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BPMN4MOOC: a BPMN Extension for the Design of Connectivist MOOC

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Abstract. Business Process Model and Notation (BPMN) is a standard formalism for business process modeling that is very popular in professional practices due to its expressiveness, the well-defined meta-model and its easiness of use by non-technical users. For instance, BPMN2.0 is used for business processes in commercial areas such as banks, shops, production and supply industry. Due to its flexible notation, BPMN is increasingly being used in non-traditional business process domains like education. The presented research work aims to develop a valid extension by applying the BPMN representation of pedagogical scenario in connectivist cMOOC context. BPMN provides a set of generic process modeling elements that make it necessary to extend the language and notation by domain specific concepts from connectivist pedagogical approach. Therefore, BPMN2.0 extensibility mechanism was explored to include the representation of specific cMOOC pedagogical concepts. Moreover, this paper provides an analysis of requirements of those concepts. Based on a cMOOC oriented pedagogical scenario model, the need for extension is identified and the valid BPMN extension meta-model is designed by the construction of a conceptual domain-specific model and the corresponding BPMN extension model.

Keywords. Business Process Modeling, Language Extension, MOOC, Technology Enhanced Learning, BPMN, Educational Scenario Design.

1 Introduction

Learning theories have long been a subject of wide discussion in the educational field. They provide concepts that contribute to the extension of teaching methods and learning practices according to world perception and changing. The evolution of the internet and the advent of social networking are changing the ways in which we think and behave, and the ways in which we solve problems and handle information. These changes are obvious and fundamental, and it is impossible to ignore them (Černý, 2020).

Lin (2021) highlights that the current development of network technology changes the ideological idea around traditional campus-based learning. Informal learning has gained a considerable place by making people inevitably pursuit a lifelong learning, that led to important changes in the nature of learning and teaching (Mellati and Khademi, 2020). To take advantage of these changes, Siemens (2004) introduced a new learning approach called connectivism, that led to the emergence of connectivist Massive Open Online Courses (cMOOC). Siemens considers that learning theories such as behaviorism, cognitivism and constructivism are not effective in this highly connected era.

That being said, cMOOCs have been the original [Massive Open Online Courses](#) (MOOCs) designed to designate connectivist ones (Siemens and Tittenberger, 2009). Since then, various categories of MOOC have raised. We can distinguish them according to the types of content, their implementation, the pedagogy used, etc. (Rosselle *et al.*, 2014). The most commonly used categorization is based on the underlying pedagogical approach, which currently differentiates between two main types: xMOOC ([eXtended Massive Open Online Course](#)) and cMOOC (Downes, 2008). On the one hand, an xMOOC is following a traditional learning model with a structured focus on content. On the other hand, cMOOC are driven by the principles of pedagogical innovation in a widely interconnected social learning mode (Sergis *et al.*, 2016; Siemens, 2004; Siemens and Tittenberger, 2009). This latter, on which we focus in our work, have been designed to facilitate the processes of aggregation, creation, production and sharing (Kop, 2011) among distributed groups of learners that communicate and collaborate online.

Despite this progress, the design and deployment of cMOOC present several challenges that are related to the assimilation of the design features of such courses and to the operationalization of scenarios by teachers. In this regard, a literature review revealed that there is no methodological and conceptual framework to assist teachers in implementing their cMOOCs. Thus, our aim is to assist the teacher-designer to explicitly define its scenario, which respects the specificity of cMOOC pedagogical concepts. These concepts refer primarily to the nature of pedagogical activities, the roles played by the stakeholders (teachers and learners) and the activities' sequencing. The objective is to support teachers with an instrumented support using a visual modeling tool, to provide a global vision of the entire scenario to be implemented.

Our idea is to use the benefits of Business Process Model and Notation (BPMN) modeling; more especially as the latter has been able to stand out in the Technology Enhanced Learning (TEL) field. Indeed, several studies point up the advantage of workflow modeling for instructional design. In this sense, a literature review reveals that the use of BPMN in an educational context has been explored and mentioned as a potential alternative to other pedagogical modeling languages (e.g. IMS-LD _ Instructional Management System Learning Design)(Adesina and Molloy, 2010; Da Costa, 2014; Karampiperis and Sampson, 2007; Stylianakis and Arapi, 2013). These works are concerned with the adaptation of pedagogical workflows for the design of face-to-face or online courses, according to different pedagogical approaches. This is possible due to its graphical notation easily understandable by different actors. We can also highlight its suitability for different audiences and especially for computer novice users. However, in order to meet our objective, the use of BPMN, in our context is not directly conceivable for several reasons.

Firstly, we may specify, as a general rule, that pedagogical design tools are driven by the educational approach to be implemented (i.e. they are not neutral and reflect a particular pedagogy). In our work, we aim to support a connectivist approach. We intend to explore the potential of this theory by focusing on teachers' practices through the description of dimensions that regulate such scenarios. Secondly, when a system does not fulfill the user expectations, is not easy to use, or is complex to understand for novice users (in computer science or pedagogical scenario design), then there are few alternatives offered to the teacher. This is one of the points justifying the different approach adopted in this work. Further, reusing the BPMN notation and extending it with domain-specific concepts is expected to be less expensive than deploying a domain specific modeling language from scratch (Bakki *et al.*, 2020). Thus, a research question can be raised: *How BPMN can be extended to represent cMOOC pedagogical scenario concepts?*

The paper presents the development of a valid BPMN extension for pedagogical scenario building in a cMOOC context. This work is in line with our previous research works aiming at providing assistance to teachers for the design and implementation of this type of MOOC. In those research works (Bakki *et al.*, 2019a, 2019b, 2020), we have developed a first outline consisting of defining the concepts governing a cMOOC scenario. This allowed us to propose an authoring tool and deployment services of scenarios to various Learning Management System (LMS). In this line, this paper aims to present the mechanism implemented for the extension of the BPMN notation. In this regard, adequate techniques, and methods from the field of engineering and BPMN extension development are used. Section 2 addresses the challenges and the motivation for a specific language for connectivist MOOC

context. Section 3 presents a first outline justifying the use of the BPMN and the need to extend the BPMN notation. The section 4 presents the extension mechanism including the extension process. Since the objective represents an artifact including modeling methods and its technical implementation, section 5 describes the technical implementation of the extension. Section 6 presents an evaluation of our proposal. Finally, Section 7 draws some conclusions and outlines some directions for future work.

2 Connectivism: Domain Specification and Motivation for a Specific Language

In online learning, the need for an e-learning system that supports multiple teaching requirements has been identified as a prominent issue. So far, a lot of effort has been devoted to online and distance education systems based on specific pedagogical methods and theories (Barari *et al.*, 2020; Yousef and Khatiry, 2021). Indeed, reflecting the theoretical underpinnings of the various pedagogical approaches and applying them in practice is not an easy task.

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 confronting the teacher. In addition, LMSs do rarely offer 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 forms 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 LMS presents many difficulties for teachers in thinking about and designing their courses, particularly, in a massive context. It results that there is a need for solutions to bridge the gap between the teachers' educational intentions and the functionalities proposed by a particular LMS. The objectives of these solutions are: (1) to use a common language allowing the description, sharing and reuse of pedagogical scenarios; (2) to facilitate the conception of pedagogical situations; (3) to bridge the conceptual dimension of a scenario with its technical implementation, notably by facilitating the deployment of a scenario to the LMS.

Moreover, the pedagogical design of massive environments, in MOOCs in general and in cMOOCs in particular, raises several questions. According to Rizvi *et al.* (2022) a number of studies on formal online environments (Rienties *et al.* 2017; Rienties and Toetnel, 2016); and MOOC environments (Rizvi *et al.*, 2022) show the importance of learning design. These studies highlight that a better understanding of the nature of engagement with various learning activity may lead to improvement of persistence in these environments (Rizvi *et al.*, 2022). In this line, studies conducted by Fianu *et al.* (2018) and Kim *et al.* (2021) emphasized the importance of course design in MOOC and its impact on different parameters of a MOOC including course completion and students' satisfaction. A recent systematic review conducted by Goopio and Cheung (Goopio and Cheung, 2021) confirmed that a poor course design contributes to the high dropout rate in MOOCs.

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. The connectivism actors describe it as a learning network theory, which draws on a series of theories such as learning, education and knowledge management. These theories are within the discussion of educational change and are in line with the transformative possibilities provided by emerging technologies. Effectively, people have become producers of information, as the growth of Web services and social networks have made "reading/writing" activities more realistic. In this sense, connectivism scope seems to be wider than the scope of existing theories. One of its novelty and attractiveness to practitioners is that it solves problems beyond the scope of traditional learning theories such as behaviorism and cognitivism (Siemens, 2004).

As stated in the introduction, cMOOCs are based on connectivist theory. Teaching and studying in an open environment such as a cMOOC is challenging, since control of educational activities is handed over from educational institutions to individuals, who are generally isolated learners (Fournier *et al.*,

2014). Tasks that were previously carried out by a teacher, such as setting pedagogical objectives and evaluating a student's progress, can now be assigned to learners. These tasks may be overwhelming for learners who are unaccustomed to learning environments that require them to be self-directed and self-regulated (Kop, 2011). Active learning has been successful and is notably required. Furthermore, the evolution that the world has experienced in the educational sector during the 2020 pandemic shows that active and self-regulated learning are paramount and essential.

Meanwhile, from a conceptual point of view, the openness of cMOOCs might suggest that pedagogical scenario design is not essential. Conversely to this idea, we believe that the design of connectivist courses can take advantages from the application of scenario design practices. In fact, we consider that it is important to provide favorable conditions for the emergence of connectivist activities. That means that in order to create and produce new resources and knowledge, learners must be guided during learning process to foster their autonomy, which cannot be taken for granted. It is therefore important to structure learning activities in a meaningful way to help them gain independence and autonomy as well as to provide them an opportunity to develop a variety of technical and vocational skills (Armatas *et al.*, 2014).

Some research work has examined the process of designing pedagogical scenarios in MOOCs, and more specifically in cMOOCs (Alario-Hoyos *et al.*, 2014; Bachelet, 2014; Peter and Villasclaras-Fernández, 2013). These works demonstrated the needs and importance of pedagogical scenario design in these environments. Most of these authors confirm the need for a conceptual framework and model for cMOOCs to support teachers in the implementation of such courses. Moreover, Pélissier and Vasasallo (2014) highlight the lack of methodological tools based on their experience with the creation of the MOOC "Sustainable City". Among the listed gaps, we can name a lack of references, methodology and tools dedicated to the design of such learning environments.

The literature review suggests few solutions to facilitate the implementation of cMOOC. On the one hand, research works focus on these environments from a theoretical point of view and aim at demonstrating the interest of a methodology of scenario development of connectivist courses. On the other hand, they propose frameworks that describe mostly the key aspects of the design processes of a cMOOC course. These frameworks define rather more the administrative aspects than the elements that a cMOOC scenario should contain. However, none of this work provides a model that describes a pedagogical scenario for a cMOOC, nor concrete and simple tools for designing and deploying these courses. They also do not provide solutions to lead teachers to think about the main pedagogical features of such scenarios. Thus, our contributions aim to reduce this gap by providing a visual authoring tool for the implementation of these courses. Before delving further into our contributions, we will show the importance of visual conception in the educational field and discuss the concordance between the BPM process and the instructional design process.

3 BPMN as a Pedagogical Language Modeling

The visual design has raised interest and has shown several 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 (Amálio and Glodt, 2015; 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 may be computed, generally at a great cost, to make them explicit. 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 *et al.*, 2010).

In instructional fields, Botturi (2006) has referred to Gibbons and Brewer's (2005) research work, which aimed to measure the impact of virtual design languages in different fields (e.g. music, architecture, software engineering, etc.). 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*" (Botturi, 2006). For Botturi, Gibbons and

Brewer's view is based on the observation that the use of a design language and the related notation brings huge benefits to the design practice. The authors highlighted some benefits including the fact that visual tools can foster the creation 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 *et al.*, 2007). Visual displays can also facilitate a collective understanding between stakeholders, and provide a dynamic way of sketching out different alternatives for the same MOOC design (Alario-Hoyos *et al.*, 2014). In this sense, we have explored the potential of BPMN for this purpose.

Today, Business Process Management (BPM) is business process engineering based on information technology. It aims to continuously model, deploy, execute, and optimize the processes and improve the agility of an organization (Ulmer, 2011). The essence of a BPM approach is the principle of re-engineering; it consistently defines the lifecycle of a business process as a continuous loop. The above definition of a business workflow lifecycle can be applied to the educational field. Indeed, a comparison between business process engineering and instructional design is possible. Nowadays, the teachers are expected to analyze, model, implement, identify the problem, and then use the resources and tools at their disposal to build a course. Generally, these elements are part of a design approach that aims, notably, at extracting the specifications of learning situations, abstracting models in order to study, design, implement and adapt teaching systems, trainings or courses.

According to Dumas *et al.* (2013) and Santoro *et al.*, (2017) a typical BPM lifecycle consists of six phases (Figure 1). In the “*Identification Phase*”, a process architecture that provides an overall view of the processes in an organization and their relationships is defined. Then, in “*Discovery Phase*”, it is a matter of understanding the operation of a business process and representing it in a model properly. Consequently, multiple stakeholders with different and complementary skills may collaborate to accomplish this task, which usually involves communication and information gathering.

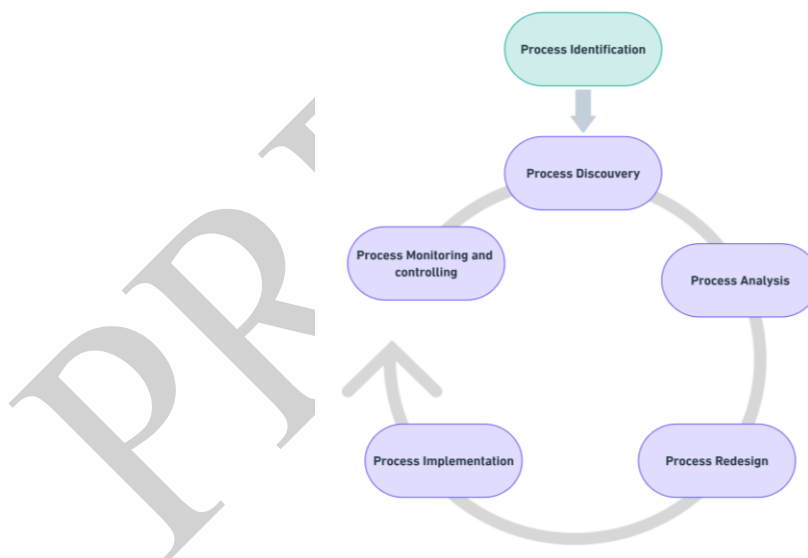


Figure 1. BPM Lifecycle (Dumas *et al.*, 2013; Santoro *et al.*, 2017)

During the “*Analysis Phase*”, the identification of process improvement takes place. In addition, the ideas and guidance presented will guide the process “*redesign phase*”. The “*Implementation Phase*” includes the execution of the process by carrying the necessary changes in the ways of working and in the information systems. Finally, the “*Monitoring and Controlling Phase*” closes the ‘*cycle*’ and serves as a basis for the new loop. Dumas *et al.*, (2013) and Santoro *et al.*, (2017) affirm that once the implementation is completed, continuous monitoring and controlling of the process execution is required in order to identify if any adjustments are needed.

In analogy with the life cycle of a pedagogical scenario, the identification phase corresponds to the requirement identification phase where teachers conduct an informal description and express their initial needs. The discovery and analysis phases correspond to the scenario building and analysis phase, which relates to the specification of learning situations. Implementation phase corresponds to the phase of deployment of the pedagogical scenario where the teachers are invited to create the pedagogical resources and to deploy these resources and the scenario on a LMS. Monitoring and Controlling Phases correspond to the Test and Evaluation phases, where the behavior of involved stakeholders (Teachers and learners) regarding the learning device is evaluated, as well as the technical evaluation of the system in order to make the necessary adjustments to eventually reuse it.

In our opinion, the development of a pedagogical scenario with BPMN suited to the implementation of the various steps presented above. BPMN is a standardized notation, which promotes contextualization, sharing and interoperability of the teaching and learning processes (including pedagogical scenarios). Nevertheless, the use of BPMN as it stands is not contemplated, as the aim is to assist teachers in this conception and implementation phases. Helic (2006) argues the advantage of using BPMN to design pedagogical situations where collaboration and connections between learners are essential. The author states that the proposal of a domain-specific notation is essential. Furthermore, he postulates that "*Since notations such as BPMN are meta-modeling notations, i.e. such notations introduce only abstract modeling elements such as task, participant, role; a pedagogy-specific vocabulary based on these abstract elements should be constructed*" (Helic, 2006).

Accordingly, the main contribution presented in this paper is a design and implementation of a BPMN extension for cMOOC context. These points will be discussed in section 4, which presents fundamentals in terms of general extensibility of BPMN and outlines the extension method.

4 A BPMN Extension for Connectivist Context

In this section, we first present our procedure process (Figure 2). Based on this latter, the design of the extension is described step by step below. First, the concepts of the extension are discussed in order to estimate their semantic match with BPMN elements. Subsequently, the extension model is defined. Finally, the concrete syntax of the extension is represented.

4.1 Extension Design

BPMN is one of modeling languages that provide generic extension elements that enables the definition of domain-specific language extensions (OMG, 2011). The BPMN extension mechanism is part of the BPMN metamodel and supports the approach of extension by addition (Stroppi *et al.*, 2011). The BPMN metamodel can be extended by integrating new domain-specific concepts to standard and predefined elements. The following elements are defined for the specification of valid BPMN extensions: *Extension Definition* is a named group of new attributes, added to original BPMN elements under a new concept name and which can be used by BPMN elements (Braun and Esswein, 2014). Thus, new elements can be built implicitly. An *Extension Definition* consists of several *Extension Attribute Definitions* that define actual characteristics of an extension. It represents an attribute defined for an *Extension Definition* element. Values of these *Extension Attribute Definitions* can be defined by the *Extension Attribute Value* class. These latter, stores the value assigned to an extension attribute of a BPMN element.

According to Braun (2015), there are two major challenges in the development of BPMN extensions. First, there is a lack of an explicit methodological guidelines for creating extensions and second there are no possibilities for generating graphical notations for extension concepts (Braun, 2015). Hence, Stroppi *et al.* (2011) presented a method for BPMN extension development, which was completed by Braun and Esswein (2014). These latter indicate that a domain requirement analysis is important in order to explicit all the necessary concepts of the domain and its semantics. The domain requirement analysis allows to consider whether the domain-specific concept is semantically equivalent to an existing BPMN element or not. In this line, we consider as necessary to integrate the equivalence

check procedure, as our aim is to propose a cMOOC pedagogical scenario specific extension. Thus, the process for the development BPMN4MOOC consists of the steps presented in Figure 2.

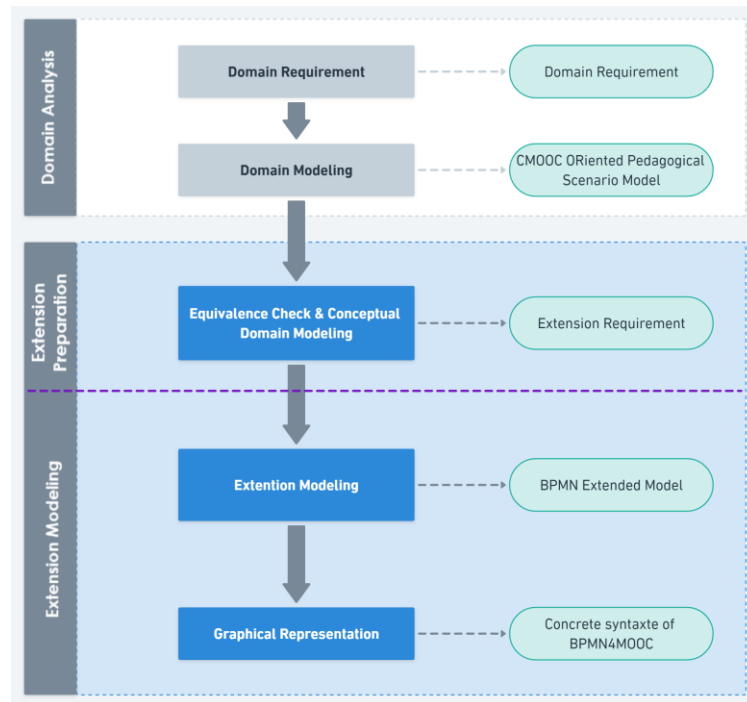


Figure 2. Process for the development of BPMN4MOOC extension

In (Bakki et al., 2019a; 2020) we presented details on domain analysis steps. For convenience, and for a clearer understanding of our extension process, we will discuss some key concepts in the following sections and notably to specify the main components of our extension. Thus, the domain modeling step will be briefly presented in section 4.1. That being said, the current paper focuses on the steps colored in blue (see Figure 2):

(1) Equivalence check and Conceptual Domain Modeling: consist of an analysis of the domain and its conceptualization. They are derived from requirements for the BPMN extension linked to our studied domain. The equivalent check step reveals which concepts are missing in the BPMN domain in order to represent cMOOC pedagogical scenario model. Then, the Conceptual Domain Modeling describes the domain concepts to be represented in extended BPMN models and their relationships with the concepts of the BPMN metamodel.

(2) Model Extension: The output of the precedent step is the groundwork for the abstract syntax definition of the BPMN extension. The extension model, depicted by a UML class diagram, define an extension model based on the specification of the BPMN extension mechanism.

(3) Graphical representation: the concrete graphical syntax is proposed based on the extension model. Some design recommendations may be taken into account for the development of this concrete syntax. These elements will be presented in section 4.5.

4.2 Domain Analysis: Domain Modeling

The results of our previous researches allowed us to identify the different elements regulating such scenarios. Generally, a scenario describes the pedagogical objectives in terms of knowledge or skills that the learners must acquire, the activities and their sequence, the roles of the participants involved in the activities, the tools and resources needed to carry out the activities. It consists in organizing and

structuring the learner's activity, the used tools, and the resources. It also involved defining the role of each actor engaged in the course.

Thereby, we need to express the structural properties specific to a connectivist environment (concepts, types of entities, etc.), as well as the temporal properties (section start, assignment due, etc.). To describe a cMOOC, the pedagogical scenario is based on a course semantic description. It consists of a description of the activities and resources it contains, but also of the properties of these entities, as well as their organization and sequencing. The domain specification process has been carried out beforehand and has led to several publications (Bakki et al., 2019a, 2020). Nevertheless, for a better understanding of the present paper, we will give a brief description of the domain specification in the following.

As presented in Figure 3, the root element of a cMOOC scenario is the "*scenario*" class. It is the entity that aggregates the different components of the pedagogical scenario. It is characterized by its name, the starting date of the cMOOC, the organization responsible of the cMOOC and a general objective. To facilitate the design of a cMOOC while preserving its educational potential, the scenario is organized according to three levels of granularity: learning unit, lesson, and activity.

A scenario is composed of one or several "*Learning Unit*". In TEL field, a learning unit is an entity that can have several levels of granularity (module, course, session, etc.) (Battou *et al.*, 2012). However, in cMOOCs, a learning unit often has a fixed duration, usually equal to a week. The *Learning Unit* can be composed of one or multiple lessons. The lessons aim to structure all learning and assessment activities during the learning unit. The teacher can define a temporal sequence of the proposed activities by specifying the predecessor and successor elements, especially if an activity has prerequisites.

The activities are classified into five categories, each of these categories has sub-components that represent the activity type (Figure 3). A given activity can be assigned to one of the five categories: Aggregation (consultation and cognition activities), Remixing (communication, sharing and metacognition activities), Repurposing (production and collaboration activities), FeedForwarding (production's sharing activities) and Evaluation activities (e-evaluation, peer evaluation or self-evaluation). The teacher expresses the way in which pedagogical activities and their sequencing are organized, bearing in mind that participants will participate in these learning activities in a non-linear context, in a conditional way (for example, according to their initial motivation, preferences and/or skills) (Ebner *et al.*, 2014; Rubens, 2014; Sergis *et al.*, 2016).

The teacher can also define different execution paths within the pedagogical scenario. In fact, activities are not necessarily organized in a sequential way. He/she can specify whether these activities are carried out "*one after the other*", "*one and the other*" and "*one or the other*", regulated by the prior fulfilment of a condition (example: finalization of an activity, production of a synthesis document, etc.). We designate by the "*actor*" class, every person who intervenes during the learning phase of the cMOOC. The cMOOC scenario actors can play, a priori, four roles, namely: teacher, facilitator, evaluator, or learner. Finally, the "*Resources*" class regroups the provided and produced pedagogical resources.

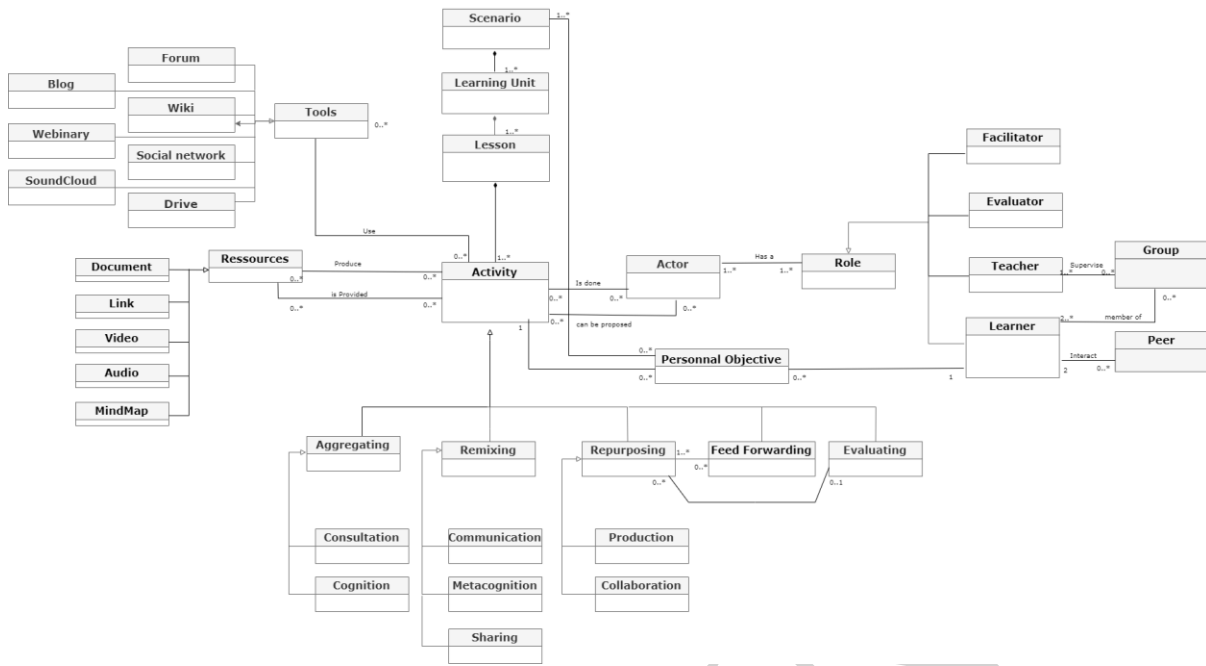


Figure 3. cMOOC pedagogical scenario model (Bakki et al., 2019).

4.3 Equivalence Check and Conceptual Extension

BPMN extension is designed and conducted based on the domain concepts (section 4.2). These concepts can be used for semantic comparison with BPMN elements in order to identify the needed elements in the form of new elements or elements' properties. Concerning the proposed model, each concept was examined regarding its semantic equivalence with BPMN elements. As shown in Table 1, BPMN lacks support for several concepts of cMOOC pedagogical scenario building concepts. Therefore, to address these deficiencies, we define an extension of the BPMN, which introduces the knowledge dimension aspects and provides a rich and expressive representation of cMOOC scenario to allow the explicit representation of those elements.

Recalling from section 4.1, the element equivalence check reveals which concepts are missing in BPMN to represent cMOOC pedagogical scenario. It allows us to identify cMOOC scenario concepts that will be implemented in the proposed BPMN extension. According to the rules defined by Braun and Esswein (2014), a classification occurs in equivalence, conditional equivalence or no equivalence:

- (1) **Equivalence:** there is a semantically equivalent construct in the BPMN in the sense of a permitted combination of elements or just a single element. In this case, no extension is necessary, and the domain concept is represented as a BPMN concept.
- (2) **Conditional equivalence:** there is no obvious semantic matching with standard elements, but rather situational discussion is necessary to provide arguments for a possible mapping or to explain why it is not feasible. This situation is caused by the partial under specification of BPMN elements (OMG , 2011). Consequently, the concept is treated either as equivalent concept or as non-equivalent concept.
- (3) **No equivalence:** when there is no equivalence to any standard element for three reasons: (i), the entire concept is missing ; (ii) a relation between two concepts is missing ; (iii) properties of a concept are missing.

The concepts from cMOOC pedagogical scenario model are semantically compared with the BPMN concepts. If a concept is not covered sufficiently by the standard BPMN, we suggest an extension as a new element. We therefore identify 13 requirements based on the domain analysis as presented in

table 1. We identified 9 extensions where no equivalence between the domain and BPMN concepts exists. Four domain concepts are conditionally equivalent with BPMN concepts.

As presented in the Table 1, the equivalence check allows identifying BPMN concepts and extension concepts that are derived from the identification of extension requirements. “*Extension Concept*” refers to the Extended Element and “*BPMN Concept*” designates the BPMN Element.

A Learning Unit, Actor and Lesson have a conditional equivalence to the BPMN elements pool, lane and sub-process respectively. A Task is specified by a *Consultation Activity*, a *Cognition Activity*, a *Communication Activity*, a *Metacognition Activity*, a *Sharing Activity*, a *Collaboration activity*, a *Production activity*, a *Feed forwarding activity* and a *Generic Activity* (that may be used to describe a non-pedagogical activity). For each one of these activities a set of new properties have been assigned according to the pedagogical scenario model defined in the domain analysis. Let take a first example, a consultation activity has a *Name*, A *RessourceType*, a *Format* and eventually an *URL*. The *RessourceType* property is designed giving a domain-specific set of values (e.g., video, Audio, Image, Link, Text-Essay and Mindmap).

For *Production Activity*, the extension defines three new proprieties. The first one is *ProductionType* that designates the type of the resource produced by the learner. The second one is *Tool* that allows the teacher specifying the suitable tool for the realization of the activity. The last one is *Deadline* that enables the specification of a delivery date for the work produced by the learners. Thereby, the domain modeling includes all listed requirements (table 1) and brings the concepts in a sufficient order. Furthermore, additional information can be attached at tasks through data objects to provide the user with additional information if they request it. For this purpose, we defined six new data Object (presentation, mindmap, text, link, audio, and video).

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Table 1. Analysis of cMOOC pedagogical scenario concepts and BPMN generic concepts for equivalence check and Conceptual Domain Model of the Extension

Pedagogical concept	Semantics	BPMN Equivalence	Property	Conceptual Domain Model
Generic activity	Definition of a generic activities, concern more especially teacher and/or pedagogical staff activities	Equivalence: Task, activity	Original	BPMN concept
Learning Unit	In cMOOC context, a learning unit represents a week, it encompasses different lessons, activities, etc. that will be proceeding during the week period.	Conditional equivalence: Pools are used for the representation of the participants and the lanes serves for roles system and departments (OMG, 2011). In our context, <i>Lanes</i> are used for the representation of roles (teacher, learner, etc.) and <i>Pools</i> for the representation of a learning unit usually represented in cMOOC context as a week. The proprieties of each of these elements have been enriched to represent all the metadata needed.	Original	BPMN concept
Actor	Definition of roles of individuals who participate to the cMOOC courses, including students, teachers, pedagogical engineers, etc.		Original	
Lesson	A lesson is a semantic entity that englobes a range of activities and resources.	Conditional equivalence: Subprocess	Original	BPMN concept
Consultation Activity				
Cognition Activity				
Communication Activity				
Metacognition Activity	Definition of connectivist activities with specific dependencies, restrictions and proprieties.	No equivalence	Extended	Extension concept
Sharing Activity				
Collaboration Activity				
Production Activity				
Feed Forwarding Activity				
Evaluation Activity	Specification of evaluation activities with specific proprieties.	No equivalence	Extended	Extension concept
Pedagogical resources	Specification of documents for learning purposes.	Conditional Equivalence: the use of data object is possible but it may conduct to a high level of semantic abstraction. The use of Properties is not possible since only Processes, Activities and Events can be associated with them.	-	Extension concept

4.4 Extension Modeling

Based on the detailed analysis of each required concept and the elaborated equivalence check (and conceptual model extension) the next step is accomplished by developing the model extension. To illustrate our purpose let's look back at our example concerning the Production activity. This class is inherited from the “BPMN Task” class, which is an existing BPMN concept. The Production activity class will therefore be defined as “*ExtensionDefinition*” in the extended model and will be linked with the parent class with a relationship “*ExtensionRelationship*”.

The class “*Production activity*” have a data type attribute “*Production Type*” which is specified in our conception as a “*Resource Type*”. “*Resource Type*” is a data type enumeration datatype, indeed, an “*Extension Enum*” class has been created. Figure 4 shows the resulted extended model. In this figure, only relevant standard BPMN classes are represented in gray. The extended concepts are shown in white.

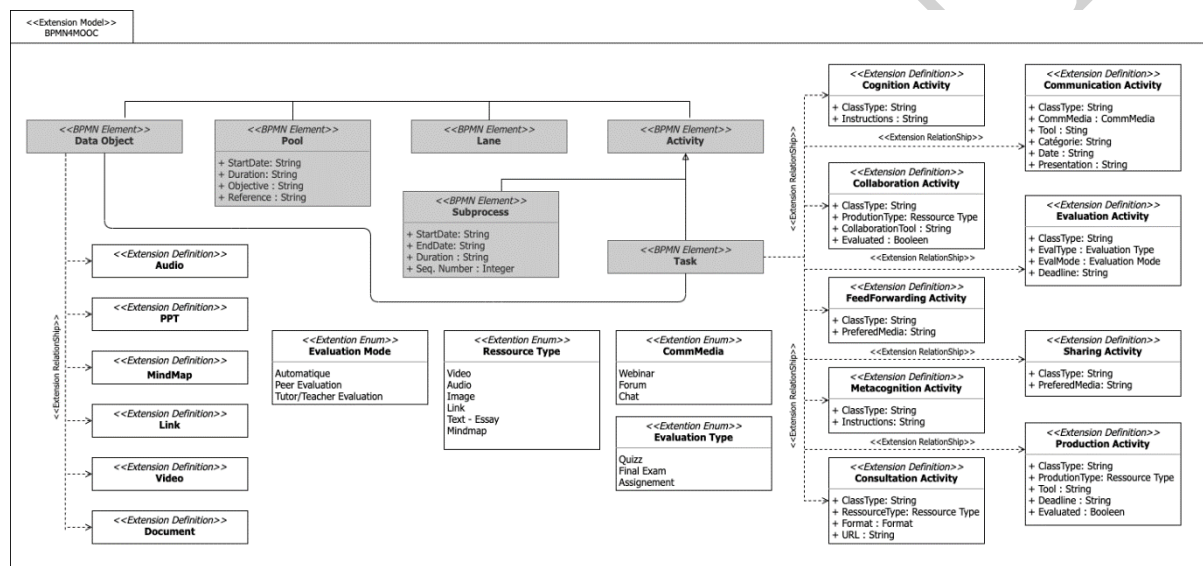


Figure 4. BPMN Extension Model of BPMN4MOOC

Our research project focuses mainly on the development of a concrete syntax and a visual authoring tool to be used by the teachers. Consequently, to cover the extension model into a new visual BPMN extension, we propose a graphical representation of the new elements (Section 4.5); and the implementation of this extension representation into a conceptual tool (Section 5).

4.5 Graphical Representation

We provide an advanced concrete syntax that defines the specific new graphical representation for the proposed concepts. As defined by the (OMG, 2011) specification, the following extension can be made:

- (1) New markers or indicators may be added to the specified graphical elements.
- (2) Graphical elements may be colored, and the coloring may have specified semantics that extends the information conveyed by the element as specified in this standard.
- (3) The line style of a graphical element may be changed, but that change shall not conflict with any other line style required by this specification.

Based upon these rules, we adapted the icons and created scalable vector graphics (SVG).

In summary 16 elements are added as graphical elements. Figure 5 shows the visual representation of some elements. We therefore identify common icon designs for specific word phrases. Assuming that many persons use these icons to represent specific domains an approximation will increase the understandability of the graphical notation of BPMN4MOOC. Task elements are specified by colored borders and new markers that vary depending on the activity type for representing Consultation Activity, Cognition Activity, Communication Activity, Metacognition Activity, Sharing Activity, Collaboration Activity, Production Activity, Feed forwarding Activity and Evaluation Activity. A pedagogical resource is represented as Data Object with a marker that reflects the selected resource type of the element. Sub-process line shape was also changed in order to differentiate it from generic activity element.

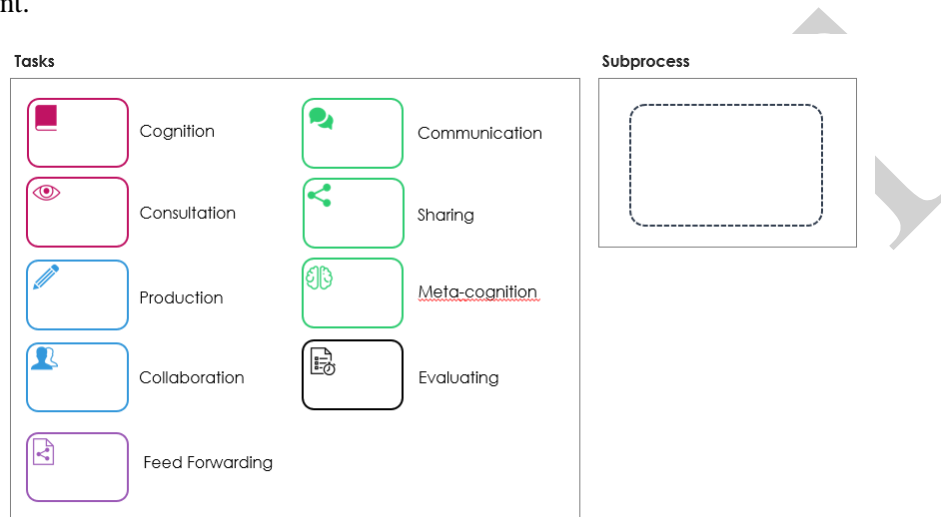


Figure 5. New BPMN4MOOC graphical representation

5 BPMN4MOOC Implementation

In order to empower our proposals, we implemented the extension model into an authoring tool based on the BPMN metamodel. This cMOOC-oriented scenario editor is intended for any teacher that is interested in implementing such courses.

To identify a suitable BPMN modeling tool, a comparative study of the principal tools available for existing BPMN modeling has been carried out. Our selection was mainly focused on the more known free tools. For our purpose, the tool should allow the users to create pedagogical scenarios effortlessly without the need to install a new program. Therefore, we prefer web-based modeling tools over desktop-based modeling tools that need additional software modules or packages. Based on the results identified in our study, we build upon BPMN.io¹ a rendering open-source toolkit for BPMN 2.0, which is based on JavaScript. It allows a comfortable integration into web applications and is further extendable. The company Camunda and an active community support the project.

BPMN.io is composed of three modules “BPMN-js”, “BPMN-moddle” and “Diagram-js”. All three modules of the tool have been modified to integrate specific functionalities to meet the needs presented in section 4. Concerning BPMN-js and Diagram-js, we first defined the new elements that will constitute our palette and their grouping. The graphical representations of the new components are implemented into JavaScript code as SVG graphics. For a correct representation of the BPMN extension, the BPMN metamodel was enhanced with the domain-specific elements. Therefore, we edit the JSON sources that are representing the BPMN 2.0 metamodel. This is realized in bpmn.io through the “BPMN-moddle”.

¹ <https://github.com/bpmn-io>

In Figure 6 shows a screenshot from the extended modeling tool. The left side shows a palette with the standard BPMN notation and the extended elements. The right side provides options to edit the element specific attributes. In the middle is the drawing surface.

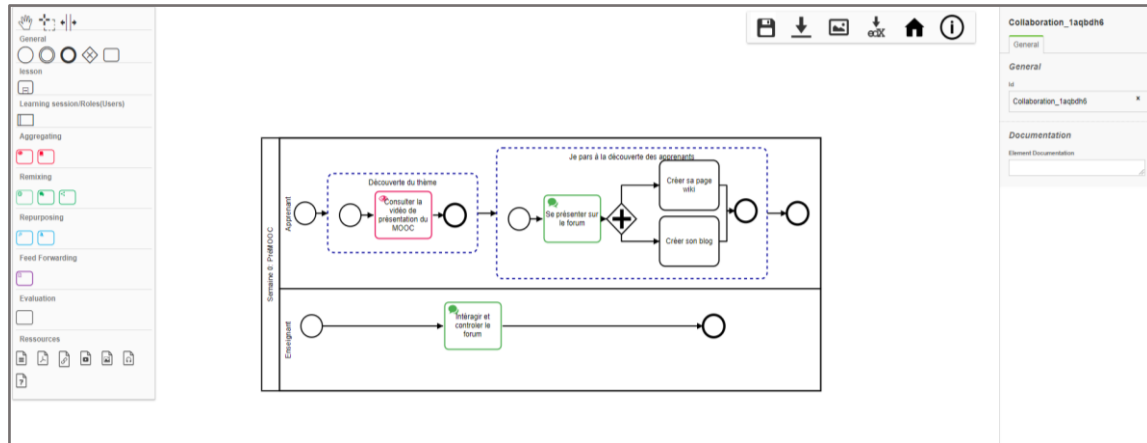


Figure 6. Authoring Tool Interface (Bakki et al., 2019)

6 Evaluation

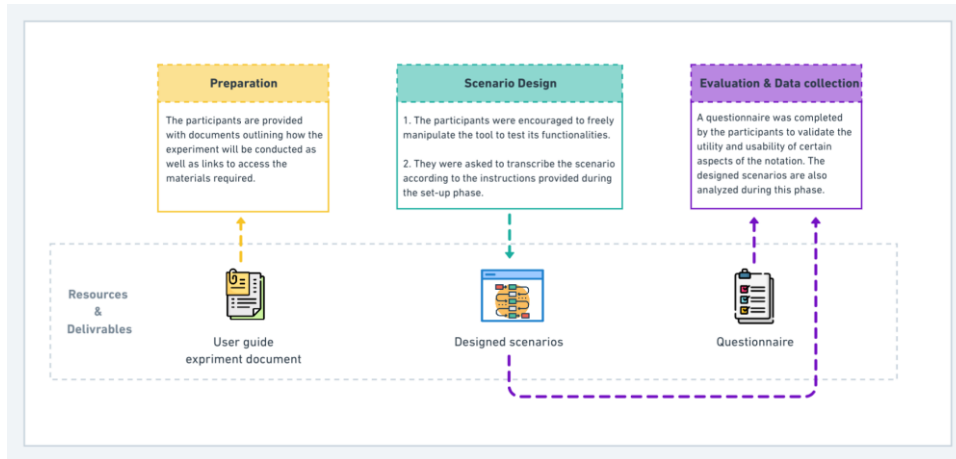
This section presents the evaluation, which aimed at assessing the ability of the proposed BPMN extension to specify cMOOC oriented pedagogical scenarios. The following subsections present our study's objectives, the experiment protocol, the procedure that was followed, and, finally, the results and conclusions of the evaluation.

6.1 Evaluation Objective and Protocol

Our objective with this evaluation was to assess the expressiveness of the proposed notation. In other words, we wanted to verify the ability of BPMN4MOOC to express cMOOC pedagogical scenarios. In our context, two main tasks that are related to process models can be mentioned: 1) model creation and 2) model implementation/interpretation. In this experimentation, we focus on model creation.

A total of 33 participants have participated in the experiment. The participants had prior knowledge and experience with pedagogical scenario design. They had previously designed pedagogical situations and had used different instructional design tools. We also intended to make sure that all the participants had the necessary prerequisites regarding the use of BPMN. We have introduced the concept of BPMN workflows and dedicated some extra training time to the manipulation of BPMN. The overall time allowed to this phase was two hours consisting of a presentation of the BPMN concepts followed by a hands-on workshop using the BPMN.io tool to design several case studies.

The evaluation was conducted over a period of three hours and was organized in three phases (Figure \$\$). The first phase (preparation phase) consists in introducing the objective and the expected results to the participants. During this phase, we also provide the participant with (1) a user's guide that explains the authoring tool functionalities and the proposed notation; and (2) an experiment guide describing the different phases to be performed and the pedagogical scenario to be deployed. During the second phase (scenario design phase) the participants were asked to design their scenarios using the extended notation while complying with the instructions provided in the experiment guide. For the last phase (data collection and evaluation phase) we asked the participants to complete a questionnaire. We also collected all the produced pedagogical scenarios. We will elaborate further on these points in section 6.2.



In the experimentation guide, we proposed a narrative description of the scenario to be modeled on the theme of "information and ethics in the digital age". We asked the participants to design a four-week cMOOC scenario. We also provided some guidelines for the first two weeks. In a second step, the participants had to design the third and fourth weeks of the cMOOC for which they had to choose the activities they considered adequate.

6.2 Data Collection and Evaluation Criteria

The methodology used to collect data for this experiment is based on two sources: (1) the participants' opinions, collected by questionnaire; and (2) the data directly resulting from the activity on the authoring tool, notably the produced scenarios.

At the end of the experiment, we asked participants to complete an online questionnaire. Concerning the elements that are relevant to this paper, the questionnaire consists of two parts. The first one allowed evaluating the usability of our proposal. For this purpose, we used the SUS (System Usability Scale) questionnaire (Bangor *et al.*, 2009). The SUS consists of a ten-item questionnaire that uses a Likert scale (from 1 = "strongly disagree" to 5 = "strongly agree") to provide a global view of subjective assessments of usability. This scale has been used to evaluate a wide range of products and services. From the answers obtained, the SUS score is calculated to establish how good or bad the system usability is (Bangor *et al.*, 2009).

The second part consists of two closed questions, evaluated with a six-point Likert scale (strongly disagree, to strongly agree). We have formulated two questions related to the work presented in this paper:

Q1. In your opinion, does the notation provide the necessary concepts to formalize a connectivist scenario?

Q2. Did the organization of the palette guide you in identifying the type of activity and how to employ it?

The collected pedagogical workflow produced by each participant was analyzed using an evaluation rubric (Allen and Tanner, 2006). The "rubrics" allow an evaluation on a scale of one to three (1: low; 2: medium; 3: high) of whether the scenario designed meets a certain number of criteria defined beforehand, as presented in Table 2.

Table 2. Evaluated criteria

E1	Correspondence of activity titles with the domain
E2	Relevance of activities and resources with the domain
E3	Number of designed weeks
E4	Use of all the concepts of a connectivist scenario

The criteria E1 and E2 relate to a semantic evaluation of the designed scenarios. In the context of our experiment, we asked participants to design a four-week cMOOC course. We wanted to measure whether participants were able to complete the requested tasks within the allocated time. For this purpose, we calculate the criterion E3 as follows:

$$N_{E3} = \begin{cases} 1 & \text{if } val = 1 \\ 2 & \text{if } val = 2 \\ 3 & \text{if } val \in [3,4] \end{cases} \quad val = \text{number of weeks}$$

As we mentioned in the section 4.2, a cMOOC course is structured around four main categories of activities. The diversity of these activities is essential in order to encourage learners to take control of their learning. As a reminder, the first category aims at encouraging learners to consult and aggregate a set of information. The second category focuses on stimulating learners to reflect and synthesize their acquired information. The third category aims to promote the construction of new knowledge; and, finally, the last one aims to transfer and share the resulting knowledge.

Thus, it is important to measure whether the participants have integrated the necessary activities to define a cMOOC-oriented scenario (E4). We estimated that the omission of more than 2 categories equated with a low ratio.

$$N_{E4} = \begin{cases} 1 & \text{if } val > 2 \\ 2 & \text{if } 1 \leq val \leq 2 \\ 3 & \text{if } val = 0 \end{cases} \quad val = \text{number of categories omitted}$$

In addition, we also computed the ratio of the use of generic activities (BPMN Task) versus the activities of the extended notation. We want to examine if the participants needed to use a concept to express their "pedagogical" activities, which were not provided in the new notation.

6.3 Evaluation Results

As mentioned in the previous section, to estimate the acceptance, a study based on the well-known System Usability Scale (SUS) was carried out. SUS questionnaire results were compiled in aggregate and descriptive statistics. Cronbach's alpha was used to measure the internal consistency of the questionnaire items. Values above 0.7 are acceptable.

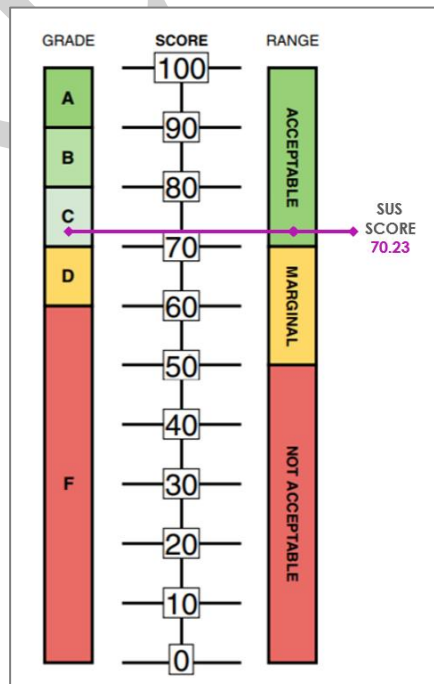


Figure 7. SUS score interpretation

The results are presented in the Figure 7 and in the Table 3. The resulting SUS Score is 70.23, which corresponds to an acceptable level of usability. As for the study of Cronbach’s alpha, we have obtained a value of $\alpha = 0.7$, which corresponds to an acceptable internal consistency of the responses.

It is interesting to look individually at the results of some of the base questions of the SUS questionnaire (Table 3). We can notice that for all negative statement we have a median < 2 . This indicates that globally, the participants disagreed with these statements. The positive statement Q3 and Q7 received the highest scores, which indicates that the participants consider that our contributions are easy to use and could be easily used by any individual.

Table 3. SUS questionnaire results

	Median	STD	Mean
Q1	3	1,3	3,1
Q2	2	1,0	1,8
Q3	4	0,7	4,3
Q4	2	1,1	2,2
Q5	4	0,7	3,7
Q6	2	0,9	1,9
Q7	4	0,9	3,9
Q8	2	0,9	2,2
Q9	4	0,9	3,5
Q10	2	0,8	2,2

In the following, we discuss the results of the responses to the questionnaire (Figure 8). The evaluation of the data collected from the questionnaire was globally positive.

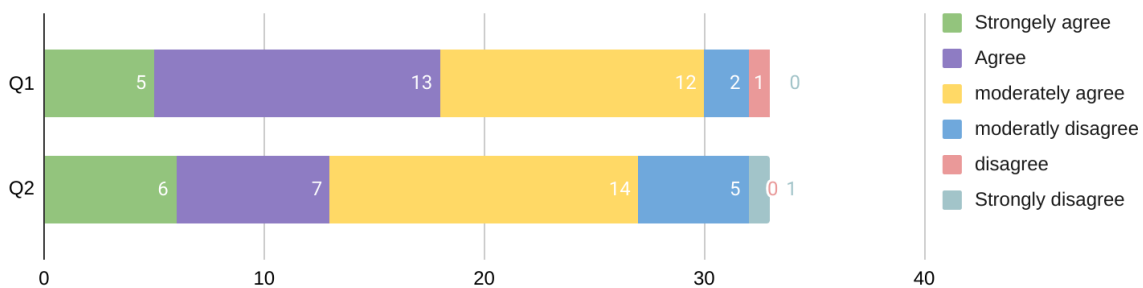


Figure 8. Questionnaire results

The results indicate that most of the participants agreed with our statements. In fact, 30 participants confirmed the toolbox offered all the required concepts to design a cMOOC-type scenario while only three participants disagreed with this statement. 27 participants stated that they were able to identify the types of activities that were organized according to the four theoretical principles (aggregating, remixing, repurposing, and feed forwarding). They were also able to easily determine their intended usage.

The final part of this section will be devoted to the presentation of the results obtained from the scenario evaluation. As mentioned in Section 6.2, the produced scenarios were collected and analyzed by us according to an evaluation grid that we have defined. We first proceeded to a general review of these scenarios. As a result, three scenarios were not retained since they did not meet the required criteria (e.g. incomplete, off-topic scenario, etc.). Table 4 shows the evaluated criteria and the average score for each criterion, for all the selected scenarios.

Table 4. Scenarios’ evaluation results

E1	Correspondence of activity titles with the domain	3
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E2	Relevance of activities and resources with the domain	2,9
E3	Number of designed weeks	2,44
E4	Use of all the concepts of a connectivist scenario	2,5

According to the results presented in Table 4, we can notice that the overall scenarios fulfill the semantic requirements of the domain. The activities, their sequencing and the resources are in accordance with the course subject.

We also observe that the majority of the participants were able to design 3 weeks of the MOOC according to the instructions (E3). The score for criterion E4 shows that some participants omitted one of the connectivist concepts when designing their week. A more individual analysis of the scenarios shows that the activity in question is "feed forwarding" which consists of sharing produced resources. Nevertheless, the participants use an explicit way for this activity, through the use of the blog and forum activity.

Finally, we aimed to calculate the ratio of the use of the generic activity. The mean of the number of the activities designed by all participants is 26 with a Standard Deviation $SD=6.3$. The analysis of the scenarios showed that the generic activities were used to bring more precision to the scenarios and were not used for pedagogical activities. Indeed, in their design, participants needed to give learners instructions for managing their learning and their workspaces. For example, they needed to be instructed to create a blog or to join a work group. Moreover, the generic activity was voluntarily integrated into the toolbox for these purposes, as indicated in Table 1. Therefore, we conclude that the ratio of using generic activity for designing pedagogical activities is equal to zero.

1. Conclusion

The importance of Massive Open Online Courses is nowadays widely established. The exponential amount of research and studies proposed in the literature are the best evidence of that. However, the lack of tools for the design and deployment of this type of courses has been raised in the literature. In this sense, we propose a visual tool adapted to this context based on the BPMN notation.

This research paper aims to develop a valid extension by applying the BPMN representation of pedagogical scenario in cMOOC context. Indeed, BPMN provides a set of generic process modeling elements that make it necessary to extend the language and notation by domain specific concepts from connectivist pedagogical approach. This paper provides an analysis of requirements of those concepts.

Based on a cMOOC oriented pedagogical scenario model, the extension needs have been identified and a valid BPMN extension meta-model is designed by the construction of a BPMN extension model. We have described in this article the technical development and implementation of the abstract and concrete syntax, and a brief description of the implementation steps into a web-based modeling tool. Further, the research addresses a relevant topic to enhance the adoption of new technologies and delivers a solution to implement business specific scenario design applications.

One of the main objectives of this research work is to ensure the link between the teacher's pedagogical scenario design and the Learning Platforms (LMS). In order to ensure this link, we had to proceed through two steps. The first step consists in proposing an authoring tool reifying the pedagogical approach and the second one deals with the operationalization of the scenario created using the authoring tool. This paper presents the implementation procedure of the first step. Namely, the proposal of an extended BPMN notation for scenario building. The reliance on the BPMN notation and its standardization aspect has allowed us to implement an artifact that enables the direct transformation of BPMN4MOOC models into learning management systems. By ensuring 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.

We carried out an experimentation whose objective is to validate the expressivity of the proposed BPMN extension to specify cMOOC oriented pedagogical scenarios. A total of 33 participants have participated in the experiment. We note that we followed all appropriate ethical guidelines for the user evaluation. In particular, we collected a consent for participating in the experiment were asked to

participant and we also anonymized all data. However, we were not able to have the experiments validated by an ethics committee because our university is in the process of setting up such a committee. The evaluation results were positive and indicate that the majority of the participants agreed with our statements. The participants confirmed that the extended notation allowed them to design cMOOCs and identify the different elements of a connectivist scenario.

To evolve the contribution of this paper, we plan on conducting separate experiments with model implementation and/or interpretation process as well as to study its impact on a real MOOC project. As part of our future work, we consider that integrating aspects of collaborative design would be valuable. Some constraints related to the mutualization of scenarios and to the management of interferences are important issues of this perspective.

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