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# MLaaS: A Cloud System for Mobile Micro Learning in MOOC

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***Abstract*—Mobile learning in massive open online course (MOOC) differs evidently from its traditional ways as it relies more on collaboration and becomes fragmented. We introduce a cloud-based system 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 can be built by a newly designed SaaS, in which educational data mining techniques are mainly employed to understand learners' behaviors and recognize learning resource features.**

***Keywords: MOOC; Mobile Cloud; Micro Learning; Eductional Data Mining;***

## I. INTRODUCTION

Nowadays learners have numerous choices to use various types of device, 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 opening 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 an equal opportunity to take courses and has access to educational content 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 can be as high as tens of thousands [3]. The explosive growth of learning resources leads to a revolution of education and learning. Many universities who contribute courses to MOOC providers gradually accredit the credits gained from MOOC learning. Learners who have accomplished a series of MOOC courses can fulfill the requirements of a degree from those universities.

Although educational professionals have strived extraordinarily on exploring the MOOC format as a regular pedagogical approach for mobile learning (m-learning) [4], established studies show that MOOC are currently suffering from low completion rate [5]. Most learners who enrolled in MOOC courses ended up dropping out. As research and development of MOOC are still in its infancy, there are evidently many opportunities to improve MOOC courses as well as their affiliations, such as learning platforms and learning support services, to enable easier access and better experience for both providers and learners.

Inspired from this, we attempt to develop a system, which aims to provide learners opportunities to have better teamwork settings and make the best use of every fragmented piece of time so as to effectively engage in the MOOC learning. In this paper we introduce 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. We also build an educational data mining (EDM) scheme to help modelling learners and recognizing potential learning resource features.

## II. BACKGROUND AND PREVIOUS WORK

### A. Mobile Learning in MOOC

It is without a doubt that m-learning is getting extensive acceptance by learners and gradually becoming a major learning means [6] [7]. 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 transcoded 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.

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 [5]. Another crucial factor is that learners deem it is not easy to find appropriate resources they want, or the chosen resources do not always meet 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 [8].

The third reason is that the types of learners engaged in MOOC courses are more comprehensively diversified. 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 [8] [9].

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 [9]. 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 of this phenomena come from many aspects which we will illustrate in the section III.

### *B. System Framework and Pilot Work*

Having investigated the feasibilities to improve the resources delivery and learning experiences of MOOC, and the potential benefits of leveraging cloud computing, we are motivated 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.

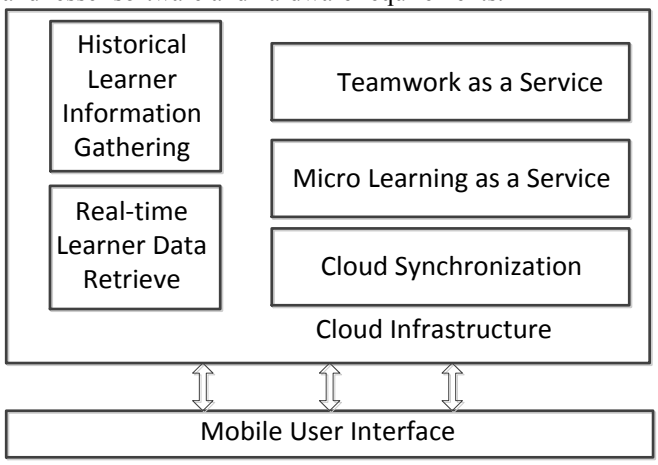


Figure 1. Framework of Mobile VLE for MOOC

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 learning 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 [10], 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 an 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 utilised 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 [7], including a genetic algorithm enclosed to discover computational choices of grouping strategy [11]. 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.

## III. MICRO LEARNING IN MOOC

### A. *The Popularity of Mobile Learning and Micro Learning in Taking MOOC Courses*

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.

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 [12] [13]. The modules ideally do not exceed 15 minutes. 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[13].

### B. *Definition of Micro Learning*

Micro learning would have positive effects on mastery learning and be an important part of blended learning [14] [15]. 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 [16]. 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 [17]. 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 [18].

In literature, "micro learning" processes cover a time span from few seconds (e.g. in mobile learning) to up to 15 minutes or more. Another explanation of micro learning is deemed Web focused: '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 resources retrievable online' [17]. Compared to the traditional hour-long e-learning modes, 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.

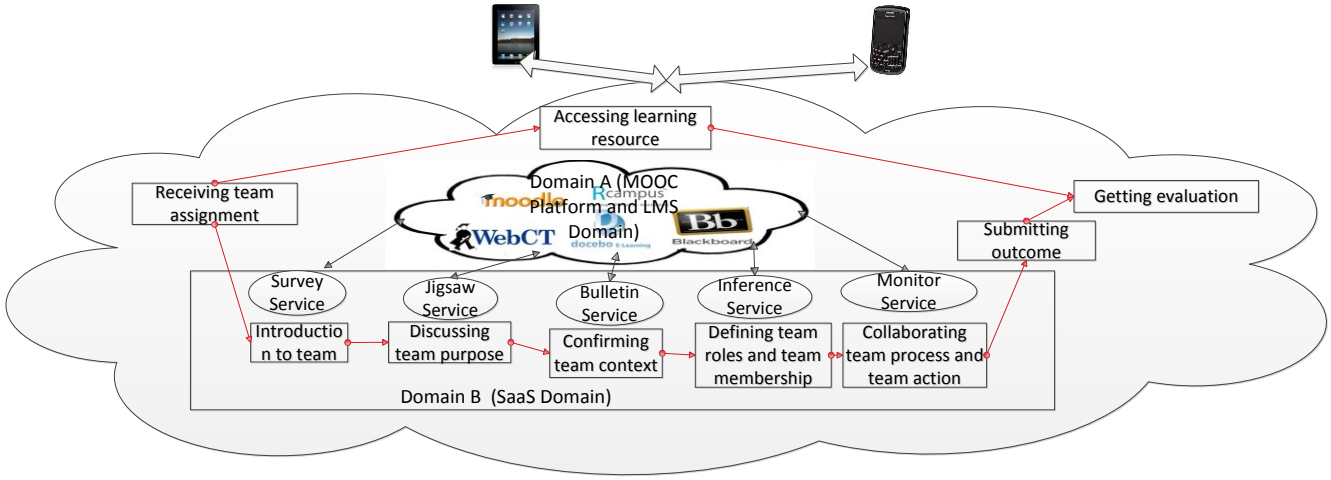


Figure 2. Teamwork-Enhanced Learning Flow for Mobile Cloud-based Learning

According to the study conducted by [19], 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 [20] [21].

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 [22]. As micro learning evolves, micro-content delivery with a sequence of micro interactions enables users to learn without information overload [23]. It is a key technology to ensure better learning results in terms of retention of propositional content [18].

On the other hand, as stated in the Section II, MOOC emphasizes collaboration and connectivism [24], 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 [17]. 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.

### C. *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.

Moreover, there are studies indicating that personality and learning styles play significant roles in influencing academic achievement [7]. As learners commonly do not have sufficient expertise in customizing learning schedules for themselves, and perhaps they are not familiar with their own learning styles, there are high probabilities that they cannot access the right sets of micro content. This may 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. So far, very few research or practitioners ever investigated the learning resources adaptation in the micro learning circumstances. Our pilot work implemented an adaptive mobile learning system, but it could not incorporate into in-progress courses [25]. In other words, 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.

## IV. MICRO LEARNING AS A SERVICE-BUILDING A SMARTER ENVIRONMENT FOR ADAPTIVE MICRO LEARNING

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 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 [26] [27]. 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 [26]. Data related to good-quality and mostly-followed/discussed learner-generated content, can be refilled in to Learning Resource Repository in order to support peer-to-peer learning in MOOC [28].

For MLaaS, the Real-Time Learner Data Retrieve Service retrieves learners' real-time data, including their learning progress and 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 are matching 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 [29] [30].

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.

## V. Educational Data Mining Scheme for Micro Learning 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 employ 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.

Much data generated along with the proceeding of MOOC courses represent learners' behaviors in a form which is longitudinal and fine-grained. The entire process of a learner taking MOOC courses is not difficult to track, monitor and record, while reporting them visually and statistically in order to reveal each learner's learning story is even more crucial. Finally, a learner model for micro MOOC learning can be established by using these screened and sorted data [25]. This is the aim of the Learner Modelling Service, and the detailed learner features and learning context we are interested to explore through EDM are listed as follows.

### *A. Learner Types*

Types of MOOC learners vary evidently in accordance with their learning purposes and work, learning and life patterns. Their background information cannot always be searched from their registration and logon data [31]. Commonly, they can be university students, employees or life-long learning pursuers.

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.

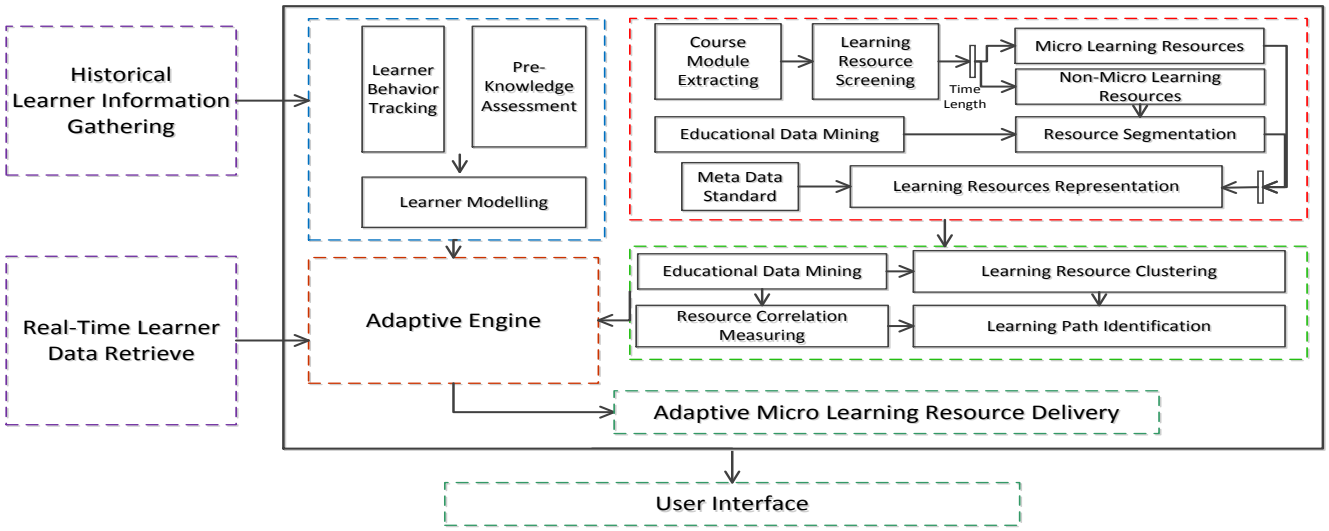


Figure 3. Framework of MLaaS for MOOC

### B. 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.

### C. Learning Engagement

Past studies such as [14] and [32] use quantitative methodologies to identify individual learner's engagement in MOOC and categorize them into cohorts with different ways. However, there is not 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.

From another perspective, learners' engagement can be categorized into active learning and 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.

### D. 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 [33], 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.

### E. Learning Locations and Environments

The ways that 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, 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.

### F. Learner 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.

### G. 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.

### H. Learning Preference and Other information

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. Other information regarding learners' behaviors is also worthwhile to be collected because it partially affects their learning experiences and achievements. This information consists of: learners' language preferences and skills should be taken into consideration to opt their learning resources; 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.

## VI. Delivery of Customized Micro MOOC Learning Resources

### A. Micro Learning Resources

MOOCs have changed what learners expect from their educational experiences 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. 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.

### *B. Non-micro Learning Resources Processing*

Given some micro learning resources are provided within shorter time lengths (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 lengths, 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. 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.

Additionally, for learners who are usually involved in passive learning, EDM has another role to make the decision of when is the best timing to push information to learners and remind them, if needed.

### *C. Assembling Complete MOOC Learning Experiences*

In a mobile services environment, it is feasible to utilize EDM to identify micro learning resources which have similarities [34] [35]. 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 courses.

There are strict sequences among some courses sections, which can be pre-defined by course providers [36]. 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 [37]. 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 MOOCs. The key considerations are that the learning activities should be short, available on-demand, or immediately relevant to a job task for employees.

## VII. 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. In particular, in the proposed MLaaS, multiple functions are dedicated to tailor personalized learning schedules, and are specific to every fragmented time piece, for each learner. The MLaaS can be used either for learners, who wish to complete an entire course to get credit, or those who solely plant to acquire the specific knowledge they actually need. In future, we will carry out case studies focusing on finding out how our proposed system can facilitate micro learning in MOOC and how it can, qualitatively and quantitatively, help learners achieve their learning expectations. Data from fragmented MOOC courses will be collected to test hypotheses regarding how micro learning can affect learners' knowledge acquirement in MOOC.

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