal. In section 3, IMS-LD is considered as the eventual formal language for representing instructional designs. Finally, we end with some conclusions.

2. Patterns for Instructional Design

Instructional Design (ID) is concerned with the processes to produce good specifications of learning experiences [5]. It is an “interlinked science” between learning theories and educational practices [3]. ID offers processes and guidelines that designers can use to arrange the learning experiences. Using these tools, a designer has to specify roles, resources, activities, etc. This implies a great effort and time investment that common teachers cannot assume. Design patterns seem
to be a good approach to help non-expert instructional designers.

The use of patterns for design was originated by C. Alexander for architectural patterns [6]: "each pattern describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way you can use this solution a million times over". This approach has been successful used in other domains to help not expert users to achieve good designs: software engineering, interaction, etc. In the same way, the idea of final users (e.g. teachers) designing learning experiences has already been taken over.

2.1. Design patterns for instructional design

The use of patterns in the learning domain and for instructional design is not new. Patterns have been proposed as a good approach to assist the designer of learning experiences. In [7] a language of about twenty patterns is proposed to address instructional design problems from overall course presentation to specific learning activities. The Pedagogical Patterns Project (PPP) [8] is devoted to gather high-level pedagogical patterns according to different pedagogical approaches. Other authors also propose collections of pedagogical patterns [9]. In a completely different way, [10] proposes a semi-formal language, with a graphical representation, to enhance the description of low-level educational patterns. Some authors [11] propose a language of patterns for Learning Management Systems in order to improve the software design and the pedagogical quality. Collaborative learning issues are considered in [12]. In [13] a pattern language that consists of a collection of high-level pedagogical patterns and interface design patterns is presented.

In the current situation there are several pattern proposals, but no common framework relating them. Patterns are proposed at different levels of abstraction with no connection among them. This is a problem when someone tries to apply patterns to instructional design to create heterogeneous learning experiences, without considering a particular pedagogical approach.

When Alexander wrote his book on architecture design patterns [6], it did not just contain patterns, the patterns formed a language of connected patterns. His language was hierarchical and started out on the level of cities, then neighborhoods, houses, until the level of windows or seats was reached.

With this vision in mind, we propose a layered structure of abstraction levels where patterns pertaining to different proposals can be arranged and related to other patterns, creating a collection of interconnected patterns, forming a truly pattern language.

2.2. A Pattern language for instructional design

To create a pattern language for instructional design we follow a hierarchical approach [14]. We interpret the hierarchical nature of architectural patterns as a hierarchy of instructional problems. The highest level problems are broken up into smaller problems for which solutions exist. In learning design there is a scale hierarchical of problems. Although it may not be visible it is always there behind the top-down design.

Usually instructional design of a course is a top-down activity that starts with the teacher gaining understanding of the learners and their goals, the resources and services available, the pedagogical approach, etc. Taking the example of a course, the design continues organizing the activities that have to be carried out by learners and academic staff. In the next step, it is necessary to define the control flow between the different activities, and for each activity to describe the actors involved, the environment (with its resources and services, and the properties, conditions and events associated) the way in which the actors are going to interact, communicate, etc. Such a top-down approach promotes a truly language where patterns are at all levels. Therefore it is possible to define layers of patterns. These layers are rough delineations of the typical levels that are encountered in an instructional design process. The levels identified so far are: pedagogical, learning experiences, and activity.

Currently, we are considering additional levels such as interaction patterns, and patterns for content.

The different levels and associated patterns can be shown in a graph of connected patterns as the one represented in Figure 1. In the picture, arrows represent connections among patterns. These relationships are at the heart of the language because they create additional value over single patterns. Identified connections in [14] are: aggregation, specialization, and association.

2.2.1. Pedagogical patterns. Every course, or learning application, has its own purpose; there are usually learning goals to be achieved and context conditions that prescribe its rationale. Proper learning design has its foundations in understanding why the learning design has been required and its purpose. A pedagogical pattern describes what the essentials of that pedagogy are: what kind of learning experiences are practiced, contents and applications involved, etc.

The Pedagogical Patterns Project (PPP) is working on this kind of patterns. They are collecting many types of patterns that can help teachers to teach and
students to learn. Pedagogical patterns try to capture expert knowledge of the practice of teaching and learning.

**2.2.2. Learning experiences patterns.** From the basic pedagogic and from user research, learning designers need to identify what learning experiences have to be supported and to what extend. A learning experience is not just about tasks and goals but also about how learners reach their goals using a certain environment, how they communicate and cooperate with their peers, and how they are supported by academic staff (e.g. teachers, tutors). This kind of pattern describes a collection of general techniques, actions, and/or tasks for a particular learning experience. The learning experience-level patterns describe common experiences and which lower level patterns can be used to create such experience. Typical learning experiences are: Team Teaching, Active Student, Try it Yourself, etc.

![Figure 1. Structure of the pattern language for learning design](image)

**2.2.3. Activity patterns.** At this level we consider the patterns directly related to IMS-LD descriptions. These patterns involve low level activities (such as Produce a Document in Collaboration, or Communicate with Peer) that are needed in high level Learning Experience patterns. These patterns are relatively pedagogic independent. The pedagogic and learning experience patterns set the context specifics and the activity patterns are used to fill in the blanks. These patterns describe series of user interactions in an environment for solving a certain problem. Such a series corresponds to a task sequence or a controlled interaction needed to achieve a certain goal.

**2.3. Pattern Descriptions & Generative Design**

The description of each pattern is a key question. Each abstraction layer requires the description of different artifacts, interactions, dimensions, etc. In general, patterns should encapsulate design knowledge in understandable way. Common pattern languages [6] usually define a set of descriptors (i.e. text paragraphs) summarizing the pattern, namely specifying the problem addressed, then describing the solution and eventually providing examples and other materials.

For the description of instructional design patterns we propose this common structure to summarize each pattern rationale. But, at different abstraction layers it is necessary to manage different elements in the descriptions. For example, in the Activity Level layer a design pattern should specify how actors have to interact among them and use resources. At this level, graphical representations are available [11] that can be used to facilitate the usability and understandability of the pattern. In addition, IMS-LD templates and examples are also provided in order to facilitate the production of IMS-LD materials. Our eventual purpose is to obtain IMS-LD constructs as software generative patterns [15] produce executable code.

In Alexander’s idea, the pattern language actually generated the design by traversing from high level patterns to the lowest level ones. It acts as a tool of a generative design process empowering users to make design decisions. Patterns are organized into a hierarchy with high-level patterns addressing problems such as the instructional approach, to patterns for individual learning experiences and activities. For example, the Active Learning pattern is related to Learning Experiences patterns. A course developed according to this pattern will be composed by several learning experiences arranged in a particular order. In
this way, some IMS-LD constructs can be generated referred to the control flow. Similarly, the Groups Work pattern consists of several patterns of the Activity layer. Finally, Activity layer patterns have a direct mapping to IMS-LD constructs.

2.4. Pattern Language Population

In the learning domain there are a plethora of learning theories and instructional design approaches. A whole pattern language for instructional design should provide patterns according to the variety of possibilities. Therefore our idea is to leave freedom to researchers in other fields to populate the pattern language. Indeed, as we presented previously, there already exist several proposals for pedagogical, instructional, and learning patterns. Patterns are proposed at different levels of aggregation. What we provide is a framework to organize all these proposals and promote their synergy.

We are mainly concerned with the low level patterns and their relation to IMS-LD constructs. At this level we are gathering and defining patterns for interaction, communication, collaboration, coordination, etc. Our sources are works in the learning field, but mainly pattern proposals in related domains such as workflow, groupware, Human Computer Interaction (HCI), etc.

3. Instructional Descriptions using IMS-LD

Our final purpose with this pattern approach is to obtain a kind of formal code that can be used to automatically generate and support learning experiences. IMS-LD provides such kind of formal language. The outcome is expressed in an XML file structured accordingly to well-know DTD specifications [16]. It is a process-based description very similar to a workflow or Business Process Model (BPM) specification.

In order to describe a learning experience, IMS-LD specification proposes the management of several dimensions that govern its execution. The dimensions involved may vary depending on the nature of the learning experience. In previous works we analyzed these perspectives and considered some extensions to IMS-LD [17] [18]. According to these works, the main dimensions involved should be:

- Organizational. This dimension describes the participants that interact in a learning experience.
- Resource. The resource dimension groups all the learning objects and services that are required to carry out the learning experience.
- Control Flow. This controls the flow of activities, deciding which actor has to do in what moment and where. IMS-LD identifies three levels accordingly to a theatrical metaphor: play, act, and role-part.
- Data Flow. The data flow dimension is not clearly included in IMS-LD. We consider it should be included in order to facilitate the specification of the flow of documents among participants.
- Policy Control. A policy control dimension can establish the interaction conditions among the participants. This dimension does not appear precisely described in IMS-LD specification.

These perspectives are important for the pattern language, mainly for the low-level patterns of the Activity layer. Different patterns have to manage different dimensions depending on their nature. For example the Master/Slave pattern is mainly related to the Policy Control dimension, while the Producer/Reviewer pattern is concerned with the Control Flow and Data Flow dimensions. In this way our patterns help designers to focus in parts of the IMS-LD specification more related to their problems.

Currently, IMS-LD specification proposes a central core of elements and two extensions, defining three levels of compliance. The purpose is to facilitate the development of IMS-LD runtime systems and promote its use. According to our works, we plan to propose new extensions to facilitate learning designs according to other learning approaches (e.g. game-based learning). In this way, it should be noted that not all the pedagogies or learning interactions can be described using a part of the IMS-LD specification. Depending on the IMS-LD extensions available some design patterns, or some of the solutions proposed, may not be employed. We consider to “profiling” our pattern language according to the IMS-LD dimensions available. In this way, depending on the IMS-LD compliance level, only a subset of the whole pattern language could be used.

4. Conclusions

IMS-LD specification brings important innovation to the e-learning domain. It has the potential to free e-learning experiences by capturing the process of education, rather than content. But problems of how to develop valuable IMS-LD materials in a structured and organized way have not been considered yet.

Design patterns have emerged as a way to capture knowledge to present design solutions. Using patterns for capturing and documenting design knowledge in
other domains is a hot topic. There are many reasons for adopting this approach in instructional design [19]:

- Patterns provide a lingua franca that can be read and understood by all.
- Patterns offer a way of capturing and transferring design knowledge.
- Patterns promote reuse of designs.
- Patterns are a valuable source of information, supporting both the analysis of the current situation and the design of the new system.

We look for a pattern language with proper support for learning design, relating it to constructs in the current IMS-LD specification. We believe a pattern language for ID based on the same IMS-LD principles of pedagogic flexibility can empower the construction of valuable learning resources. Learning designers need tools and artifacts at different levels of abstraction that support them in the description of learning designs.

The establishment of a pattern language and the mapping to executable code acquires a great importance. In the one side, we establish the foundations to support that patterns developed by different design communities. Different authors can provide their own patterns, relating then to the existing ones. In the other side, the use of IMS-LD constructs enables that eventually, the obtained product is a kind of formal description that can be used to automate and support the whole learning process.

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6. References


