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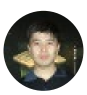
5 AUTHORS, INCLUDING:

Sajid Iqbal
Harbin Institute of Technology

Xizhe Zang
Harbin Institute of Technology



Yanhe Zhu
Harbin Institute of Technology

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Sajid Iqbal, Xizhe Zang
Harbin Institute of Technology, China.
sajidiqbal62@gmail.com

Yanhe Zhu, Yan Yan Chen
Harbin Institute of Technology, China.

Jie Zhao
Harbin Institute of Technology, China.

***Abstract*—From the early 90s, online education has been continually reshaping the notion of open learning. Massive Open Online Courses (MOOCs) have generated a paradigm shift in online education by presenting free high-quality education to anyone, anywhere with Internet access. Since 2012, MOOCs got attention of the universities, media and entrepreneurs. These online courses may change the world by 2022. This paper discusses major elements of MOOCs that can influence teaching and learning in engineering. It also explores the promise of online education in improving standard in-class engineering education.**

Keywords*—*MOOC; engineering education; online education; open learning;

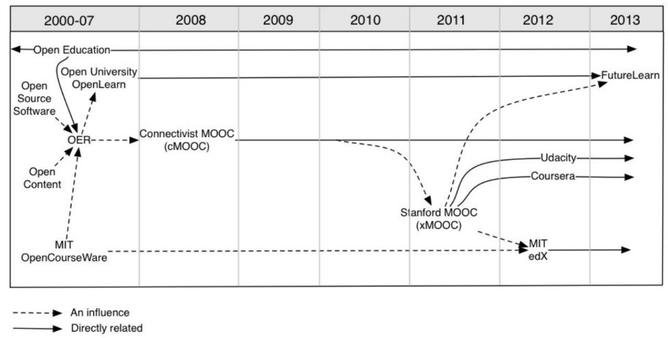

Fig. 1: MOOCs and open education timeline [3]

I. Introduction

MOOCs, according to IEEE CS 2022 Report, are one of the 10 technologies that could revolutionize the world by 2022 [1]. The instructors of the first online course—Dave Cormier and Bryan Alexander coined the term *MOOC* [2], [3]. The acronym stresses the vital components of this genre of online education. MOOCs became famous, when in the fall of 2011, Sebastian Thrun of Stanford University conducted a course on Artificial Intelligence. Enrollment quickly reached 160,000 students from 190 countries—only 23,000 finished it.

MOOCs came into limelight at a time when universities are under extreme pressure to increase accessibility and reduce costs. Currently, these online courses are the focus in higher education and the number of courses available is growing all the time [3]. MOOCs have the potential to enhance our brick-mortar classes but the prospects and challenges of these massive courses should be considered cautiously.

The advent of MOOCs may seem abrupt, but they are the next stage in the development of Open Educational Resources (OER). From open Learning Objects (LOs), the OER evolved into Open Course Ware (OCW) and now grown into MOOCs and more and more universities are participating in this *open learning* movement [3], [4]. Fig. 1 presents that concept of openness in education is developing rapidly since 2000.

With increasing population and rising expenses, brick-and-mortar classes are unlikely to meet the demand for higher education. Professor Ng has rightly said,“*When one professor can teach 50,000 people, it alters the economics ofeducation*” [2]. This democratizing aspect of teaching a MOOC is very appealing to teachers as they can educate learners around the world in one class that otherwise they cannot reach out. In online education, MOOCs are the next big thing and they will certainly transform higher education. The subject of MOOCs is progressing very swiftly.

II. Significant Highlights

Coursera and edX are two main MOOC providing companies. Coursera (www.coursera.org) claims 679 courses in 25 subjects, whereas edX (www.edx.org) boasts 212 courses [5], [6]. The companies offering MOOC platforms are also increasing and many famous universities are offering courses through these platforms.

With the prospect of teaching thousands of learners, these online courses seem to be a cost effective way for allowing students to realize some of their broad educational needs. Fig. 2 shows the origins of Coursera students [2]. This chart demonstrates that majority of MOOC learners are outside the US.

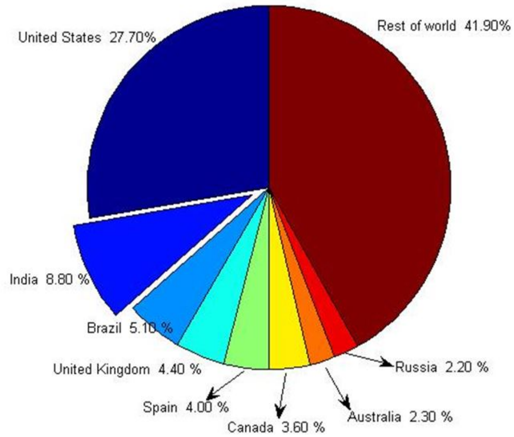

Fig. 2: Breakdown of students of MOOCs [2]

TABLE I: Comparison of key aspects of MOOC companies [3]

Initiatives	For profit	Free to acess	Certification fee	Institutional credits
edX	×	✓	✓	✓
Coursera	✓	✓	✓	×✓
Udacity	✓	✓	✓	×✓
Udemy	✓	×✓	✓	×✓
P2PU	×	✓	×	×

Key
× = Not a feature
✓ = Feature present
×✓ = Feature partially present

University administrators are captivated by MOOCs as they are the epitome of scale. Often attracting tens of thousands of students, these massive courses are providing high-class, free university education to anybody in any part of the world [7]. In future, tuition fee of online courses would certainly enhance income of institutions. Table I shows that different MOOC providers are focusing diverse aspects of online education [3].

Each new instrument—blackboard, radio, motion picture and television, was labeled the most important advancement since Gutenberg's printing press. But from the start of new millennium, it has been claimed that Information and Communication Technology (ICT) aids could revolutionize education because they absorb all these earlier innovations. MOOCs are a fascinating development [8]. Unlike previous enterprises, MOOCs are more dynamic and interactive. They will certainly map novel avenues for higher education.

III. Prospects And Challenges

MOOCs have presented us different opportunities as well as hurdles as shown in table II [9]. Since the format of MOOCs typically removes the need for prerequisites so there are no formal entry requirements. Hence, they can be used as prerequisites and introductory courses. They can also be employed to decrease the number of years required to complete a degree [9]. Universities are exploring ways for students to earn credits from these massive online courses.

Lifelong learning has a great importance in the emergence of the global knowledge economy. MOOCs may support lifelong learners in gaining understanding of the subject matter. The aims of continuing education learners are to enhance their ability to perform their present job and to develop the skills necessary to execute more complicated tasks [10]. Online education makes such continuing education goals not only practical, but compulsory.

Since more corporations are becoming global enterprises, online education is a boon for employee training [11]. Utilizing MOOCs, employees can keep themselves abreast of the needs of the competitive labor market. MOOCs can complement continuing professional education (CPD) and certification preparation [7]. MOOCs can work well with competency-based education. Hence, it is a learning model that fits introductory courses, interdisciplinary education and expert training.

In MOOCs, personal aims of learners drive learning since instead of having prior knowledge only willingness to learn is required as it has been told "*He who seeks finds*" (Matthew 7:8) [12]. In contrast to formal education, MOOCs are chiefly self-directed learning. These online courses certainly demand more maturity, and discipline than in-class education. This new pedagogical paradigm works best for motivated learners.

Since MOOCs are built around a self-regulated approach so sometimes they feel chaotic as learners generate their own content [13]. It has been established that learning is not a linear phenomenon; it is a continuous iteration, which connects to prior knowledge. Knowledge and learning are in a state of flux. Our brain functions in a chaotic fashion [14], [15]. Similar chaotic dynamics have been discovered in dissimilar dynamical systems like fundamental electronic circuits and complex events like weather [16], [17], [18]. Scientists believe that a bit of chaos may help us avoid rigidity in our physiology [19].

The basic concept of *the flipped classroom* is to flip the common instructional style—students watch video lectures at home and in classroom, time is spent on problem solving and collaborative learning [20]. Students can access course websites at their convenience. This model will provide teachers more time engaging students and less time lecturing in class. Some teachers have successfully put this idea into practice [21], [22]. This way of blending online and offline learning improves student learning in regular in-person classes.

MOOCs have certain shortcomings. A big downside is low completion rates, which are typically lower than *10 percent*. Like online education, completion has been a problem for earlier forms of distance learning—such as correspondence courses and broadcast courses. MOOCs also lack sufficient student-teacher interaction [23]. Currently, they require set business models for generating revenue. But their biggest challenge is the validation of original work and prevention of plagiarism.

IV. MOOCs and Engineering Education

Engineering education is the activity of teaching knowledge and principles related to the professional practice of engineering. The laboratories are a distinctive part of engineering education. Practice is the key in engineering profession. In engineering courses, student attendance in laboratories is necessary as the theoretical concepts must be augmented by the hands-on training [11], [24]. Virtual and remote laboratories can help in this regard. Table III illustrates the number of courses offered by the main MOOC companies.

Since engineering courses require prerequisites like—linear algebra, calculus, programming so initially upper-level engineering courses were virtually absent from MOOC list but the situation is changing gradually. I attended a MOOC on control of mobile robots [21], [22]; it was a learning experience. The course was a well designed combination of quizzes, assignments, programming exercises and practical demonstrations. Since engineering courses demand hard work from teachers as well as learners so both the student view and the teacher opinion should be matched as illustrated in Fig. 3

TABLE III: Courses Offered by Coursera and edX [5], [6]

MOOC providers	Total courses	Engineering courses
Coursera	679	51
edX	212	52

TABLE II: Opportunities And Hurdles Of MOOCs

Opportunities	**Challenges**
Democratizes education	Lack of revenue models
Focus on learning, personalized learning	Completion rates
A new learning dynamic based upon learning analytics	Limited methods to assess learning
Collaborative, social, peer-to-peer learning	Not for all students, one size does not fit all
Transforming relationship between academe and community	Limited instructor interactions
Lifelong learning	Learner authentication
Transformation of the relationship between instructor and learner	Transformation of the relationship between instructor and learner
Convenience, flexibility, affordability	Issues related to credits, certifications, badges
Experiment before commitment to degree	Accreditation issues

[25].

MOOCs have immense possibilities for engineering education. Learners, teachers, institutional managers, policy makers and venture capitalists are the stakeholders for MOOCs. The most crucial issues at stake are the issue of awarding credits and problem of laboratory requirements. The concerns about cheating and plagiarism are compelling when engineering courses are entitled for academic credits. New ways should be explored in which MOOCs might enhance student engagement, student authentication and accessibility.

V. Discussion

Every few years an innovative disruptive technology emerges. MOOCs are the newest in the line of disruptive technologies [26]. The intellectual giants of worlds leading universities are teaching the students from the developing countries and the lifelong learners. Idealists see MOOCs as a cure for expanding access to inexpensive education and evolving novel pedagogical methods [4]. Whereas, cynics consider these massive courses as a new disruptive technology, which will demobilize teachers and devalue scholarship.

Advanced education is already experiencing an era of unparalleled change worldwide. MOOCs will certainly open up higher education by providing accessible, affordable, flexible and fast-track completion of university courses for learners. The online education will create new opportunities for innovation in higher education that will allow academics and institutions to discover new online learning models and innovative practices in coaching and learning [3].

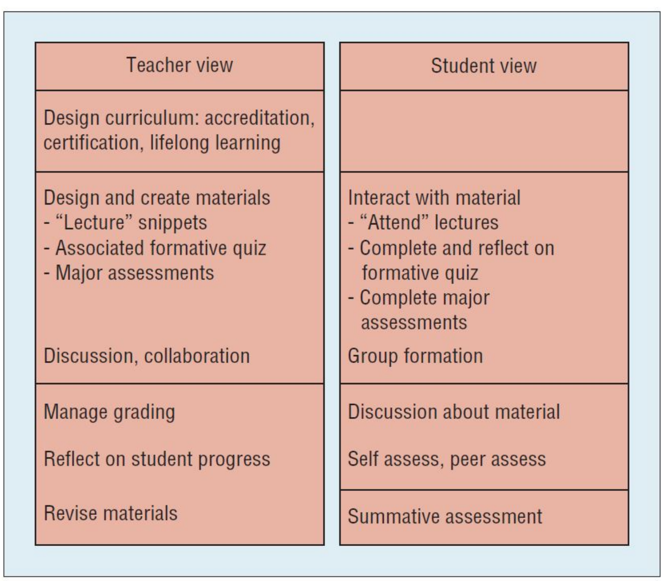

Fig. 3: Overview of the teacher and learner views of MOOCs [25]

Universities consider MOOCs for many reasons—reducing the cost of education, eliminating the need for student loans, using present resources more proficiently e.g., by offering blended learning, and reaching new learners [27]. The MOOC providers are gathering data about the ongoing classes. This data will play a major role in the ultimate value proposition of the MOOC companies. These online courses have combined education and social networking [28].

Online education will not render teachers obsolete and it can augment traditional education [29]. MOOCs can provide excellent education only if teachers and administrators embrace new educational technology and pedagogical innovation [30]. MOOCs have the potential of transforming the roles of institutions, teachers and students.

This paper reviews the current status of online engineering education. MOOCs will ultimately impact both continuing education of engineering graduates and degree-seeking students. The quality of online education must be equivalent to or better than the traditional education. It should be the shared aim of all the stakeholders.

VI. Conclusion

Engaging thousands of students, MOOCs have truly democratized education. They have recently received a great deal of attention from the education professionals, media, and entrepreneurs. The number of MOOC providers is growing and universities are considering MOOCs for credit hours. These online courses are an excellent chance for integrating course content, pedagogical techniques and ICT aids. They are providing a great opportunity for lifelong learners. A flipped classroom is an ideal use of MOOCs.

MOOCs are revolutionizing ivory tower education as well as providing data for research. MOOC companies are facing challenges like low course-completion rates and lack of suitable business models. Student assessment and plagiarism avoidance are realistic apprehensions for online learning like traditional in-class education. Thus, major contentious issues around MOOCs are: financial models, accreditation issues and pedagogical innovation.

Currently, online education is contributing to continuing education of graduate engineers. In future, it might fill a major gap in the undergraduate and graduate education. MOOCs will certainly transform higher engineering education. This paper looks into MOOCs and the openings they offer for engineering education. Since the number of introductory courses in mathematics, physics, statistics, and computer programming is increasing so in future more advanced engineering courses will be offered. Hopefully, these engineering courses will be immense learning opportunities.

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