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# A context modeling approach and a tool for reusing learning scenarios

Mariem Chaabouni<sup>a,b</sup>, Mona Laroussi<sup>a</sup>, Claudine Piau-Toffolon<sup>b</sup>, Christophe Choquet<sup>b</sup>, Henda Ben Ghezala<sup>a</sup>

<sup>a</sup>RIADI, Manouba University, Tunisia

<sup>b</sup>LIUM, Maine University, France

{Mariem.Chaabouni, Claudine.Piau-Toffolon, Christophe.Choquet}@univ-lemans.fr,  
Mona.Laroussi@univ-lille1.fr, Henda.Benghezala@ensi.rnu.tn

**Abstract:** With the evolution of teaching modalities and the high integration of the technology in the learning processes, teachers proceed to the design of learning situations in order to plan and formalize their educational experiences and share them with students and other teachers. Various academic and community initiatives of experience sharing and resulting learning scenarios repositories have emerged. This leads us to discuss the learning scenarios reuse issue, which becomes an essential practice for capitalization. Since the learning contexts are continuously changing, it could represent an obstacle to the reuse and the appropriation of learning scenarios. It therefore becomes important to consider the context dimension to assist teachers in the scenarios reuse situations. This paper deals firstly with the proposition of an approach to model learning scenarios context. Based on this modeling approach, this paper is interested in the retrieval of learning scenarios that most fit a target learning situation context by presenting a context similarity algorithm matching contextual models. The retrieval is based on contextual indexes related to scenarios. The indexing process is consolidated by the observation of the prior user-experiences of learning scenarios. An authoring tool is then presented integrating the context modeling approach and the detailed algorithm. Simulations of the implemented tool and related results are detailed within this paper.

**Keywords:** Learning scenarios, learning context, reuse, context-based similarity, pedagogical indicators, indexing

## 1. Introduction

It becomes important to organize and capitalize the teacher's practices. This leads us to discuss the reuse issue of the learning scenarios that can be considered as the results of the formalization of these teaching practices. The reuse rate can be reduced due to the multiplicity of the scenario's formalisms, the definition of rigid scenarios, the variation of learning contexts especially when the scenarios are detailed in a very specific way for a particular context, the high variability of resources used in the scenarios and the lack of tools to assist in finding the proper scenarios for reuse. Various approaches and technics are proposed in literature helping the reuse of learning objects (LOM, 2002; Moura, 2007) and learning scenarios in particular (Paquette, 2007; IMS, 2003a). This paper is mainly focused on facilitating reuse by treating essentially the context aspect related to the learning scenario. It proposes an approach, addressed to teachers-designers, to assist the scenario reuse task by suggesting the scenarios that better fit a target context of learning situation. This approach is reinforced by the observation of the past learning experiences to support the pertinence of reuse.

Section 2 exposes related works in the literature that discuss the learning scenarios formalisms, the reuse of these scenarios and the learning contexts. Section 3 describes the context modeling approach allowing the construction of the contextual index of a learning scenario. After that, Section 4 shows how to use this index to promote the scenarios reuse. It so describes an algorithm calculating contextual similarity between a planned context and a contextual index associated to a scenario. This algorithm returns as output the scenarios which have been indexed by the most similar contexts to the planned context in a situation of design by reuse. Then, Section 5 describes an author tool supporting the scenario design by suggesting the most appropriated scenarios to a given learning situation. Finally, the paper will discuss the obtained results.

## 2. Related works

The designations and the representations of the teacher practices have been widely treated with different views in prior works. IMS-LD (IMS, 2003a), a proposed Educational Modeling Language (EML), defines the concept of a learning process as "a time ordered series of activities to be performed by learners and teachers (role), within the context of an environment consisting of learning objects or services". We cite also the PoEML language (Perspective-oriented Educational Modeling Language) (Caeiro-Rodriguez, et al. 2007) sharing a similar approach by referring to the term "educational scenario" that is "intended to support the modeling of any kind of educational unit at different aggregation levels, from simple lessons, to complete courses or curriculums".

With the increase of these modeling approaches, learning scenarios repositories (E-LEN, 2005; BASAR project, 2012) appeared implementing these approaches and containing a large number of scenarios. These bases are supplied to share the experience of the scenarios designers. This leads us to discuss the scenario reuse problematic that becomes an essential practice. An exploratory study of the BASAR base (Bank of hybrid, reusable and interoperable learning scenarios) (BASAR project, 2012) has revealed an important need of reuse of scenarios or activities sequences of scenarios. The study also shown a wide variation and a diversification of contexts associated with these learning scenarios. In fact, these scenarios implement different modalities like temporal, spatial, and collaborative. The designed scenarios are also targeting learners with different educational levels, technical skills or social characteristics. This variability might reduce the potential reuse of the scenarios by another designer or leads him to reuse non-adapted scenarios to its usage context.

It thus becomes important to consider the contextual dimension to assist teachers in the scenarios reuse situations. For that, we opt for a multidimensional modeling approach of the context of a learning scenario including any environmental factor that can influence the scenario progress whether educational, technical, social or others. The context of a learning situation is seen from a large perspective varying from educational and social profile of the learner or the teacher, pedagogical and affective objectives of the learning situation, used software/hardware resources, to the physical environment surrounding the execution of the scenario. Therefore, trying to use the same scenario in a different context from the original one may be not adapted to this targeted context.

The principal aim of the study presented in this paper is to define an approach to model and to analyze the context in which the scenario was implemented and to use it to build a contextual index. This will help a designer to reuse scenarios that have been indexed by closest contexts to his target context. A scenario performed in a specific context can succeed or fail with this particular case. So, the past learning experience can be useful for enhancing the indexing scenarios. In that situation, we propose to integrate this dimension of user experience in order to reflect the degree of success of a scenario in a particular context, and so benefiting from previous experiences already implemented in a given context. In order to consider the past learning experiences, it is proposed to use the observation of the learning sessions by calculating pedagogical indicators. Thus, the observation allows the teacher-designer to assess the progress of the scenario and to determine whether it was successful in a such specific context and if it has been effectively adapted to this context.

## 3. A context modeling approach of learning scenarios

Firstly, we present the approach of modeling of the learning scenario context. This modeling approach is useful to express the contextual information of a learning scenario. The main characteristics of this proposed approach, that will be more detailed thereafter, are: "multi-leveled", "scenario language-independent", and "multi-faceted" modeling of a scenario context enhanced by observation.

The forms of the scenario context vary during the phases of the engineering process of a learning scenario. This process is detailed in prior works (Chaabouni, et al. 2015). So, we distinguish 3 levels of context related to a scenario as shown in Figure 1: the real usage context of the scenario during its implementation phase (ECM-LS: Effective Context Model of Learning Scenario), the contextual index of the scenario at its indexing phase (ICM-LS: Indexed Context Model of Learning Scenario) and the context of the scenario that is planned during the design phase (PCM-LS: Planned Context Model of Learning scenario). The context is formalized independently from the scenario

language. So the context modeling approach is not restricted to a specific scenario's language or formalism.

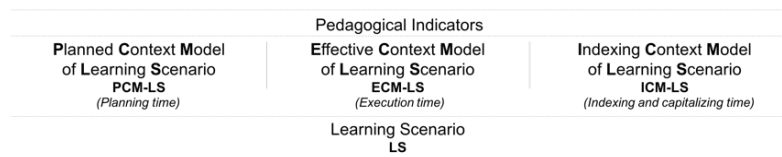


Figure 1. Positioning of a scenario, its context levels and related pedagogical indicators

The contextual elements related to a learning scenario are diverse. They can be seen from didactic dimension, educational, social, technical, etc. As illustrated in the meta-model of the context in Figure 2, we opt for a multifaceted modeling ("EContext\_Facet") of contextual elements ("EContext\_Item"). Assessments ("EAssessment") can be assigned to the context items. The form of an assessment differs depending on the phase in which the context is instantiated and modeled. Some assessments of the context of the index may represent constraints ("isAConstraint()" operation) on the reuse of a learning scenario such as the presence of a learner pre-requisite skill or a material resource for fulfillment of the scenario. Other assessments represent characteristics ("isACharacteristic()" operation) describing the context of the scenario and which the looseness don't constrain the reuse.

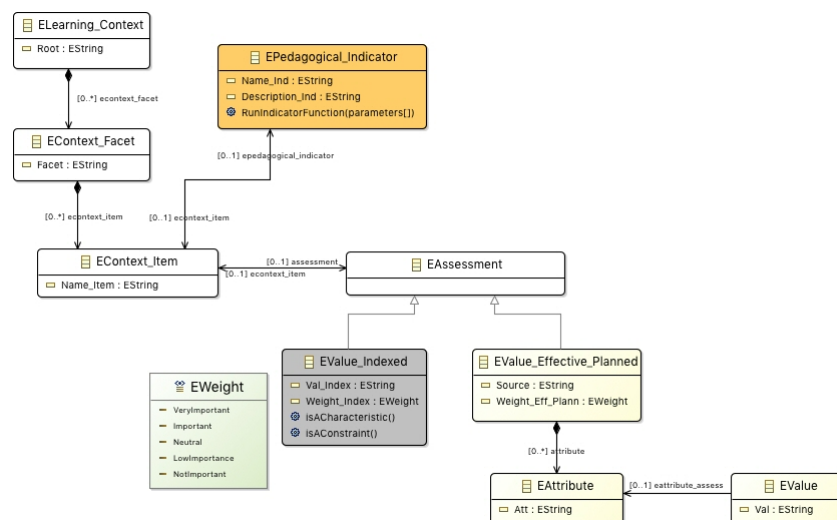


Figure 2. Meta-Model of the context of a learning scenario

In order to consider the observation dimension, the context modeling is enriched with pedagogical indicators ("EPedagogical\_indicator"). These indicators are associated to the context items, at the execution time, in order to provide calculated additional information about the context (as the Device status indicator or the learner trajectory indicator) or the scenario progress on this specific context (as Division of labor or Evaluation results indicator). In fact, such indicators interpret the effective context and inform about the progress of the scenario in this context. These indicators are associated with functions taking as input the scenario usage traces (collected from LMS databases, log files, etc.) or data provided by the teacher. The pedagogical indicators are positioned at the highest layer of the contextual models and the scenario (see Figure 1). So this layer adds indicators representing calculated data of a scenario in a given context used to characterize the effective user experience of such scenario.

For example, the collaboration level indicator calculates the level of the collaboration between learners perceived in the activities "Lab work" (see Act1.2.2 in Figure 3) and "Peer Review Exercise" (see Act1.3.2 in Figure 3). For instance, the indicator needs as function inputs the traces about the number of messages sent by each learner during a chat session. This indicator can additionally inform the teacher about some identified context elements.

This would inform the teacher if the "Peer Review pedagogical practice (see CE2 in Figure 4) has succeeded and if the learners have collaborated with this type of practice. So, the presented meta-model is instantiated to lead uniformed and structured context models of a scenario that are, at the same time, adapted to the community of usage. Figure 3 shows an example of a learning scenario. This example has been extracted form the BASAR base. The Figure 4 is an example of an associated ECM-LS shown both in graphical and JSON notation.

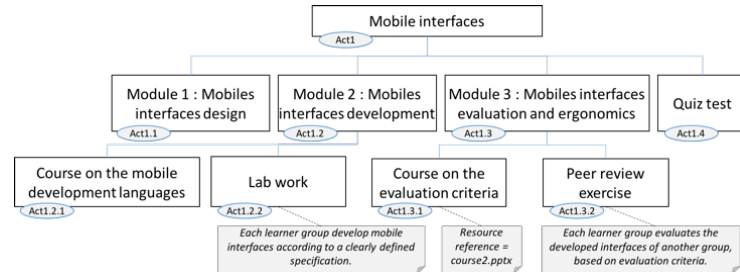


Figure 3. Example of a Learning Scenario (LS)

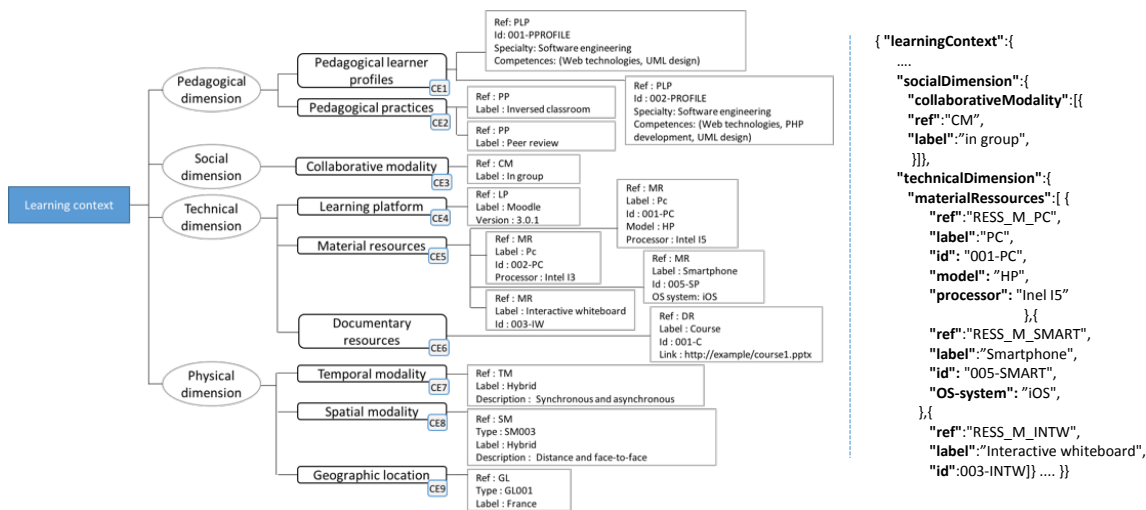


Figure 4. Example of an Effective Context Model of a Learning Scenario (ECM-LS)

In order to use the presented contextual models enriched with indicators for indexing purposes and then for reuse, it is needed to filter/identify the elements that are relevant to indexing. This task is performed by teacher-designer who, with the system assistance, interprets the contextual model. The assistance is ensured through calculated indicators. The teacher-designer highlights the relevant elements to indexing and downgrades useless items. In order to illustrate this emphasis/downgrade, teachers attribute weights (see Weight\_Index attribute in Figure 2) to the contextual elements. After treating how we can represent the context of a learning scenario and how to build a contextual index of a scenario based on the observation of the progress of the scenario and its context, we present then how to use this contextual index to assist the reuse of the associated scenarios. So, the next section describes an algorithm calculating contextual similarities between learning scenarios.

#### 4. Context-based similarity algorithm for learning scenario reuse

We have a set of Learning Scenarios  $LS = \{LS_i / i=(1..N)\}$ . Each  $LS_i$  is associated to one or more contextual indexes  $ICM = \{ICM_j / j=(1..M)\}$ . In a  $ICM_j$  index, each context element (i.e. pedagogical\_learner\_profile/competences, collaborative\_modality, etc.) is associated with an evaluation represented as a weighted vector  $IC$ . So, let  $ICM_j$  be a set of weighted vectors of different context elements valuations  $ICM_j = \{IC_k / k=(1..n)\}$ .  $IC_k$  takes as values the weights assigned by the teacher during the indexing phase. In addition, each  $ICM_j$  is associated with a Success Rate ( $SR_j$ ) reflecting the success of the concerned scenario  $LS_i$  in this indexed context  $ICM_j$ . In a situation where

designers want to reuse existing scenarios, they express the planned contexts in which they expect to execute their scenarios. This planned context is presented by PC vectors.

The algorithm, detailed below, calculates the similarity between the Planned Context Model (PCM) and each contextual index (ICM<sub>j</sub>) associated with different stored learning scenarios (LS<sub>i</sub>). The algorithm is based on the weighted DICE similarity (Jousselme & Maupin, 2012).

**Input**

- A set of N learning scenarios: **LS**
- A set of M index instances and associated Success Rates: ICM, SR
- A Planned Context: PCM
- Min similarity Threshold: MinTh

**Output**

- A list L of the most relevant scenarios corresponding to the planned context PCM, and insuring a minimum similarity threshold MinTh

**Procedure**

1. For each ICM<sub>i</sub>
    - 1.1. Match correspondent elements and establish links between IC<sub>k</sub> vectors and PC<sub>1</sub> vectors valuations
    - 1.2. In the PC<sub>1</sub> vectors, verify the presence of all index constraints (elements with the w=1 in IC<sub>k</sub> vectors)
    - 1.3. If all index constraints are satisfied
      - 1.3.1. For each matched IC<sub>k</sub> vectors and PC<sub>1</sub> vectors
        - 1.3.1.1. Apply Dice similarity formula, reinforced by the success rate SR<sub>k</sub> associated to the given index:
 
$$\text{Similarity}(IC_k, PC_1) = SR_k \times \frac{2 \sum_t w_t \times v_t}{\sum_t w_t^2 + \sum_t v_t^2}$$
        - 1.3.1.2. Calculation of similarities Average in the tree to retrieve global similarity value:
 
$$\text{Similarity}(ICM_i, PCM)$$
      - 1.3.2. If  $\text{Similarity}(ICM_i, PCM) \geq \text{MinTh}$  then Add LS<sub>i</sub> corresponding to ICM<sub>i</sub> to the L list
2. Return L List

## 5. An authoring tool to assist the reuse of adapted learning scenarios

The identified levels of the scenario context and the presented similarity algorithm have been implemented and integrated into an authoring tool named "CAPtuRe-tool" (Context-based Approach to assist educational scenarios Reuse) addressed to teachers-designers. This tool is principally conceived to assist the teacher-designer in the scenario reuse task. Firstly, the tool helps designers in retrieving the most relevant scenarios to a planned learning situation, and so to enhance the learning scenario reuse. The teacher informs its planned context (PCM-LS) in which the scenario will be implemented through the form (see "Inform my context" part of Figure 5). The form shows the multidimensionality of the context model. This planned context is also enriched by data from other sources such as universities databases, location sensors, etc.

After executing the similarity algorithm, the tool identifies and suggests interactively the existing scenarios having been indexed by the most similar contexts ICM-LS to the planned context (see "Reuse scenarios" part of Figure 5). The CAPtuRe-tool is integrated with the "Scenario Basar" tool enabling the design of learning scenarios.

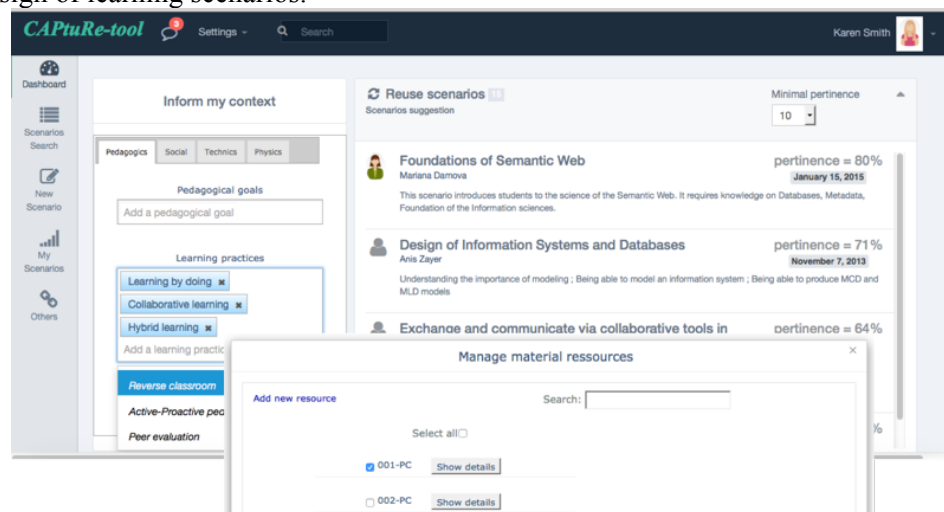


Figure 5. Interface of managing planned context and scenario retrieval in the CAPtuRe-tool

Parallel to the design, the teacher plans the observation through selecting and specifying the indicators to be calculated during the execution of the scenario. These indicators help the teacher to observe the context and to perceive the success of the scenario in this specific context.

## 6. Results and conclusion

During the setting up of the exposed approach, and in order to highlight the need of reuse, a first phase of controlled experiments has been performed with teachers placed in design situations without having a tool assisting the scenarios reuse task. Results have been collected through an online survey diffused for BASAR designers. In this usage case, the survey demonstrates that, during the design phase, 80% of teachers did not reuse existing scenarios from any scenario's repository and 92.3% did not reuse scenarios from the BASAR base especially. The main reason of the non-reuse is "after research, I didn't find the appropriate scenario" with a percentage of 51.1%. In addition, 57.1% of participants confirm a need of reuse, with, on the other hand, 42.9% expressing that they did not feel the necessity of reusing scenarios. This analysis reveals the importance of reuse and confirms the need of assisting teachers-designers in the scenarios reuse task.

Then, in order to validate contextual model data and the presented similarity algorithm, we firstly start by the analysis of the existing BASAR scenarios (currently 106 scenarios) and the extraction of the associated context of each one. We complement these contextual data through the establishment of a survey addressed to BASAR designers. This survey allowed us to collect complementary context information in which the scenarios were effectively executed, and which is not available in the existing scenarios (learners and teacher's competences and specialties, environmental and technical constraints required for the scenario execution, geographic location of learners and teachers, etc.). Therefore, we construct, from the collected data, the associated contextual indexes (ICM-LS) to enrich existing BASAR scenarios. We proceed then to different simulations of planned contexts (PCM-LS) through the implemented tool.

To conclude, we have firstly proposed in this paper a representation formalism of a learning scenario context in different phases (Planned time - execution time - indexing and capitalizing time) and the main characteristics of the adopted approach. Based on this representation, we have then defined an approach of indexing a learning scenario with its contextual dimension. The idea is to consider the user experience to index the scenario with contexts having been the most adapted to this scenario. This is performed by observing the scenario progress through pedagogical indicators calculating and analyzing the success of the scenario in a given context. An algorithm of context-based similarity is then illustrated calculating the similarities between a planned context in a learning situation and contextual indexes associated with learning scenarios. In order to concretize the proposed approach and the context-based similarity algorithm, the tool "CAPtuRe-tool" has been presented. In a situation of pedagogical design by reuse, this tool suggests the scenario that can be the most adapted to the context of the learning situation. Finally, results are discussed through the simulations of usages of the implemented tool in controlled experiments performed by a group of teachers-designers.

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