The development path of MOOCs for China's higher education and its applications in engineering and technology education

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ABSTRACT: In recent years, MOOCs have sparked a frenzy of on-line learning worldwide, which altered teaching models of higher education and reshaped teaching objects, learning environment and teacher - student relationships; and triggered certain changes in terms of the boundaries of physics for higher education and its organisational forms, thereby, exerting far-reaching implications on higher education. In this article, the authors summarise the types and traits of MOOCs, then, describe the status quo of the development of MOOCs practice and study in the field of China's higher education. Additionally, the authors also analyse and generalise typical applications of MOOCs in China's higher engineering education, making it possible to grasp the development path of MOOCs in China's higher education.

INTRODUCTION

The concept of massive open on-line courses (MOOCs) was originally put forward by David Cormier in 2008 and initially used to refer to on-line courses named Connectivism and Connective Knowledge (CCK08), offered by George Siemens and Stephen Downes. A large number of American universities and colleges have been channelling considerable endeavour into the development of MOOCs since 2011, with a raft of links of platforms and courses based on open concepts released, sparking a mania for on-line learning across the globe [1].

With earnest zest, Chinese universities and colleges also began to take their part in the campaign in 2013 and, hence, for this very reason, the year was dubbed as being *the First Chinese MOOC Year*. In May 2013, Tsinghua University, Beijing University, the University of Hong Kong, the Hong Kong University of Science and Technology among other Chinese universities joined edX. In July of the same year, Shanghai Jiao Tong University and Fudan University also announced that they had joined Coursera.

People from all walks of life are generally upbeat about the outlook of MOOCs; business companies have also realised business opportunities hidden in MOOCs, with Chinese Internet businesses, such as guokr.com, zhihuishu.com, chaoxing.com and NETEASE rolling out their own MOOCs platforms or channels. After 2014, Chinese MOOCs took a gradual step closer to maturity, which was not only manifested in the release of numerous courses and platforms, but in the emergence of course alliances based on MOOCs.

As a new approach to carry forward and pass down knowledge, MOOCs were even considered as a pivotal innovation in education, next in line only to the invention of printing. While the comparison appears somewhat overstated, the far-reaching implications of MOOCs on traditional higher education are self-evident. It is due to the unprecedented challenges and opportunities presented by MOOCs to the future of higher education that MOOCs are preferred among business companies and venture capital, occupying the spotlight for Chinese universities and colleges, teachers and research fellows.

Based on the collections and analyses of relevant literature concerning the MOOC practice and study in the field of China's higher education, this article presents summaries of MOOC practice conducted in Chinese higher education institutions, development tendencies and hot spots related to the study of Chinese MOOCs, intending to outline the development path of MOOCs in China's higher education. Grounded upon this, typical applications of MOOCs in China's higher engineering education were analysed and generalised.

The following parts of the article include:

- Classifications and features of MOOCs;
- Headway made in MOOCs practice by several representative Chinese universities and colleges;
- Advances in research on MOOCs and research focuses by Chinese scholars;
- Applications of MOOCs in China's higher engineering and technology education.

CLASSIFICATIONS AND FEATURES OF MOOCS

Even though MOOCs share many common features, there are some distinctions among various courses, which were demonstrated in the organisational forms of curricular contents, learning processes of courses, roles and relationships between teachers and students, with the most fundamental one being disparate theories of learning. As per the varied theories of learning on which courses are based, MOOCs can be divided into cMOOCs based on connectivism and xMOOCs based on behaviourism theories of learning.

cMOOCs

Connectivism states that the growth rate of knowledge renewal is ever-quickening and, therefore, it is more significant to come by the approaches and methods of acquiring knowledge than knowledge acquisition. Instead of learning via the Internet and focusing on internalising fixed knowledge, one should learn through attainment and connections of external information sources, thus, broadening and forming a network for separate knowledge. cMOOCs (e.g. CCK08) made up the bulk of earlier MOOCs, whose courses tended to be on rudimentary fixed topics and provided scant guiding materials. Revolving around the topics, learners gathered materials, conducted discussions and contributed their own learning resources. In cMOOCs, learners enjoy more self-reliance and can freely choose learning materials, accounting for varied networks of knowledge set up by different learners, even if the same topic is involved. In addition, in cMOOCs, the main tasks of teachers no longer play the role of imparting knowledge; instead they play the role of a coordinator in study, encouraging learners to share learning resources and maintaining sound knowledge-sharing networks among learners.

xMOOCs

Compared with cMOOCs, the teaching modes of xMOOCs resemble traditional classes. In xMOOCs, learners study through watching on-line videos of teaching, participating in discussions targeted at curricular contents, finishing unit exercises and taking part in final examinations for courses. Furthermore, xMOOCs serve as a learning method based on behaviourism, and behaviourism holds that study is a process to establish links between *stimulation* and *reaction*, and the grasp of knowledge can be facilitated when learners study through watching on-line videos of courses and finishing corresponding exercises. Major platforms of MOOCs (including Coursera, Udacity and edX) all adopt xMOOCs, the essence of which is replicating traditional classroom teaching and rendering it on-line. The majority of learners are quite familiar with this type of teaching mode, making xMOOCs easier to be accepted than cMOOCs. In xMOOCs, teachers play a dominant role and most of the learning resources in the learning management system are organised and provided by teachers, with the method of knowledge transmission being one-way from teachers to students.

Based on the above analyses, cMOOCs and xMOOCs bear prominent distinctions when it comes to learning theories, roles and relationship between the teacher and student, means of knowledge transmission, carriers of curricular materials and basic requirements of study. Table 1 shows a summary of dimensional and characteristic differences between cMOOCs and xMOOCs.

Table 1: Dimensional and characteristic differences between cMOOCs and xMOOCs.

Dimension	cMOOCs	xMOOCs
Learning theories	Connectivism	Behaviourism
Role of teachers	Coordinator of curricular activities	Dominant of curricular activities
Role of learners	Contributors of knowledge	Recipients of knowledge
Teacher and student relations	Relative equality	Relative inequality
Means of knowledge transmission	Multi-way (between students and teachers)	One-way (teachers to students)
Carriers of curricular materials	Social media software	Learning management system

HEADWAY MADE BY CHINESE UNIVERSITIES IN MOOCs PRACTICE

Amid the rapid development of Chinese MOOCs, the active participation indubitably plays a key role as a driving-force. Reasons why universities emphasise MOOCs is not only that they consider expanding their academic influences, but also that MOOCs highly accord with the spirit of multiple documents introduced by education authorities regarding

strengthening the development of on-line educational resources. The following part will introduce the headway made in MOOCs by several representative universities, in an effort to grasp the major processes of MOOCs practice in Chinese universities.

Tsinghua University

As a top-notched and renowned university in China, Tsinghua University enjoys clear and forward-looking expertise in terms of the role and outlooks of MOOCs, setting specific objectives and undertaking systematic planning. According to several crucial events in the development of MOOCs at Tsinghua University, the process can be classified into three phases. The first of these is represented by the iconic event of Tsinghua's joining in edX, which formally ushered its development process of MOOCs.

The second one is represented by the iconic event of the advent of MOOC platform *xuetangx* in October 2013, becoming the first university in China to own self-developed platform. The third event is represented by the iconic event of the founding of MOE Research Centre for On-line Education at Tsinghua University in April, 2014, forming a two-pronged on-line teaching model. In June, 2016, *xuetangx* became an on-line education platform for the UNESCO Engineering Education Centre, with the number of registered on-line subscribers exceeding five million and over 6.9 million learners choosing courses.

Shanghai Jiao Tong University

As a first-class university in China, Shanghai Jiao Tong University develops MOOCs for the following four reasons: making the development of world-recognised MOOCs a necessity to build a world-class university; materialising the sharing quality educational resources with other high-level Chinese universities and taking the lead in the reform for higher education; contributing to the equality improvement of China's higher education through sharing its high-calibre resources; and realising education geared to the general public and worldwide cultural transmission.

On 8 April 2014, the CNMOOC, a MOOC platform wholly developed by Shanghai Jiao Tong University officially went on-line. Meanwhile, a total of 19 universities and colleges (cooperative education institutions among some of the universities and colleges in Shanghai founded in August 1994) in the southwest part of Shanghai signed agreements on jointly building and sharing MOOCs, to serve the need of curricular study and mutual reorganisation of credits. The joint building and sharing of MOOCs among universities and colleges in the southwest part of Shanghai marks a relatively significant practice for mutual reorganisation of credits among different colleges in China's higher education. Students from the signed universities and colleges can avail themselves of *xuetangx* and learn courses through complete on-line study or flexible classes based on MOOCs.

Shenzhen University

As the bulk of Chinese higher education systems, local higher learning institutions (provincial ones) account for over 90% of the total both in terms of the number of universities and students on campus. These universities are confronted with the fact that their own academic influences are conspicuously inferior to those of China's top-notch counterparts and, hence, how can they participate in the practice of MOOCs? Shenzhen University, together with National UOOC Alliance for Local Higher Learning Institutions (abbreviated as UOOC) led by it, provides a feasible and effective approach for them.

In May 2014, an inaugural meeting of the National UOOC Alliance for Local Higher Learning Institutions launched by Shenzhen University was held. The purposes of the UOOC Alliance are integrating quality teaching resources of local universities and colleges, building a large-scale on-line open courses, forming a sharing mechanism for quality courses, providing options and services for students from the Alliance and people from civil society when it comes to curricular study; thereby, boosting the balanced development of higher education, improving levels of talent cultivation of the local colleges and their capability of social services. Students attending the courses offered by UOOC Alliance headed by Shenzhen University are largely from member universities and colleges, with curricular learning linked with credits. As of March, 2016, there were 93 members in the UOOC Alliance, setting up 53 MOOC courses, with the number of courses selected surpassing 70,000.

RESEARCH PROGRESS AND HOT TOPICS OF MOOCS IN CHINA

In order to analyse the current research status and progress of MOOCs in China, the authors collected and analysed the MOOC-related literature listed in the CNKI.net database. The source categories of the literature were limited to the core journals and the CSSCI journals providing a total of 508 items. After carefully reading the titles, abstracts and texts (if necessary) of these items literatures, the authors eliminated 91 that do not have practical academic value (such as irrelevant subject matter of MOOCs and notices), leaving 417 valid documents. To analyse the related research of hot topics and trends of MOOCs in recent years, the key words of the effective literature was analysed, and 1,055 keywords were obtained. For a more intuitive appearance of the distribution of key words, the top frequently-used 20 keywords were selected and used to draw the word diagram shown in Figure 1. Numbers of documents are shown in brackets.

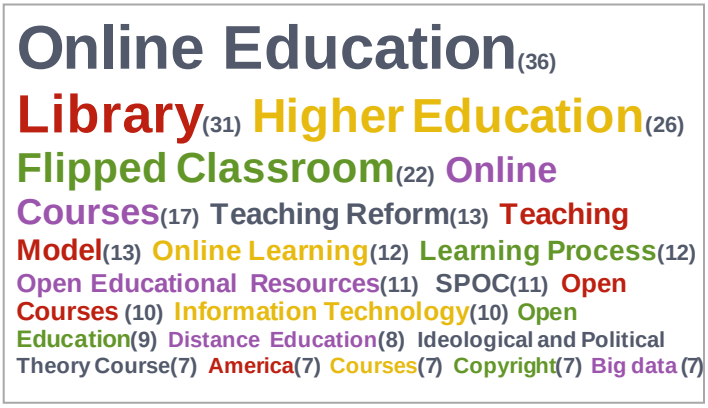

Figure 1: Word graph for key words of MOOC-related literature.

It can be seen from Figure 1 that MOOCs are closely related to several fields of education, including: on-line education, higher education, open education and distance education. On the one hand, it shows that MOOCs have characteristics such as *on-line* and *open*; on the other hand, it shows that current scholars pay more attention to the application of MOOCs in the teaching of higher education. Chinese scholars are mainly concerned with MOOCs in relation to their application scenarios on: library, flipped classroom, on-line learning, SPOC (small private on-line course). In addition, MOOCs-based teaching reform, teaching models, learning process, the copyright issues brought by MOOCs, and big data applications in MOOCs and other information technology are also becoming topics of concern to Chinese scholars.

The next section focusses on three topics, which are mostly concerned with and summarise the research results and the main points of view: MOOCs' impact on higher education in China; the integration of MOOCs and classroom teaching; data analysis of MOOCs.

The Impact of MOOCs on China's Higher Education

The emergence of MOOCs enables learners to study high-quality courses of the world's leading universities without paying fees. This has brought unprecedented challenges to the traditional higher education system, which have aroused extensive discussion among scholars. Views can be broadly divided into two categories: one considers that MOOCs will influence traditional higher education and may change the original pattern of higher education [2]; the other argues that MOOCs are only a form of distance education and if integrated with the existing model of higher education, they will not produce disruptive effects. It is noteworthy that, with the progress of practice and research work on MOOCs in China, the academic understanding of MOOCs has become more objective and some scholars view them as mainstream. In addition, some scholars have analysed the impact of MOOCs on higher education based on disruptive innovation theory, and argue that when MOOCs develop to the stage of offering degrees, they will have a huge impact on the existing pattern of higher education [3].

The Integration of MOOCs and Classroom Teaching

The openness and large-scale characteristics of MOOCs provide a low-cost way for the public to accept higher education, but it has also brought a few problems, which arouse the scholars' thinking. For example, in MOOCs, teachers cannot effectively interact with large-scale learners; learners have a low rate of completion of courses; and they also have applicability problems in subjects. Since those problems cannot be effectively solved within MOOCs themselves, scholars have tried to integrate MOOCs with traditional classroom teaching models [4]. Flipped classroom and small private on-line courses (SPOCs) are the typical teaching models for this kind of fusion thinking.

Data Analysis in MOOCs

The MOOC learning platform is the basic information system supporting on-line teaching activities, which not only stores the learning resource files of the course, but also holds a large amount of learning activity data of the learners. The data include: the basic personal information of learners, click and browse behaviour for learning resources, assessment and examination data, forum information, and so on. With the advancement of data analysis methods and tools, the impact of data mining and large data technology can be extended to more areas. More and more scholars in the field of education are aware of the value of the data in the learning platform, and they use data analysis techniques to explore the potential rules and knowledge [5].

APPLICATION OF MOOCs IN ENGINEERING EDUCATION IN CHINA

Engineering and technology education not only focuses on training students for understanding theory, methods and tools, it also pays more attention to training students to solve practical engineering and technical problems. The cultivating of students' practical ability often relies on experimental teaching and practical teaching activities and

teachers play the role of instructor in these teaching activities. However, the *large-scale* characteristics of MOOCs limit the effective interaction between teachers and students, and the *on-line* features make it difficult for students to participate in practical training in laboratories. Thus, the teaching effect in engineering courses has been questioned to a certain degree.

In view of the inherent deficiencies of MOOCs in the education of engineering and technology courses, educational institutions and teachers try to improve the teaching model and teaching methods of traditional MOOCs by two main approaches: firstly, through hybrid learning, such as flipped classroom and small private on-line courses (SPOC), which can enhance communication between teachers and students; and secondly, by incorporating virtual laboratory functions into MOOCs, which can build an on-line experimental (or training) environment and support operation-related teaching activities. The application of MOOCs in engineering and technology education in China has carried out a series of teaching practices in the above aspects, which will be introduced in the following sections.

MOOCs-based Flipped Classroom

Flipped classroom is to adjust the learning time inside and outside the classroom, so that students can get greater learning initiative. In the flipped classroom teaching mode, students first learn the resources provided by MOOCs before class and, then, teachers will discuss issues with students in order to guide the students' study in the classroom. Zhang et al applied the *MOOC-classroom teaching-innovation practice* trinity flipped classroom teaching model in the teaching of *modern educational technology*. The results of the questionnaire for students showed that the model was beneficial to the students' individuality development. It can also be used to enhance the interest in learning and even to strengthen students' awareness and ability of using the educational technology to promote the teaching reform [6].

Wang et al used a combination of flipped classroom and MOOC in the *embedded software engineering* teaching practice. The results showed that this reform measure can stimulate students' interest in learning. It can also promote students' grasp and understanding of theoretical knowledge, and the cultivation of students' practical and innovative ability [7]. Based on a hybrid MOOC-based teaching model, Zhu and Tang proposed a cloud environment for learning targeted at computer courses to support student-focused teaching [8]. The advantage of integration of flipped classroom and MOOCs is that structured and systematic organisation of learning resources of MOOCs enables learners to effectively complete the learning at the stage of autonomy outside the classroom, so that the exchange and discussion in the classroom can be carried out efficiently.

Small Private On-line Course

SPOC replaces the massive and open characteristics of MOOCs with small and private characteristics, and the limitation of the number of students can guarantee the effective interaction between teachers and students. Thus, SPOC has better performance in relation to the learner's satisfaction and learning results. The association between SPOC and MOOC is mainly embodied in the improvement of the latter's course resources in the former one, so SPOC is considered to be a variation of MOOCs. For example, Tongji University uses the SPOC teaching model in the physics curriculum and the results show it has led to an improvement in academic performance [9]. Zhu proposed a *S+C+H* (self-directed learning + collaborative learning + hybrid learning) SPOC teaching model, and applied it to the engineering graphics course [10]. Unlike MOOCs, which do not have admittance requirements and are entirely open to the public, SPOCs are generally open only to students on campus, which can be seen as a combination of traditional classroom teaching and MOOCs.

Virtual Laboratories in MOOCs

Virtual laboratory is an open and networked virtual experiment teaching system based on Web technology and virtual reality technology. It is the digitisation and virtualisation of various laboratories. Experiments, training and other forms of practical teaching are important ways to cultivate engineering and technology students' ability of comprehensive application and innovation. However, MOOC is an on-line learning model, which makes it difficult to rely on the real experimental environment to carry out practice teaching. Yet virtual laboratories make up for this shortfall in MOOCs practice teaching. Cui proposed a practical teaching platform framework for MOOCs based on cloud computing technology, making them integrate with each other better [11]. Guo et al focus on the problems of disunity of experimental environment, such as computer programming languages and operating systems in MOOCs, and inefficient communication between teachers and students. They designed and implemented an on-line experimental platform based on WebRTC and Docker for students to provide a unified experimental environment [12].

SUMMARY

MOOCs have become a hot topic in the field of education in recent years. As a new educational model, MOOCs are thought to have profound influence on higher education and may even lead to the reform to the higher education system. In order to take the initiative and enhance their influence and the quality of teaching, many Chinese colleges and universities have joined this educational campaign that features open education resource and sharing as core concepts. The attractiveness of such a wide range of concerns has been linked to the significant value and meaning of MOOCs in

achieving equity and democracy in higher education. It is foreseeable that the practice and research of education will generate considerable heat for some time, and its application in engineering technology education will be more extensive.

However, as with other educational technologies or educational models (such as e-learning, open education, etc) that preceded MOOCs, they need to be examined in a more objective and rational manner. The problems of low completion rates, difficult evaluation of the learning effect and difficulty in identifying the learning outcomes are the real problems that MOOCs are facing at present. These problems need to be solved by further research and practice.

ACKNOWLEDGEMENT

The authors gratefully acknowledge the financial support of the Open University of China under Grant No. G16A3301Z.

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