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▶ **To cite this version:**

Zeyneb Tadjine, Lahcen Oubahssi, Claudine Piau-Toffolon, Sébastien Iksal. Rethinking learning design for learning technologies: formalized vision to operationalize pattern-based scenarios. The 16th IEEE International Conference on Advanced Learning Technologies (ICALT 16)„ 2016, Austin, Texas, United States. pp.57-61. hal-01433174

HAL Id: hal-01433174
https://hal.science/hal-01433174

Submitted on 5 Mar 2018

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Rethinking learning design for learning technologies:

A formalized vision to operationalize pattern-based scenarios

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***Abstract*— The operationalization of learning scenarios on learning management systems (LMS) is more than a technology-related question. Different research issues around instructional design are to be addressed in order to provide pedagogical expressiveness of the different elements within a learning scenario, while it respects sufficiently the structure to describe it. In this work, we examine existing pattern-based approaches for learning design, and we provide a pattern's formalism for learning designs that enables their deployment automatically on the chosen LMS. We have adopted a methodology elaborated on the basis of a case study on which we have executed a process of learning scenario's operationalization. One of the results was to prove the usefulness of a pattern's formalism to design learning scenarios. We have considered the structural, constraints and content aspects of a learning scenario from both human and computational point of view. The formalism described in this paper is part of a process based on ontologies and semantic web principles, offering a support for teachers-designers to produce deployable learning scenarios without having to master the target platforms.**

Keywords-component: Operationalization, Patterns, Formalism, Instructional design, LMS, Teaching situation.

I. INTRODUCTION

The use of technology systems in learning is far from being a new idea, it has offered a new way to design, create and mediate educational content. According to [1], compared to the theories developed in educational psychology, instructional design can be seen as a form of engineering aiming to improve educational practice. Research work around this field is still evolving, especially in terms of design and implementation. Despite this, we note that teachers-designers tend to use learning management systems (LMSs) more like a content repository. In order to improve the use of LMSs by teachers, we take interest in our research on the "full cycle" of designing, operationalizing and adapting educational situations. Our goal is to prove that if the learning scenario is well designed to be imported on a computer environment, we can have more than one positive effect: on the one hand it can help the students to understand the concepts better than learning from a textual description and/or figures, taking advantage of the pedagogical features embedded in the LMSs. On the other hand, it can help teachers to ensure an automatic deployment of their designs. In fact, using the existing tools [2] [3] [4], instructional designer must make decisions about the transformation of human-readable representation to machine-readable representation of their teaching practices. They are not experts of learning platforms, and considering the insufficient support during this phase, they find it difficult to keep the semantic meaning of their pedagogical intentions [5]. Our main focus is to help teachers and designers to automatically operationalize their learning scenarios on distance learning environments, such as Moodle [6] Sakai [7] etc. We aim to mitigate the existing gap between the expressiveness, (scenarios formalization) and the computer usability of a learning scenario representation form (deployment on a target platform). To do so, we propose a process based on patterns and ontologies, the different phases of the process are presented as a whole in [26].

The main idea of this paper is to present some results about the step of formalizing pattern-based scenarios. Our goal is to show that a platform-oriented formalism, to create pattern-based learning scenarios, is a valuable support for teachers-designers to be aware of the misconceptions they may hold. We also show that this kind of formalizing learning scenarios plays a major role on the process of oprationalizing pattern-based learning scenarios. For the proposed research work, we do not get into the details about the validation of the formalism use by the community of teacher-designers, which is the subject of further work focusing on the capitalization and the reuse of teaching practices and sharing platform oriented pedagogical constructs. In section IV, we introduce our proposed formalism for platform oriented learning scenarios. Section III of this paper shows the importance of such an approach through a case study that helped us defining the main aspects of a learning scenario to take into account for a platform oriented design. The next section (section II) provides a short summary of the related research work on instructional design, from the operationalization perspective. We focus on the pattern-based approaches which have been proven to be the most suitable choice of design to our operationalization goals, for their structural representation helping to better illustrate teachers practices for an LMS oriented design [26].

II. FROM LEARNING DESIGN TO LEARNING SYSTEMS

Various research works have been active to develop tools, to experiment with Learning Design which is not necessarily dedicated in a practice for learning management systems [8] [2]. Several modeling languages and graphical tools are considered, each one requiring specialized implementations of both design and runtime system. Starting with the Educational Modeling Languages from which has been defined the IMS Learning Design specification [2]; it

aims to represent the learning design of units of learning in a semantic and formal way. Even though its XML structure is machine interpretable, it is not usually platform compatible. Also, teachers' feedback has noted deficiencies while adapting the resulted scenarios they acquire technical help.

Taking the Glue PS! tool as example [3], they deal with deploying learning designs from multiple IMS-LD-based learning design language/authoring tools, into multiple learning environments. The authors used their collaborative Learning Flow Patterns tool (Collage) [9], one of the issues related to the deployment point of view, is that the definition of patterns is mostly collaboration-centered. It does not give the teacher the aid to design any learning idea according to a learning platform paradigm. Since most of the platforms do not follow any educational standards, deploying a standardized scenario would not be easy for a novice teacher to do and scenarios structure adaptations in terms of computing notation are quite hard to apply. By another way, when those standardized tools take the operationalization step into account, it is always about one targeted LMS (e.g. CADMOS [10] generates scripts to only deploy scenarios on Moodle). Some of those standardized tools are relying on a pattern approach as a compromised solution for the lack of EMLs' expressivity. Patterns provide a mean to abstract and represent good practices. They are used to capture expert knowledge of the teaching practice, in that direction we note the work of [25] wich aims to provide teachers as designers with ideas based on broadly accepted practices and let them collaboratively expressing their own pedagogic ideas.

A pattern is pictured as a three-part structure, specifying a problem and a solution addressing this problem according to a specific context [11]. One of the issues around patterns-based learning design is in how patterns can be developed; the most common approach is based on pattern recognition by identifying sets of reoccurring XML constructs in coded courses [12]. The other approach is where experts are developing pedagogical patterns based on their interpretation of teaching practice [13]. We note that pattern detection is a field where research is blooming, but we note that taking advantage of the pattern's semi structured formalism is worthwhile to elaborate. We note that until present time, there is not much progress in terms of orienting the use of patterns toward developing tools for learning designers having platforms deployment goals. Tools like [14] [15] proposed an engineering design process framework with a pattern structure and formalization in order to improve the instructional design process, taking advantage of what patterns offer in terms of structure and ease of expression but they do not address their integration into technology enhanced systems (TEL).

Through this quick survey, we can state that standards-based tools impose a high complex use for the teacher-designers. While patterns are more and more used for designing purposes, we should focus our research on how we can present to teachers, in a user-friendly and flexible way, pattern-based tools that preserve the semantic meaning of teacher intention while transposing it on a learning system [16]. Moreover, the use of conceptual models, for both designing as well as operationalizing, can make patterns-based learning design knowledge reusable and can conserve the semantics of the teacher's intention. Through our study of the research work on ontologies for e-learning, we believe capturing the knowledge of the learning designer as an ontology allows having one same semantic base retaining the essence of the scenario, according to an operationalization point of view. For our work we try to reduce the gap between what an LMS is and how it is defined theoretically (comparing what it is and how it is used in practice). We propose to link learning design and operationalization of pattern-based scenarios.

We have been studying research works on ontologies for e-learning, and we concluded that it have played an important role as knowledge representation and sharing mechanism. We find ontologies based on IMS LD language [17], as well as ontologies describing the learning scenario [18] and also ontologies to describe common modules of learning platforms [19]. We noticed that the main advantages take place during the learning design phase. But we highly believe that it would simplify the implementation phase and help us to automate the deployment of patterns based scenarios. Our vision is to extend the approaches where Learning Design is the starting point, adding the learning environment dimension from the beginning of the design process. The use of ontologies to describe the set of the useful concepts for the deployment phase will provide us the semantic modeling to build on our pattern formalism.

III. A STUDY FOR PATTERN-BASED SCENARIOS DEPLOYMENT

As explained earlier, our approach is to establish a mapping between the human design of a course structure and a pedagogical structure of an LMS. Through the case study explained in this section, we particularly studied how to integrate pattern-based Learning Design into an LMS that consists of a number of services and features that can affect the teachers-designers designs (e.g. tests, forums, chats etc.). We explain how both patterns and ontologies would be a key solution for the automation of learning scenario's deployment reducing the semantic loss of information. We study the design of a learning scenario on the Moodle platform, which is our platform for experimentation.

The work was carried out in three steps following the lead of an algorithmic course design [26]. As a first step we extracted a list of learning concepts identified in the textual version (e.g. course plan, role, chapter, etc.). In order to prove the efficiency of a pattern-based design for keeping teachers intentions, we secondly used a pattern-based tool [15] for modeling the learning scenario. The idea behind using this "Free design" tool is to gather different versions of designs for one pedagogical intention.. As a proof of the expressivity feature that pattern-based design offers, we note that while listing the concepts used in this design, there was no loss of the learning concepts identified in the first step. After that, we studied the implemented scenario; the purpose was to identify the operationalization point of view requirements on a learning design. We identified as well the learning scenario's concepts in this deployed scenario. Once again, the concepts list remained unchanged. Though, taking

into account the deployed scenario and identifying its concepts on the pattern-based scenario, we noticed a lack of a set of information needed for the operationalization. For example the "Activities completion conditions" was implemented on the platform, but was not mentioned in the pattern-based version of the scenario. Teachers didn't pay attention to add the information to their design, even though they are necessary for the deployment. The concepts confrontation observations lead us to an ontology-based modeling solution. Using the ontologies when defining patterns for scenarios would reduce the semantic gap due to the transformation from the teacher's pedagogical intention to the platform. The pattern's rubrics must belong to the concepts used to structure the learning scenario, it will ease the mapping between the teachers design and the LMS's to use by instantiating the right concept progressively.

The final step was to confront the XML file of Moodle scenario, according to Moodle meta-model [20] with the XML files generated from the pattern-based editing tool. We noticed that a pattern component corresponds, sometimes, to more than one educational concept. The identification is not "unique". We take as an example the Human resource concept "Student", it is defined in two different places, as a "Human resource" and as the "participant" component of the design pattern. Also, the same pedagogical concepts are identified in differently for each formalized version. This makes it difficult to automatically deploy the scenario.

We got from this study that a pattern-based formalization, considering its semi structured data, may allow teachers-designers to express their pedagogical needs without extensive loss of semantic information. In the mean time, this open way of expressivity raises some difficulties for automating the learning scenario operationalization phase and leads to a complex and redundant description of the scenarios. In fact, learning platforms have their own pedagogical structure and language. Thus, the mapping of each element of the scenario with the relevant concepts in the platform is not obvious. The patterns formalism has to take into account the LMS deployment constraints, as well as the level of the granularity of the teachers design and the knowledge level of the activities. We believe that we should offer to teachers a merging of expressivity, structured enough, to make scenarios machine-readable representations of a teaching practice and guide them toward the right adaptation of their scenarios according the targeted LMS.

After identifying the assets (patterns formalism requirements and ontological modeling) leading us to automate the deployment of learning scenarios, we worked on how to use these assets to figure out how platforms deployments adaptations of a pattern-based scenario should be dealt with. We defined a five steps process [26] for pattern-based learning scenarios operationalization. Structuring (1) and indexing (2), allowing a mapping of the educational concepts with the learning platforms concepts and features. Based on the observation we made earlier in this section about the need to reduce the semantic loss, we identified in the structuring phase the different concepts of a learning scenario, useful to its deployment. This identification is the result of a research work about ontologies and educational standards [21] [22]. After that, our motivation for the indexing phase is that neither learning platforms nor learning theories in isolation can provide the support required to realize deployed learning scenarios.We believe that by mapping their two ontological descriptions, we ease the detection of the relevant pedagogical information, in order to associate it to the most suitable platform feature. To build a platform oriented ontology, we used the transformation rules to build a semantic description out of Moodle's metamodel [20] reduced to its embedded pedagogical language. This resulted ontological modeling is a key to design the learning scenario using deployable concepts that are linked to the patterns-based scenarios formalism as shown section IV. The formalizing step (3), proposes an approach based on pattern notation to better create and deploy learning scenarios, the use of patterns structure can be considered as a method of creating deployable scenarios, and at the same time, as a mean for capturing good design practices dedicated to different learning platforms. It is considered as a guide for teachers-designers. Finally, adapting (4) and operationalizing (5) reflect the adjustments to apply on the pattern-based learning scenario. Depending on the target LMS, we use a set of transformation rules to help assist teachers in their choices about the platforms features. We use the learning scenario importation [5] to instantiate the indexed concepts as an XML file in accordance with the LMS meta-model. The XSLT transformations are applied to cover the missing information if necessary. Teachers have only to express their pedagogical intentions in a "semi-open" structured language, without requiring any learning platform expert.

For this paper, we will specify more particularly the formalizing step, where we will explain our formalism and its role in the operationalization process.

IV. LEARNING PLATFORMS-ORIENTED PATTERNS

Since teachers are the starting point in the creation of a course, the formalization step of our operationalization process is dedicated for guiding them designing platform oriented learning scenarios. The focus of this kind of scenarios is on the relationship with a learning platform, to take advantage from its support for pedagogical features. In our research work on automating the deployment of learning scenarios, we have decided to rather develop a pattern dedicated formalism for producing embedded scenarios in existing LMSs. The platform-oriented patterns will be a result of the learning design based on the formalism we propose. Teachers create and reuse semi-formal and conceptual representations of concrete scenarios by modeling their intentions. Pedagogical engineers can validate the resulted scenarios to provide collections of patterns (depending on the pedagogical relevance of each scenario for a targeted learning platform, and using its features in the most suitable way). The created collections of patterns support the users (teachers-designers) in selecting a pattern, using it and/or adapting it to design and deploy the patterns-based scenarios.

The formalization of learning scenarios is mainly inspired by the design patterns that have been adopted in learning context and after studying formalisms in other domain used to represent pattern's structure. We finally chose to adapt P-sigma's formalism [21]. The definition of a structure as a set of three components "Interface, realization and relationships" was the nearest to satisfy our operationalization needs. We studied the role of each part of the formalism and we considered the results of our case study, to define the adaptations to apply: on the level of granularity of a design [22], the targeted knowledge types [23], and most importantly, the operationalization constraints of the LMS. This designing approach has not only the benefit of easing the description of pedagogical scenarios but we can handle the detection of the relevant information to instantiate on a learning platform thanks to the semantic background (cf. Structuring and indexing phases) covering the present concepts in the formalism.

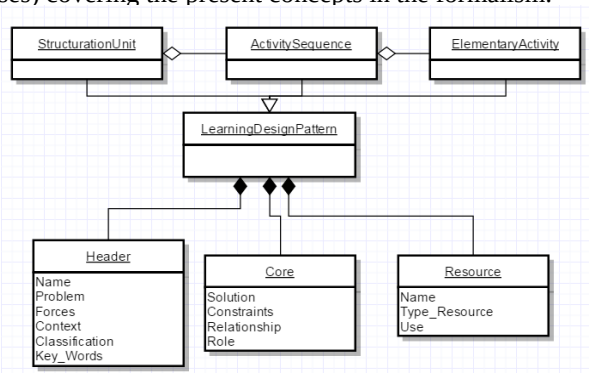

Fig.1. Pattern's formalism for learning design

As illustrated in Fig.1, designing and operationalizing requirements include to defining the granularity of defining a learning scenario. We relied on [22] to define types of pattern-based scenarios. It consists of classifying our scenarios in three categories in order to facilitate their further instantiation on the targeted LMS passing by the ontological model. We have the "Structuration unit" in which a set of instructional sequences are gathered to constitute a logical unit about a given learning theme and dedicated to a specific audience, the "Activity sequence" where several activities or sequences are organized in order to reach a learning goal clearly defined in terms of knowledge and competencies. This organization must be able to express conditions of sequentiality, optionality and parallelism. It must also describe the associated data flow process. Finally, the "Elementary activity" where one or several actors interact within a defined environment, for a generally short and contiguous determined duration. An elementary activity may pursue a precise learning goal or more simply contribute to the goal associated with the sequence in which it will be integrated.

The rubrics represented in Table.1, list the parts of a learning scenario on which a pattern could be defined, it is a three part structure: The header defines a "Pattern identity", it contains the elements necessary to its reuse and adaptation for a targeted learning system. We focus on the "*Classification item"*, which we consider as very important as it is the key to detect the right platform tool to propose to the teacher for his design. Based on Bloom's taxonomy, this item would indicate for us the type of the targeted knowledge acquisition. The "*Core item*" defines a way to schedule the activities of a course, to handle the deployment of the learning scenario. The item "*Constraints*" is very important, according to the targeted environment: teachers-designers have to fill it in two sets of constraints: deployable constraints, which are platform oriented such as activity completion condition, and non-deployable ones to ease the expressivity of their scenarios such us Anonymity of evolutions etc. The "*Resource item*" explains the aim of using a resource in a given activity in different contexts, this rubric is organized following a classification of learning objects (presentation, practice, simulation, conceptual models, contextual information and representation objects) [24]. Table.1 gives more details about our formalism:

Item	Definition
Header	
Name	The name of the pattern.
Problem (pedagogical objective)	The problem solved by the pattern.
Forces (pedagogical gain)	The pattern contributions through a collection of quality criteria.
Context	The pre-condition of pattern application.
Classification	This item allows distinguishing the pedagogical classification of each modeled activity.
Key words	The mean to provide an intuitive definition of the pattern's context.
Core	
Solution	The problem solution in terms of a pedagogical process of activities to follow (As a graphical diagram)
Constraints	The rules necessary for the pattern's implementation.
Relationship	The relation is expressed by an item (or another pattern) giving a type of link to the pattern described. The meaning of each link is based mainly on the pedagogical intention of the teacher (use, refine, follow etc.)
Role	The role defines the actor and the targeted of each part of the pattern's solution.
Resource	
Type of Recourse	The role of a mediated representation of the learning object.
Use	The manner of how the resource is used. (Upload / download)

Table.1. Pattern-based learning scenario's rubrics

Figure 2 gives an illustration of the designing tool home page, where teachers are assisted to be more open for extending their practice to TEL designs (in accordance with our proposed formalism), without having to manipulate the XML representations and the ontological instantiation generated behind. Our perspective is to test the user-acceptance of our prototype. The upper part of the interface is about describing the scenario's header and resources, to ease the scenarios/patterns recognition. The lower part, is dedicated to the core of the scenarios, where teachers can create the representation of their pedagogical intentions.

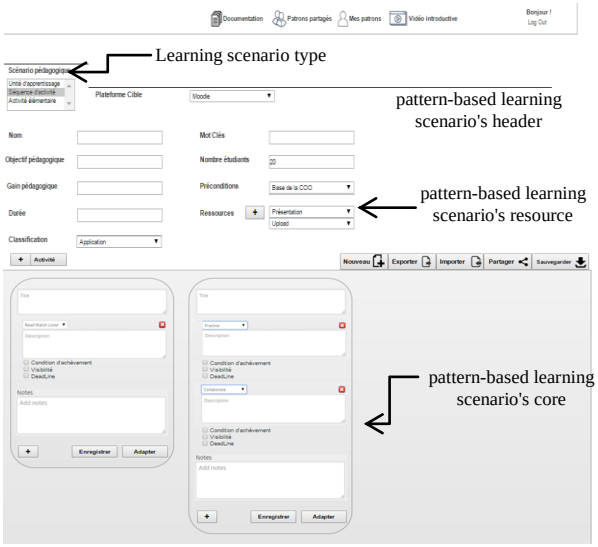

Fig.2. Pattern-based design tool: Home interface.

V. CONCLUSION

The current work has described a pattern-based approach to design deployable learning scenarios by teachers, with a minimum knowledge on learning platforms. We strive to show that using a pattern-based design, with a semi-structured representation of scenarios allows browsing for relevant information retrieval and the deployment of this information on different LMSs. The approach consists on a step from a whole process of operationalization, where our choice of patterns formalism was made after the review of mechanisms to represent formal learning scenarios, while conserving teachers' expressivity. We defined it general enough to be adapted to different learning platforms. We aim at experimenting our designing tool with teachers-designers to validate the use of our scenarios representation (pattern-based formalism) as a positive contribution in the process of automatically operationalizing learning scenarios. We also look for having a collection of platform oriented patterns based on teacher's scenarios. As a perspective of this works we propose to work on defining an adaptation model to automate the integration of this formalism on a tool with more effective adaptation rules assisting the teachers.

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