Learning Scenarios' Operationalization
A Process based on Ontology and Patterns

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Abstract: This article describes our work that aims to support teachers deploying automatically their instructional design, by the mean of patterns. We seek to balance between the need of expressive instructional scenarios, and the technical constraints that occur while deploying those scenarios on learning management systems (LMS). This could be seen as a need of a formal description in order to translate the concepts of a pedagogical scenario, according to those embedded in the LMS. To address this need, we propose a process of structuring formalizing, indexing and finally adapting and operationalizing the instructional scenario. This Process is based on a model of knowledge representation. Different Data levels around the scenario representation as well as the functional essence of educational systems will be presented. We also describe the way this model is structured so that it allows preserving most of the scenarios semantic.

1 INTRODUCTION

The deployment phase of learning scenarios allows the translation of scenarios intended by teachers, into an implemented version on learning platforms. As part of the current research in LIUM laboratory, we are interested more specifically in the dimension of designing, operationalizing and adapting educational situations. We consider the operationalization as the development of specific research procedures that will result in empirical observations, representing the learning scenario's concepts in the real world (learning management systems). We need to offer for teachers a mean to design adaptable and importable scenarios on distance learning environments such as Moodle (Rice, 2011) Sakai (Sakai, 2015) etc.

We focus on scenario-based design approach with patterns. This approach aims to provide teachers as designers with ideas that are based on broadly accepted practices (Hernandez-Leo et al., 2010) and help them collaboratively expressing their own pedagogic ideas (Laurillard, 2012). According to Laurillard this formalism can be expressed computationally and may help teachers-designers in providing deployable scenarios with a minimum loss of semantic information (Clayer et al., 2014) (Loiseau et al., 2014) (Abedmouleh et al., 2012) (Oubahssi et al., 2013). Despite of the significant advance of research work in the domain of learning environments, the operationalization phase of learning scenarios still remains a challenge in the technology enhanced learning (TEL) field. Teachers-designers are still poorly assisted in this phase. Educational languages and standards were proposed (Berggren et al., 2005) (Ferraris et al., 2007) to design learning scenarios in a machine-readable version. However, on the one hand this formalism may allow reproducing the author's design and running it online, but the teacher may find it difficult to express, design and adapt their pedagogical scenarios. On the other hand, their computational integration requires an extra effort, for each implementation, because of the technical and pedagogical constraints set by platforms. This complexity is due to the fact that existing platforms use instructional knowledge coded in different levels of granularity using implicit instructional language.

We aim to help teachers and designers to operationalize their learning scenarios by automating this activity. We propose a process based on patterns to guide the teachers from the learning scenarios formalization to their deployment on a target platform. Some research work has proven the efficiency of pattern approaches for learning design (Laurillard 2012). The semi-structured representation of scenarios will enable the capitalization and the reuse of teaching practices

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used by teachers. Most importantly, our hypothesis is that this representation allows browsing the patterns for relevant information retrieval and the deployments of this information on different learning management systems (LMS). We strive to show that regardless of the learning environment, using a pattern structure combined with a semantic representation of pedagogical objects (ontology approaches), will facilitate the operationalization.

This paper is structured as follows; the next section will gather related research work on instructional design for the operationalization of pedagogical scenarios. We focus on pattern based approaches to formalize and express scenarios and ontology based approaches for indexing and conserving the semantics of pedagogical objects. We describe in section 2 a pilot study we have conducted using a pattern editing tool. In this study, we sought to identify different needs and constraints for an automated operationalization. As a result, we present in section 3 the process we proposed based on patterns and ontologies to help achieving this automatic operationalization of learning scenarios. We conclude the paper by discussing further works.

2 INSTRUCTIONAL DESIGN AND OPERATIONALIZATION OF LEARNING SCENARIOS: RELATED WORKS

Although many research works addressed the learning design issues, few are those who take into account the aspect of operationalization, in particular, to facilitate the implementation of learning scenarios on existing platforms. This would be justified by the fastidiousness of this step. As a matter of fact, many difficulties and constraints are related to learning platforms, that range from the basic instructional language and rules to the implicit and complex structures related to each particular platform. Thus, these problems will create a semantic gap when considering learning scenarios concepts and platforms features. For example, designing tools based on modeling languages (EML) (Koper, 2001), more specifically the educational standard languages (IMS-LD, 2015) such as CADMOS (Katsamani et al., 2012) consider an XML notation, which is judged complex and tends to change the teachers-designers view of theirs scenarios. Also, since platforms do not follow any educational standards, deploying a standardized scenario would not be easy for a teacher to do. It will require the expertise of a pedagogical engineer. By another way, when those standardized designing tools take the operationalization step into account, it is always about one targeted learning environment (eg: CADMOS generates scripts to only deploy scenarios on Moodle).

As a solution to the lack of expressivity of Educational Modeling Languages, we chose a structured and formalized pattern approach for learning designs. Patterns are used to capture expert knowledge of the teaching practice. A pattern is pictured as a three-part structure, specifying a problem and a solution addressing this problem according to a peculiar context (Alexander et al., 1977). Defined links between patterns (association, composition, etc.) are considered as a pattern language. As shown is (Buendia and Benlock 2011), a pattern structure and formalization have been proposed in order to improve the instructional design process, by taking advantage of what patterns offer in terms of structure and ease of expression.

Educational language representation was used to help structure the proposed patterns (Anderson and Krathwohll 2001). We also note the WebCollage (Villasclaras et al., 2013) designing tool, it is based on pedagogical patterns. Within this approach, the implementation step still requires a platform expert assistance. (Clayer et al., 2014) elaborates a framework of an engineering design process and an editing tool based on patterns, however, the operationalization aspect of the patterns is not addressed. Finally, GLUE!-PS is a tool dealing with instantiation and deployment that allows deploying learning designs from multiple learning design language/authoring tool to multiple learning environments, yet, the design languages are based on IMS LD, which is too complex for the teachers (Prieto et al., 2011).

However, having as a main goal to automate learning scenario's operationalization, we have noticed that most of the proposed design languages and tools do not preserve the semantic meaning of teachers' intention while transposing it on a learning system. There will always be a lack of information, and as consequence a need for adapting and modifying the initial learning scenario. Moreover, we believe that the use of ontologies for both designing as well as operationalizing scenarios can solve this problem. Ontologies allow having one same semantic base which will retain the essence of the scenario during the transition between learning design and deployment phases. In educational fields, ontologies have played an important role as knowledge representation and sharing mechanism.

We find ontologies based on IMS LD language (Amorim et al., 2006), as well as ontologies around the learning scenario (Paquette, 2014) and also ontologies to describe common modules of learning platforms (Montenegro et al., 2010). We noticed that the main advantages of these ontologies take place during the learning design phase. We note that we highly believe that it would simplify the implementation phase and help us automate the deployment of patterns based scenarios.

The main concern of this work is to study the mechanisms supporting instructional design and scenario's deployment activity by teachers-designers. We are adopting a co-participative and iterative approach with teachers-researchers. The approach is called "Design Based Research"(Wang and Hannafin 2005), a methodology suitable to both research and design of technology-enhanced learning environments (TELEs). Especially those design experiments involve both scientific and educational values (through scientific processes of discovery, exploration, confirmation, and transmission that create strong links among researching, designing, and engineering). By this approach, we try to reduce the gaps between what a technology enhanced learning environment is and how it should be used theoretically (comparing what it is and how it is used in practice). We propose in this work to link learning design and operationalization of pattern-based scenarios. The main goal is to automate operationalization of scenario without losing its semantic information.

3 NEEDS AND CHALLENGES FOR A PATTERN-BASED SCENARIO OPERATIONALIZATION

The present section provides an introduction to issues related to the deployment of pattern-based scenarios in TEL environment. As shown in Figure 1, we worked on an example following the process of operationalization of learning scenarios based on patterns design, in order to study its feasibility and hen, identify the problems to deal with in our research.

In this direction, we put our focus on patterns-based learning design approaches as they offer a high level of expressivity and formalization for learning design concepts (Laurillard 2012).

We expect to benefit from their formalized structure to achieve an operationalization of scenarios on LMS. Ontologies are also a very important part of this work, considering the knowledge representation and the sharing mechanisms they offer, we model and browse all the learning vocabulary and language embedded in learning platforms as well as in learning scenarios. Ontologies allow making a description of learning scenario's context, taking into account the level of granularity used in it (teaching program, course, learning unit, etc.).

We performed a pilot study aiming to explain how would both patterns and ontologies be a key solution for the automation of learning scenario's deployment reducing the semantic loss of information. The two starting points were the following: in a first step we collect the textual version of a learning scenario (as intended by the teacher) and model it with a pattern-based design tool (Clayer et al., 2014). Then we looked at the version of the same scenario already operationalized manually on the Moodle platform. The idea behind this example is to identify the different needs in terms of technical and theoretical constraints around the deployment of learning scenarios on TEL environments.

The learning scenario is about an algorithmic introductory course for students in computer science in first university degree. The work was carried out in three steps, as a first step we extracted a list of learning concepts identified in the textual version of our scenario. We modelled the learning scenario using a pattern-based design tool (Clayer et al., 2014). During this step, we noticed that even though we consider the same textual version as a base of our design, numerous pattern formalizations could be realized (without any loss of the learning concepts identified earlier).

After that, we studied the "manually" operationalized version of the scenario on Moodle platform, and following the same logic, we identified the learning concepts in this deployed scenario. Once again, the concepts list remained unchanged.

Though, we have noticed a lack of a set of information needed for the operationalization (they were missing in the initial textual description). The information would make the connection between concepts describing the scenario and their equivalents on the platform. (eg courses, course structure etc.)

Those two first steps results and the literature leads us to conclude that the use of ontologies and meta-modeling when defining patterns for scenarios would reduce the semantic gap due to the

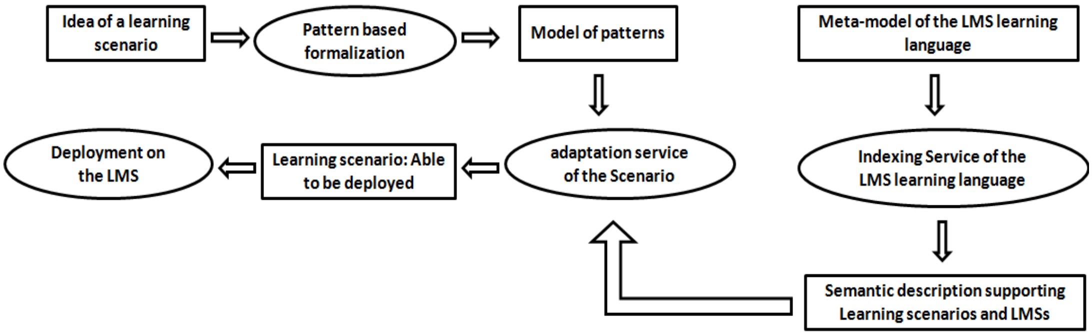

Figure 1: A process for formalizing and adapting learning scenarios for an operationalization purpose.

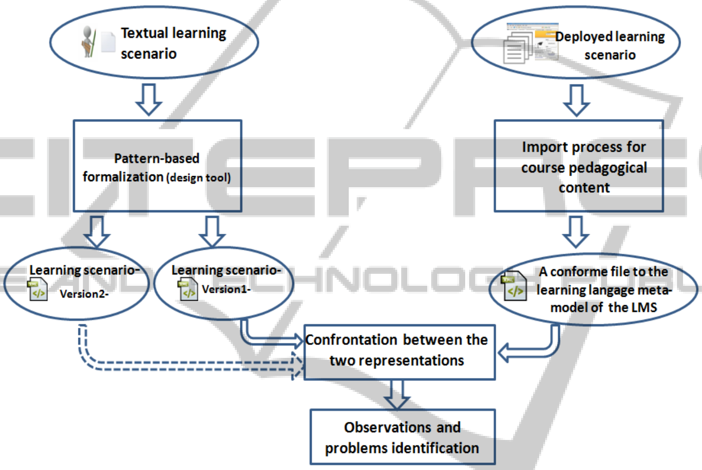

Figure 2: Case study and methodology.

transformation steps from the teacher's pedagogical intention to the platform. A pattern-based formalization -considering its semi structured data-allows teachers-designers expressing their pedagogical needs without extensive loss of semantic information while representing their pedagogical intention with a pattern-based editing tool. On the other side, this open way of expressivity raises some difficulties for automating the learning scenario operationalization phase (Bézivin and Lemesle, 1998)

In fact, learning platforms have their own pedagogical structure and language. So, the mapping of each element of the scenario with the relevant concepts in the platform is not obvious. We noticed that several solutions could be possible. Then we need to guide the teacher-designer toward a learning design approach that considers the operational needs and constraints, without forcing them to use any specific platform formalism.

The third and final step was to confront the XML file obtained from Moodle scenario (after transforming the backup file according to Moodle meta-model (Abedmouleh et al., 2012)) with the XML file generated from the pattern-based editing tool (we kept two versions of the learning scenario formalization). We noticed that: a pattern component corresponds, sometimes, to more than one educational concept. The identification is not" unique". Also, the same pedagogical concept is identified in different locations for each formalization (according to the teacher's point of view), this makes it difficult to automatically implement the scenario on a computer environment.

Our conclusions lead us to identify the need for techniques to establish the best correspondence between pattern's components and educational concepts for the targeted learning platform. We suggest to use an indexing service (Dietrich and Elgar, 2007).

According to our study we formulate more precisely our main research concerns as: which approaches models and / or techniques to consider for transforming the pattern-based scenarios into implementable models on different learning platforms? To answer this, we should deal with three major questions:

- How could we provide to the teacher-designer some predefined components or "patterns" that

would be used to gradually build a learning scenario ready to be directly implemented on any learning platform?
- Which formalism can be proposed for the patterns so that the learning design process delivers a structure helping the automatic operationalization without limiting the degree of expressivity and reuse?
- How to successfully maintain the semantics of learning scenarios while transforming its pedagogical concepts into learning platforms features?

4 A PROCESS FOR OPERATIONALIZING PATTERN-BASED SCENARIOS USING ONTOLOGIES

To answer our research questions presented in the previous section, we propose to define a process that aims at assisting teachers-designers to manage the instructional learning design activities (Figure 03). We believe that we should offer to the teachers a certain merging of expressivity, but it should be structured enough to make the scenarios deployable on learning platforms. This process consists of five steps. The first two: structuring (1) and indexing (2) allow a mapping of the educational concepts (coming from the teaching practices and needs of designers) and the learning platforms concepts and features. Formalizing (3), which consists on developing pattern-based scenarios by teachers-designers? Then we have the step to automate the implementation of scenarios (5). Before that, an adaptation step (4) is conducted to reduce the gap between the pedagogical language embedded in the platforms and the one used by teacher-designers.

4.1 Structuring

This step aims at structuring the learning scenario. It consists of two phases: the **identification** phase and **classification** phase. On the basis of the work presented in section 3, one can observe that the patterns-structured learning design scenarios as used, cause some difficulties while deploying on computer environments. Some pedagogical concepts could be missing or ignored, or poorly linked to the concepts of the targeted learning platforms. This lack of information prevents the automatic implementation of the scenarios (eg. not mentioning the course structure, activities dependencies etc.).

In this phase, different concepts of the learning scenario are identified in order to be formalized as patterns (Course, structuring unit, Sequence of activities etc.). The identification is based on research work about ontologies and educational standards (see in particular work presented by (Paquette, 2014) (Neven and Duval, 2002). Each of the scenario concepts are also linked to other concepts such as course outline, study plan, learning method, pedagogical method, strategy or tactics of teaching. We also mention that a pedagogical activity is defined as a series of steps or sub-activities that could be considered too as a learning scenario. Once the vocabulary for the scenario is built, we proceed for the classification phase. In order to offer pedagogically correct, significantly related and well structured patterns, we relied on the research work about the different dimensions and classification levels of the a learning scenario (Pernin and Lejeune, 2004). We consider different levels of granularity for a learning scenario: a structuration unit, an instructional sequence and even an elementary activity. We also rely on Bloom's taxonomy to classify the educational knowledge (Anderson and Krathwohll, 2001) and the different types of learning scenarios and activities (Paquette, 2014).

This classification will help the indexing work (presented next), because the structure of the learning scenario should satisfy the requirements of its implementation on a learning platform. We are talking about how to facilitate the detection and extraction of the relevant pedagogical information in order to map it to the most suitable platform feature, having a minimal semantic gap.

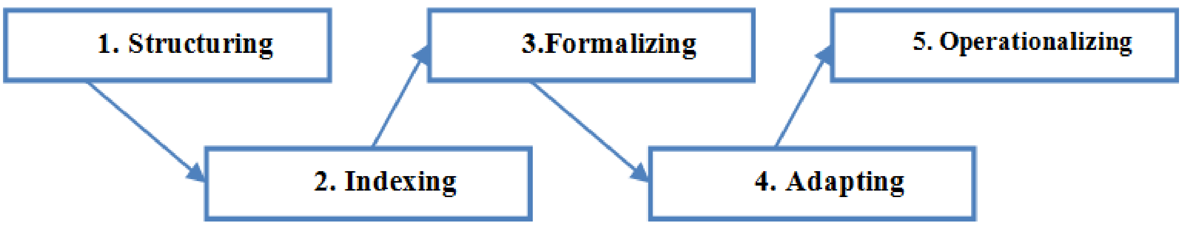

Figure 3: A process for formalizing and adapting learning scenarios for an operationalization purpose.

In this step, we aim to classify the learning scenario's patterns on several levels. Meaningful semantic relations should be defined between the different levels (Hierarchy, Typology, Compositions, Use etc.).

4.2 Indexing

In our context, we consider indexing as matching the pedagogical features offered by learning platforms with the learning scenario content. This phase consists on a mapping between both learning platforms and learning scenarios pedagogical language. Through our confrontation work (section 3) between a pattern-based learning scenario and its operationalized version, we identified a component of the learning scenario that has been translated into several features on the learning platform. Consequently, we need this indexation as a necessary intermediate phase between the structuring/formalizing the pattern-based learning scenario and its operationalization on a learning management system. We initially use an ontological description about the learning scenario concepts (Paquette, 2014) (Montenegro et al., 2010). The ontology description should respect the structure of patterns previously explained. Defining semantic relations intra and extra packages is very important in order to facilitate the detection of any relevant information from the learning scenario. Once the ontology is built, we proceed on matching every concept, every semantic relation and every constraint with the paradigm offered by each learning platform to consider. This indexation will create an extension to our ontology. It is part of the originality of our proposal. The ontology extension allows adapting any set of patterns designed by the teacher-designer, to a directly implemented scenario on any learning platform. We note that, the pedagogical language of the learning platform is extracted from its pedagogical meta-model. To identify this meta-model, we use the process of identification and formalization of the LMS instructional design language (Abedmouleh et al., 2012).

4.3 Formalizing

Once the structure of our learning scenario is defined, comes then the step of formalizing it. The formalism to offer is different from a pattern package to another. We are mainly inspired by the design patterns that have been adopted in e-learning context (Goodyear Yang, 2008) (Clayer et al., 2014) and more particularly pedagogical patterns (ppp 2015). While modeling our scenarios with the pattern-based editing tool (Clayer et al., 2014) (Part 3), we noticed that it is more likely an open tool for learning design that allows a free expression, this leads to some difficulties for detecting a specific needed concept. For example, the course duration could be set differently from one version of a scenario to another. Therefore, and in order to get over the automated operationalization problems, the composition of a pattern, should not compromise the detection of the relevant information, it should be well formalized while offering for teachers some freedom to design their scenarios. To be able to locate any information in a pattern is the key to an automatic operationalization, also, ensured by the use of an ontology allowing combining the pedagogical language concepts of a teacher-designer and the learning platform concepts as defined in the next phase of indexing.

4.4 Adapting

This step reflects the adjustments to apply on the learning scenario aiming to allow its automatic operationalization. The starting point is the pattern-based learning scenario, it should be structured and organized according to the previous step of the process (for each pattern used and each component filled by the teacher). Depending on the target LMS, an instantiation of the indexed concepts (as presented in section 4.3) should be executed as well, thus, providing an XML file in accordance with the meta-model of the learning platform. XSLT transformations are applied to cover the missing information and properties if necessary. Finally, we get a scenario file ready to be deployed on the target platform.

4.5 Operationalizing

Consequently of the steps above, the learning scenario is formalized as structured patterns, well adapted to instructional language of the target platform. The next step is to implement this resulted scenario. To do so, we use the module of learning scenario importation. This importation is automatic and does not require any intervention of the learning platform expert. All that the teacher has to do, is to express his/her intention and pedagogical need in a semi-open structured language. We will then offer tool support to guide the automatic operationalization with a minimal semantic gap, especially without requiring him/her to master the complicated instructional language of the learning platform. The progression of this process is based on data about the pedagogical scenario and learning platforms (inputs / outputs). This data is organized and represented as a model introduced in the following paragraph.

4.6 Data Representation

Considering the data level point of view, the process of operationalization of learning scenarios involved is specified on different levels of representations (From a logical level to the physical level). As shown in the following illustration (Figure 4), we define three levels of representation, depending on our operationalization needs of pattern-based scenarios

4.6.1 Conceptual and Semantic Level

This first level of representation stands with the "Computationally Independent" viewpoint, and enables us to have an instructional design knowledge representation as closer as it could be to the language used by a human teacher as well as the language embedded in a learning management system. this layer is about the "Learning scenario" modeled in an ontology inspired. This ontology should reflect the different teaching strategies and the diffenrent levels of granularity in a learning scenario (a course, a learning unit etc.).

Keeping in mind our main objective to automate the operationalization process of learning scenarios, this ontology should include in its definition of concepts, the features provided by the various LMS to consider. This extension is an indexation of the instructional language of a learning platform. Building this semantic level ensures a common vocabulary for all teachers-designers and facilitates the interoperability between different LMS.

4.6.2 Instructional Design Level

The previously presented process's phases "structuring" and "formalizing" provide a representation of the pattern-based scenario. This result is what makes the content of the instructionl design level. Each element of instructional design level is connected to one or more nodes from the semantic representation (level 1).
The elements are linked through "Instructional Relations" that establish the function and identify the various features to use on the learning platform while deploying the scenario.

4.6.3 Content and Ressources Level

This content layer consists of different learning objects (documents and material resources) used in different contexts (Churchill, 2007) Such as: course notes, exam's forms, the use of software and any mean of communication etc. A classification of these objects has to be considered (Churchill, 2007) (presentation, practice, simulation, conceptual models, contextual information and representation objects). This level is strongly related to levels 2 and 3, it allows to instantiate the objects on learning platforms depending on the choice of use of the teacher-designer (as a support resource, mediation, building knowledge or as course application).

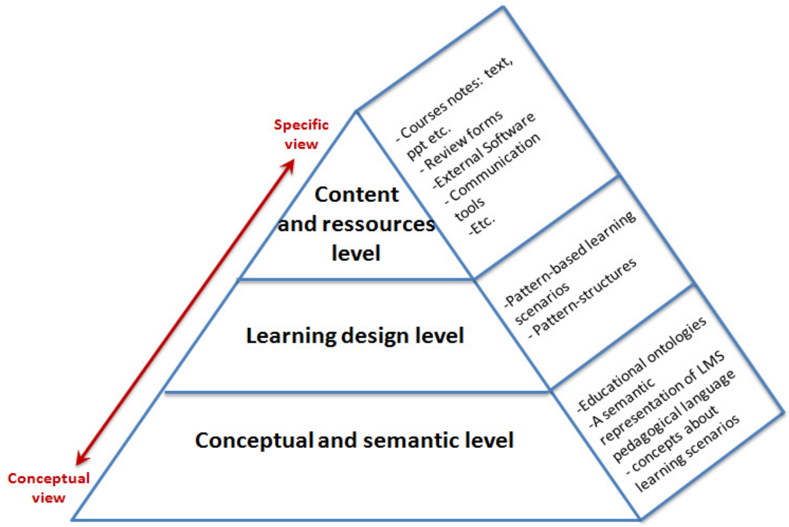

Figure 4: Data layers for the automatic operationalization of pattern-based learning scenarios.

5 CONCLUSIONS AND FUTURE WORK

This paper presented the research about a process of designing deployable learning scenarios, based on a model of data representation. We tried to answer our main question of research, which concerns the way of transforming pattern-based scenarios into implementable models ready to be automatically operationalized on a learning platform. It is important to consider the use of the semantic web advantages. We leaned on a case study that helped us to highlight the problems facing the operationalization of learning scenarios based on patterns. We intend to provide a structure and classification of scenarios to help the LMS's features indexing purpose. We take into account the taxonomy of activities, resources and other educational concepts, according to the teacher's intentions while designing. At the present time, we prepare an experiment, which will allow us to experiment a pattern-based formalism and collect multiple versions of patterns structures for the same learning scenario. Then, we plan to apply the process presented earlier on these resulting scenarios to study their operationalization in a design-based research approach.

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