

E-LEARNING PATTERNS: AN APPROACH TO FACILITATE THE DESIGN OF E-LEARNING MATERIALS

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Abstract. During the last years several proposals of e-learning patterns have been published and some projects have been initiated. E-learning patterns are focused to produce mechanisms to help in the design of learning materials and systems, considering the same principles initially established for architectural design patterns. In this paper we review the different alternatives and discuss about their nature and usability. Then we propose an organization to arrange patterns according to a clear structure. We also relate the pattern initiative with Educational Modelling Languages (EMLs) to facilitate the production of eventual educational materials.

1 Introduction

The most influential definition of a design pattern was coined by architect C. Alexander as it conveys all central aspects of a pattern (Alexander, 1977): “*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, without ever doing it the same way twice*”. In other terms, a pattern is an abstract solution to a problem in a certain context. The primary goal of patterns is to create an inventory of solutions to help designers resolve development problems that are common, difficult and frequently encountered.

Patterns have been a successful tool to model design experience in several domains: architecture, software design, *Human-Computer Interaction* (HCI), business process, etc. Alexander’s goal in publishing architectural patterns was, above all, to provide a didactic medium for human readers, even (and specifically) for non-architects. In software engineering design patterns have been used in a different fashion. Software design patterns are considered a useful language for communication among software developers, and a practical vehicle for introducing less experienced developers into the field.

We have reviewed these pattern ideas and the patterns proposed for learning from a end-user perspective. We focus our attention on the idea of final users (e.g. teachers) designing learning materials and resources. Our final purpose is to adopt the pattern approach to facili-

tate the labor of learning design, improving the communication, and introducing less experienced developers in order to produce valuable learning materials.

In the next section we present the results of a review of learning patterns found in the literature. In section 3 we discuss about the results of this review. In section 4 we make some proposals to organize and drive the development of patterns for the design of learning materials and resources. We finish the paper with some conclusions in section 5.

2 A Forest of Patterns for Learning

The interest for patterns in the learning domain is reflected by the publication of several recent works and proposals, and by the creation of international organizations and working groups. We have found 13 different initiatives that have proposed more than 340 patterns.

2.1 Nature of the Proposals

Initiatives of learning patterns do not share a unique focus or interest. We classify them according to three goals in design: software, pedagogic, and learning materials.

Some proposals are related to **design of e-learning software systems**. For example, Asensio et al. (2004) discuss about the use of patterns for collaborative learning systems design. Similarly, Avgeriou et al. (2003) propose a language of patterns for Learning Management Systems. This work was used to launch the European project E-LEN¹, devoted to gather and promote the use of patterns for e-learning.

Another set of proposals are concerned with the **design of good educational practices**, but not directly involving the use of technology. These works are related to educational theories and instructional disciplines. The proposals include patterns for: classroom education (Anthony, 1995); study groups (Kerievsky, 1999); seminars (Fricke & Voelter, 2000); running of a course (Eckstein, 2000); and pedagogical patterns (Bergin, 2002) that initiated the *Pedagogical Patterns Project* (PPP²). This PPP is the most outstanding initiative in this field. They are collecting many types of patterns that try to capture expert knowledge of the practice of teaching and learning. Patterns are organized in sub-languages with different focuses, such as: *Active Learning*, *Experimental Learning*, *Feedback*, and *Teaching from Different Perspectives*.

¹ E-LEN Web page <http://www2.tisip.no/E-LEN/>

Finally, there are proposals devoted to **the design of good e-learning materials**. These patterns have been proposed as a good approach to assist the designer of e-learning experiences. In (Frizell & Hübscher, 2002) a language of about twenty patterns is proposed to address instructional design problems, from overall course presentation to specific learning activities. As part of the E-Dilema³ European project they proposed a language pattern (Finlay & Allgar, 2003) to assist in the selection and design of learning objects. Related to collaborative learning, DiGiano et al. (2002) gather some patterns related to mobile and wireless environments involving collaborative learning experiences. As a recent contribution, patterns for blended and project-based learning were proposed (Derntl & Motchnig, 2004) arranged in layers and with relationships among the patterns.

2.2 Structure of the Proposals

Similarly to the focus, the different proposals present a great diversity in their description and organization.

According to the fields used to describe each pattern, the different proposals follow more or less the schema proposed by Alexander (1977), but always introducing some variation. Four sections are usually found: *Classification*, *Problem*, *Solution* and *Additional Information*. All four sections are important, but in order to produce final designs the *Solution* is the core. At this point, some proposals simply provide an explanation on how to proceed, others present examples for certain contexts, and the most advanced ones provide templates and implementation hints. It is very interesting the work of Belfer and Botturi (2003) that propose a semi-formal language, with a graphical representation, to provide a description of the pattern implementation.

According to the pattern organization, almost all the proposals are presented as pattern languages but, in essence, they are simple collections of patterns. Usually patterns are classified around a set of categories used in the same kind of problems. Sometimes, representation maps or tables are used to present patterns and help final users. There are very few proposals (really only in (Derntl & Motchnig, 2004)) that propose a hierarchical organization of the patterns with explicit relationships among them. More often, these issues are discussed implicitly, as part of the textual description of the patterns.

² Pedagogical Patterns Project (PPP) Web page <http://www.pedagogicalpatterns.org>

³ E-Dilema Web page <http://e-dilema.uhk.cz/default.asp>

3 Lost in the Forest of Patterns for Learning

In the previous section we have presented the main outcomes of our review, without discussing about the advantages or drawbacks. Now, to carry out this task we claim the reader attention in the intended objective of design patterns: to provide a didactic medium for human readers, even (and specifically) for non-expert users, and to serve as a communication mechanism. Existing learning patterns proposals have the following problems towards this goal:

- **Variability in the focus and intention.** There are proposals for design of software systems, pedagogical practices, and e-learning materials; all of them named as learning patterns. This creates confusion in the community of users when reading and deciding what set of patterns to use. The different proposals should be clearly classified according to their intended goal and nature. In addition, proposals for pedagogical practices and for e-learning materials should be related in a more clear fashion, because they are focused towards the same goal: the description of good learning experiences.
- **There is no common structure to describe the patterns.** Patterns descriptions of different proposals provide different data and information about the problem, context, and solution of the pattern. This creates confusion in readers since they have to consider different fields, requiring a great effort to compare and evaluate.
- **Patterns are too abstract.** There is not a clear mechanism to produce learning materials from existing patterns. Non-expert users require the availability of mechanisms that facilitate the production of learning materials and resources. This requires examples and mechanisms to pass from the pattern to final products and materials.
- **There is no common organization.** In this way, patterns proposed in different works are not related and it is very difficult to establish any relationship between them. It is necessary to have in mind that the real value of patterns is not considering them as individual entities, but as a collection of interconnected patterns that can be used in a homogeneous way. In addition, the design of learning materials is a complicated process that involves a broad range of levels and aspects. In this way, a single pattern is not enough to obtain final learning materials, but it is required the combination of several patterns.

4 Towards a Garden of Patterns for Learning

To overcome the shortcomings presented in the previous section we propose a pattern language organized around a hierarchical layered structure with explicit relationships among the patterns. We also propose the utilization of *Educational Modelling Languages* (EMLs) (Koper, 2001) as the implementation language to support the construction of final electronic resources. One of the main problems in these languages is the complexity and the difficulty in their use by final users. In this way, we have proposed the use of design patterns to facilitate the labour of users in the construction of learning materials using EMLs (Caeiro et al., 2004).

4.1 Proposal for a Pattern Language

A pattern language is a set of patterns that work together to generate complex behavior and complex artifacts. When Alexander wrote his book on architecture design patterns (Alexander, 1977), it did not just contain patterns, the patterns formed a language. His language was hierarchical and started out on the level of cities, then neighborhoods, houses, until the level of windows or seats was reached. In Alexander's idea, the language actually "generated" the design by traversing from high level patterns to the lower level. The patterns community realized that patterns in isolation provided only incremental improvements to software systems, organizations and processes. The question is whether a similar language for learning design can be created or not. In the following sections we propose a layered structure for the language and a set of relationships between the patterns.

4.2 The Layered Language

To create a pattern language for learning design we follow a hierarchical approach (Welie & Veer, 2003). 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 hierarchy* of problems. Although it may not be visible it is always there, behind the top-down design.

Usually 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 an actual 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, see section 4.3, are at the heart of the language because they create additional value over single patterns.

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 pedagogic are: what kind of learning experiences are practiced, contents and applications involved, etc.

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.

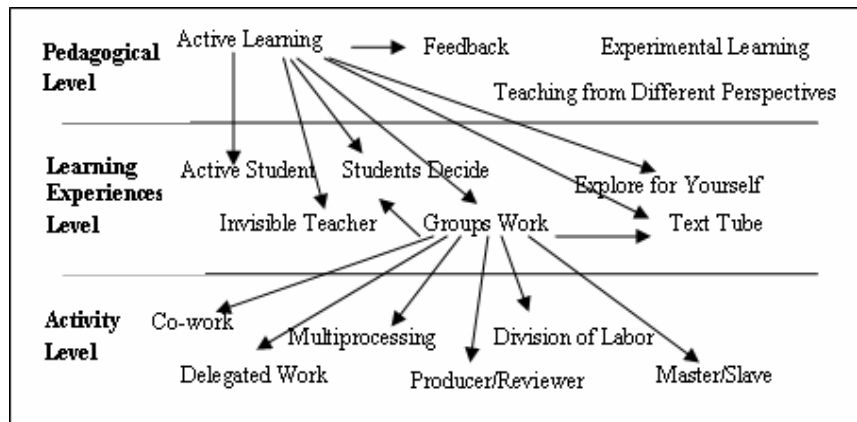


Figure 1. Structure of the pattern language for learning design

Activity patterns. At this level we consider the patterns directly related to EML 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.

4.3 Connections between Patterns

Patterns are related using the following relationships:

- **Specialization.** This relationship interconnects a more concrete lower-level pattern with a more abstract higher-level pattern. For example, the *Peer Review* pattern is basically a *Pairing Up* but with extended options. It inherits the basic idea of pairing up with a team mate, but considering that the fellow can take a look at the work and review it as early as possible. We call this a “*is-a*” relationship, one pattern is more specific version of other pattern.
- **Association.** The association relationship refers to all the patterns that may be used for the same purpose. For example, the *Active Learning* pattern is associated with patterns such as: *Exploratory Learning*, *Virtual Lectures*, *Learning by Doing*, *Collaborative Learning*, etc. This is a “*related-to*” relationship.

- **Aggregation.** This relationship is referred to the inclusion of a pattern as part of another pattern. For example, the pattern *Student Group Management* aggregates two patterns, such as: *Asynchronous Collaborative Learning* and *Synchronous Collaborative Learning*. This is a form of “*has-a*” relationship.

4.4 Learning Design

To describe learning material designs and provide clear implementations we use an EML: the *IMS Learning Design* (IMS-LD) language (Koper et al., 2003). Currently, this is the most outstanding proposal of an EML devoted to support the crafting of learning experiences. The IMS proposal is a meta-language that allows to codify *units-of-learning* (e.g. courses, course components, study programs), 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 to achieve learning goals.

IMS-LD language is mainly concerned with interoperability and reusability issues. It is not devoted to be used by final users (e.g. teachers, learning designers) to create courses directly. The language demands management of a huge amount of low-level concepts, coordination, and control mechanisms that are difficult for non expert users. That is, a domain largely controlled by and accessible to only those with special knowledge and skill. To solve this problem, we have proposed design patterns to facilitate the labor of learning designers, e.g. teachers, to compose courses and general learning experiences.

5 Conclusions

This paper presents a snapshot of the current proposals of patterns in the e-learning domain. Patterns are used implicitly by many learning designers who have found solutions that have worked for them in the past. Using patterns for capturing and documenting design knowledge in other domains is a hot topic. There are many reasons for adopting this approach in e-learning (Erickson, 1998):

- Patterns provide a lingua franca that can be read and understood by all.
- Patterns offer a way of capturing and transferring design knowledge.
- They promote reuse.

- Patterns are a valuable source of information, supporting both the analysis of the current situation and the design of the new system.

We have reviewed the main proposals that we found in the literature about e-learning patterns. These proposals are at initial state and therefore they present a great variability. In our opinion, this is a problem that hinders the development of this approach, creating difficulties for final users. We argue that structure of the pattern language is a key point to obtain a useful tool. We propose the creation of a pattern language rather than collections of patterns. Our approach follows a top-down methodology where high-level design problems are gradually decomposed into smaller design problems.

We consider that the concept of a pattern language with proper support will be very valuable for the design of learning materials. Toward this point we connect e-learning design patterns with EML initiatives. Specifically, we consider patterns as a valuable tool to help non-expert users to produce IMS-LD materials.

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