

Online Learning and Higher Engineering Education

The MOOC phenomenon

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Conference Key Areas: New learning concepts; Information and Communication Technology; Engineering Educational Research.

Keywords: Online learning, Engineering education, MOOC, Educational technology

INTRODUCTION

The purpose of this paper is to gain a better understanding of the phenomenon of Massive Online Open Courses (MOOCs) and other trends towards greater openness like Open Educational Courseware and Resources, and to think about the implications for Higher Engineering Education (HEE). A MOOC is an online course aimed to provide free access to university level education for as many students as possible. MOOCs differ from traditional university online courses in two ways [1] Open access, anyone can participate in an online course for free, and Scalability, courses are designed to support an indefinite number of participants.

The speed in the development of MOOCs is a novelty in the history of education as well as the media coverage that exceeds any preceding innovation. Some consider the situation to be explosive, but there has not been enough time yet to confirm early experiences and to draw definite conclusions. The background of this phenomenon is multi layered, but there are three connected elements that seem to be decisive: a. The public discussion about the mere existence of higher education on the issue of incompetence of the institutions to cope with today's learning demands as the need for higher productivity and more flexibility; b. The rising costs for and of students, decreasing state support and multiplying debts of institutions, and c. The significant acceptance of internet technologies in society in general and in education, increasing the likelihood that the technology can serve as a problem solving opportunity.

Especially the discussion on the very different dynamics of education in the 21st century play a role and the fact that most institutions very much relate to the factory model of mass instruction which was the dominant model for centuries. An important defect of this model is that most universities and colleges are essentially traditional and conservative not being able to cope with the changing demands in society appropriately. The fear is that if institutions do not respond, they will not survive [2]. Today's reality is that new models of education are emerging initiated by a selective group of high class institutions and investing companies with a history in education,

publishing and public media. This is quite a different arrangement with a strategy focusing on online student centred approaches and the exploitation of smart personal technologies for anytime and anywhere learning and partnering with an industry that is looking for easy, efficient and low priced talent management [2].

In a sense this situation for HE is decades old. The British Open University started in 1971, the for-profit University of Phoenix is online since 1989 and MIT and lots of other Universities including the Delft University of Technology have been posting free online 'open courseware' since a decade. These developments were not considered disruptive for the existing HE system, but with the emergence of Massive Open Online Courses (MOOCs), this seems to change rapidly. In this context HEE has a special position since the development of technologies that enable online learning are at the core of the learning innovation business. HEE though is not a prominent partner in the discussion on the perceived consequences of this development for education and therefore this paper should help to extend the debate in the HEE sector on the role to play in this arena for learning innovation.

1 MAKING SENSE OF MOOCS

MOOCS can be seen as an extension of existing online learning approaches, in terms of open access to courses and scalability and a design that allows for large-scale feedback and interaction. The increasing range of different MOOCs are demarcated by two basic approaches: a crowd-sourced interaction and feedback by leveraging the MOOC network e.g. for peer-review, group collaboration, the so-called cMOOC and an automated feedback through objective, online assessments, e.g. quizzes and exams, the so-called xMOOC. The cMOOC was the first type of MOOC becoming available in 2011. This type of MOOC provides opportunities for non-traditional forms of teaching approaches and learner-centred pedagogy where students learn from one another. Online communities 'crowd-source' answers to problems, creating networks that distribute learning in ways that seldom occur in traditional classrooms in universities. The xMOOC represents much more a knowledge transmission model and is in essence considered to be technology-enriched traditional teacher-centred instruction [3]. Such systems offer an individualised experience in that they allow students to take alternative routes through material and offer automated feedback. However, they do not provide a social learning experience or one of being dealt with personally. The c- and x-Mooc represent more or less the broad spectrum of different models and usages.

1.1 The stakeholders

MOOC providers

The scale and open nature of MOOCs provide opportunities for large audiences and creates a space for experimentation with online teaching and learning. This has generated significant interest from governments, institutions and commercial organisations. For institutions to invest in MOOCs the main reasons seem to be the "enlarged access, experimentation and brand extension" [5]. MOOCs can expand access to education, for those who are interested and extend institutions' reach and reputation internationally. The first to introduce these courses on a large scale were leading universities like Harvard, MIT and Stanford operating in conjunction and investing large sums of money. In the meanwhile others have joined this trend by engaging in initiatives like edX, the non-profit venture from Harvard and MIT, Udacity set up by a former Stanford employee and Coursera, initiated by some other colleagues from Stanford. And sure there are other initiatives from small colleges, the

training business and from individuals, but most attention goes to the big ones. The Open University in the UK started a consortium of British universities to develop a new platform for free courses called Futurelearn, which is expected to be online competing with the American initiatives in the fall of 2013. Where Universities tend to take years to decide about anything, the MOOCs initiative seems to push decision making to another level. No wonder this phenomenon gets a lot of attention also because the media partners in this online endeavor know how to raise attention and sell a product [3, 2, 6].

In table 1 an overview of the early and main MOOC initiatives and their user policies. EdX is the MIT / Harvard not for profit initiative with a fee for 'certification', but without credits. Coursera and Udacity are run for profit with the intention to qualify the students with credits. Udemy has a restricted access policy and strives for crediting the students work. The PeerToPeerUniversity (P2PU) harnesses the approach that people collaboratively can do the job (learning for everyone, by everyone, about almost anything)..

Table 1: Comparison of key aspects of MOOCs or Open Education initiatives [4]

| Initiatives | For profit | Free to access | Certification fee | Institutional credits |
|-------------|------------|----------------|-------------------|-----------------------|
| eDX | x | ✓ | ✓ | x |
| Coursera | ✓ | ✓ | ✓ | x ✓ |
| Udacity | ✓ | ✓ | ✓ | x ✓ |
| Udemy | ✓ | x ✓ | ✓ | x ✓ |
| P2PU | x | ✓ | x | x |

Key

x Not a feature

✓ Feature present

x ✓ Features partially present

Some see MOOCs as a powerful tool that will cause fundamental changes in the organisation and delivery of HE over the next decade [6]. For politicians, MOOCs help address the problem of HE budget constraints and help to lower the cost of degree courses by enabling inexpensive, low-risk experiments in different forms of HE provision [4]. Commercial organisations see MOOCs as a way to enter the HE market by providing a MOOC platform and developing partnerships with existing institutions and to explore new delivery models in HE. For example, Udacity has teamed up with Google, NVIDIA, Microsoft, Autodesk, Cadence and Wolfram to develop new courses, including HTML5 game development and mobile applications development. For those organisations and the universities MOOCs seem to have a viable role in selection and recruitment of talented employees [4].

MOOC learners

The MOOC has been hailed as the potent defence against the increasing debts of students, the rising cost of education, the insular culture of HE, the ability to offer large audiences lectures at no cost and a high level of flexibility. Up till now these courses do not yet supply the learner with transferable credit and institutions struggle

with their online learning strategy for on and off campus students and how MOOCs and similar developments relate to the curriculum. A fact is that MOOCs seem to make learning more feasible and greatly attractive for students worldwide. Just to get an idea of the size: a Harvard course on 'How to reason and argue' attracted over 180.000 students. A Udacity course by Google's director of research Peter Norvig, attracted 160.000 students. A group of 155.000 students registered for MIT's prototype 'Circuits and Electronics' course of which only 45% was aged between 18 and 25 and most students came from America, India, Britain, Columbia and Spain and some 7.100 passed the course [7, 3, 6].

A survey at Duke University showed that student motivations typically fell into one of four categories [4]:

1. To support lifelong learning or gain an understanding of the subject matter, with no particular expectations for completion or achievement,
2. For fun, entertainment, social experience and intellectual stimulation,
3. Convenience, often in conjunction with barriers to traditional education options,
4. To experience or explore online education.

On the pre-course survey, fun and enjoyment were selected as important reasons for enrolling by a large majority of students (95%) and on the post-course survey, most reported that they have a general interest in the topic (87%). Students used the online course to help them decide if they want to take college/university classes (15%) while a significant minority of students claimed that they could not afford to pursue a formal education (10%). Further research will be needed in order to understand learner motivations at the outset, and also what maintains learner motivation during a MOOC course.

The MOOC technical platforms allow for using the technology to capture large data sets that can deliver useful insights into online teaching and learning with very large numbers of students at low or minimal cost. The opportunity to capture viable data for research is practiced by for example others the edX institutions such as MIT and Harvard to use the MOOC concept to understand "how students learn" and "improve innovations in teaching and learning on campus".

1.2 Issues and challenges

There is an extensive discussion going on about online learning which has been spurred by the MOOC development. The media coverage is stunning and it seems that everyone agrees at least on the fact that something very exciting is going on, but how to deal with it? There is definitely no consensus about the way to go so there are different objectives and different strategies also among the educational institutions. Some consider the MOOC as an opportunity to learn more about teaching and learning using different technologies and educational models. Others see it as an opportunity to raise new organisational structures next to the existing institutions and a series of industrial partners are interested in the MOOC purely as a business for profit. So there are a lot of issues and challenges because all the stakeholders will be affected by the initiatives of the others not knowing yet what these will be.

It is worth mentioning a couple of issues that dominate the discussion at this time and blend this in with the rest of the argumentation.

- If the MOOC becomes as popular as some like us to believe, than this could drive down the cost of university-level education and potentially disrupt the existing models.

- In one way or another the time and money spent on a MOOC will have to show some profitability from an educational point of view or whatever perspective the initiator claims. So the challenge will be to develop a convenient and sustainable business model.
- The use of ICT in education for online learning has not been very successful up till now and it is surprising that hardly any reference is being made to the very recent disappointing results.
- It is unlikely that all institutions have enough staff with significant working knowledge of online pedagogy to produce and arrange the quality that reflects the status of the institution.
- Elite universities, setting up open learning platforms such as edX and new commercial start-ups as Coursera and Udacity strive for certification and for credit. So the MOOC world might look attractive from that perspective, but what about the other colleges, can they profit from the quality courses offered by others when mentored locally?
- The commercial interest of venture capitalists and major corporations such as Pearson and Google which are planning to move into HE as global players and are likely to adopt a MOOC-based approach as part of their plans.
- The disruptive potential of the MOOCs forces the educational establishment to re-visit online learning and open education as strategic choices for the future.
- Most agree that online learning in some format contain lots of opportunities to improve education and become in general a better fit for purpose in the knowledge society.

2 EXPERIENCES

Currently thousands of learners are being served by the MOOC offerings of predominantly US origin while most European institutions are deliberating what to do and what strategy to select. The MOOCs movement originated in the US and Canada. Some European universities have joined US initiatives and recently the UK and Australia have launched national initiatives. On a Europe-wide scale the European Commission started in close collaboration with the European Association of Distance Teaching Universities (EADTU) the 'OpenupEd' initiative. The intention is to have 40 courses available by the end of 2013, covering a wide variety of subjects, in 12 different languages. OpenupEd is coordinated by the EADTU and mostly involves open universities.

The experiences on a European scale are moderate, but to be able to reflect on what is happening a couple of experiences with MOOCs are being discussed here, that relate to the working field of HEE. The first is from the University of Edinburgh in Scotland as an early adopter, presenting experiences with their first six courses. The second example is the experience at MIT with their 'Circuit and Electronics' course. The third example is about the proposition of Georgia Tech that one can acquire a technical Master's degree online for only one tenth of the costs of a regular on campus program. The fourth example is the initiative of Siemens, a technical company, offering initial IT courses for free.

2.1 The MOOCs @ Edinburgh 2013 – Report # 1 [8]

The University of Edinburgh launched six MOOCs on the Coursera platform early 2013 with short fully online courses, each lasting either 5 or 7 weeks and with a total initial enrolment of 309.000 learners. The courses offered were from Humanities and Social Science (*Introduction to Philosophy; E-learning and Digital Cultures*), Science

and Engineering (*Artificial Intelligence Planning; Astrobiology and the Search for Life on Other Planets*): Medicine and Veterinary Medicine (*Equine Nutrition; Critical Thinking in Global Challenges*). AI Planning was at Master level, the rest were on Bachelor level. Each team selected their preferred delivery which resulted in six different course structures. Teams experimented with content delivery and collaboration methods using the Coursera platform. One could enter and exit the course freely and participate without active engagement with quizzes or social media, allowing behaviour patterns distinct from those of on-campus degree courses.

There were 203 countries represented with 28% living in the USA, 11% in the UK; 33% were between 25-34 years of age. The highest current employment was 17% in 'Teaching and Education' and 15% as 'Student'. The educational background of the participants was degree-level academic (over 70%) and postgraduate degree (40%).

In the exit survey 98% indicated that 'they felt they got out of the course was what they wanted' and the pacing in the course had been about right. Of the total enrolment 12% accomplished the course, which was 21% of the active learners. The main reason for participation was interest in the subject matter and curiosity about the MOOC and online learning.

It took the staff approximately 10 months to prepare and test. The findings were promising and the staff was pleased with the overall outcome. The attraction of mainly adults with high educational attainment seems to be related to the publicity that was largely through educational media channels.

2.2 MIT: research into edX's First MOOC [9]

The research looked at the 'Circuits and Electronics' course (6.002x), which began in March 2012. The course attracted nearly 155,000 students and the study particularly focused on the 7,100 students who earned a certificate for passing the course, which was composed of video lectures, interactive problems, online laboratories, and a discussion forum. The researchers started analysing the data this course generated after the end of the course in June 2012 and published the findings in May 2013.

The researchers examined the time spent by the students on the resources, they looked at who these students were and how their background and capabilities related to their achievement and persistence and how their interactions with the curricular and pedagogical components contributed to their level of success in the course. Student came from 194 countries with the USA, the UK, Columbia and Spain as the main suppliers. Participation and performance do not follow the rules by which universities are traditionally organized which was a complicating factor in the research. A large number of students may not have any interest in completing assignments and assessments. Of the learners 67% spoke English and 16%, the next largest group, Spanish.

The focus of the research was on the behaviour of the successful students in order to identify common traits or behaviours. There was no correlation between motivation for enrolment and success in the course. Success was defined as in the traditional college setting, by the grades students earned. One striking observation was that collaboration with another person, whether a novice or expert, strengthens learning and in this case led the learner have a predicted score almost three points higher than someone working by him or herself. Troubling is the low completion rate with less than 5% of the students who signed up completed the course.

The issues that MIT wants to cover in future research relate to research-based comparisons of instructional strategies; the social context of education, how to help students to learn more per unit of time and the more political questions like the possible certification, changes to the traditional cost structure, access and equity.

2.3 Georgia Tech offers an online low cost alternative [10]

The Georgia Institute of Technology will soon begin offering an online master's degree in computer science at an unusually low cost. Georgia Tech works with Udacity, one of the MOOC supplier companies. AT&T is donating \$2-million to help get the program started, and the company will play an active role in some courses, offering guest speakers or suggesting class projects if the professors agree. The courses in the program will be free through the Udacity's site, made up of video lectures and computer-graded homework assignments. Students who want the possibility of credit or a degree will have to apply for admission to the university and pay tuition, and those students will get access to teaching assistants and, in some cases, have their assignments graded by people.

The fees are about \$134 per credit, compared with the normal rates at Georgia Tech of \$472 per credit for in-state students and \$1,139 per credit for out-of-state students. The program is expected to take most students three years to complete, and cost less than \$7,000. This sounds like a bargain compared to the regular costs at any US university.

The university and Udacity will split the revenue from the paying students, with 60 percent going to Georgia Tech and 40 percent to Udacity. The expectation is that technology will help reduce the cost of instruction without reducing quality. Students on the degree track will have to take tests in person at one of 4,000 proctored testing centers run by Pearson VUE. By the end of the three-year pilot, officials hope to have thousands of students enrolled.

Georgia Tech is unique in that it is trying to reduce costs by adapting teaching for an online setting rather than simply transferring traditional methods online. An issue mentioned is the involvement of AT&T in relation to the academic integrity of the program. AT&T main goal seems to preserve a pipeline of qualified applicants and not to downgrade the program into a business course. The general opinion is that by harnessing the power of MOOCs, Georgia Tech hopes to embark on a new era for higher education and increase the contribution to the development of a highly skilled work force.

2.4 Open Technical Education Classes for Students from Siemens [11]

To assume that the MOOC phenomenon is a purely academic issue is wrong. Not only venture capitalists and other businesses try to enter this potential market, also a technical company like Siemens is interested and launched a MOOC initiative for students interested in IT, using an informal learning environment within an open forum. The Enterasys Networks, a Siemens Enterprise Communications Company in the education and networking field, offers these technical classes at no cost and provide technical skills in fundamental areas around IP data networking, wireless technologies and security concepts, all key areas of recognized growth within the IT sector. Unlike traditional MOOCs, the Enterasys MOOC is self-paced and students can attend the weekly scheduled module when it is best for them.

- The MOOC runs a total of four, sixteen week sections, with eight modules per course (a total of 32 modules) based on courses like: Data Networking Fundamentals, Wireless Fundamentals, Security Concepts and IPv6 Networking Fundamentals.
- Courses are open to all students globally, although the lecture materials are delivered in English. No background knowledge or prior skills are required, just an interest in the subject matter.
- The communication and transcript tracking mechanisms are all based on Twitter. Students can view their current course completion transcripts and compare their ranking to other students via leaderboard statistics. The top student for each section will be awarded a prize for his/her success. Student interactions among peers or teachers are based on the Twitter hashtag #ETSMOOC.
- Delivering the modules are industry certified instructors, who are versed not only within the technology for discussion but also across the breadth of wired and wireless standards and solutions.
- Students who successfully complete the section of modules will receive a Statement of Accomplishment. Efforts are underway to achieve college credit for attending these MOOCs.

It very much looks like Siemens aims to recruit the best students through this MOOC initiative and prepare others to maybe join the company, but then well equipped with knowledge and skills acquired in their own free time. This feels like an innovative boarding policy to acquire talent on the competitive labor market for engineers.

The four examples of MOOC activities clarify that although the academic world might be in the lead, it is a shared playing field with very different participants, intentions and expertise that not always fit, but obviously support the vision that something promising is going on. For all players goal setting seems to be the most urgent action to avoid disappointment. Especially the academics are slow decision makers and have been very reluctant to follow the innovation trail that has been so obvious in other parts of society. In that sense HEE has not yet positioned herself as an innovator as such, but that could change since technology is inherent part of the profession.

3 IN NEED OF A BUSINESS MODEL

From the little overview of experiences it becomes clear that online learning will not work without looking closely and learn from the different initiatives outside traditional institutions that are developing new business. The need for new and other financial models and revenue models are evident to meet the needs of new learners in a very different HE market place. At the same time it is true that Open education will open up new opportunities for innovation and to explore new online learning models and innovative practices in teaching and learning. At a national and international level, new frameworks for HE funding structures, quality insurance and accreditation to support different approaches and models for delivering higher education will be required [4].

Looking at the actual situation the most common revenue stream for the major new MOOC providers is to charge fees for certificates. EdX is a not-for-profit MOOC platform but will in the long also need to be self-sustaining. Coursera and UDACITY are for-profit organisations developing a variety of business models which include strategies as: selling student information to potential employers or advertisers; fee-

based assignment grading; access to the social networks and discussions; advertising for sponsored courses; and tuition fees for credited courses [5].

4 SUMMARY

This purpose of this paper was to supply an entry to the MOOC phenomenon and at the same time feed the discussion in the engineering education field and raise additional questions. The short analysis clarifies that MOOCs are supposed to have an important impact in improving teaching and learning and encouraging institutions to develop distinctive missions. It is also clear that to be successful one needs a clever design and a well-organized technical and organizational setting to achieve a viable and sustainable level of innovation.

At this point the main concern is that the online learning hype could very quickly turn into a solution provider for various kinds of deficits in the European educational system. The learning providers though are not necessarily European and this means that the European institutions should take the prospect of being daringly innovative using their academic freedom and creativity to develop new educational models, new learning arrangements and new opportunities for knowledge reliance with the Industry at large [2].

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