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MLaaS: a cloud-based system for delivering adapative micro learning in mobile MOOC learning

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Abstract—Mobile learning in massive open online course (MOOC) evidently differs from its traditional ways as it relies more on collaborations and becomes more fragmented. We present a cloud-based virtual learning environment (VLE) which can organize learners into a better teamwork context and customize micro learning resources in order to meet personal demands in real time. Particularly, a smart micro learning environment was built by a newly designed SaaS (Software as a Service), namely Micro Learning as a Service (MLaaS). It aims to provide adaptive micro learning contents as well as learning path identifications customized for each individual learner. To personalize the micro learning, a dynamic learner model is constructed with regards to the internal and external factors that can affect learning experience and outcomes. Educational data mining (EDM) techniques are employed as the main method to understand learners' behaviors and recognize learning resource features. A solution of learning path optimization is also proposed towards assembling a complete MOOC learning experience.

Index Terms—Mobile Learning, MOOC, Collaborative Learning, Micro Learning, Service-Oriented System

1 Introduction

Nowadays learners have numerous choices to use various electronic devices, whenever they want and wherever they are, to get access to learning resources. The quantity of available learning resources is also exponentially rocketing. One of the most noticeable trends in that enrichment is, along with many leading universities open up access to their courses, the massive open online course (MOOC) gains its popularity in the whole higher education sector [1]. It is an online course targeting on large-scale interactive participation and open access via the Web, which is an important supplement to the traditional distance education [2]. Using MOOC, anyone from anywhere is given the equal opportunity to attend courses and have access to educational contents that they otherwise could not afford. Till 2014, statistics show that millions of people are participating in the virtual classroom of MOOC, particularly, the number of students who are enrolled in a single course at the same time could be as high as tens of thousands [3]. The explosive growth of learning resources online leads to a revolution of education and learning, and the year of 2012 was named as 'the year of MOOC' [4]. Educational professionals have strived extraordinarily on exploring the MOOC format as a regular pedagogical approach for mobile learning (m-learning) [5]. Many universities, who contribute courses to MOOC providers, are gradually accrediting the credits gained from MOOC courses. Learners who have accomplished a series of major-related MOOC courses can fulfill the requirements of a degree from these universities.

However, as research and development of MOOC are still in its infancy, there are evidently many opportunities to improve the learning mechanisms in MOOC, such as more effective learning platforms and learning support services, to enable easier access and better experience for both service providers and learners.

In our pilot study, we investigated the development trend and acceptance of MOOC, particularly in Australia, and analyzed existing shortcomings as well as its potential improvement directions. Inspired by the observations from this investigation, we designed a mobile service-oriented system which targets on organizing a virtual learning environment (VLE) to support smart collaborative and micro learning in MOOC. In addition, we particularly concentrate on delivering learners adaptive learning resources in small chunks, which are supposed to be learnt in relatively short time duration, and sequencing these courses chunks in series as an identified learning path. Therefore, learners will be able to make the best use of the fragmented pieces of time so as to effectively engage in the MOOC learning.

Section 2 will briefly introduce the principle of MOOC, the observations obtained from our pilot study and the overall framework of the VLE. Section 3 will give the definition of micro learning and discuss the current challenges for bringing micro learning into MOOC. Based on it, we illustrate the framework of our proposed SaaS, Micro Learning as a Service (MLaaS) in Section 4. Learner modelling and resource delivery for micro MOOC learning and an educational data mining (EDM) are provided in Section

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5 and Section 6, respectively. Section 7 will present a learning path optimization solution and Section 8 will talk about proposed evaluation approach. Finally Section 9 will conclude this paper.

2 Background and Preliminary Work

2.1 Background and Pilot Study

Online learning through Massive Open Online Courses (MOOC) is one of the latest technologies in the field of education. MOOC, as an emerging technology, is evolving into new pedagogy to benefit both teachers and students. It is offered free to students of any age group and also works on an open network learning model. It enables participants to be connected beyond the traditional learning environment, thereby offering autonomy and openness. As the growing trend of encouraging connected learning among students, it is needed for teachers to participate in an online course. Connected learning indicates that learning can happen outside classroom and through online networks and interactions [6]. Learning can take place informally by taking part in webinars, attending workshops, listening to Podcasts. This shows very clearly that a 21st century educator has to be well connected, in order to prepare students for their career. It is suggested that educators' participation in MOOC would help them encourage their students to effectively use their digital literacy for learning.

MOOCs place significant challenges for what is becoming accepted as mainstream practice in learning analytics. As MOOCs is a widespread yet very new phenomenon, there is not yet a substantial body of literature on the learning analytics of MOOCs. There is limited analysis of MOOC data [7]. This study intends to identify the features of MOOC that may influence the Australian educators and to develop a better understanding of how higher education institutions as MOOC providers can inspire learners in order to increase their performance. We have conducted a survey to collect views regarding MOOC development and utilization from educators and practitioners in leading Australia education institutions. We are mainly interested in the benefits of MOOCs for Australian educators, and how we can encourage the Australian educators to use MOOCs. Using typical statistic methods to analyze their feedback, the main findings can be summarized as follows:

- Educators' intention is to continue using MOOCs.
- MOOCs have high importance regarding facilitating the presentation of online learning.
- MOOCs have low importance regarding providing instructors to learners.
- MOOCs have low importance regarding facilitating the instructions between collages.
- MOOCs have high importance regarding reuse of materials.
- MOOCs have low importance regarding automatic integration of results.
- MOOCs have low importance regarding free learning options.
- It is very important that within MOOCs educators do not provide enough support to students.
- It is very important for educators that MOOCs do not let them have face to face interaction with students.
- It is not very important for educators that within MOOCs they cannot use perfect course design.
- MOOCs have high importance regarding mastery learning
- MOOCs have high importance regarding blended learning.

Details of the pilot study can be referred to [8]. Among these findings, a noticeable future of MOOC is mastery learning. In mastery learning, students demonstrate the understanding of a concept through repeated assessment and exposure to material before moving on to the next lesson [9]. In many traditional classes, if a student attempts a homework assignment and does not do well, he or she simply gets a low score on the assignment and instruction moves to the next topic, providing the student a poor basis for learning the next concept. The feedback is also often given weeks after the concept was taught, by which point students barely remember the material and rarely go back to review the concepts for better understanding. However, in the MOOC, the technology makes it easy to provide immediate feedback on concepts students do not understand. In many cases, Australian educators can provide randomized versions of the same assignment, so that a student can restudy and reattempt the homework. According to [9], the instructor's tools are designed to facilitate the use of question banks with extensive randomization. This strategy is aligned with general aim to leverage technology to support effective pedagogical approaches.

Another important factor for educators is the ability of blended learning. Blended learning (the strategic combination of face-to-face and online learning experiences) is growing in popularity within higher education and is a new educational model with great potential to increase student outcomes and create exciting new roles for teachers [10]. The Centre for the Support and Advancement of Learning and Teaching in Australia helps academic staff implement blended learning strategies into their courses and programs to enhance the students 'experience and the quality of learning and teaching. With this new technology, teachers no longer have to begin from scratch if they have a desire to teach using a blended learning model. With the recent explosion of digital educational resources, it is feasible to examine free resources, research the use of a learning management system and be prepared for potential setbacks in the road on the blended learning path [9]. These ways can help a teacher dive right into blending learning.

2.2 Mobile Learning in MOOC

Without a doubt, mobile learning is getting extensive acceptance by learners and gradually becoming a major learning means [11] [12]. The benefits of m-learning are well studied in numerous researches. As a result, most MOOC providers promptly released their mobile apps on mainstream mobile OS (i.e. iOS, Android and WP8) and

adapted their webpages to adapt the screen size and operation mode of mobile devices in order to catch the trend of m-learning and enable more convenient use for learners.

MOOC providers try to popularize their courses and affiliated educational productions at full stretch. They are spreading out their available learning resources everywhere all around the world and they are leveraging m-learning to enable learners to easily participate in learning activities regardless the restriction of time and location. However, they are still and often at loss. More specifically, although these courses can have a large number of learners enrolled at the very beginning, it is found that they gradually quit halfway. Researchers intend to look for the reasons why MOOC cannot fascinate learners throughout the overall process of course learning in MOOC and what elements make the journey feel long and tedious.

As a key concern, MOOC is currently suffering from low completion rate, with several sources indicating that about 5% to 15% of participants finish the courses on average while most learners who enrolled in MOOC courses ended up dropping out [13]. However, some authors suggest that dropout statistics might not be representing the only reality of MOOC learners. This is because different patterns of student behavior exist, and analyzing further each participant's objectives can provide additional insight into the different personal goals when attending a course besides finalizing it. Therefore different measures should be available in order to evaluate whether MOOCs are effective for individual participants [7]. Arguably, this is mainly because learners fail to conduct effective time management, so that they are suffering from time consuming and conflicts with their real life responsibilities [13]. Another crucial factor is believed that learners deem it is not easy to find appropriate resources they want, or the chosen resources do not match their expectation. They simply give up and look for substitutes, and some of them repeatedly enroll to try a new course until they eventually find their preferred ones [14].

The third reason is that the types of learners engaged in MOOC courses are more comprehensively diversified [15]. Some MOOC learners do not have a concrete aim to complete an entire course as to get the credits, because they just want to acquire the specific knowledge they actually need. Such knowledge are often enclosed in small course units or passed on during phases going by midway of the course delivery. Therefore, once they are satisfied with the progress they have made, they are possible to quit while leaving assignments or tests unfinished [7] [14].

This can explain why m-learning in MOOC appears distinct from its traditional forms and modes in on-campus and distance education. MOOC teaching and learning highly rely on connectivism. Teamwork, collaboration, communication and peer-to-peer learning are of attached important educational value in MOOC. However, despite the advantages of mobile cloud-based learning and forthcoming mobile apps, learning resources for non-mobile devices cannot be directly adapted to mobile devices due to their indeterminacies of context, such as unpredictable network bandwidth, and specificities, such as different operation systems. Learners may be at their wits end to choose which courses to learn at first or next when there are many options to be considered. In addition, enhancing learners' teamwork performance in collaborative learning plays a significant role when MOOC learners are achieving their learning objectives as a group. How to enhance learners' teamwork performance comes down to a variety of pedagogical concepts and is scarcely supported by any Web based tools. Hence, some researchers are very concerned that open online courses may not reach its promises because many aspects of traditional classes, such as small-group discussions and face-to-face time with instructors, would not work in the MOOC format [7]. Moreover, it is found that learning activities are off and on frequently during the progress of MOOC course and many learning activities are completed within fragmented pieces of time. In other words, their learning processes become fragmented or of micro size. The reasons for these phenomena come from many aspects which we will illustrate in the section 3.

2.3 Comprehensive VLE Framework

Having investigated the feasibilities to improve the resources delivery and learning experiences of MOOC, and the potential benefits of leveraging cloud computing, we are inspired to design a comprehensive cloud-based system, which builds a VLE to have both learners and instructors engaged in through mobile devices. As shown in Figure 1, it consists of a couple of Software as a Service (SaaS) and three functional Web services. All services and applications in the VLE will work in conjunction and be deployed over a cloud infrastructure to borrow the strong computing capability and massive storage space so as to offer learners a one-stop interface with transparent, hence easier, operations and lesser software and hardware requirements.

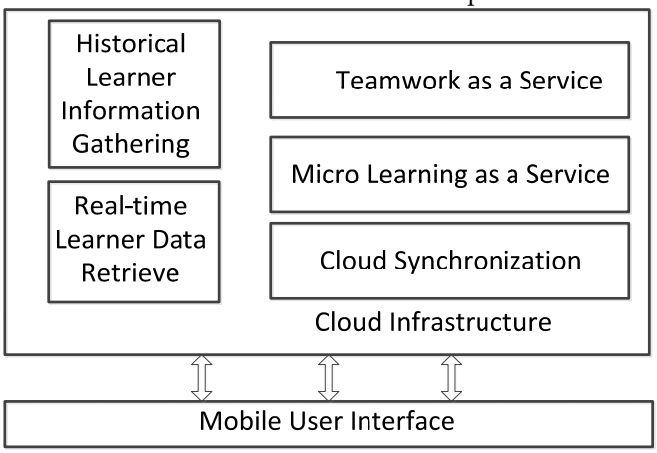

Figure 1. Framework of Mobile VLE for MOOC

Combining the features of the mobile cloud environment, where applications are normally interoperable and platform independent, a feasible way to realize the whole teamwork-enhanced learning process is to orchestrate a learning flow, including time sequences, logical relationships, connected patterns and occurring conditions of various learning activities. Learning flow refers to the formal description of a set of rules and the process during which the learning activities occur or change. A completed learn-

ing flow blends all activities together to form a suitable process.

A teamwork-enhanced learning flow is realized by one SaaS, named Teamwork as a Service (TaaS) in the VLE. In the learning flow, which is shown as Figure 2, the activities of 'proceeding team learning' is divided into five sub-activities, each of which will be in charge of one new web service of TaaS. These five Web services can be executed sequentially to form a whole suitably collaborative learning process.

In particular, the Survey Service offers the workaround for covering the unstable communication condition of mobile environment in order to ensure learners are able to know about one another; the Jigsaw Service organizes efficient discussions among learners; the Bulletin Service allows learners to clearly plan for their team assignments; the Monitor service provides mutual supervision among learners while the teamwork is in progress. Moreover, because rational grouping is an important premise for each team of learners to perform better [16], the Inference Service allocates each learner to a specific subtask in regard of their learning styles and preferences, while the learners working towards the common task therefore form as a competitive team.

As a part of the whole VLE, TaaS has been developed and implemented over a typical cloud infrastructure, Amazon EC2. Five web services in TaaS can be de-coupled or re-coupled according to specific teaching demands, although it is recommended for them to be utilized as a whole to add a complete set of functions to legacy LMSs. Particularly, as TaaS has its own user interfaces and can work as plug-and-play, it will maintain its own full and independent registration and administration mechanisms.

The details of TaaS has been presented in [12], including a genetic algorithm enclosed to discover computational choices of grouping strategy [17]. In this paper we will focus on the other SaaS, namely Micro Learning as a Service (MLaaS) which will be introduced in the rest of the paper.

3 Micro Learning in MOOC

3.1 The Popularity of Micro Learning in Taking MOOC Course

Standard models of m-learning, whether they are instructor-led or computer-based, look very much like college classes, where learners are taken out of their normal work or living environments to spend four or eight or forty hours "learning" stuff which they may or may not encounter in their day-to-day lives. But standard models are quickly being swept out the door by the learning methods that do take place inside the normal work environment, but right smack in the middle of it. This has resulted in a new interest in micro learning, which is essentially any type of learning carried out in very short bursts of period. Digital learning environments, like MOOCs, can actually provide frameworks for a wide variety of micro learning activities.

From a research [18] which analyses the time lasting for young learners' attention in m-learning, the results show that when proceeding m-learning they frequently interrupt their learning activities and transfer their attention to another thing, so that their attention spans are often limited in 15 minutes.

In addition, by analyzing 6.9 million records of video playing, edX found that the videos with a time length less than 6 minutes are more attractive, while students' engagements drop sharply after 6 minutes [19] [20]. Regardless the exact length of the videos, the actual median value of viewing time is 6 minutes. In addition, 6-9 minutes for which some videos last are in the inflexion, while longer videos have less median values of viewing time.

Hence, according to available studies to investigate MOOC's learner behavior tracks, it is not surprising that MOOC actually follows the principles of micro learning and even MOOC is typically designed around the principles of micro learning enabling learners to go through bytes of learning in short duration [19] [20]. For instance, some course materials have been chunked and sequenced from the simple to complex in order to enable faster processing by students. The units ideally do not exceed 15 minutes. One popular way to link two micro course units is to add a simple assessment, normally in the form of quiz, true/false questions or multiple choices, between them [21].

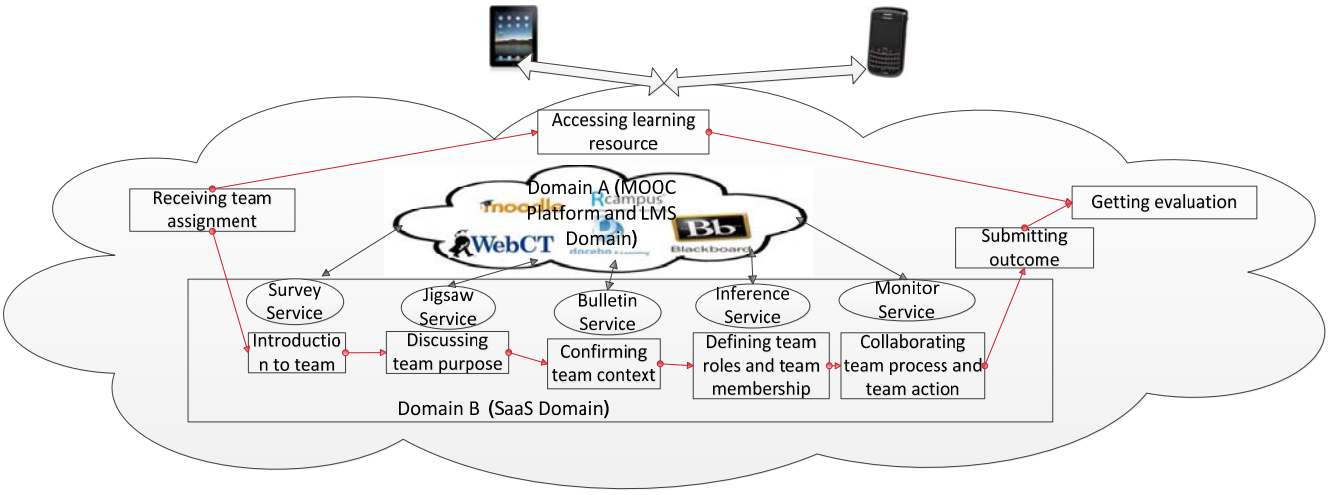

Figure 2. Teamwork-Enhanced Learning Flow for Mobile Cloud-based Learning

3.2 Definition of Micro Learning

Micro learning can have positive effects on mastery learning and be an important part of blended learning [22] [23]. It can help learners make use of every fragmented piece of time to participate in learning activities in very short terms. Compared to accomplishing a course chunk with one or more interruptions, this can lead to positive effects for them to acquire targeted knowledge [24]. Learning in small steps (contrary to the traditional approach of learning through hour-long courses) is made possible with the aid of small and well-planned chunks of units or activities. Thus micro learning becomes short-term, digestible, and easily manageable [25]. Micro learning also adapts to the constraints of the human brain with respect to its attention span. It is also supposed to align with research that proves people learn better when engaged in short, focused sessions, than hour-long sessions that cause information overload [26].

In literature, "micro learning" processes cover a time span from a few seconds (e.g. in mobile learning) to up to 15 minutes or more. Another explanation of micro learning is suggested as: 'micro learning refers to short-term learning activities on small learning units. In the contemporary mobile/web society, micro learning pertains to small pieces of knowledge based on web resources' [25]. Compared to the traditional hour-long e-learning, micro learning features higher flexibility, and it can be in various forms, and, more importantly, it has less time limitation. In other words, it can be started anytime, whereas it may also be terminated anytime.

In mobile learning, learning activities occur for learners' conveniences, regardless the location and time. By this means, learners can get access to learning resources within various scenarios. With mobile devices, quite often learners accomplish learning missions in a short time period. According to the study conducted by [27], micro learning can be an assumption about the time needed to complete a relevant learning task, for example answering a question, memorizing an information item, or finding learning materials. Hence, micro learning booms with the wide use of mobile devices, and it becomes a major learning means in mobile environment. Micro learning shares some similar specialties with mobile learning as they are both individually referable, self-contained, reusable and re-mixable [28] [29].

Australian educators use different kinds of multimedia to make the courses more comprehensive, help learners understand more effectively. The contents of courses can be reused among different courses. On the other hand, these popularly used course materials are in the form of visual information, while educational micro content is suggested to be in the similar form, which may consist of a text, a video, an audio, a picture, a graph, a drawing, a photo, etc. [30]. Mobile learning and micro learning go hand in hand. People are using their mobile devices more and more in the workplace, for communication as well as for finding answers to questions. It brings learning to employees while they are performing their daily activities, rather than requiring them to leave their work environments. Micro learning resources can be made available on-demand to facilitate just-in-time learning [31]. These small learning bytes not only aid quick assimilation but also make it possible to learn on the go, thus reducing the dependency on a fixed time slot or the need to take a large chunk of time out of one's working day [20].

As micro learning evolves, micro-content delivery with a sequence of micro interactions enables users to learn without information overload [32]. It is a key technology to ensure better learning results in terms of retention of propositional content [25].

On the other hand, as stated in the Section 2, MOOC emphasizes collaboration and connectivism [33] [34], where learner-generated contents are also of attached importance in MOOC delivery. It is believed micro learning is an efficient way to carry out problem-based learning and exchange just-in-time feedback. MOOC also provides essential basis for life-long learning. The learn-as-you-go mode of micro learning makes people feel free to acquire any particular knowledge they need or are interested as soon as they want [25]. If they do not have a necessary demand to get credits from MOOC providers, by micro learning they can still easily get through specific learning content without finishing the entire MOOC course. By this means, micro learning can lead to better integration across disciplines in MOOC.

3.3 Research Challenges

MOOC practitioners have already made much effort to enable MOOC courses resources being workable in micro learning circumstances. For instance, some course materials have been chunked and sequenced from the simple to complex in order to enable faster processing by students. One popular way to link two micro course units is to add a simple assessment, normally in the form of quiz, true/false questions or multiple choices, between them. However, so far these trials have not been extended in large-scale MOOC deliveries.

Fragmented learning with mobile devices requires learners' concentration and reflection. However, being on the go (riding a train, sitting in a cafe, walking down the street) is fraught with distractions. Students are often found themselves in situations with unpredictable but significant annoyances on their attention. This leaves the mobile learners with a highly distracted, and at the same time, highly fragmented learning experience.

MOOC appeared along with the big data era. Statistics show that the number of online courses reach tens of thousands while the course modules affiliated to them rocket to millions. As a consequence, the operation of MOOC generates a huge amount of data about the learners, courses, educational institutions, networking, and technical details and so on. It could be very difficult for learners to quickly choose the preferred and suitable course chunks in a timely manner. Since the acquirable learning resources become massive, how to set and select the right and appropriate objectives, which stand out from the numerous available resources, brings a challenge for both MOOC providers and customers.

In addition, there are studies indicating that personali-

ty and learning styles play significant roles in influencing academic achievement [7]. As learners commonly do not have sufficient expertise in customizing learning schedule for themselves, and perhaps they are not familiar with their own learning styles, there are high probabilities that they cannot access to the right sets of micro content. This can affect them to achieve satisfactory learning outcomes though a lot of time might be spent.

In the current situation, learning resources are generally divided and wrapped up by education providers or courses lecturers. It considerably lacks flexibilities to fit every specific learner's time availability so that learner should get accommodated to the time length of course setting and manage to squeeze time to accomplish those learning activities. At present, as far as we know, researchers and practitioners have not investigated the learning resources adaptation in the micro learning circumstances. Our pilot work developed an adaptive mobile learning system prototype, but it cannot go deep into in-progress courses [35], which mean learners can be allocated with appropriate learning resources for an entire course, but they should prepare for themselves a detailed schedule and plan their time carefully in a comparatively long period, without personal guidance. Therefore, bringing micro learning into MOOC still exposes a huge research gap to fill.

Moreover, it is insufficient that learners only have micro learning contents adapted to their own needs by using our proposed system. This is because there would be sequences of contents suggested for them to learn in order to achieve better learning outcomes. Personalized curriculum sequencing is an important research issue for Web-based learning systems because no fixed learning paths will be appropriate for all learners [36]. Most online MOOC platforms often demand the prerequisites between course modules and/or some relationships between involved concepts to be explicitly provided by the course instructors, so that an optimizer can be ultimately used to find an optimal learning sequence of the involved concepts or modules for each individual learner after considering his/her past performances, profile, and learning styles. However, relying solely on the course instructors' input on the relationship among the involved concepts can be imprecise due to the individual biases by human experts [37]. Furthermore, the decision will become more complicated when various instructors hold conflicting views on the relationship among the involved concepts, which may hinder any plausible logical deduction [38].

3.4 Motivation

By investigating current research gaps and challenges, and considering the natural of mastery learning and blended learning of MOOC, we are motivated to propose a study to introduce adaptive micro learning into MOOC learning scenarios to tackle the following problems:

- Given learners are using micro learning mode in random and self-regulated manner, we aim to provide them a smart environment to be smartly engaged into MOOC learning via mobile devices, according to their current time availability.
- This study is looking for a solution to provide learners appropriate learning resources from the huge pool where massive courses and affiliated contents are available. This new approach can be used either for learners who wish to complete an entire course to get credits, or those who just acquire the specific knowledge they actually need.
- For the former learners, this study structure knowledge points/course units in series to assemble as entire learning experiences. For low completion rate of MOOC, they are able to make the best use of every fragmented time pieces so as to conduct effective time management.
- For the latter learners, who are often quit halfway once they are satisfied with their learning achievement, the proposed approach also looks through and compares all course units provided from different education institutions and further places their demands accurately in or across parallel resources. This enables them to gain their task-related knowledge or get skilled training in a short time.

4 System Design for MLaaS

In this paper, we attempt to employ both design science methods to overcome the above challenges so as to deliver learner customized learning resources, in the form of small chunks or fine-grained units. Optimally learners can easily complete the learning process of each unit within fragmented pieces of time. For example, a learner may spend normally 15 minutes on his/her way home from work by train, and s/he prefers to use mobile devices to learn a piece of MOOC course within this time. In this case, an ideal course module delivered to him/her should be limited in the time length (e.g. 15 minutes) to ensure a micro but complete learning experience.

The framework of the proposed SaaS, Micro Learning as a Service (MLaaS), is shown in Figure 3.

The Learner Modelling Service aims to build a specific model for each learner, on the basis of his/her historical information and ongoing learning behavior. Learners' basic information about learning styles, preference and learning purposes is gathered from the Historical Learner Information Gathering Web service in the VLE. Based on these data collections, this service assesses the pre-knowledge level for each learner and marks up these features by a set of measurable variables. It is also provided with a function, which tracks learners' behaviors during micro learning process and ensures their models being kept up-to-date once new data are detected or generated.

The Learning Resource Representation Service stores all representations of the available micro learning resources. It extracts course modules from well-developed MOOC courses. Based on their time lengths, they are categorized into micro learning resources (less than 15 minutes) and non-micro learning resources. Referring to the results of EDM, these longer course modules are cut off programmatically and encapsulated into small units

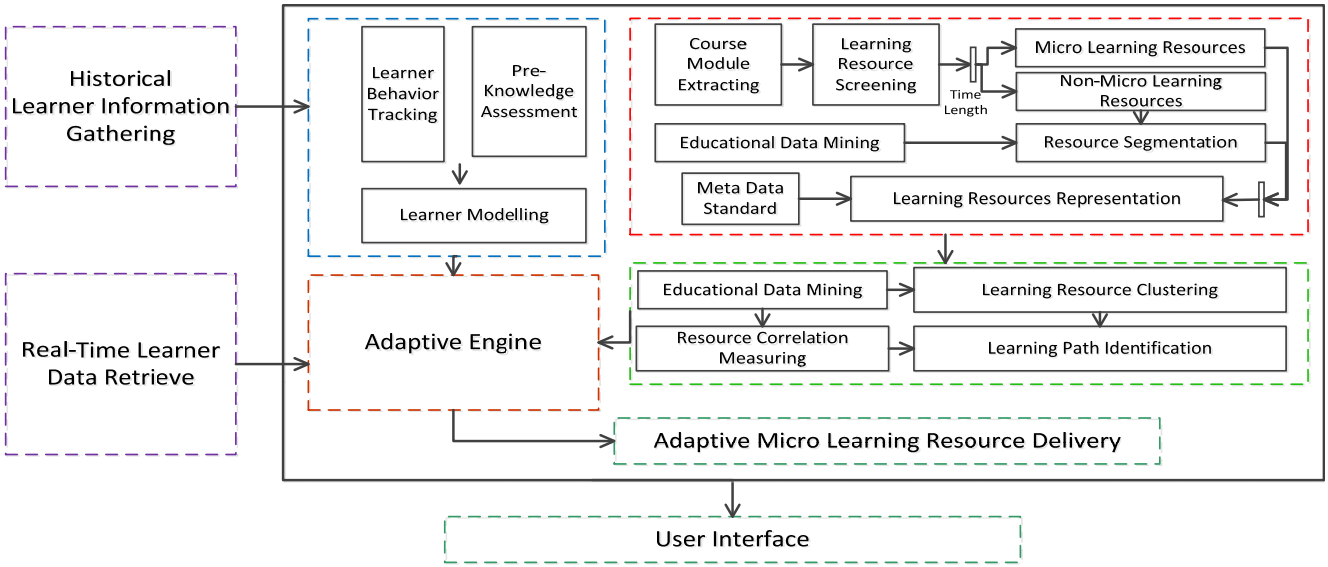

Figure 3. Framework of MLaaS for MOOC

with reasonable time lengths. As this module holds a metadata repository, a metadata standard for describing micro course units is going to be established semantically [39] [40]. According to this standard, all learning resources are represented in terms of discipline, key words, time length, language of instruction, popularity, difficulty and so on [39]. Data related to good-quality and mostly-followed/discussed learner-generated content, can be refilled into Learning Resource Repository in order to support peer-to-peer learning in MOOC [40].

For MLaaS, the Real-Time Learner Data Retrieve Service retrieves learners' real-time data, including their learning progress and current time availabilities (how many minutes they prefer to use in the moment).

Furthermore, in the Learning Resource Repository Service, selected course modules are clustered using text/data mining technologies. This service also measures correlations among chunks, or, if feasible, derives correlations from existing MOOC course modules. It helps to set learning start point and exit point and it also distinguishes the suggested sequences of learning resources and identifies a learning path among them.

Taking inputs from all the above services, the Adaptive Engine acts by providing learners with customized learning resources, which can match their current micro learning context, personal demands, learning styles and preferences. It is the core of the proposed system, which embeds machine learning technologies to realize the adaptive mechanism [35] [41].

The MLaaS will also expose its functions over the mobile Web with standard service oriented architecture specification, and it is interoperable with other SaaS and Web services in the VLE.

5 Micro Learning Learner Modelling

5.1 Learner Model for Micro MOOC Learning

The data generated along with the proceeding of MOOC courses represents learners' behaviors is longitudinal and fine-grained. It is not difficult to track, monitor and record the entire process of a learner who takes MOOC courses, however, reporting them visually and statistically in order to reveal each learner's learning story is more crucial. This plays a significant role in conducting study ratiocination, judging learners' study status, estimating learners' study progress and carrying out learning strategy decision making.

Finally, a dynamic learner model for micro MOOC learning can be established by using these screened and sorted data [42], according to their historical and real-time data. This is the aim of the Learner Modelling Service.

As shown in Figure 4, the learner model consists of two domains of factors (i.e. internal and external), while the internal factors can be classified into personal intelligent and non-intelligent factors. Some components can fall in the intersection of two domains which means these components are multi-correlated to two factors. Also, a component can be overlapped with others which suggest that they are associated and mutually affected.

5.2 Components and EDM Scheme for Micro Learner Modelling

To understand the specific learning pattern of each learner from huge amount of data tracked from daily MOOC usages, EDM is the key technique we employed to explore the common shape and trend of micro learning and set the basis for subsequent adaptation mechanisms. Therefore, how to carry out the EDM as well as what we expect to obtain from the EDM are the major contributions of our research. The data collection for building learner model can be realized in two ways: mandatory request and automated extraction. The detailed learner features and learning context we intend to explore through EDM are listed as follows.

5.2.1 Personal Non-Intelligent Factors

Learner Types

The types of MOOC learners vary evidently in accordance with their particular learning purposes and work,

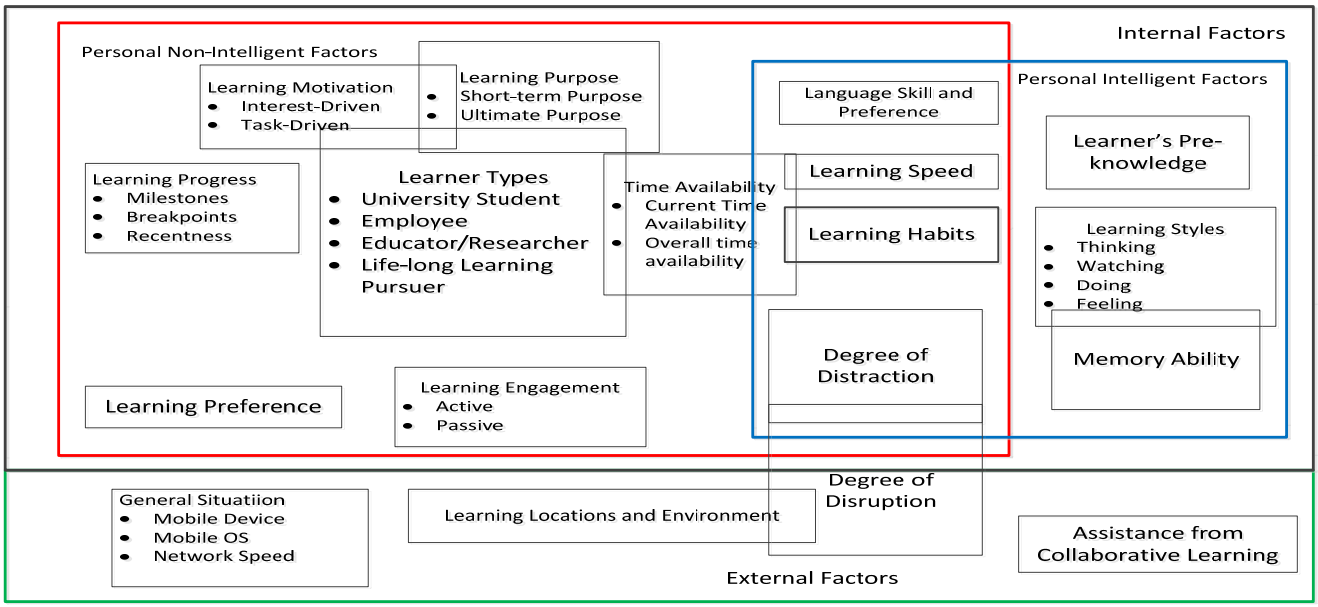

Figure 4. Personalized Learner Model for Micro MOOC Learning

learning and life patterns. Their background information, though not always, can be searched from their registration and logon data [15] [43]. Some common types are:

- Full time students in universities who prefer to learn distantly and electronically rather than attend lectures in person. They are willing to enjoy the convenience brought by smart and portal devices.
- Full time university students in developing countries where education is lower-developed. Because of scarce learning resources from their own university, MOOC gives them greater opportunities to remotely participate in classes provided by leading universities so that they can make step forward their daily learning and appreciate the advanced knowledge management and teaching approach.
- Educators who work in universities in developing countries. They take MOOC courses to obtain experiences from leading universities as well as learn how to teach in an efficient way to improve their own teaching approaches and flows.
- Researchers who are following up the flow of MOOC courses to explore potential defects in them which result in barriers for learner to get knowledge passed on. Their goals are to refine the current MOOC teaching flows and to look for enhancing teaching approaches in a virtual manner. During the progresses when they are engaged in MOOC, pauses are frequently made and several specific sections of courses are retrieved repeatedly in terms of research demands.
- Employees who are required by their corporations or organizations to take MOOC courses for training purposes. Commonly they have concentrate timeframe to complete MOOC courses. Their overall learning schedule is driven by their trainers and they have freedom to complete their allocated tasks continuously and arrange their time for each specific course units in place.
- Employees who wish to enrich their knowledge or improve their skills by taking MOOC courses in their off-work hours. Their final target is to become more competitive in workplace and they are generally self-motivated. So they set targets and milestones for each learning period by themselves with relatively more freedom and autonomy.
- Life-long learning pursuers. They can be employees whose learning contents in MOOC courses may not be closely related to their daily work, or they may be non-working persons such as housewives, elders or retired people. Generally these kind of MOOC learners are interest-driven.

Time Availability

EDM performs to clustering similar learners into a cohort. Their disposable time varies to a great extent, which is highly indicative for whether and how often these learners would adopt micro learning modes.

Their current time availability is a mandatory request for them to input before they start each micro learning activity.

Learning Engagement

The study [20] argues that the more engaged learners got higher marks in their MOOC courses. Much of their findings depend on analyzes of students' participations and publications in the education forums provided with MOOC platforms. They state that more engaged learners show more frequently in forums and are very positive to raise questions and attract other learners' interests to join their discussion regarding learning content. It does not mean they lower-performing learners contribute less in forums to seek useful advices and experiences, while the lowest-engaged learners even do not appear in the forums.

Past studies such as [22] and [44] use quantitative methodologies to identify individual learner's engagement in

MOOC and categorize them into cohorts with different ways. However, there isn't a unique definition for the extent of engagement of a learner. Mainly it is measured in terms of a learner's total online time length, frequency of logon, submission of required assignments, participation in forums, completion of courses or course chunks, etc.

Learners' engagement can also be categorized into active or passive learning. The former refers to that learners are self-motivated to attend virtual classes in MOOC platform so that they look for and initiatively access MOOC learning resources, which they need when they want; while the latter refers to that learners act as recipients of knowledge through information pushed by MOOC platforms or MOOC affiliated social medias, for example, they might have subscribed electronic reading materials.

Progress Identification

This is basically identified by breakpoints and milestones made by learners. In micro MOOC learning, learning activities become disperse, and the content in two continuous learning phases can be not rigidly restricted in accordance with the sequences in the course curriculum. For this reason, EDM has another significant duty to retrieve back to learners' latest learning content and activities in order to profile a learners learning recentness. Recentness is not confined into particular time points. The recentness of learning categories can be extracted automatically.

Learning Motivation and Purpose

Basically in MOOC learning learners are either interest-driven or task-driven. There learning purposes are identified by mandatory request data which means learner are suggested to input their learning purpose prior to the commencement of their MOOC learning.

Learning Preference

Learning preference refers to learners' subjective and affective opinion about learning content. It can be sorted out through learners' comments and tags made on resources they have accessed.

5.2.2 Personal Intelligent Factors

Learner Pre-knowledge Assessment

To build a profile for each learner and customize micro learning strategy for learners with different backgrounds and basis, a measure that is necessary to take in prior is to assess each learner's knowledge in terms of several standards. In micro MOOC learning, it is suggested to investigate and identify their pre-knowledge level in terms of the extent of their education, their historical courses grades in MOOC, and results of pre-course quizzes which are easy to be quantized.

To build a profile for each learner and customize micro learning strategy for learners with different backgrounds and basis, a measure that is necessary to take in prior is to assess each learner's knowledge in terms of several standards.

A typical measure adopted by many e-learning systems is the pre-knowledge assessment [45] which refers to taking exams before learners commencing their courses. Although this is common to organize in on-campus course, it is not feasible to directly migrant this into micro MOOC learning as learners are more distributed and on-the-go.

For the EDM purpose, it should be taken into account that the outcomes of the pre-knowledge assessment are easy to be quantized. Hence, in micro MOOC learning, it is suggested to investigate and identify their pre-knowledge level in terms of:

- The extent of their education. This can give a general image of a learner's academic background and capabilities of acquiring new knowledge.
- Their historical courses grades in MOOC. This is to find learner's performance in related courses in order to build a reference to predict at what level s/he can commence a new course.
- Results of pre-course quizzes which are in the form of multiple choices. It does not increase the difficulty of operation on mobile devices.

Learning Styles

Individuals differ in how they learn. Learning styles refer to the systematic differences in individuals' natural or habitual pattern of acquiring and processing information in learning situations.

According to [46], learning styles can be represented as concrete experience (feeling), reflective observation (watching), abstract conceptualization (thinking) and active experimentation (doing). However, because operations on mobile devices are relatively simple, which are limited in input and output methods, these four learning styles are difficult to be reflected straightway through monitoring learners' operation. Thus, identifying learners learning style requires extra efforts. For example, some external approaches are feasible to employ, such as self-evaluation. In addition, if learning activities in other MOOC courses are specified in terms of relevant learning styles, learners' performance in an exact learning activity can indicate their value on the corresponding learning styles.

Memory Ability

Memory ability can impact learning outcomes after the retention and reproduction stage of learning [47]. For MOOC courses in the disciplines of culture, literature, arts, language and history, etc., memory ability is one of the key measures that help learners transfer the content of online MOOC resources into their own knowledge. It is particularly important when learning these disciplines using fragmented time pieces [48].

5.2.3 Intersection of Non-Intelligent and Intelligent Factors

Learning Habits

Each individual has a completely isolated structure of available time and learning time. Learning times for on-campus instructor-led learning mostly falls in day time. Unlike that, the mobile/micro MOOC learning time spread over all 24 hours of the day. By analyzing the distribution of hotspots of frequently used learning time, EDM serve as to discover whether there are regular patterns of time organization among learners in or across cohorts, and to set up a unique learning habit summary

for each learner. Their personal situations affect their learning habits, which refer to, in this paper, how learners utilize their time on MOOC learning, in what way they get learning resources passed on, how often they make pause and repetition, after how long they take a review, whether they learn several MOOC courses in parallel, during what time stages in a day they are more often to make MOOC learning happen, and among those time stages, when they are more often intending to adopt micro learning means.

Learning Speed

This feature simply refers to the extent that they have spent to go through a course chunk and finish related tasks in average. It can be estimated from their historical learning record.

Language Skill and Preference

Learners' language skills and preference should be taken into consideration to opt in/out their learning resources. Because most MOOC courses are taught in English so that identification for learners' level of English skills is essential. Alternatively, this service investigates whether they are preferred to learn in their native languages or second languages other than English.

Degree of Distraction

Internally it concerns a learner's mood and emotion, and it is highly correlated to the degree of disruption which is a component of the external factors.

5.2.4 External Factors

Learning Locations and Environments

The ways how learners get connected to Internet apparently reveal their learning locations and surrounding environments. Generally in micro learning scenarios, they are brought to Internet through wireless networks by two means, namely Wi-Fi or mobile cellular network (e.g. 4G, 3G, and GPRS). Simply, connecting to internet through mobile network means learners are taking on learning activities ad hoc, the strength changes of the mobile signals can reflect their statuses of being on-the-go. The logon data of Wi-Fi portal may also determine learners' exact indoor learning places. Normally connecting Internet via Wi-Fi provided in public places rather than homes indicates learners are possible to experience higher frequency of interruptions as their surrounding environments can be more noisy and complicated.

General Situation

General situation regarding learning context partially affects their learning experiences and achievements. Information regarding the mobile devices and mobile OSs the learners utilized to carry out micro MOOC learning must be specified in order to determine devices capabilities, features and limitations [49].

Assistance from Collaborative Learning

Encouraged by the nature of how MOOC is structured and its pedagogical concept, learners can get helpful information from collaborative learning, virtual social activities over social network and content generated by other learners.

Degree of Disruption

The degree of disruption depends on the noise and interference factors from their surroundings, conflicts with their daily works, comfortableness with the setting and layout of the MOOC platforms and course design and so on [50].

6 Micro MOOC Learning Resources Customization

6.1 Micro Learning Resource

MOOCs have changed the expectation of learners and the technologies that support MOOCs can also support micro learning. Now that MOOCs have expanded, in both size and format (i.e., MOOCs have evolved and now the acronym encompasses many different types of courses), they offer several options for training departments or education providers and agencies to implement micro learning paths within an organization, and for learners to build up their own learning schedule with full of varieties and joys [51]. Some typical learning resources involve short videos and other visual learning resources, spaced repetition and practice activities, communication and collaboration environments, and credentials and gamification.

For these well-designed resources, specific EDM schemes can be developed to establish a recommendation model for students in similar situations in the future, for grouping web documents using clustering methods in order to personalize e-learning based on maximal frequent item sets; for providing personalized course material recommendations based on learner ability and to recommend to students those resources they have not yet visited but would find most helpful [52].

6.2 Non-Micro Learning Resource

Given some micro learning resources are provided within short time length (i.e. 15 minutes), they are normally delivered right away. However, most achievable MOOC contents are non-micro learning resources, which need to be refined properly. These contents need further processing and revision to fulfill micro learning demands, which can be instructor-led or computer-based.

For non-micro learning resources, EDM is utilized to discover which stages of them are generally finished within relatively larger time length, and determine time spans where the pauses made by learners usually fall in. EDM can be carried out more deeply to find out actually why learners spent more time on these stages and made such pauses. Common reasons can be ascribed to learners' preferences, resources' difficulties that need effort to assimilate, or resources' suitability for micro learning, for example, whether a hands-on practice is needed, or whether the courses delivery is necessarily associated with lots of writing or computation work which is inconvenient to complete on mobile devices.

The ultimate shapes of resources after processing are summarized as follows:

- Visual encyclopedia: Learning key points are listed out in terms of the knowledge structure of the entire course. For each key point, a video or textual material is set out without time limit to

clearly illustrate the contained content. Because the content contained solely cover a particular scale, accordingly the time length to go through it is short.

- Logical segmentation of course videos: Herein each unit covers the complete information of a learning section, which includes the conditions of beginning and ending, carries coherent content, and can be studied individually.
- Course-related and educational information in affiliated social media: This is a ramification of learning resources and also rich in educational values. This resource can be found not only in forums or blogs embedded in MOOC platforms, but also in other popular social media (e.g., Facebook, WeChat, Twitter, Tumblr, etc.), where learners, educators or external experts publish course-related materials [53]. A noticeable feature of this kind of resource is that its amount increases from time to time while some of the content may contain pseudoscience or incorrect information. EDM serves as to distinguish such information, which can be useless, harmful and may cause time wasted for learners. EDM also screens well-recognized information in order to recommend to learners as their learning augmentation besides the materials from course providers. Text mining technique is suggested to be utilized for this purpose.
- Two-way interactive contents or activity settings, ranging from feedback, assessment, review for contents generated by other learners, peer-to-peer learning, cooperative writing, collaborative work, and flipped classroom, etc...

Additionally, for learners who are usually involved in passive learning, EDM helps to push information to learners in the best timing and remind them, if needed.

6.3 Learning Resource Modelling

For modelling purpose, a learning resource chunk is considered to be measured with regards to the following features:

- Time length
- Suitability for mobile learning (inferred from frequency of historical records or instructor)
- Shape of expression
- Difficulty (level of knowledge)
- Completeness
- Requirement of attention
- Preferred learning styles
- Imparted or interactive
- Requirement of input or hands-on practice

7. Assembling Complete MOOC Learning Experience

In a mobile services environment, it is feasible to utilize EDM to identify micro learning resources which have similarities [54] [55]. In addition, based on learners' historical learning records, the sequence by which learners go through resource chunks can be sorted out. In MOOC learning, various providers or universities may offer the same course with considerably different contents and section divisions. It is possible to learn cross several available course sections from different providers and synthesize such pieces to assemble a complete learning experience for a specific MOOC course.

There are strict sequences among some courses sections, which can be pre-defined by course providers [56]. In other cases, sequences are just suggestive and some learners can acquiesce in such sequences on the basis of others' recommendation and experiences if these are retrievable [36]. EDM can contribute to explore latent learning paths from historical cases and expose them to all MOOC learners.

There are many other ways that micro learning paths can be formalized via MOOC [57]. The key considerations are that the learning activities should be short, available on-demand, or immediately relevant to a job task for employees.

Building and optimizing learning path are undertaken by the Learning Resource Repository Service, Concept title and description need to be extract from the concerned course materials manually. Thereafter, key words are worth to be extracted to deduce the importance of keywords through a document classification technique. The algorithms similar to the one proposed in [58] could be utilized in our co-occurrence statistical information based keyword extraction. Each micro learning resource chunk can be parameterized as a keyword vector. Similarity calculation (e.g. Pearson correlation coefficient or the cosine similarity) will then be applied to measure the correlation coefficient between two resource chunks.

All course modules available in MOOC can be clus-

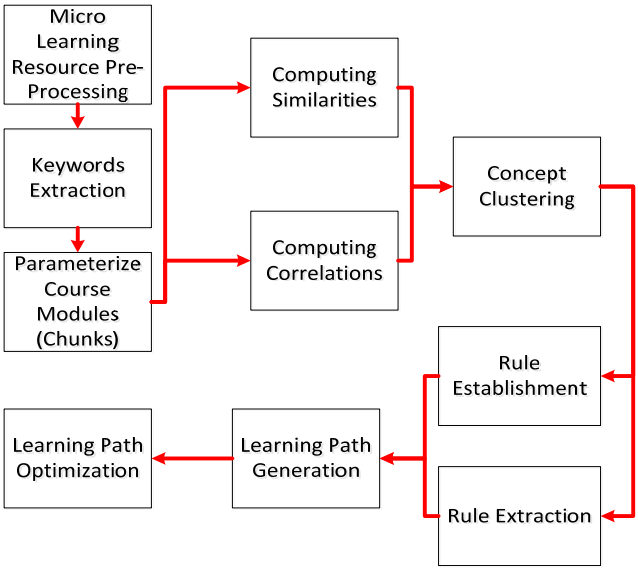

Figure 5. Workflow of Assembling an Entire Micro Learning Experience

tered by using clustering algorithms, such as K-means and K-nearest neighbors, with their similarity metrics to categorize the course modules into different knowledge groups. Each cluster of course chunk is treated as an individual knowledge domain under the course. By leveraging EDM, we can establish rules within each cluster or among various clusters to identify the sequence of two course modules.

Learning paths can be generated randomly as initial solutions, and then they are optimized by artificial intelligence techniques or heuristic algorithms (e.g. genetic algorithm) in terms of established rules and with respect to multiple purposes. The workflow of learning path optimization is shown as Figure 5.

8 System Implementation and Architecture Consideration

For the complete mobile VLE for MOOC, in which TaaS has been already implemented and deployed over a typical cloud infrastructure, Amazon EC2 [12], its interaction with MOOC platform and educational institutions' LMS are highly emphasized. Hence, EC2 is the ideal choice for MLaaS to be hosted as well. Auto Scaling and Elastic Load Balancing services will work together with the EC2 Container service in order to adjust its volume and control internet traffic. MLaaS is naturally service-oriented and exposes its functions through standard Web Service portals for external services, including the Historical Learner Information Gathering and Real-time Learner Data Retrieve services, to call and then invoke. It is ultimately loose coupling which provides the most benefit for portability and interoperability, and also eases more of the burden of further extension and re-development.

The personalized learner model for micro MOOC learning is suggested to be deployed in the Amazon Relational Database Service offered in conjunction with EC2. It has resizable capacity in terms of real-time demand of data extraction and inference. Given the overall MOOC learner and course data could be extremely huge; Amazon S3 will be employed as the data storage because of its robustness and mature disaster recovery mechanisms.

9 Proposed System Evaluation

In a typical working scenario of our proposed adaptive micro learning framework, the system tailors each course chunk and makes it fit a specific time scale. Supposedly, while learners are studying MOOC course using fragmented pieces of time. In this case, learners will be able to use each time piece to go through a chunk completely, neither with any unexpected pause or breakdown, nor leaving any unfinished part to next available time.

At present, besides tests or exams, there lacks effective approach to assess what learners have actually achieved from MOOC learning, so that a quantitative research is needed to investigate their satisfaction towards learning process and progress periodically.

The key questions of our research are to evaluate 'whether learners can enjoy MOOC courses through micro learning manner' and 'how micro learning can influence learners' knowledge acquisition'. To answer these questions, we will test our system with a pilot study and formulate the following hypotheses as listed in Table 1.

TABLE I. HYPOTHESES ABOUT MICRO LEARNING EXPERIENCE AND KNOWLEDGE ACQUISITION

H1	Participating in MOOC learning activities by accessing small unit of customized learning resource has positive impacts on learners to assimilate and internalize specific knowledge while avoiding obtaining interference information
H2	Learning resources in the form of visual information are easier for learners to memorize or internalize in short durations.
H3	Adaptive learning resources with personal tailoring help learner to conduct effective time management so as to contribute to fulfilling the requirements of entire course learning.
H4	Learners who do not intend to get course credits have higher satisfaction on micro learning experience than hour-long learning.
H5	Micro learning contents with concrete time restrictions are better for learners to acquire targeted knowledge. Failing to complete a course unit at a time can result in information missing.
H6	Simple types of course assessment, such as quiz, multiple choice, etc., are suggested to be finished in micro learning units, which can timely provide refresher and knowledge review for learners, and then help to fix it in memories deeply.

Data from fragmented MOOC courses will be collected to test the above hypotheses. We will also carry out case studies focusing on finding out how our proposed system can facilitate micro learning in MOOC and how it can, qualitatively and/or quantitatively, help learners achieve their learning expectations. It is suggested to initiate interviews as well as surveys among engaged learners to collect data and analyze the main aspects of feedback. Also, evaluations will be carried out to test the usefulness and ease of use of the proposed system.

10 Conclusion

In this paper, we introduced a system for improving mobile learning in MOOC courses by drawing up a strategy of enhanced collaborative learning and adaptive micro learning. Two SaaS, TaaS and MLaaS are working in conjunction to build a VLE over a cloud infrastructure. The main contribution of our work are:

- We proposed the system framework of MLaaS, in which multiple functions are dedicated to tailor personalized learning schedules, and are specific to every fragmented time piece, for individual learners.
- We built a personalized learner model for micro MOOC learning, combing factors that can affect their learning activities and outcomes in micro learning context.

- We organized an EDM scheme to discover features of learning resources in order to measure, classify and customize them accordingly.
- We illustrated a solution for learning path optimization which works on assembling a complete MOOC learning Experience.
- An evaluation plan is also scheduled to investigate the effects on learning experience and knowledge acquisition.

The MLaaS can be used for learners with various purposes to learn effectively through MOOC platform.

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