As One Size Doesn't Fit All, Personalized Massive Open Online Courses Are Required

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Abstract. Most of the time, lifelong learners have different backgrounds, abilities, experiences and prior knowledge. This is especially true in case of MOOCs that can reach a large number of learners but the same content is proposed for learners. According to the low average completion rate for MOOCs, the "one size fits all" policy is not relevant. This paper aims to define the functional and technical architecture to personalize content in Massive Open Online Courses in a Lifelong Learning (LLL) perspective to overcome these drawbacks. The main goal of the European project ITEA 3, called MOOCTAB to create a Tablet-based platform dedicated to LLL using an on-demand cloud based MOOC platform with a personalized content. Our approach is applied on a Java course where we present the domain model modelled in the LMAP editor and the learner model for three different learners.

Keywords: Personalization · MOOCs · Learner model · Course model · Lifelong Learning

1 Introduction

Lifelong Learning (LLL) refers to systematic and purposeful learning throughout a person's life involving formal (schools) and informal (work, recreation, leisure, social relations, family life) domains [5]. The original concept of Massive Open Online Courses (MOOCs) is to offer free and open access courses for a massive number of learners from anywhere all over the world [19]. Access to and effective use of relevant information and continuously learning in MOOCs is essential for lifelong learners. LLL as a concept has gone through many changes over the years especially with the arrival of MOOCs and the increase of their learning resources. Acknowledging this, professional learning has become a central asset for MOOC providers [21]. The number of courses (started/scheduled) has grown from about 100 MOOCs in 2012 to more than 2000 new free online course every month in 2018, with a duplication of the number of courses between 2015 and 2016. However, according to [9] by the International

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Review of Research in Open and Distributed Learning, the average completion rate for MOOCs has only been about 6%. There is a growing trend of researches in the possibility of MOOC personalisation and adaptation in order to improve users' engagements, and hence reduce MOOCs' drop-out rate problem [15].

In order to understand the reason behind this low rate, we have relied on the MOOCs annual report published by the *École Polytechnique Fédérale de Lausanne* (EPFL) [20] as EPFL is one of the first universities to experiment with MOOCs, and among the few in Europe to integrate the use of MOOCs on its own campus.

The motivation that drives users to register to an EPFL MOOC varies according to the need of each learner. Six reasons are behind the registration to the MOOC: Finding a new job, getting a promotion, meeting family expectations, earning a higher salary, solving a specific problem, and helping to pass class. The "solving a specific problem" motivation is the main motivation for 60% of the courses. The academic degrees held by users of the EPFL MOOCs are very diverse. The highest degree obtained are high school, associate degree, bachelor degree, master degree, and doctoral degree. The percentage of MOOC users who are currently enrolled in an educational program is low. Only 34% of registered learners are students (including part-time students). The remaining enrolees are not in an educational program. Therefore, it is important to understand that users do not have the same background.

The diversity of users' background who followed a MOOC is a key issue [10]. For example, in the matter of the Analyse Numérique course, 34% of learners have Mathematics, Computers, Engineering backgrounds, 21% of learners have Architecture, Civil Engineering backgrounds, 12% of learners have Education and Training, 2% of learners have Business, Finance, Sales, Management backgrounds, 4% of learners have Arts, Design, Entertainment backgrounds, 13% of learners have Construction, Food, Utilities, Healthcare, Life Sciences backgrounds, and 2% of learners have Legal, Administration, Social Services backgrounds. It means that learners do not have the same prior knowledge for this course.

In this context, the motivation behind our research work is that (1) differences exist among learners in terms of background, ability, experience, prior knowledge, and (2) MOOC platforms unify the educational content to all learners without taking into account these differences. According to [14], learners' personalization and social learning are essential concepts in Lifelong and Life wide Learning contexts. The next challenge is about how to insure adaptive learning that gives each student a personal experience in a MOOC. [1] also believes that MOOCs should offer student-centred learning for effective and quality education in order to meet each individual learner's learning expectations in MOOCs. Furthermore, [12] and [11] point out that MOOCs environment is convenient for offering personalized contents and feedbacks to learners based on their learning goals. This is because MOOCs provides learning flexibility and sense of independence between learners and teachers, which are important when implementing personalization in technology enhanced learning.

This work takes place within the context of the European MOOCTAB (Massive Online Open Course Tablet) project. Its main goal is to create a Tablet-based platform dedicated to LLL (primary, secondary, higher and continuous) using an on-demand MOOC platform with a personalized content. The MOOCTAB project in-tends to offer a cloud based European MOOC on Demand platform with a Plug & Play approach deployable in Europe and developing countries. This platform is based on existing technology bricks and existing open source platforms like edX. Note that this work is an extension of our previous research paper [6].

The paper is organized as follows. Section 2 proposes the theoretical background of the study. Section 3 presents several existing solutions for personalized MOOCs. Section 4 details our scientific positioning and defines our functional and technical solution. Section 5 is dedicated to the application of our approach on a Java course. Finally, Sect. 6 summarizes this paper and presents its perspectives.

2 Theoretical Background

In this section, we discuss theoretical background directly related to the personalized of MOOC content [6].

Personalization is the process of providing relevant content based on individual user preferences or behaviour [18]. It is the explicit user model that represents user knowledge, goals, interests, and other features that enable the system to distinguish among different users [3].

In the e-learning field [17], personalization is education, where participants have different learning objectives, depending on their learning needs. The training is customized, so this is possible, and personalized instruction may also provide opportunities for differentiation and individualization. In this context, differentiation is education, where participants have the same learning goals, but the teaching method varies so they adapt to the individual student's needs. Individualization is teaching, where the participants also have the same learning goals, but participants can move forward at different speeds and relate to a particular content area or a given activity in different ways, and teaching is tailored to individual needs.

According to [7], personalization is classified in categories: Link Personalization, Content Personalization, Context Personalization, Authorized Personalization and Humanized Personalization. In this paper, we focus on content personalization. [8] defines four forms of content personalization: information filtering systems, recommender systems, continuous queries, and personalized searches. Information filtering systems screen out irrelevant data from incoming data streams and distribute relevant data items according to a user profile. Recommender systems have automated the everyday procedure of relying on recommendations from other people whenever personal experience is not sufficient for making choices. Continuous queries are issued only once and executed continuously over the database. Personalized searches are based on the observation that "to enhance user searches one needs to take into account the fact that different people find different things relevant". In our research work, we are interested in the form of information filtering systems.

To allow the personalized content, we need to model the learner. The model must depend on the learner himself and the domain which is the course in our case. The next section details existing projects on MOOC personalization. Note that we consider the personalization as a specific concept of the adaptation where adaptation is based on the personal preferences and background of the learner.

3 Related Work

In this section, we consider existing projects related to personalized MOOCs and we deduce important elements to ensure this personalization [6].

3.1 The MOOC Personalization for Various Learning Goals Project

The MOOC Personalization for Various Learning Goals project is a project funded by the Bill and Melinda Gates foundation. It aims to identify how students' goals are expressed through their activities on the edX learning platform, and how they evolve over time.

The objectives of this project were: (1) classify student learners by learning goals; (2) cluster learners by engagement with the platform, comparing various groups by learning outcomes (i.e., certificate attainment), and aiming to predict user transition from one cluster to another; (3) study how the clustering could be used for platform customization and personalization of learning experience.

This research was expected to proceed in the context of HarvardX, (Harvard's division for online learning) and to be based on the data on 17 HarvardX courses running on the edX platform, focusing on 5 courses that must be completed by December 2013. Since December 2013, there are no research papers that concern the project.

3.2 The POEM Project

The POEM (Personalised Open Education for the Masses) project aims at designing a platform that reconciles Massive Education—as with the strong development of MOOCs (Massive Open Online Courses)—with Personalized Education. According to [4], one of the important concepts that allows personalized education is the deconstruction of courses and curricula into hundreds and thousands of short independent units that will interact together as a complex system. The objective is then to get these thousands of small independent courses to self-organize into optimal pedagogical paths that allow individual students to validate curricula as fast as possible depending on their personal skills, aims and previous knowledge. POEM is developed under Creative Commons and will be as interoperable with edX. Students involve in many individual and collective educational activities for their mutual benefit: assessment, inter-tutorship and construction of dynamical Knowledge Maps of domains to provide different learning paths to learners.

3.3 The Knowledge Map on Khan Academy

Khan Academy proposes math courses with a knowledge map that makes learning objectives and individual progress available to learners. The motivation behind the map is that learners miss an overview of how all the math exercises tie in together. The concept of the Knowledge Map is behind the Math Missions in the sense that exercises build on another and basic concepts are introduced before advanced ones. This knowledge map is in forms of skill-meter (display and badges) [16]. It contains a starry night, containing all of the stars. The stars represent lessons. Yellow stars with a blue border are lessons, users are proficient at, green borders mean recommended lessons, and others are lessons that are not recommended. An orange border means a lesson a user should review. It also tells the user how skills are connected to each other. The Knowledge Map also has a navigation bar, with which students could search for a particular skill.

3.4 The ECO Project

[2] proposes the European ECO (Elearning, Communication and Open-data: Massive Mobile, Ubiquitous and Open Learning). The motivation behind this project is that MOOCs are proving to be inconsistent with the European standards for formal higher education due to their low-level of learner support and lack of an enriched pedagogical approach. This project introduces the notion of sMOOCs ("social" MOOCs) which provides a learning experience marked by social interactions and participation.

The sMOOCs are accessible from different platforms and through mobile devices and integrated with participants' real life experiences through contextualization of content via mobile apps and gamifications. It also supports adaptive learning strategies and ubiquitous, pervasive and contextualized learning. ECO sMOOCs have the potential to adapt to the changing intentions of participants during the course.

3.5 The aMOOC Project

[19] proposes an adaptive MOOC (aMOOC) platform, providing a strong pedagogical framework and a personalized learning experience in a MOOC learning environment. The aMOOC allows for different ways to organize content, offering different context and perspective for learners. It also aims to identify the way a learner would like to learn by conducting diagnostic assessments on the learning preference. It uses assessment results to provide continuous intelligent feedback that motivates and provides guidance to overcome concept deficiencies and maximize learning performance.

In this project, learning strategies are related to five learning pedagogies: apprentice (learning through mentor–student interaction), incidental (learning through case study), inductive (learning through example), deductive (learning through application), and discovery (learning through experimentation). The content of the aMOOC is presented to students based on the learning style of preference. For example, in the incidental learning study, learning happens primarily within a context of case studies. Content provided by the expert is sequenced in ways that explain the events involved in the case study.

3.6 Discussion

This state-of-the-art allows us to define important elements for our content personalization approach (Table 1): learning goals, learning experience, learning recognition, learning path, and content granularity.

Note that for clarity reasons, in Table 1, E1 refers to learning goals, E2 to learning experience, E3 to learning recognition, E4 to learning path, E5 to content granularity, P1 refers to the MOOC Personalization for Various Learning Goals project, P2 to the POEM project, P3 to the knowledge map on Khan Academy, P4 to the ECO project, and P5 to the aMOOC project.

The learning goals are a key element in content personalization. It is a very personal decision that has its roots in a social environment providing examples, discussions and opportunities. A learner has a set of realistic and achievable goals and based on these goals the content must be delivered to him. The learning experience refers to Learning by doing which takes place through on-the-job and leadership experiences. The learning recognition is important in our approach. It acknowledges achievements and constitutes certified evidence. It includes formal learning such as diplomas, certificates, and recommendations. The learning path makes learning objectives and individual progress available to learners. It allows an overview of how all learning concepts tie in together and where is the learner's current position in the learning path. The content granularity is related to the pieces of learning content that are combined to form the whole MOOC content. For example, if a content package is comprised of only a few pieces of large grained learning content then re-sequencing them to form a new learning path for another learner may not be possible. This issue is paramount in the delivery of any personalized content.

Table 1. Important elements/levels for content personalisation based on existing projects [6].

	Learning			Visualisation	Content
	E1	E2	E3	E4	E5
P1	✓	–	✓	–	–
P2	–	✓	–	✓	✓
P3	–		–	✓	–
P4	–	✓	–	–	–
P5	–		–	✓	–

These elements can be categorized in three levels (Table 1): (1) the learning level includes learning goals, learning experience, and learning recognition; (2) the visualization level includes the learning path; (3) the content level includes the content granularity.

To highlight all these ideas, we are going to detail in the next section our approach that takes into account these elements and provides innovative solutions in this domain.

4 Our Proposed Approach

In this section, we present an overview of our approach. Then we detail our functional architecture and our Domain/Learner Models before discussing the presence of our elements categorized in three levels as defined in Sect. 3.6 [6].

4.1 An Overview of Our Approach

The difference between a course completion in a classic MOOC and in our approach is the personalization of the course content.

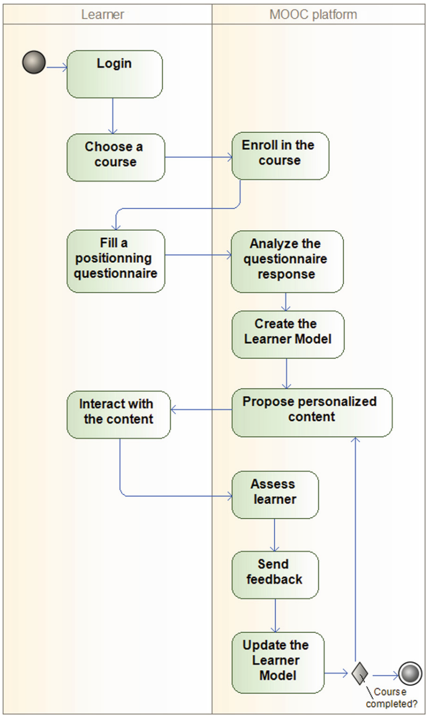

Fig. 1. The course completion [6].

Figure 1 shows how the personalization occurs during the course completion. The learner logins in the MOOC platform. He can, therefore, choose a course to take. Before starting the course, the platform asks him to fulfil a positioning questionnaire. This questionnaire is about the current professional situation, his diplomas, his certifications, and the platform permission to access to his LinkedIn profile. Once the questionnaire is submitted by the learner, the platform analyses the questionnaire response and creates the Learner Model for the learner.

Note that the Learner Model is addressed in Sect. 4.2. Based on the Learner Model and while the course is not completed, the platform proposes a personalized content to each learner who can interact with it. Then the learner will be evaluated on this specific content before updating his Learner Model.

In the next section, we will detail our functional architecture that allows this personalization.

4.2 Our Functional Architecture

Our learning architecture (Fig. 2) is designed in order to be compliant with different MOOC platform architectures. In general, MOOC platforms distinguish two main components dedicated to different steps in the course lifecycle: the Content Management System (CMS) and the Learning Management System (LMS). The CMS is used to manage students' enrolment, track students' performance, and create/distribute course content. The LMS focuses on course management including user registration, tracking courses, recording data from learners, and analysis purposes.

In our vision, we consider three main roles: the pedagogical engineer, the teacher, and the learner. In a standard course creation, the pedagogical engineer has to provide the course structure and populate it with the course content. In our approach, the course structure is becoming a part of the Domain Model (DM). We propose an LMAP editor that enables to define the structure of the Domain Model with related content and provision of potential exercises. The LMAP editor replaces the classical linear description of a course in traditional platforms while the content description does not change. When the DM is created, the course structure and content are up-loaded by the pedagogical engineer in the LMS.

When the learner will access the course, he will get personalized content through our "Course Navigation" plug-in. Content will be proposed according to his own current Learner Model (LM). He can also visualize his current progress through the LM Dashboard and point specific topics in the DM. Other MOOC activities such as forums and quizzes are maintained in our approach.

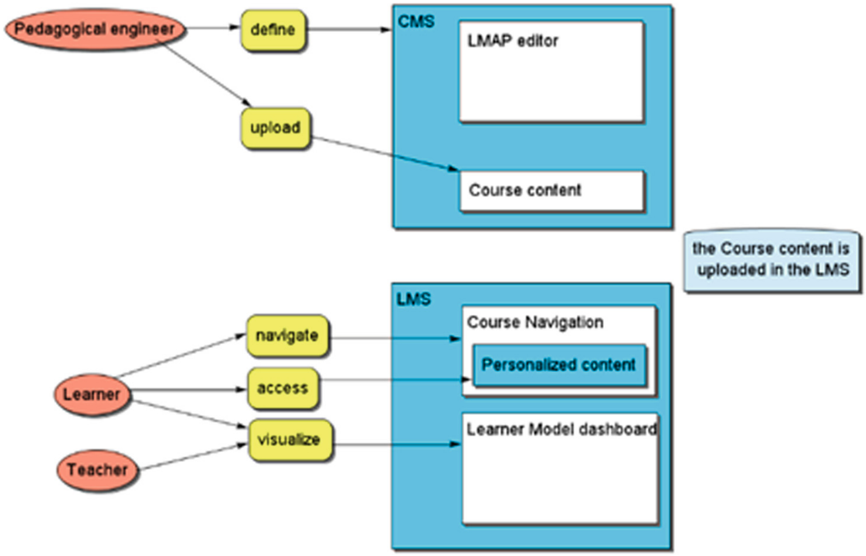

Fig. 2. Our functional architecture [6].

Teachers have standard access to learner progress and productions on the platform. They have also aggregated access to LM of the learners registered in their course.

Now we will detail the domain and the Learner Models which are main elements in our approach.

4.3 Domain and Learner Models

Our Domain Model is shown in Figs. 1 and 3. It has three layers: subject, topic, and concept. The Domain Model is composed of a set of subjects, each subject is composed of many topics, and each topic refers to many concepts.

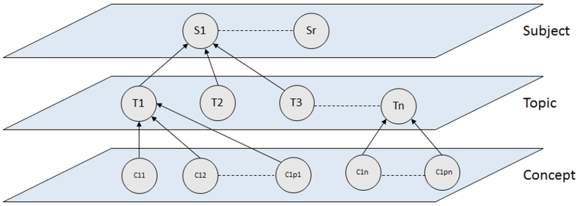

Fig. 3. The structure of our Domain Model [6].

Our Learner Model (Fig. 3) is based on the Generic Bayesian Student Model (GBSM) [13]. It is composed of two different kinds of variables: knowledge and evidential variables. Knowledge variables (K) represent students' knowledge (either declarative or procedural knowledge, but also skills, abilities, etc.). These are the variables of interest in adaptive e-learning systems, in order to be able to adapt instruction to each individual student. Their values are not directly observable (i.e., they are hidden variables). In the GBSM, all knowledge variables are modelled as binary, and take two values: 0 (not-known) and 1 (known).

Evidential variables (Q), which represent students' actions, are directly observable. For example, the results of a test, question, problem solving procedure, etc. The values of such variables will be used to infer the values of the hidden knowledge variables. In the GBSM, evidential variables are also considered to be binary, with values 0 (incorrect) or 1 (correct).

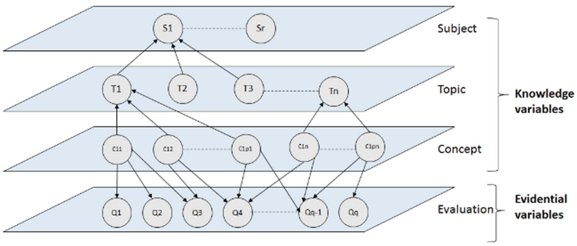

Fig. 4. The structure of our Learner Model [6].

In Fig. 4, there are two types of relationships: aggregation relationships and causal relationships. Aggregation relationships are between knowledge nodes (basic concepts, topics and subject). Causal relationships are between knowledge and evidential nodes (concepts and evaluations).

4.4 Our Conceptual Architecture

Technically, our conceptual architecture (Fig. 5) relies on three main components: the learner environment, the Learning Record Store (LRS), and the Learning Map (LMAP) core.

The learner environment is composed of different learning tools. The LMS platform is the main component of this environment. It contains the Course Navigation module that gives the learner a personalized access to content. In the learner environment, MOOCs are central but there are also other assessment platforms and social networks offering learning services.

Since we have different learning services and platforms, we need to collect learning experience and performance data from many different sources and present them in a meaningful way. That is why we choose the use of the LRS that supports the open standard, xAPI (Experience Application Performing Interface). In this way, all learning traces collected from the learner environment are transferred to the LMAP core via the LRS. Note that a statement (to be approved by the teacher) can be made by the user himself based on a certification or on a previous/current job.

The Learner Models are dynamic and must be updated. As such, we used the LMAP core to (1) store the Domain and the Learner Model, and (2) update the Learner Models.

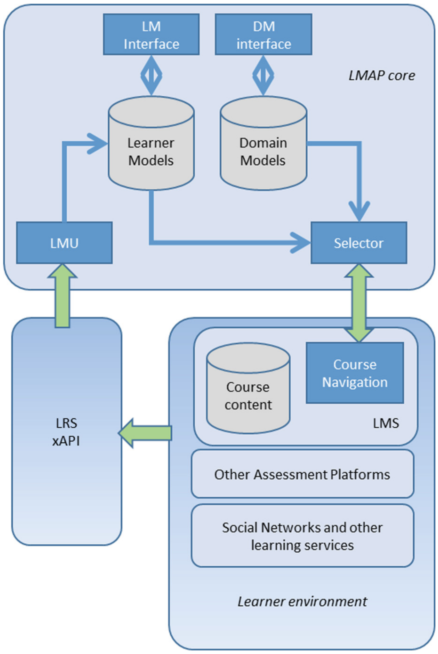

Fig. 5. Our conceptual architecture [6].

In the LMAP core, we have two main components and two interfaces. The main components are the Learner Model Updater (LMU) and the Selector. The LMU updates the Learner Model based on new assessments and learner achievements collected by the LRS. The Selector chooses the personalized content from the Domain Model according to the current Learner Model. The access to the models is provided separately by the Domain Model (DM) Interface and the Learner Model (LM) Interface. The DM interface enables Domain Models creation, modification, and deletion. It is defined for the DM editor in the CMS. The LM interface enables achievement updates, and access. It enables interactions with the learner and the teacher through LM Dashboard in the LMS.

Our first implementation is based on the edX platform, as it is the main open source platform with an active developers' community. We have developed xAPI connectors in order to collect learner traces of statements. Course Navigation is integrated by using LTI standard that permits seamless integration of external components.

As we explain in Sect. 4.3, the pedagogical engineer defines the Domain Model. The Domain Model is created via the LMAP editor which we have developed for this purpose. The frontend of our LMAP editor is based on Javascript, html, css, and svg. The backend is created using open source software LAMP (Linux-Apache-Mysql-PHP) server technology and PHP-framework Symfony 2. When the pedagogical engineer adds a new element (subject, topic, concept, or evaluation) in the LMAP editor, he needs to define properties below: the name of the element (label), its priority, the order it has in relation to other elements, its acquisition link (link to an online content), its acquisition mode, its validation link (if it exists), its validation approval, and the number of hours and weeks for acquisition.

4.5 Discussion

Our functional and technical architectures take into account the important elements for MOOC content personalization as detailed in Sect. 3.6 (see Table 2).

At the learning level, the positioning questionnaire (Sect. 4.1), the statements made by the user himself based on a certification or based on a previous/current job, and all learning traces are transferred to the LMAP.

At the visualization level, the LMAP shows the learning path of the learning and his current position in the learning path.

At the content level, we have three layers of granularity: subject, topic, and concept (Sect. 4.3). These layers are comprised of a large number of pieces of small grained learning content which allow to re-sequence them to form personalized learning paths for each learner.

Table 2. The presence of the important elements/levels for content personalization in our approach [6].

	Learning			Visualisation	Content
	E1	E2	E3	E4	E5
Statements + traces	✓	✓	✓	–	–
LMAP	–	–	–	✓	–
3 layers of granularity	–		–	–	✓

To summarize, in this research work, we propose a functional and a technical architecture to allow personalized content for each learner who attends a MOOC course.

5 A Java Course Case Study

In this section, we apply our approach on a Java course. We present the domain model modelled in the LMAP editor and the learner model for three different learners. The LMAP editor and some learner models are also shown on the following website: http://www.spoc.pro. Indeed, Immanens launched the commercial exploitation of "SPOC PRO", a cloud professional training. It is an outcome of the MOOCTAB Project.

5.1 The Domain Model of Programming Languages

The Java is a programming language. As we explain previously, the domain model is dedicated for a specific domain and its structure is detailed in Fig. 3. In our case, the domain is the programming languages. The domain is a set of subjects. In our case, subjects are different programming languages like Python, Ruby, Java, C, PHP, and JavaScript. Each subject is composed of many concepts. Figure 6 shows an extract of the domain model of programming languages. This model is produced by The LMAP editor detailed in Sect. 4. For clarity reasons, we present only some topics and concepts of the Java subject. In Fig. 5. Our technical architecture. Figure 5, the subject Java has three topics: introduction to Java, basic constructs, and OOP concept. The topic basic constructs include six concepts: primitive data types, variables and the assignment statement, how to run the example programs, input and output, floating point input, control statement (if, loops, while, for).

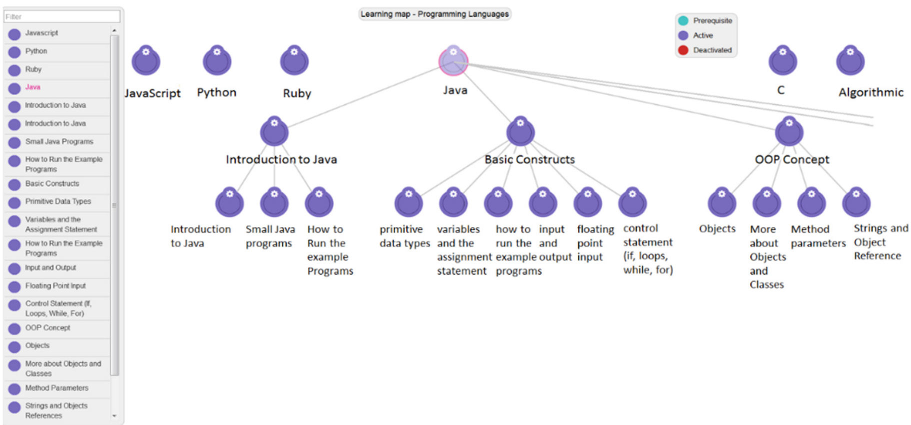

Fig. 6. An extract of a domain model in the LMAP editor. (Color figure online)

5.2 An Example of Three Different Learners

In this section, we present the application of our approach on different learners who want to attend a java course on a MOOC. Note that structure of a learner model contains also evaluation nodes (see Fig. 4). For reasons of clarity, these nodes are not presented in Figures Figs. 7, 8, and 9.

Consider the following example; Bill a Beginner in programming, Charles is a C programmer, and Elise is an Engineer who has developed skills through attending Java programming and algorithms courses.

Bill, Charles, and Elise are motivated to try our personalized content MOOC approach and they decide to subscribe to a Java course. The question raised involves discerning how initially, our approach is unable to provide any meaningful content suggestion to the three learners? This is the well-known cold-start problem.

In fact, the learner model is initiated from three different inputs:

- The positioning questionnaire (Sect. 4.1),
- A statement (to be approved by the teacher) made by the user himself based on a certification,
- A statement (to be approved by the teacher) made by the user himself based on a previous/current job.

Note that the time is a very important factor in our approach because knowledge can be forgotten with time. That is why every time the learner gives a new input, he must define when it goes back.

In concrete terms, Bill declares in the position questionnaire that he has never written a single line of code. Our platform proposes to him the full course of Java. The estimated effort for his personalized content is about 48 h, he needs to spend approximately 4 h of coursework per week for 12 weeks.

Charles owned a C programming certification from Coursera one week ago. He developed professional skills at work from various positions. Consequently, since Charles has already a good knowledge in programming, just equivalence syntax between Java & C and few exercises about the new syntax are proposed to him by our platform. Those exercises will also introduce algorithmic approach of the course, with some basic examples. Object programming will be introduced through abstract types and generalization. The estimated effort for his personalized content is about 24 h, he needs to spend approximately 4 h of coursework per week for 6 weeks.

Elise has a diploma in Computer Science. She declares that she took a Python and algorithmic courses five years ago. As a result, Elise is potentially expert in Python algorithmic but needs a refresher course in these two fields. Her personalized content starts with a short introduction to Java constructs and a focus on key differences between Java and Python with some exercises. The estimated effort for his personalized content is between 12 and 24 h, she needs to spend between 3 and 6 h of coursework per week for 4 weeks.

5.3 The Learner Models of Three Different Learners

In our case study, we have three learners: Bill, Charles, and Elise. Bill is a beginner in programming languages. Charles is an expert in C programming (certification from

Coursera one week ago) and he held various positions. Elise has a diploma in Computer Science and she took a Python and algorithmic courses five years ago. Our main contribution is that our platform takes into account these differences between Bill, Charles, and Elise in terms of background, prior knowledge, diplomas, and professional experience. That is why the three learners has three different learners Model. Learners can visualize their learner models through the Learner Model dashboard. Each element (subject, topic, concept, or evaluation) in the Learner model can have 5 statuses: Validated, pending, Unavailable, Failure, and ToDo.

As explained in Sect. 5.2, Bill needs to attend the full course of java. His learner model is based on the domain model and it is composed of all Concepts and evaluations of the Java Topic. Figure 7 shows an extract of Bill learner model. All the subjects (Javascript, Python, Ruby, Algorithmic…) except the Java are unavailable to

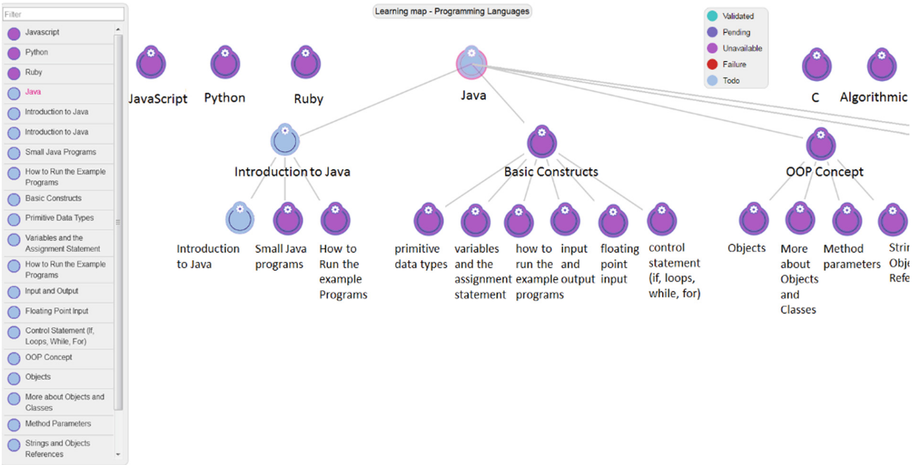

Fig. 7. An extract of Bill Learner Model in the Learner Model dashboard. (Color figure online)

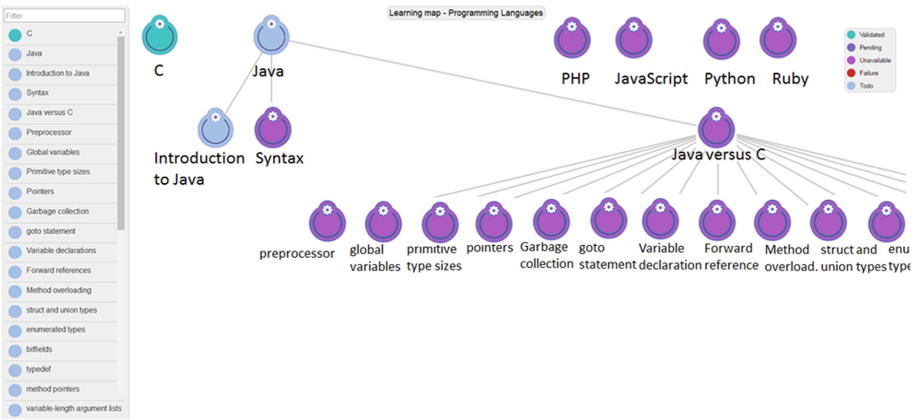

Fig. 8. An extract of Charles Learner Model in the Learner Model dashboard. (Color figure online)

him. He needs to focus only on the Java subject, he needs to learn Java concepts in order (first “introduction to Java”, second “basic constructs”, third “OOP concept” …). That is why “Introduction java” is blue (ToDo status). Once this concept is validated, it will be green and the concept “Small Java programs” will be blue.

Let us go to Charles case (Fig. 8). As discussed in Sect. 5.2, Charles needs to learn the syntax in Java and the difference between Java and C. His learner model is based on the domain model and it is composed of some concepts and evaluations of Java (The syntax and the difference with C) and he needs to start first by the introduction to Java topic before moving to the Syntax topic and finally to the Java versus C topic. This why the introduction to Java is in blue (ToDo status). The topic C is validated in his model (coloured in green).

In the case of Elise (Fig. 9), she needs to attend a refresher course about Python and Algorithmic and then she will learn the difference between Java and Python. Her learner model is based on the domain model and it is composed of some concepts and evaluations of Python (refresher course), some concepts and evaluations of Algorithmic (refresher course) and some concepts and evaluations of Java (difference with Python). She can start by Python or Algorithmic refresher course. This explains why these subjects are in blue (ToDo status). Once they are validated, Elise can move to the Java subject.

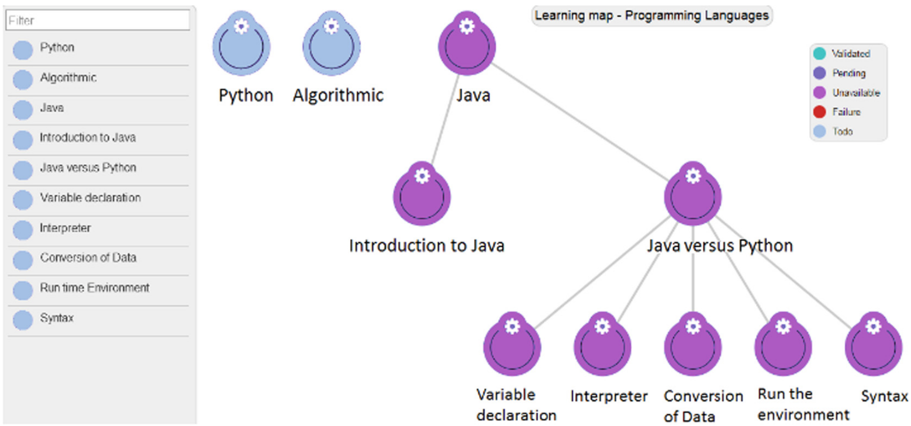

Fig. 9. An extract of Elise Learner Model in the Learner Model dashboard. (Color figure online)

5.4 Discussion

Bill, Charles, and Elise have a concept map/a graphic path indicator, these help them to visualize the structure of the domain knowledge of the course. The sequence preference in the concept map differs from a learner to another depending on his level of knowledge, his background, and his learning goals.

Table 3. Different learning paths.

	Java	C	Python	Algorithmic
Bill	Full course	–	–	–
Charles	Syntax in Java + equivalence between Java and C	✓	–	–
Elise	Java versus Python	–	Refresher course	Refresher course

For example, Elise must begin with a refresher course in Python and Algorithmic before attending the Java course (according to her personalized content).

While Charles and Bill start directly start by the Java course but with two different paths (see Table 3). Our approach therefore meets all the criteria set out in Sect. 3.6.

To summarize, in this research work, we propose a set of criteria, a functional and a technical architecture to allow personalized content for each learner who attends a MOOC course.

6 Conclusion and Perspectives

This research addresses the problem of "One Size Fit All" policy in Massive Open Online Courses for Lifelong learners. The study focuses on how to address the different learners (in terms of background, ability, experience, prior knowledge). In other words, the main issue is how to personalize content in MOOCs to the different learners and to increase the completion rate. According to the literature, no existing approach can meet our requirements to personalized MOOCs, to support of learner's level of knowledge, learner's background, learning goals, navigation preference, and the presence of a concept map for the course and a graphic path indicator. Thus, a functional and technical solution to our problem is proposed to personalized content in MOOCs and to provide more choices for learners. In others words, the goal is to increase the learning outcome and the average completion rate.

Now, we have to refine our learner and domain models and to implement them before deploying our solution in classrooms in France and Turkey for the MOOCTAB Project. To evaluate our approach, we will focus on results about the domain knowledge acquired by learners. To estimate the learning for a controlled period of time, learners will be divided into two groups: the first one will attend a course on a standard MOOC platform and the second one will attend the same course on our personalized MOOC platform. The learner selection will be based on a preliminary questionnaire to test learner prerequisites and to drive down inequalities in knowledge. The questionnaire will have to minimize knowledge heterogeneity of the two groups according to the knowledge addressed in the course. To evaluate the platform, learners' traces such as learning outcomes (i.e., course completion, course grades) and parameters related to the platform use (time spent on watching videos, on answering questions, on passing an exam) will be gathered and analyzed. These interaction data will be used to compare the various learners in the two groups. Next, we will consider how learners' interactions with the platform evolve over time to track changes in their learning goals.

To support our conceptual architecture, the MOOCTAB infrastructure (Fig. 10) relies on: (i) a web server in a cloud architecture with the role of hosting MOOCs contents and the global information system; (ii) some embedded servers hosting classroom-level information (called classroom servers or MOOCTAB Boxes) and used by teachers; (iii) tablets used by learners to interact with classroom level information and software. Synchronization processes are required between the Web server and the classroom servers, and between the classroom servers and the tablets.

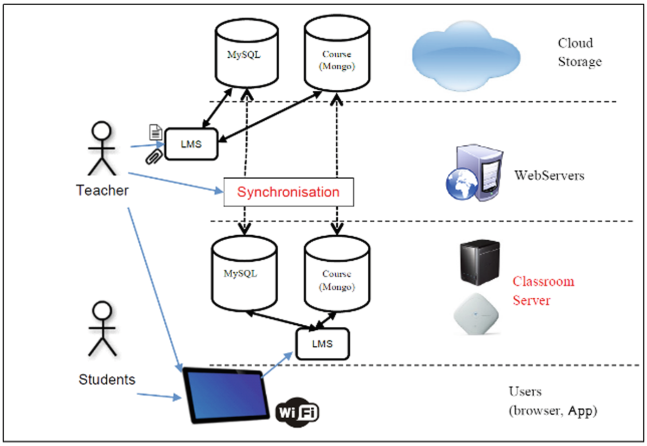

Fig. 10. The MOOCtab infrastructure.

Fig. 11. A MOOCtab Box and a card reader for authentication.

The Classroom Server of MOOCtab Box has two main purposes: (i) It is a standalone server in a classroom; (ii) a teacher can store and update courses by connecting to the cloud server. In the MOOCtab project, every student will use a tablet as learning support. To make the lessons' contents available for the students, a MOOCtab Box is used as middle support, where students and teachers can connect using their own wireless tablet.

This MOOCtab Box – an Intel NUC - (Fig. 11) contains the whole data needed for the learning sessions, and the means to authenticate authorized students. It can work out of any connection as a standalone server. The students and the teacher of a specific lesson access different resources depending on their role in the lesson. The MOOCtab Box can also be used as official support for exams. A strong user authentication is achieved by identifying and authenticating the user using her student Id card (Fig. 11). The device authentication is achieved by using a device manufacturer certificate and associated keys that are stored in the tablet secure element. These credentials enable to authenticate the device to be sure that it respects the needed configurations.

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