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A Model and Tool to Support Pedagogical Scenario Building for Connectivist MOOC

Aicha Bakki^{1,2} · Lahcen Oubahssi¹ · Sébastien George¹ · Chihab Cherkaoui²

¹ Laboratoire d'Informatique de l'Université du Mans, Le Mans Université, LIUM, EA 4023, Avenue Messiaen, 72085 Le Mans Cedex 9, France

² IFR-SIC Laboratory, Ibn Zohr University, Agadir, Morocco

Abstract

The work presented in this paper examines part of a broader issue in the field of technology-enhanced learning and focused on Massive Open Online Courses environments (MOOC). The main goal is to provide an approach, models and tools to assist teachers in the scenario design process and the operationalization of pedagogical scenarios in a connectivist MOOC context. The major contribution of this work is the MOOC Authoring Tool (MOOCAT), which is a visual authoring tool that is intended for the design and deployment of cMOOC-oriented scenarios. MOOCAT has two main innovative features. The first feature offers a tool for designing educational scenarios in a simple way, through a graphical representation for defining learning workflow. The second feature is related to its capacity to bridge the gap between the design phase and its execution in different Learning Management Systems (LMS), by offering services that allow the automatic deployment of pedagogical scenarios to existing LMS. This paper presents the underlying model of MOOCAT, and describes the cMOOC scenario-building process. The tool was evaluated primarily from the point of view of utility and usability. A total of 40 individuals have participated in the experimentation. The findings confirm that MOOCAT can be used to design connectivist pedagogical scenarios and can provide all the necessary elements for the design of such courses. Feedback from participants emphasized the ease of use and the benefits of the proposed visual authoring tool.

Keywords: TEL, MOOC, cMOOC, Authoring tool, BPMN, Connectivism, Instructional design, Visual language.

1 Introduction

In this digital age, in which people are constantly connected and information widely shared via social media, Siemens and Downes have proposed a pedagogical approach that is suitable for this new model of learning. As a result, massive open online courses (MOOCs) have emerged.

MOOCs are environments that focus on promoting and supporting a wide range of educational experiences for online learners. Since their first emergence, the aim has been to build an environment that can contribute to teach various audiences, either students or individuals with a lifelong interest in education. MOOCs also aim to extend education to people who for social or geographical reasons are unable to access it (Alario-Hoyos *et al.*, 2017).

Since 2011, many institutions of higher education have integrated this new form of learning, and as a result, new forms known as xMOOCs have begun to be developed. These environments are mainly based on a transmissive, teacher-directed pedagogy, in contrast to the original MOOCs (or cMOOCs); the latter are based on a connectivist pedagogy (Downes, 2008), which is also known as a “networked-based pedagogy” (O'Brien *et al.*, 2017). cMOOCs are based on a model that encourages collective and participatory learning. They support a learner-centered pedagogy in which

learners generate content and control their learning. Although they were developed at the beginning of the MOOC phenomenon, cMOOCs have not been implemented on the same scale as xMOOCs.

The characteristics of MOOCs have generated a variety of research areas, which are primarily related to the taxonomy and classification of MOOCs, analysis of dropout rates, design of user interfaces, learning analytics, profiles of learners, adaptation and personalization via different criteria (learning styles, learners' preferences, etc.), learning design (strategies and frameworks) and educational scenario building in MOOCs. The current research proposal focuses particularly on the last of these. The main purpose is to provide an approach, models and tools to support teachers in the process of pedagogical scenario building and operationalizing it in the context of a cMOOC.

The pedagogical principle of connectivism is based on the notion of social networked learning, in which knowledge and resources are generated by participants through their progression in the course (Jasnani, 2013; Youssef *et al.*, 2014). In these environments, participants have effective control over the course by defining the course objectives, generating content, suggesting activities and distributing new resources to other participants and over the web (Admiraal *et al.*, 2015).

One of the major difficulties faced by teachers wanting to design such courses is to determine how to model educational activities within this connectivist context. The issue lies in creating pedagogical, monitoring and tutoring scenarios to support learners so that they do not feel overwhelmed. Designing such scenarios is challenging, since it requires an effective collaboration between the teacher and learners throughout the course. Another difficulty involves setting up cMOOCs in a way that respects the openness and freedom of learners to define their own educational objectives. In this perspective, teachers should not establish a specific linear course plan, but should propose resources and activities that can guide learners toward the main objective of the cMOOC and then encourage them to create, produce and collaborate. These complexities require some mechanisms and methods that can guide and support teachers in the design of the cMOOC; these mechanisms should be simple, understandable, and easily applicable to a wide range of fields of knowledge.

In the last few years, it has been pointed out that the research community has increasingly focused on methods and tools that can be used to support teachers in their quest to design xMOOCs/cMOOCs. As described in Section 2 below, several research works have focused on the use of learning design principles within xMOOC and cMOOC environments. There are numerous proposals for conceptual frameworks to assist teachers in designing such courses, but none of them propose effective models or tools for conceiving and deploying a cMOOC. From a conceptual point of view, the major difficulties faced by teachers are, firstly, how to put in place a scenario that emphasizes the new roles played by the learner as both contributor and teacher, and secondly, the lack of adequate tools and/or models for designing cMOOC scenarios without prior knowledge of the underlying pedagogical model. In terms of implementation, this involves proposing methods for deploying a pedagogical scenario on different platforms, without having to do this manually on a given LMS. An automatic deployment solution would both allow the reuse of the conceived scenarios, and would allow the teacher to avoid thinking about and defining the target platform in advance. These are the main issues we address in this study.

The section 3 presents a cMOOC authoring tool for the design and deployment of pedagogical scenarios. The implementation of this tool, named MOOCAT, involves two main aspects of technology-enhanced learning (TEL) research. The first concerns the educational scenario building process; in order to define this process in a connectivist context, we aim to formalize the course design process, which must take into account the massiveness, openness and theoretical aspects of connectivist courses. Based on a literature review, we define a cMOOC scenario model (the cORPS model), and then reify this model using a visual authoring tool. The second aspect is related to the operationalization of pedagogical scenarios, which consists of deploying an educational scenario in an automated or semi-automated way on a learning platform (Abedmouleh *et al.*, 2011). Based on these ideas, MOOCAT offers a visual tool to assist teachers throughout the cMOOC design process, helping them to design and deploy their courses.

Sections 4 and 5 present BPMN extension and the MOOCAT tool. Section 6 presents the main results of an experimental study aiming to evaluate the usability and utility of the MOOCAT tool. Finally, we draw conclusions and discuss future work.

2 Related Works and Key Concepts

The advent of cMOOCs has generated great interest within the research community, and particularly regarding pedagogical models for these new connectivist courses. Several authors have highlighted the interest in and the need for a specific learning design (LD) to implement this type of course. In this section, we carry out a literature review of this subject in order to: (i) outline the existing studies of the pedagogical scenario-building process for cMOOCs; and (ii) define the characteristics of a pedagogical scenario in the context of a cMOOC. The following section describes the learning design that motivates our proposal.

2.1 Pedagogical Scenario Building and cMOOCs

Since the advent of online learning, different platforms have emerged; some of them have been more successful than others. The upshot is that LMSs are in continuous evolution and discussions regarding different versions of a platform are miscellaneous (El Mawas *et al.*, 2016). This constraint is compounded by the diversity of pedagogical approaches with which the teacher is confronted. Due to the complexity of LMS functionalities, the users are expected to have some pre-existing knowledge of these functionalities (Abedmouleh, 2014). In addition, LMS do not offer any support to help teachers in clarifying, defining and then specifying their learning situations before setting up them. They have to appropriate the various screens and form-based interfaces to abstract some low level details to think about their global design courses (El Mawas *et al.*, 2016).

All that being said, the use of Learning Management Systems presents many difficulties for teachers in thinking about and designing their courses. It results that there is a need for solutions to bridge the gap between the teachers' educational intentions and the pedagogical functionalities proposed by the LMS. The main objectives of these solutions are to: (1) to facilitate the conception of pedagogical situations; (2) to allow the description, sharing and reuse of pedagogical scenarios using a common language; (3) to bridge the conceptual dimension of a scenario with its technical implementation, notably by facilitating the manual or automatic deployment of a scenario to the LMS (Bakki, 2018).

A further challenge related to the connectivist approach is coupled to these constraints. Without meaning to anticipate these various aspects, we shall point out initially that the state of the art on connectivism reveals a lack of conceptual and methodological framework to assist teachers in implementing this approach, either in face-to-face or online contexts (Bakki *et al.*, 2019). This section discusses these aspects.

The first cMOOC, developed by Siemens and Downes, aimed to put into practice the principles of connectivist theory. This theory has contributed to the development of innovative pedagogy in which control of learning is no longer limited to the teacher, but is shared with learners, making them more responsible and autonomous (Kop & Hill, 2008). The principles of connectivism are based on the emergence of resources and knowledge through connected networks, and on the ability of learners to be active. It aims to redefine learning in various contexts and to provide a theory of learning in the digital age (Kop *et al.*, 2011). This approach involves the promotion of learning through collaboration, production, sharing and the creation of connections between peers within the context of quasi-total openness. In this environment, learners are empowered to make their own choices and to define their learning objectives, from which connections between individuals who share the same objectives can emerge.

The openness of cMOOCs might suggest that pedagogical scenario building is not essential, and that this would be contrary to the underlying principles of a connectivist course. However, we

believe that connectivist course design can be enhanced by the implementation of scenario-building practices. Indeed, despite this openness, we believe that it is essential to create suitable conditions for the emergence of connectivist activities.

The construction of a cMOOC involves the promotion of and support for the autonomy of learners in terms of control over their learning, thereby encouraging the creation and emergence of new resources. Autonomy cannot be considered as acquired, since it arises from the ambiguous nature of human activity as self-regulatory and organizational but also emotionally dependent and socially determined, as shown by Linard (2003). According to this author, autonomy involves a strong self-identity that is able to resist the risks and frustrations inherent in any independent action (*ibid.*).

In order to create and produce new resources and knowledge, we believe that learners must be oriented and guided through this process to develop and promote their autonomy. It is therefore necessary to structure learning activities in such a way as to help learners to become independent and autonomous while giving them the opportunity to develop a range of technical and professional skills (Armatas *et al.*, 2014). Hence, there was a need for a scenario model adapted to this approach.

In the connectivist context, several solutions have been proposed to facilitate the implementation of such courses. These studies focus on cMOOCs from a theoretical point of view, and primarily aim to demonstrate the value of a methodology for the scenario development and implementation of connectivist courses. However, they also offer frameworks that describe the main axes of the design process and the implementation of a cMOOC course. These frameworks chiefly define the administrative aspects rather than the elements that should be contained by a cMOOC scenario.

Among these studies, the work of Pettenati et Cigognini (2007) presents a knowledge flow model to support the design of learning experiences in a connectivist environment, taking into account new social practices and technologies that are widely used on the Internet. Their model also aims to provide recommendations for instructional environment designers in order to exploit the benefits of such courses to improve learning.

In another context, O'Brien *et al.* (2017) focused on the metaliteracy model, which emerged as MOOCs began to gain in popularity. This model provides a framework to guide the implementation of self-directed learning in complex and interconnected learning environments. In their article, the authors provide specific examples of how metaliteracy can be applied as a pedagogical strategy in cMOOCs.

Other research works have focused on the pedagogical scenario-building process in MOOCs, and more particularly in cMOOCs (Alario-hoyos *et al.*, 2014; Glance *et al.*, 2013; Peter & Villasclaras-Fernandez, 2013). These studies have demonstrated the need for and importance of pedagogical scenario building in these environments. Indeed, all of these studies confirm that cMOOCs rely on a specific conceptual model that helps teachers to conceive such courses. However, this body of work provides neither a model to describe a pedagogical scenario for a cMOOC nor concrete and simple software tools to design and deploy connectivist MOOCs. There is also a lack of solutions that can encourage teachers to reflect on the main pedagogical characteristics of cMOOCs.

Based on the points above and the scenario aspects discussed in the previous section, we assume that in order to design such courses and to ensure that the pedagogical scenario is able to describe and manipulate a cMOOC environment, the scenario needs to combine several aspects: openness, collaborative learning with a social dimension and targeting at a massive audience.

In order to develop an open and dynamic scenario that meets the requirements of a cMOOC, we believe it is necessary to provide all the stakeholders involved (teachers and learners) with the flexibility to design and modify the scenario throughout the course, according to the emergent learning objectives. It is not a matter of “producing a model corresponding to a given specification, but about developing an adaptable model, often in use, according to the evolution of the context and the users’ needs” (Ourai, 2012).

In practice, the teacher does not design the entire scenario, since it forms only a starting point (Zarraonandia *et al.*, 2006). The learners' attitudes cannot be predicted in detail during the design phase, but can be monitored during the learning session to adjust it. The social dimension is regulated by several factors: the use of social networks, the creation of connections between learners who share the same interests and learning objectives, and the type of proposed activities.

Several studies of the collaborative dimension have been carried out in the TEL field. We are particularly interested in computer-supported collaborative learning (CSCL) scripts. The CSCL domain focuses on how collaborative learning, coupled with technology, can improve peer interaction and group work, and how collaboration and technology facilitate the sharing and distribution of knowledge among learners (Lipponen, 2002). A CSCL script describes how learners should collaborate, and defines the distribution of tasks, roles, work phases, productions, etc. (Dillenbourg & Jermann, 2007). The aim here is to define appropriate mechanisms for effective learning in order to support collaboration between learners (Dillenbourg & Tchounikine, 2007; Tchounikine, 2008).

Henri, Compte et Charlier (2007) raise a very important point regarding the openness of scenarios. In particular, they emphasize the work of Dillenbourg et Tchounikine (2007), who proposed approaches for integrating greater flexibility into pedagogical scenarios. They define, "on the one hand, the intrinsic constraints of the scenario, which refer to fixed elements, which cannot be modified without compromising their integrity, and, on the other hand, the extrinsic constraints of the scenario, which can be adapted" (*ibid.*).

In our opinion, in order to model a cMOOC-oriented pedagogical situation, the scenario model must take into account the above-mentioned concepts, which describe the pedagogical situation, the course of learning in a connectivist environment, the resources and materials provided etc., while leaving significant flexibility for the learners to guide their own learning and encouraging collaboration between participants.

2.2 The Four Components of cMOOC-Oriented Activities

In accordance with the theoretical grounding of the connectivist approach, cMOOCs are structured into four essential activities that aim to promote networked learning and the use of technological tools and the Internet (Kop *et al.*, 2011; Downes, 2008): aggregation, remixing, repurposing and feed forwarding.

The objective of **aggregation** activities is to encourage learners to read and consult the most appropriate content and resources to meet their learning objectives. For the teacher, this involves bringing together not only a set of resources related to the course, but also all the achievements of the learners, which are published on the web. For learners, this means that each creates his or her own perspective on resources by choosing what is important and what is in line with his or her learning objectives (Downes, 2012).

Remixing activities are based on the interpretation of data, resources and information collected during the aggregation phase and on web searches for relevant additional resources. The main objective here is to encourage participants to keep track of all the material they have read or consulted in the aggregation phase. In practice, learners are encouraged to synthesize this acquired knowledge and to transcribe it into blogs or wiki articles. They can also participate in online discussions and exchange ideas with other course participants using either tools provided by the platform (forums, webinars, etc.) or external tools (Google groups, etc.).

The objective of **repurposing** activities is to encourage learners and to support them in an individual or group process of production. Siemens (2014) postulates that this is probably the most difficult activity in the learning process in a cMOOC. For this author, learning is more than just a process of reception and filtering; it is important to create, and to actively participate in the course.

Feed forwarding activities aim to encourage learners to share their productions across the network and on the web. These are essentially sharing and transmission activities. Siemens (2005) states that feed forwarding activities should be used to distribute the knowledge and new resources created by the participants not only to other participants, but also to the world over the web.

We assume that a cMOOC scenario should contain all four groups of activities presented above. The challenge for the teacher is to be able to integrate and orchestrate these activities while preserving the educational potential of a cMOOC course. Furthermore, a teacher proposes the initial resources and a certain number of activities; the course then evolves and emerges through a co-design process involving both learners and teachers. Thus, we postulate that the cMOOC process consists of a learning phase and continuous co-design phases. Teachers should use a learner-centered approach toward course design that takes into account the different roles played by learners, including: (i) that of a contributor, by employing the four main activities above in which learners are tasked to read course material, understand the connections, and then repurpose and share their interpretations; and (ii) that of a teacher, by allowing learners to assume a participatory role in the generation of the course content and to take a formal role in teaching and evaluating their peers.

2.3 Visual Pedagogical Language for a cMOOC Activities

In the previous section, we presented the concept of pedagogical scenario building and outlined its specific characteristics in a cMOOC environment. Based on the literature review, we outlined the characteristics of a cMOOC-oriented pedagogical scenario. In this section, we focus on a review of existing LD tools and we point out the lack of a specific authoring tool for the cMOOC context.

Research into LD languages has given rise to several works and tools. Before the advent of LD languages and tools, teachers generally created their pedagogical scenarios using a narrative and textual format. However, such scenarios do not use a standardized template, meaning that it is difficult to disseminate and reuse them (Katsamani & Retalis, 2013), and thus the IMS-LD specification emerged (IMS-LD Consortium, 2003). IMS-LD is essentially a “description language” that allows the generation of XML files to model the lesson plan and describes roles and activities without handling the instantiation and implementation processes (Da Costa, 2014). However, since IMS-LD “is not an easy-to-understand process for the teachers” (Barchino et al., 2012; Morales et al., 2008), the first generation of LD authoring tools was proposed. For the purposes of this study, we focus primarily on visual LD authoring tools for several reasons which are discussed below.

The visual conception has raised interest and has shown a number of strengths in several areas. In software engineering the “visual” is the most wide spread representation which is entirely consistent with the ubiquity and importance of visual representations in this field (Moody 2009). Amálio and Glodt (2015) stipulate that the “prevalence of visual notations can be explained by certain properties of diagrams that benefit cognition”, which have been explained by the fact that visual representation display information that is only implicit in sentential or textual representations (Larkin and Simon 1987). This information has to be computed, generally at great cost, to make them explicit (*ibid.*). This is in accordance with the view of Britton and Jones who had mentioned that “*a major incentive for using visual notations is the widely-held belief that they convey information more effectively than text, especially to novices*” (Britton and Jones 1999; Genon, Heymans and Amyot, 2010).

In educational and instructional design fields, Botturi (2006) has referred to Gibbons and Brewer's (2005) work, which aimed to measure the impact of virtual design languages in different fields, such as music, architecture, software engineering, and dance. The authors concluded that “Instructional Design will also benefit from this trend as designers and theorists become conscious of the existence and application of design languages and their related notation systems.” (*ibid.*).

For Botturi Gibbons and Brewer's (2005) view is based on the observation that the use of a design language and the related notation system brings huge benefits to the design practice. The authors highlighted some benefits including the fact that visual tools can foster the creation of a culture

based on good practice and provide a structured problem-solving workspace in which designs can be developed and shared.

Indeed, visual approaches are a good solution for supporting reflective communication and the creative generation of designs (Hernández-Leo, 2007). Visual displays can also facilitate a common understanding between all the stakeholders, and can provide a dynamic way of sketching out and changing different alternatives for the same MOOC design (Alario-Hoyos *et al.*, 2014). A significant number of research works has proposed tools and languages to help with the visualization of learning designs, and these works can be divided into two main groups. The first concerns solutions that provide specific notations (symbols and rules) for the creation of a pedagogical scenario, but that are not implemented in a tool; these formalisms are independent of any infrastructure that allows for the design or implementation of pedagogical scenarios. The second group concerns visual modeling tools that try to offer teachers more abstract languages; these are visual or graphical in nature, and their use is more intuitive (Barchino *et al.*, 2012). Thus far, none of the above-mentioned LD authoring tools have allowed teachers to design MOOC courses and to automatically deploy them on a MOOC platform. In addition, some of these LD tools are directed either toward a particular pedagogical approach or are specific to a particular platform.

In a second step, we focused on BPMN notation as an alternative to instructional modeling languages. BPMN is a notation for the graphical representation of business processes within a workflow, and was developed by the Business Process Management Initiative (BPMI), which merged in 2005 with the Object Management Group (Da Costa, 2014; OMG, 2011). Despite the lack of work investigating this approach (Da Costa & Schneider, 2015; Adesina & Molloy, 2010; Mariño *et al.*, 2007; Stylianakis *et al.*, 2015), BPMN has stood out in the educational field due to its advantages, and in particular its expressiveness, its simplicity of use and the graphical representation of pedagogical scenarios.

Languages and tools have particular advantages and disadvantages that influence their use and execution. Several studies have been carried out to specify the requirements and/or needs for LD tools and languages, and more specifically for visual types. Although each classification work proposes the use of a different specification, it is clear that some criteria recur, namely usability, orientation, formalization, design flexibility and the use of models (Botturi *et al.*, 2006; Figl & Derntl, 2006; Nodenot, 2007). One of the most commonly used classification models is that proposed by Nodenot (2007).

Table 1. Comparative study of learning design tools and methods (Nodenot 2007; Da Costa, 2014)

	COMPENDIUM	LAMS	CADMOS	MOT	BPMN2.0
Roles and responsibilities	•		•		•
Learning modalities	•	•			•
Knowledge representation				•	
Learning objectives	•		•	•	
Dependencies of activities	•	•	•	•	•
Collaborations			•		•
Links to infrastructure		•	•	•	•

Nodenot (2007) proposes a classification of visual LD tools (Table 1) based on seven criteria that reflect the information contained in the pedagogical scenario:

- (1) The representation of the roles and responsibilities of the involved actors in a learning session;

- (2) The representation of learning modalities. These modalities cover the development over time of the activities of the module, the synchronization of activities carried out by different actors and the differentiation of learning activities mediated by the IT tool;
- (3) The representation of knowledge for the implementation of activities;
- (4) The precise representation of learning goals: objectives, prerequisites, etc;
- (5) The representation of the structure of the dependencies between activities;
- (6) The representation of synchronous/asynchronous collaborations between actors;
- (7) The representation of links with the infrastructure, i.e. how the scenario can be implemented or deployed.

Referring to Nodenot's classification (2007) and to the literature review of the pedagogical characteristics of cMOOCs, the targeted cMOOC authoring tool should allow: (i) the representation of the roles and responsibilities of the actors involved in a learning session; (ii) the representation of learning modalities, which cover the time spent on the weekly activities of the cMOOC and the synchronization of activities carried out by the different actors; (iii) the representation of the dependency structure between activities; (iv) the representation of the collaborations between the actors; and (v) the representation of links with the infrastructure, i.e. how the scenario can be implemented or deployed.

Table 1 presents the summary of LD tools and languages proposed by Nodenot (2007), to which BPMN 2.0 was added by Da Costa (2014). If we refer to the synthesis presented in Table 1 from a pedagogical point of view, BPMN meets our needs based on the theoretical framework developed in this paper. BPMN allows the representation of learning modalities by specifying the different activities, their sequencing, their dependencies, and the actors who carry them out, and particularly by offering the possibility of defining a nonlinear pedagogical scenario with several connections. This language also allows us to model collaborative pedagogical situations.

BPMN is a generic modeling tool that has demonstrated a high expressivity for the design of pedagogical situations. From a techno-descriptive point of view, BPMN has several advantages that make it an easy-to-use tool for the teacher, due to its visual notation, its formal character and its stratification into layers that provide a different representation for each of the modeling elements. As previously pointed out, the literature review revealed two needs: one for a cMOOC-oriented scenario model, and another for a tool that can provide the necessary elements to conceive such pedagogical situations.

As it stands, the BPMN notation can be used to model various pedagogical situations. Indeed, BPMN is a pedagogically neutral language that does not embed any particular model and is based on metamodeling notation. However, in order to meet our objective of helping the teacher in the design and deployment of a cMOOC course, the modeling tool has to incorporate a connectivist pedagogical approach, with a specific notation (Helic, 2006). These points will be further developed in later sections of this paper.

3 A cMOOC-Oriented Pedagogical Scenario Model

3.1 Research Methodology

In the previous sections of this paper, we justified the need for a cMOOC-oriented scenario model, and then presented the three levels of abstraction for such scenarios. In this section, we present the methodology used to develop the model.

First, we reviewed the literature on pedagogical scenario-building practices, and particularly those related to open and collaborative scenarios. A study of the pedagogical scenario aspects of cMOOCs

was also carried out, and we examined a set of requirements that teachers may have for the design and deployment of such courses. A list of criteria and elements that govern the scenario of a cMOOC course was established.

We subsequently conducted a study of existing cMOOC courses, by conducting a keyword search. The results obtained are a reflection of the progress made in the state of the art study presented in the previous sections, since the number of cMOOC courses is very low in comparison with that of existing xMOOCs. The first cMOOCs found were a follow-up to the cMOOCs developed by Siemens and Downes: CCK09 and CCK11. They are organized over nine weeks, and implement the connectivist approach. The second cMOOC found was a reference in French called ITYPA (“Internet Tout Y est Pour Apprendre” that means “Internet everything is there to learn”), in its third edition. This is a nine-week course that provides information on how to get organized to learn on the web. The third is a cMOOC called “QuidQuam?” in its second edition that was developed by Unisciel and the University of Lille 1 and hosted on the FUN platform. It is a participative MOOC that encourages exchange and discussion around six themes over six weeks. During our research, we were only able to follow the QuidQuam? cMOOC, which began on March 7, 2016, and ended on April 20, 2016, as the other courses mentioned had already been completed. Based on the elements available online, we were able to identify the different types of activities and resources that were common to the different courses.

In order to refine our research, we contacted a teacher who was a contributor to the cMOOC ITYPA, and were able to obtain a set of documents related to the creation and implementation of the cMOOC project, which we reviewed and analyzed in depth. This allowed us to: (i) validate all the elements collected following the initial exploratory work; (ii) identify the roles and actors that interact during the learning phase of a MOOC; (iii) categorize the different activities according to the four principles of connectivism; and (iv) identify the sequencing of activities.

3.2 Modeling Levels of a cMOOC-Oriented Pedagogical Scenario

The Object Management Group (OMG) distinguishes four levels of modeling, based on the definition of a meta-metamodel, to describe the states of expression of a pedagogical scenario (Crawley *et al.*, 1997). Of these OMG levels, M0 refers to the execution level of an instance, and corresponds to the real system; M1 refers to the expression of the real system in a given language; M2 refers to the expression of the language in which the system is built; and M3 to the grammatical expression that defines the M2 metamodel level (Bézivin & Gerbé, 2001).

The modeling work for a cMOOC-oriented pedagogical scenario is located at the M2 level, and allows teachers to express their scenarios at the M1 level; these will then be executed at the M0 level (Figure 1).

The M2 level (the cORPS model) represents the cMOOC-oriented pedagogical scenario model from which the pedagogical scenarios are created, and this model is described in this section. It is an abstraction of the elements that regulate an online connectivist course. Based on this model, the pedagogical scenarios of a cMOOC course are described. It defines the pedagogical concepts needed to determine the concepts used by the pedagogical scenarios to produce the abstract scenario (M1).

The M1 level describes the activities that take place in a cMOOC environment, their sequencing, their temporalities, the resources necessary for their achievements, the actors who carry them out, the type of interaction, etc. Finally, the M0 level represents the operationalized pedagogical scenario, i.e. the instantiation of the pedagogical scenario on a particular platform.

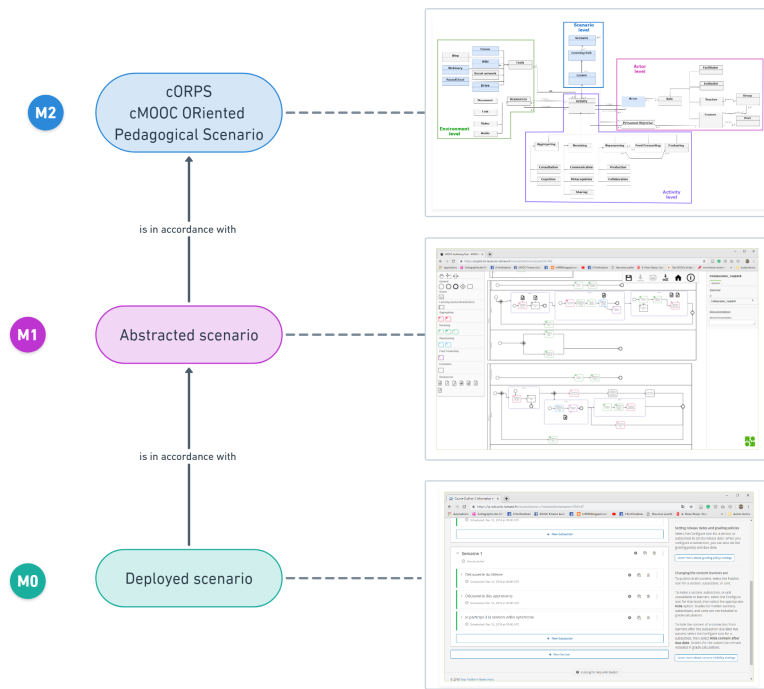


Figure 1. Modeling levels of a cMOOC-oriented pedagogical scenario (Bakki *et al.*, 2017)

3.3 cORPS Model

In the previous sections, we presented a literature review related to our research work, justifying the need for a specific conceptual context to promote pedagogical scenario building in cMOOCs, and arguing that there is no existing model that explicitly describes the elements of a connectivist scenario. We have also described the different levels of abstraction of a scenario, as we perceive it. The purpose of this section is to describe the M2-level cORPS model. This model is described in this section in order to provide a better understanding, before the proposed MOOCAT tool that is described in detail in Section 3.

In our model, as shown in Figure 2, the principal class is represented by the “Scenario” class. This is based on a semantic description of the course, and describes the activities and resources that the course includes, and the properties of these entities, their organization and sequencing. In order to simplify the design of a cMOOC while preserving its educational potential (openness, autonomy of learners etc.), the scenario is structured into three levels: a learning unit, a lesson and an activity. In cMOOCs, a learning unit has a fixed duration, usually one week; however, in our proposal, we have chosen to provide this class with a duration that can be defined by the teacher. The “Learning Unit” class may contain one or more lessons. A lesson class is a static entity, defined by the teacher at the start of the course, that aims to structure the learning and evaluation activities throughout the course. A lesson can be identified by a name, a duration and a sequencing number.

A lesson is composed of learning activities (the “Activity” class). In our model, as shown in Figure 2, a learning activity is regulated by an actor, who may either carry out or propose an activity. An activity is characterized by a name, a start date, a duration, a serial number and a category. The category of the activity is defined based on the theoretical anchoring presented above; thus, an activity can be attributed to one of the four categories (Kop & Hill, 2008) discussed in the previous section: aggregation (including consultation and cognition activities), remixing (including communication, sharing and metacognition activities), repurposing (including individual production

and collaboration activities), and feed forwarding (sharing produced resources), with an additional category for evaluation activities.

The “Actor” class refers to any person involved in the learning phase of the MOOC. The actors in a cMOOC scenario can a priori perform four roles in this connectivist context (teacher, facilitator, evaluator or learner) as executor of the activity.

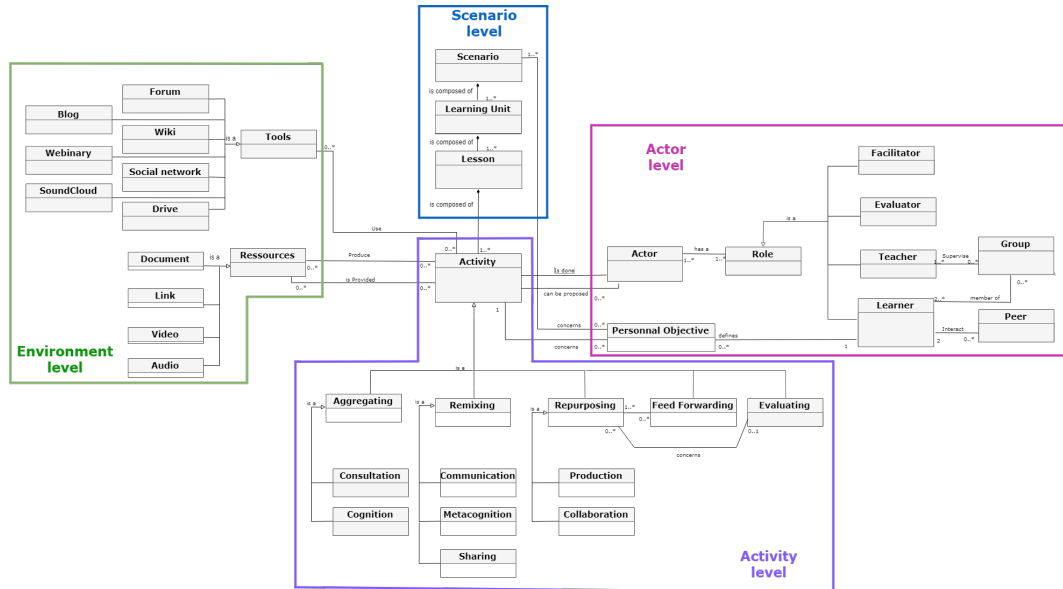


Figure 2. The cMOOC-Oriented Pedagogical Scenario Model

We have defined the “Personal Objective” class in order to allow the learner to specify his/her personal learning objectives. These objectives may relate to the cMOOC course or a particular activity, and are used to measure how the learner is developing his/her self-assessment abilities in order to recognize the specific actions that need to be taken to improve his/her progress and to plan for the next steps.

We also identify the possible social interactions in a cMOOC environment and integrate them into the model, meaning that the Learner class can have two types of interaction: group and/or peer. A major factor in the success of cMOOCs is collaboration, which is generally carried out by a group of individuals who share the same learning objectives. Consequently, group interaction is very prominent in these environments, primarily because it allows the involvement of learners in a process of creating new resources.

A second aspect highlighted in cMOOCs concerns peer evaluation. This is a common practice in cMOOCs to review group essays, projects and productions that are not automatically evaluated by the system. In this case, learners assess and provide feedback on their peers’ work. Indeed, peer interaction is a fundamental part of cMOOCs, whether in terms of generation of content, motivation or evaluation (Lojacono, 2016).

The “Environment” level involves the resources and tools required to carry out the pedagogical activities, and the resources produced. It describes the characteristics of the environment that will sustain the scenario, the components of the scenario and their properties.

4 BPMN Notation and Metamodel Extension

The BPMN metamodel describes the BPMN concepts and their properties. The BPMN 2.0 specification provides detailed UML class diagrams, illustrating the characteristics of the different BPMN elements and their relationships (Da Costa, 2014).

As shown in Figure 3, the BPMN metamodel includes six main elements. The **BPMN Pool** is a set of containers that structure and group all the objects that compose a BPMN process and represent the borders of this process. The **BPMN Lane** represents sub-partitions of pools that can be used to represent the roles of the different actors involved in a process. **BPMN Activities** represent actions performed either by humans or an IT system. They can be elementary (tasks), i.e. indivisible elements, or decomposable (sub-processes), representing a regrouping of several tasks. **BPMN Events** are the actions that occur during the process. The workflow process is modified following the occurrence of a particular event during its execution. **BPMN Flows** are a set of graphical components that connect objects to each other to represent their sequencing and define workflow behavior. **BPMN Gateways** are used to control the flow development in the process. They allow the routing condition between an incoming flow(s) and an outgoing flow(s) to be represented.

As part of our research, an extension to the BPMN meta-model is proposed. Figure 3 illustrates the different adaptations made to the BPMN meta-model. Gray classes represent non-modified elements, green classes represent the elements that exist in the BPMN meta-model that have been adapted in the new architecture, and red classes represent additional elements.

We also propose an extension to the BPMN notation that allows explicit representation of the different concepts defined in the cORPS model. The proposed graphical notation aims to distinguish the graphical elements representing a cMOOC scenario, using colors and icons, and is subjective.

Most of these modifications relate to activities and resources. For activities, we propose a toolbox that is organized into four distinct blocks, each representing one of the principal categories of connectivist activities. We use pink for aggregation activities, green for remixing, blue for repurposing and purple for feed forwarding. Activities are represented by rounded rectangles (following the initial BPMN scheme) with colored borders and an icon that varies depending on the activity type. Figure 4 shows some elements of the toolbox and their corresponding meanings.

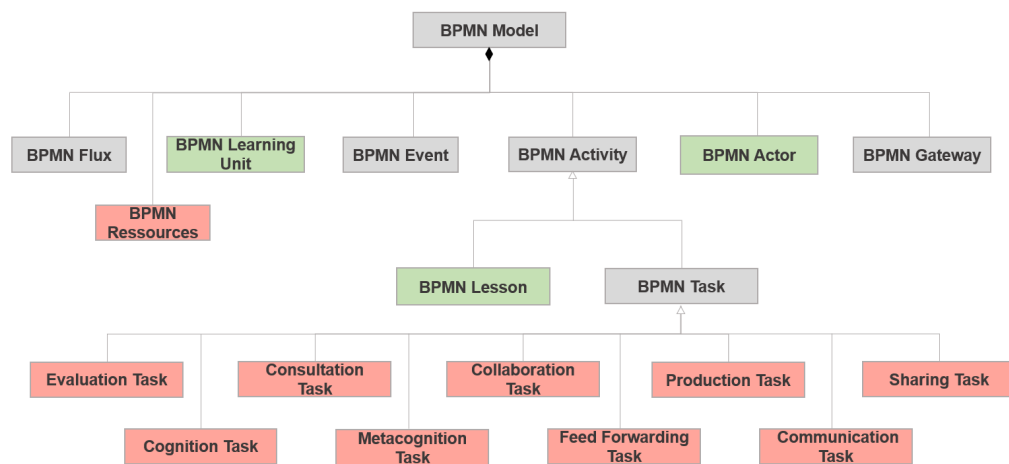


Figure 3. BPMN meta-model extension

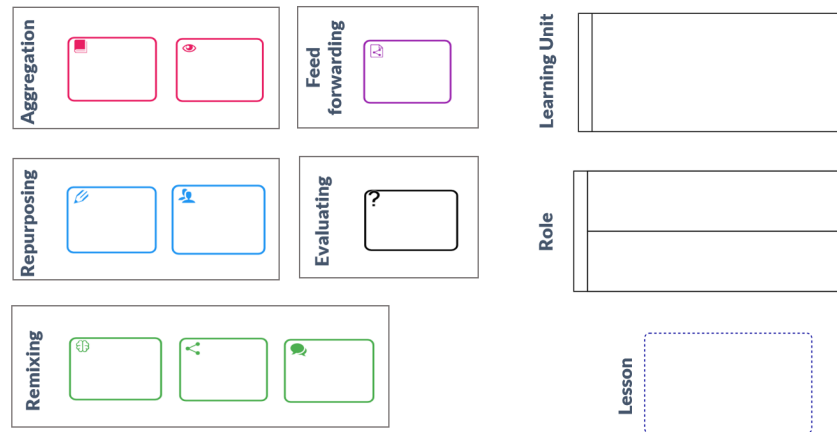


Figure 4. Extension to the BPMN notation

5 MOOCAT Authoring Tool: Elements and Architecture

MOOCAT is a visual authoring tool based on BPMN that is aimed at teachers who want to design and deploy a pedagogical scenario in a cMOOC context. In this section, we present the underlying motivation behind MOOCAT and its technical and conceptual architecture, and describe MOOCAT from the user's perspective.

5.1 Motivation and Aims

The first objective of MOOCAT is to help teacher-designers who want to create a cMOOC to clearly define an initial scenario. We note that cMOOC courses are dynamic, meaning that they change as they progress. Thus, the purpose is to allow the teacher to establish the initial building blocks of the course, which will subsequently evolve.

The second objective is to give teacher-designers (who do not have the technical knowledge required to deploy a cMOOC course) the ability to deploy and adapt their pedagogical scenarios without specific knowledge of pedagogical scenario-building languages or cMOOCs. They have the possibility of producing pedagogical scenarios using the cORPS model, which provides them with a methodological framework to describe learning activities and their organization using a visual LD tool.

5.2 MOOCAT Technical Architecture

In Section 2.3 of this article, we discussed the advantages of BPMN as a pedagogical modeling language. We should point out that this language has also been used to design various pedagogical situations in several contexts (face-to-face, hybrid, collaborative work, etc.) (Da Costa, 2014; Silvestre, 2015; Stylianakis *et al.*, 2013). However, in order to meet our requirements to provide the teacher with support for designing cMOOC-oriented pedagogical scenarios, the use of BPMN is not considered as it stands. We first propose an extension to the BPMN concept (Section 4) to take into account the specificities of a cMOOC-oriented pedagogical scenario (Section 1), and then embed the extended metamodel in our tool. The objective is not to rebuild a new platform, but to start from an existing tool and extend it. We therefore selected the BPMN.io¹ tool, which is an open source web application that uses BPMN 2.0 notation. The architecture of the BPMN.io application is composed of three main modules, as follows.

¹ <http://bpmn.io/>

We want our proposal to be specific to cMOOCs, and have therefore chosen to reuse an existing tool. We define a set of criteria: for example, the tools should be open source, in order to be able to embed our cORPS model. It is also preferable that the tool does not require prior installation. **Bpmn-js** is the principal module of the tool, and controls the simple and visual human-computer interface used for creating, visualizing and validating BPMN schemas. This module displays and operates the toolbox elements, the modeling rules specific to BPMN 2.0 notation, and the main modeling interface. It provides a viewer element for visualizing BPMN diagrams, and a modeler module to create, to edit and validate BPMN workflows.

Bpmn-moddle embeds the meta-model defined by the BPMN 2.0 standard, and allows for mapping between the graphical elements and the elements of the BPMN meta-model. This module provides the appropriate modeling rules to validate BPMN workflows, and also allows reading and writing of XML files according to BPMN 2.0. Finally, **Diagram-js** provides features that display and memorize changes in BPMN workflows during the conception process.

The architecture of MOOCAT is based on the BPMN.io architecture, including the three modules presented above, namely Bpmn-js, Bpmn-moddle and Diagram-js, which are extended with a module for scenario management. Each module of the BPMN.io tool has been extended to incorporate specific features to meet our needs. Figure 5 illustrates the architecture of MOOCAT, with its different modules and interactions.

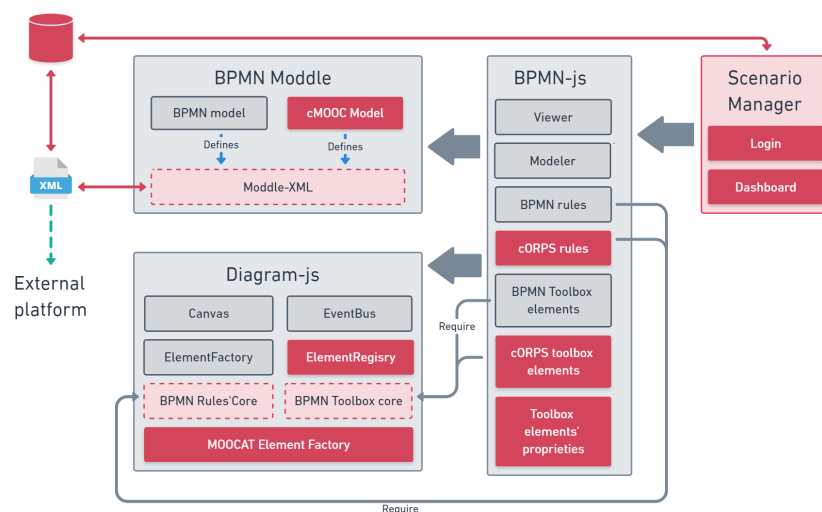


Figure 5. MOOCAT elements and architecture

The red shaded blocks in Figure 5 show the main changes that have been applied to the BPMN.io tool. Since the tool does not offer a user management module, we have included this. In the Bpmn-js module, we have incorporated changes relating to the extension of the BPMN notation (as proposed in Section 4). We have also redefined the behavior of each of the toolbox elements to which the teacher will have access. The embedded business model regulates the behavior specification of the different elements. In this context, the business model is expressed as a set of rules that control the sequencing of the scenario.

Finally, we restructure the Properties tab. In order to ensure the operationalization of MOOCAT scenarios and to avoid semantic waste between the modeled scenario and the deployed course, the teacher is required to provide a set of information (i.e. type of the activity, type of resources, links to the resources, etc). Thus, each MOOCAT element has its own properties based on the cOPRS model.

At the Diagram-js level, we define the graphical aspect of the new notation. We add the MOOCAT *ElementFactory* module, which describes the visual appearance of each new element added to the

toolbox and allows a mapping between the graphical representation and bpmn-moddle (i.e. it defines the link between the graphics and the cORPS model and their representation in the BPMN file).

In the *Bpmn-moddle* module, we have added the elements of the cORPS model through an extension of the BPMN meta-model. We have also modified the *moddle-XML* file to allow the identification of objects added to the toolbox (new elements specific to the building of cMOOC scenarios) and to indicate how these will be represented in the BPMN workflow. A unique identifier for each element provides a concise way to translate the elements of the cORPS model into JavaScript objects that are interpretable by MOOCAT.

5.3 MOOCAT Interfaces and functionalities

In the previous section, we presented the specifications for the proposed authoring tool. We have presented the cMOOC scenario model from a semantic perspective in Section 2, and have explained our conceptual design choices, including a modular architecture reifying the conceptual aspects of the cORPS model. On a visual level, we use a graphical notation that aims to allow users to visually identify the different elements and easily recognize the key elements of a connectivist scenario (using colors and icons). In the next section, we describe the proposed scenario editor from a HCI (Human-Computer Interaction) perspective.

MOOCAT is a web application that is accessible via a browser with no prior installation. Once logged into MOOCAT, the user is able to create a new pedagogical scenario or to modify an existing one. If a new scenario is created, the teacher specifies the name of the scenario and chooses an empty model of the course before accessing the design area. Figure 6 shows a screenshot of the tool in which the principal interface areas are highlighted.

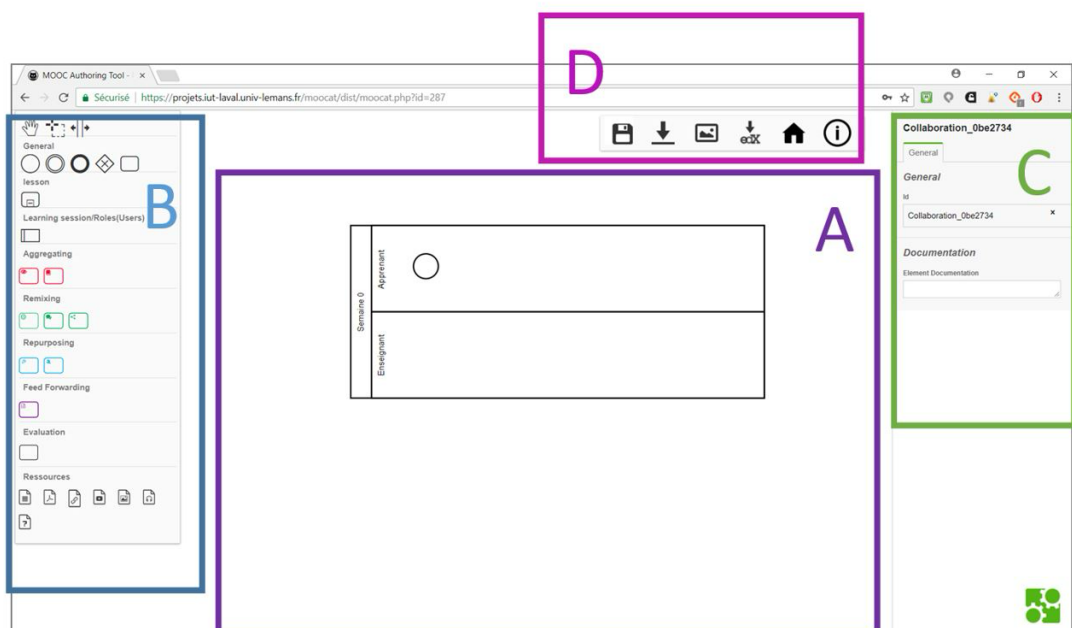


Figure 1. The MOOCAT conception user interface

The teacher must first create a learning session. This element is accessible via the Toolbox (Figure 6, B) under the Learning Session block, and this involves dragging and dropping this element onto the canvas (A). In order to assist the teacher, an initial learning session represented by a “pool” is created by default. In MOOCs, a session typically lasts for a week, but the teacher can use the Properties tab (Figure 6, C) here to specify the duration of the session (start and end dates).

The teacher then defines the roles of the users involved using the Lanes elements. In order to create these roles, the teacher first needs to select the learning session. A menu appears to the right, and the teacher can then choose to create as many roles as necessary. After creating this session and specifying the different roles, the teacher can then start creating various learning activities that may have different granularity levels, that is, lessons or activities. The teacher can then continue designing the course by dragging and dropping elements from the Toolbox.

Once the design is complete, the teacher can save the scenario and deploy it on a chosen platform (Figure 6, D). At present, deployment is possible on both the OpenEDX and Moodle platforms. This action triggers the conversion of the BPMN file into a structured XML file that can be imported to OpenEDX or Moodle.

5.4 MOOCAT Scenario Operationalization Service

In order to deploy the modeled MOOCAT scenarios on a cMOOC platform, we have developed an operationalization service that offers teachers the possibility of automatically deploying their pedagogical scenarios on a specific platform. The operationalization of the pedagogical scenario consists of implementing the teacher's intended scenario within a TEL environment (Abedmouleh *et al.*, 2011; Caron *et al.*, 2005). In the literature, two approaches can be highlighted: manual or automatic. In this work, we are particularly interested in the latter.

In line with our work, we have provided a solution that transforms the pedagogical workflow (i.e. the pedagogical scenario created with MOOCAT) into a deployable and executable scenario. This takes place in two phases: the first consists of mapping MOOCAT scenario elements to the corresponding platform elements (activities and/or resources), while the second consists of structuring files into a format that can be imported by both of the platforms. Our goal is to offer a solution that is platform independent, and thus allows a scenario to be deployed on a specific platform when an import module has been developed by MOOCAT administrator. The import module has to be implemented only once and can be based on the processes described below.

In order to test the technical feasibility of our proposal, we created import modules for the OpenEDX and Moodle platforms. We chose the OpenEDX platform for several reasons: firstly because it is an open source platform, and secondly because it is widely used for MOOC deployment (Hajri, 2018). A further reason concerns its scalability, i.e. its flexibility in integrating and developing new elements and functionalities (via xBlocks or LTI for example). We also chose Moodle because it is an open source, modular and extensible platform with a large community of users and developers, and because it has been used in various educational contexts, including for cMOOCs (Cooch, 2014).

Transformation Phase

We developed an application for the OpenEDX platform that allows the conversion of BPMN files generated in MOOCAT into XML file structures that can be imported into OpenEDX. This process was based on conversions available in PHP (using the simpleXML API). These conversion rules aim to match each of the concepts designed in MOOCAT to a concept of the target platform. The general concept of the transformation algorithm is as follows:

1. Generate the BPMN educational workflow (in MOOCAT).
2. Create the file tree for importing, based on the information specified in the BPMN file.
3. Complete and convert the scenario to be imported into the format required by the OpenEDX platform. For the Moodle conversion module, we based this on the import process proposed by Abedmouleh (2014) as part of the Graphit² project. In these work, the authors described a conversion

² Graphical Visual Instructional Design Languages for Teachers (www-lium.univ-lemans.fr/~laforcad/graphit/)

algorithm using the following steps: (i) create a backup of the Moodle course; (ii) modify the backup archive with the information contained in the XML file from the new scenario; (ii) operationalize the modified package.

In contrast to OpenEDX, Moodle requires the course to be exported beforehand. We adopted the same process as for the OpenEDX platform, by proposing a conversion file that maps between Moodle and the scenario elements in MOOCAT. Figure 7 illustrates these processes.

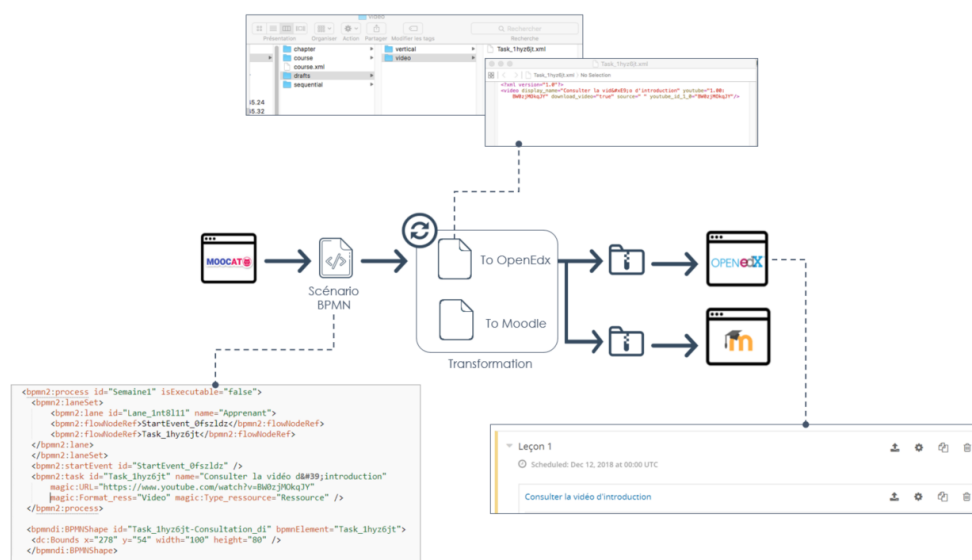


Figure 7. MOOCAT to OpenEDX and Moodle deployment process

Deployment phase

The operationalization service acts as a communication gateway between MOOCAT and the chosen platform. For automatic deployment, the teacher needs to specify the address of the target platform server, and a login and password. The application automatically connects to the platform and collects a list of available courses, from which the teacher can select one. Finally, the deployment process is performed automatically using the platform's import function.

An extension of the transformation and deployment module to other platforms is also possible. As mentioned above, the XML format of the scenarios produced by MOOCAT considerably facilitates the production of transformation and deployment scripts, as long as the target learning platform includes import/export functionalities. Therefore, for a given platform, it is first necessary to find a correspondence between the elements of a MOOCAT scenario and the target platform's scenario model. When all the correspondences have been identified, a transformation script needs to be created. This script navigates through the MOOCAT-generated scenario, and parses and generates an XML file that can be imported by the platform.

6 Experiments with MOOCAT

6.1 Experimental Protocol

In order to test the MOOCAT tool, we carried out a case study to determine the usability of the proposed tool and its utility in designing a cMOOC-oriented pedagogical scenarios. In this section, we explicitly state the objectives of the experimentation and discuss the various MOOCAT characteristics that we intend to evaluate. We propose an experimentation methodology and detail the evaluation protocol that we have used.

We conducted our experiments with several different stakeholders: non-experts in pedagogical scenario building, individuals that had already developed a pedagogical scenario, and individuals that had been involved in developing MOOCs or cMOOCs. The purposes of this evaluation case study were to discern: (i) for non-expert users, whether MOOCAT can help them to easily design cMOOC courses; (ii) for experts, whether MOOCAT can provide solutions for designing connectivist courses in a simple and dynamic manner, and whether the tool allows them to adapt a pedagogical scenario; (iii) for all participants, whether MOOCAT supports the design of cMOOC courses and whether they are satisfied with the tool and its functions.

In the context of this type of experimentation, it is very difficult to engage candidates. The experimentation of MOOCAT in a real-use situation by integrating it into an effective project with users in the design phase of a cMOOC would have been a major asset. At the scale of our work, this real-life situation was not achievable because it is too risky for MOOC designers to rely on a research prototype under evaluation.

However, a call for participation was distributed via two French scientific mailing lists. In addition, e-mails were sent to teachers and researchers at the LIUM and IRF-SIC Laboratories and to all teachers at the University of Bretagne Loire. We also sent e-mails to individuals who had participated in the development of a MOOC. Finally, we tested our tool in a pedagogical scenario workshop with Master's students (studying engineering of interactive systems for education). A total of 40 participants were involved in the MOOCAT experimentation, with different profiles: teachers-researchers, educational engineers, TEL researchers and Master's students who had knowledge and experience of pedagogical scenario building.

The participants were invited to use MOOCAT to create a design for a given cMOOC course, deploy the created pedagogical scenario and finally answer an online questionnaire. Our evaluation process took place in three steps, as follows:

Preparation phase: We provided users with several documents: the MOOCAT user guide, which explains the MOOCAT philosophy and the functionalities of the tool; a document describing the stages of the evaluation; and a narrative scenario. We chose the generic topic of “information and ethics in the digital age”, avoiding a technical or domain-specific subject, in order to target the largest number of participants regardless of their area of expertise. We asked users to design a four-week cMOOC scenario. Some details were provided to the participants for the first two weeks, while for the last two weeks, participants had more flexibility to carry out their own activities.

Conception and deployment phases: In these phases, participants were invited to model the proposed scenario using the MOOCAT authoring tool, and then to deploy the scenario on the OpenEDX platform using the proposed deployment service. As soon as this step was complete, each participant was asked to adapt one or two of the concepts of the scenario and to re-deploy it on the OpenEDX platform.

Report phase: We asked participants to complete an online questionnaire containing 26 questions, i.e. 25 closed-ended questions, rated using a six-point Likert scale (totally disagree, disagree, somewhat disagree, somewhat agree, agree, totally agree) and one open-ended question. The first set of closed-ended questions collected data on the participants, their expertise level in terms of pedagogical scenario building and their involvement in the development of xMOOCs/cMOOCs. The second set investigated whether the MOOCAT tool supported by the LD method enabled participants to model complete connectivist scenarios and then automatically deploy them on the OpenEDX platform. The third set was related to measurement of the usability of the MOOCAT tool; for this part, we used a system usability scale (SUS) questionnaire (Bangor *et al.*, 2009). In the open-ended question, the participants were asked to give their feedback, impressions and suggestions for improvement.

6.2 Primary Results

All of the submitted scenarios were analyzed using an evaluation rubric (Allen & Tanner, 2006; Brookhart, 1999) using a scale from one to three (one: low; two: medium; three: high). We reviewed all scenarios and assigned each criterion a score of between one and three. We then calculated the average score, and this was then compared to the median, which in our case was two. Table 2 shows the measured criteria and the average grade for each criterion, for all the scenarios submitted. The criteria established here can be divided into two groups: qualifiable indicators that were measured by observation (C3, C5 and C6), and quantifiable indicators that can be automatically calculated from the collected traces (C1, C2 and C4).

Table 2 shows that the participants were able to create structured and organized pedagogical scenarios. This demonstrates that teachers can easily create pedagogical workflows, and proves the benefits of the use of BPMN as a LD language. The low mean score for “Completeness in description/documentation of the scenario (defined roles, described metadata in activities/resources)” shows that teachers had difficulty in choosing and completing course information, and particularly metadata concerning activities and/or resources. This was validated by examining all the submitted scenarios, which showed that the majority of participants did not fully complete the information in the Properties panel. The averages obtained for Criteria 2 and 3 show that the participants were able to create a better-structured cMOOC scenario in conceptual terms that contained all the essential connectivist elements.

Table 2. Average grades per evaluation criterion for the participants pedagogical scenarios

Nº	CRITERION	AVERAGE GRADE/3
1	Completeness in description/documentation of the scenario (roles, metadata in activities/resources)	1.8
2	Number of weeks	2.7
3	Expressiveness of the scenario representation (names of: activities, learning resources, weeks, lessons, etc.)	2.7
4	Use of all the concepts of a connectivist scenario	2.5
5	Appropriateness of the proposed learning resources in relation to the activities and course topic	2.5
6	Visual representation and organization of the scenario	2.7

From the evaluation of data collected from the questionnaire the majority of participants were satisfied with the overall design process, with 31 participants reporting that they were satisfied with MOOCAT, 4 who were rather dissatisfied with the use of MOOCAT, and 5 who were not satisfied.

The analysis of the first part of the questionnaire was divided into two sections. The first section (Questions 11 to 19) aimed to evaluate the utility of MOOCAT and whether the underlying philosophy of the tool allowed the straightforward creation of a connectivist course. This part also evaluated whether participants were satisfied with the tool in general, whether they had difficulty in learning to use MOOCAT and whether the interface and notation of the tool were simple to understand. Finally, it aimed to evaluate the potential of MOOCAT to design a cMOOC course and provide guidance for designing connectivist courses. In this part of the questionnaire, the results were positive, with 31 participants reporting that the organization of the toolbox provided guidance to teachers in identifying the elements and how to use it. In addition, 33 participants stated that the blocks of four connectivist activities helped them to identify the activities.

A total of 37 participants reported that MOOCAT offered all the concepts necessary to design a cMOOC course, and only three disagreed with this affirmation. All of the expert participants stated that MOOCAT completely facilitated the design of cMOOC courses. Thirty-three participants found the notation used in the tool adequate for the design of connectivist courses. In addition, 34

participants reported that the visual representation of the scenario was expressive and helped teachers to design the course.

We analyzed separately the results of the three participants with a high level of expertise in pedagogical scenario building and who reported having previously participated in the conduct of a MOOC (3 MOOC for the first participant of which 1 is a cMOOC, 2 for the second participant and more than 8 MOOC for the third participant). All three participants stated that they had successfully formalized all the concepts of their scenarios. They state that MOOCAT provides all the necessary elements for the conception of cMOOC-oriented scenarios and that the organization of the toolbox facilitates the identification of the different activities and their utilities. Finally, the three experts judged the tool easy to use.

The second section (Questions 20 to 23) evaluated the deployment service. 30 participants completed the deployment step, with ten participants failing to complete this task due to technical issues. This part of the questionnaire aimed to evaluate the ease of use and the utility of the deployment service. 24 of the 30 participants reported that the operationalization service was useful. Moreover, an examination of the responses of these participants showed that their scenarios had been successfully deployed: between 75% and 100% of the designed concepts were found on the platform after deployment. These results are broadly consistent with the scenario analysis presented above. Again, we found that a large proportion of the users failed to complete all the metadata, and this explains the rates obtained. However, 22 participants found the automatic operationalization service easy to use. These findings were quite unexpected, and suggest that the deployment service needs to be improved from an ergonomic point of view.

The last part of the questionnaire aimed to evaluate the usability of MOOCAT. For this, we used the SUS (Bangor *et al.*, 2009) questionnaire (System Usability Scale), which is composed of ten statements, each with a five-point scale ranging from strongly disagree to strongly agree. Each statement's score contribution (S_i) ranged from zero to four. For items 1, 3, 5, 7 and 9, the score contribution was the scale position minus one. For items 2, 4, 6, 8 and 10, the contribution was five minus the scale position. To obtain the global SUS rating, the scores are then summed and multiplied by 2.5 to obtain an overall score between zero and 100 (*ibid.*).

$$SUS\ score = 2.5 \sum_{i=1}^{10} S_i$$

Equation 1. SUS score

We preprocessed the participants' results to remove possible errors. Sauro et Lewis (2011) observed for SUS questionnaires that approximately 13% of the responses are likely to contain errors, which can be caused by the inability of participants to understand the negative statements of the questionnaire. To identify these errors, we relied on the grid presented by McLellan *et al.* (2012), in which all responses where the participant provided a score of more than three to negative statements are considered incorrect. Six of the 40 responses were withdrawn.

The Mean obtained for all participants who completed the MOOCAT experiment was 69.25 (Table 3). In accordance with the rule of thumb for the interpretation of SUS scores (Bangor *et al.*, 2009), products with scores of less than 50 are judged to be unacceptable, products with scores between 50 and 70 are marginally acceptable, and products with scores above 70 are acceptable. By comparing the score with these acceptability ranges and adjective ratings, the mean SUS score of 69.25 indicated that MOOCAT was generally perceived to be in the high range for marginal acceptability and lay between "OK" and "Good" in terms of adjective ratings.

Table 3. SUS evaluation results for MOOCAT

Mean	SD	Min	Max
69.25	14.96	45	100

However, a relatively wide variation in individual score contribution (S_i) was observed, ranging from 45 to 100 (a 55-point range). The 40th percentile was calculated with a score of 51.35, indicating moderate usability (with an adjective rating of between “OK” and “Good”), while the 60th percentile indicated good usability (with an adjective rating of between “Good” and “Excellent”) with a score of 82.60.

Sauro et Lewis (2011) suggests that although the SUS questionnaire is intended to generate a score indicating the overall perception of a system’s acceptability, factor analysis indicates that it incorporates two correlated measures: learnability and overall system usability. The usability score was obtained by analyzing the responses provided by participants to questions 1, 2, 3, 5, 6, 7, 8 and 9, while the learnability score was obtained by analyzing the answers provided in questions 4 and 10. The results of this analysis are presented in Figure 8.

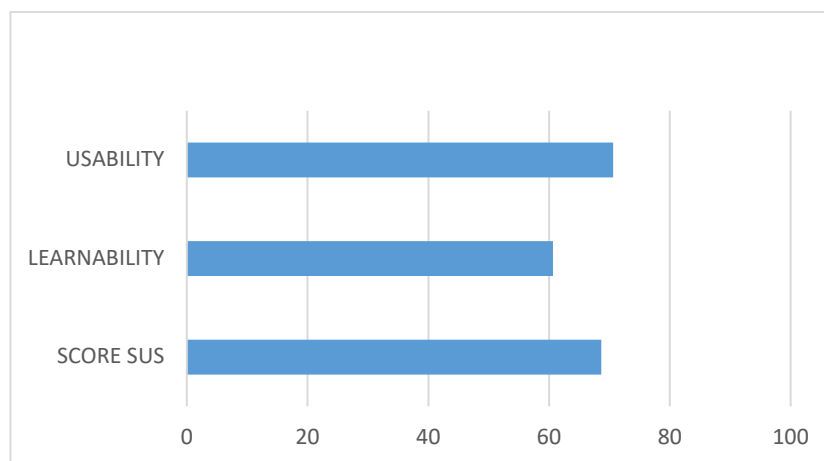


Figure 8. SUS scores, learnability and usability for MOOCAT

By positioning the scores obtained for learnability (60.70) and usability (70.76) on the rating scale, we obtain a notation for learnability that is between “Correct” and “Good”. For usability, we get a relatively “Good” notation and an acceptable usability.

7 Limitations and Future Work

The work presented in this paper has provided a scientific approach that addresses a concrete problem in TEL field, namely educational scenario building in massive and open environments. We focused especially on pedagogical practices related to the connectivist approach, and we had concluded that need for models and tools to design and deploy such courses became obvious. We have examined the issue of instructional design, which we describe as a “process”, otherwise known as an educational workflow. Our goal was therefore to provide teachers with a tool that allows them to model and reuse scenarios by integrating complex sequences and multiple pathways that a connective learning situation requires.

Designing and implementing such pedagogical scenarios is a complex task for a teacher, especially since when a used tool does not meet his/her expectations, is not easy to use, or is complex to understand for novice users (in computer science or pedagogical design). To meet the expectations

of teachers, we explored the possibility of using an existing conception model: the BPMN. In this perspective, and in order to meet this need, we first structured a cMOOC-oriented scenario model called cORPS. Based on the latter, we designed a cMOOC-oriented visual scenario design tool based on the BPMN notation, called MOOCAT, and integrated into it a service for the operationalization of pedagogical scenarios to platforms that can host cMOOCs.

As explained in section 5.4, the developed deployment process is based on a rule-based transformation. This process implies exploring the scenario and then generating a package file that can be imported by the platform via the import functionality. This procedure raises several limitations that need to be pointed out. Actually, the current method can lead to a semantic deficiency, due to the fact that the applied conceptual approach is not platform-oriented approach, being rather based on a pedagogical modeling language centered approach. Whereas a surjective transformation has been proposed, this transformation may not be in line with the teacher's initial intention. To address this issue, an alternative method consists of integrating a post-validation step during the deployment phase. This would provide the teacher with an overview of the transformations carried out and give him/her the possibility to verify the transformations which are not suitable for him/her and validate the ones in line with his/her pedagogical intentions.

A second point that needs to be pointed out concerns a larger scale experimentation of MOOCAT with a larger group of teachers with previous cMOOC experience. Several improvements in the conceptual level as well as improvements concerning our tool's functionalities would be achievable through this process. In addition, it would be interesting to experiment MOOCAT in a real use situation by embedding the tool in an effective MOOC project. At the scale of this work, this real-use implementation was not possible due to the financial and time constraints generated by MOOC implementation projects. Through these experiments, the design and reuse aspects of scenarios could be evaluated. That is to say, that it will allow to develop a reusable cMOOC scenario database and to study requirements for a larger scale use of our tool.

Besides, these research works open up many perspectives and raise several implications at both conceptual and pedagogical levels for involved stakeholders, namely: the teacher and the learner. Likewise, a perspective of this research work is to implement an adaptation process involving learners in a process of collective and collaborative design process. This is in line with the connectivist approach philosophy, highlighting the role of the learner as an active actor of his/her learning.

In conceptual and methodological terms, in a massive MOOC context, there may be as many scenarios as learners, resources and granularities, as fine-grained they might be. Indeed, we cannot approach the pedagogical scenarios' adaptation issue without talking about the granularity of the educational objects and entities; and the complexity generated by the openness and massiveness of these environments. In concrete terms, the cMOOC is initially designed by the teacher, and learners are then encouraged to adapt the scenario according to their learning objectives. We therefore consider that a methodology based on the co-design of a scenario that is currently in use would be a possible solution to this challenge, by giving to the learners an access to MOOCAT with special and restricted roles and privileges. However, several scientific issues arise regarding the articulation of adaptation needs, the capitalization of these proposals, and the negotiation and validation of any changes carried out, especially in a massive environment.

8 Conclusion

In this paper, we have proposed a solution to support the pedagogical scenario building of connectivist MOOCs by providing a tool and model for this purpose. The main objective of this research work is to support teachers in designing connectivist activities. Our main contribution is a tool called MOOCAT, a visual authoring tool that is intended for the design and deployment of cMOOC-oriented scenarios. It produces pedagogical scenarios using the BPMN model for graphical

representation. These scenarios are internally represented using a cMOOC scenario model entitled cORPS.

Our first proposal consists of a pedagogical scenario model (cORPS) that can describe cMOOC scenarios independently of the domain and context. The starting point for the development of this model was to identify all the elements needed to describe a cMOOC scenario. For this, we rely on concepts that are used in a connectivist approach that are enriched by case studies of existing cMOOCs, in order to take into account the specific aspects of this pedagogical approach.

To facilitate the use of the cORPS model by teachers, we embedded it into MOOCAT, which allows the design and deployment of cMOOC scenarios. We identify two steps leading from the design to the operationalization of a cMOOC-oriented scenario. The first consists of modeling the pedagogical scenario using MOOCAT; this editor is based on the BPMN graphical notation, and is aimed at teachers without specific technical knowledge or knowledge of the embedded model. We chose to adapt an existing open source BPMN modeling tool (BPMN.io) to embed our scenario model (cORPS). This adaptation was made on several levels: the architecture level, the functionality level and, finally, the human-computer interaction level. The second step consists of the automatic deployment of a scenario designed using MOOCAT on a MOOC platform. For this deployment phase, a web service solution was developed for the OpenEDX and Moodle platforms. MOOCAT ensures that the mappings between the elements of its own scenario and those of the LMS are correct and comprehensible from both a semantic and a functionality point of view.

Our contributions were evaluated and tested as they were developed, in order to verify them against the real needs of the final users. These evaluations were conducted through simulations, technical feasibility tests and end-user tests. The final evaluation was carried out with 40 participants in order to evaluate the benefits of MOOCAT. This experimentation allowed us to evaluate the usability and utility of MOOCAT as a cMOOC-oriented pedagogical scenario editor, by scoring the quality of scenarios conceived on the basis of an evaluation grid and also via a questionnaire that was supplied to the participants when the experiment was complete. The findings confirm that MOOCAT allows users to easily design connectivist pedagogical scenarios. For experts in pedagogical scenario building, MOOCAT offers a complete environment to design a cMOOC-type course.

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