

Chapter 1.

The Coming Of MOOCs

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Abstract. A MOOC is a Massively Online Open Course. It is massive because there are many students (sometimes hundreds of thousands). It is online because it uses the Internet for course delivery. It is open because it is publically available to anyone without selection barriers or payment. And it is a course, teaching a particular subject, often in engineering and science, but increasingly in all domains of human knowledge including the arts. MOOCs burst on the scene of online distance learning in the fall of 2011 and caused a wave of excitement followed rather quickly by a wave of scepticism and resistance. What are MOOCs? Will they help to deal with the 'crisis in education'? How do they fit within the earlier developments in distance-education and the use of computers and telecommunication for supporting learning processes? What are the limitations of MOOCs? How can we strengthen them and fully profit from their potential? This paper addresses these questions from my personal viewpoint as an educator involved for decades in teaching and online distance-education. It looks at MOOCs, bringing in a European perspective, and suggests avenues for further research and practice.

Keywords. MOOCs, online learning, distance-education, social MOOCs.

Introduction

For several decades I have been a university professor at the Free University of Brussels (VUB) and thus active in educational practice, at first teaching 'ex cathedra' for large groups of students in the first bachelor years of computer science, and gradually focusing on master's level courses in Artificial Intelligence and directing PhD's with more than 30 having graduated so far. In addition, I have been active throughout my career with distance education.

During the late eighties and early nineties I worked with the Dutch Open University to turn some of my courses into educational materials that could be studied at home with occasional tutoring in the educational centers of the (Dutch) Open University. The most successful course on knowledge engineering [23] was attended by thousands of students, which is a substantial number given that the course was in Dutch and so the possible population of students was restricted to the Netherlands and Northern Belgium. I was also involved in a start-up company called Knowledge Technologies, located in Brussels, that specialised in the application of knowledge-based systems to education. The company later became part of Didael, still an italian leader in distance education (<http://www.didaelkts.it/>).

In the mid-nineteen nineties, I started to work extensively with EuroPACE, a European-wide organisation for distance education [28]. EuroPACE was using primarily televised lectures, broadcast via satellite or through national broadcast organisations. The World Wide Web started with a few servers only in 1992 and so satellite television was the only option at that time to spread video materials. For EuroPACE, I made a total of 60 hours of lectures about a variety of topics, many in the domain of computer science, more specifically Artificial Intelligence.

One of my biggest projects, in 1994-1996, was titled *Science on the Edge of Chaos* (https://arti.vub.ac.be/previous_events/chaos/intro.html). It was announced as “an interactive multi-media web on complexity and chaos”, which was at that time an emerging hot topic. Different themes were covered through the eyes of complex systems science - from physics, biology, and technology to cognitive science and socio-economics. Each theme was worked through five components:

1. A lecture introducing basic concepts from complex systems science in small chunks, using a format similar to today’s MOOCs.
2. A case study based on work of a leading scientist. For example, one case study focused on chaos in the solar system based on the work of Jacques Laskar (Observatoire de Paris)
3. A conversation with a high profile scientist on chaos and complex systems science (including Noble prize winners Ilya Prigogine, Manfred Eigen and Christian De Duve).
4. A live panel discussing hot topics and recent progress for each theme.
5. Various web resources and ways for student interaction using email, videophone and occasionally live telephone interaction during the panels.

This project was, in 1994, probably the first one in Europe to use the web as a rich educational medium, and it clearly foreshadowed many aspects of the MOOCs that arose twenty years later. No video could be transmitted through the web and so television broadcasting had to be used. The number of people having access to the web at that time was still very limited and also financial resources for the independent development of distance-education were hard to come by, so this particular project stopped after six themes were covered. However, it illustrates clearly that the vision of online education using video lectures and web resources was already alive in the nineties and it was just a matter of time—until personal computers, widespread internet access, and sufficient server capacity were available—before it would become really possible and scale up to the MOOCs we see today.

My various educational activities and experiences with online distance education in the eighties and nineties culminated in a series of workshops in the beginning of the 21st century, which I organised in Bagnols (France, 2002), Calheiros (Portugal, 2004) and Carmona (Spain, 2003). The outcomes of these workshops were published in two books on *The Future of Learning* [25], [24]. The workshops were motivated by two insights: a growing sense of a crisis in education, and hence pessimism, but also a growing awareness of the opportunities that new technologies, particularly those centered around the use of computers and telecommunications, were beginning to offer, and hence optimism. The current rise of MOOCs is realising many of the visionary ideas that we were dreaming about decades earlier.

The rest of this paper first discusses the nature of the crisis felt in education. I then turn to the trend towards personalisation and decentralisation that is emerging as a pos-

sible answer to deal with the crisis, and discuss how the development of information and communication technologies is progressively enabling this trend to become reality. Against this backdrop, I then focus on MOOCs and reflect on their positive sides but also on the criticisms beyond the initial hype.

1. The crisis in education

The worrisome problems encountered by the educational systems in European countries were already jumping from the facts around the turn of the century, and they have been since exacerbated.¹ What is the nature of this crisis and what are the possible causes?

1.1. The nature of the crisis

Here are some of the key observations [6]:

- There has been a clear *diminishment in academic achievements*. In France, 21 to 42 % of the students finish their high school education without adequate reading and math skills, which is lower than in the 1920's. Still in France, there is an increase in the proportion of low achievers from 15.2 % in 2000 to 21.8 % in 2006, showing that the downward trend is continuing [16]. Similar statistics can be found for other European countries. The effect of diminishing achievement is percolating into the higher educational system. For example, many university students, even in scientific and technical fields, still graduate without adequate programming skills or the ability to express themselves in clear writing. They have memorised some of the main facts in their fields but are unable to engage in the kind of life-long learning that is required in today's rapidly evolving society.
- There has been a growing trend towards *violence* in schools. For example, in France 15,000 incidents are reported every month (already in 2002). Some of these incidents—occasionally caused by parents supposedly 'defending' their children—have led to the death of teachers or significant physical harm [21]. This trend is obviously making it difficult to establish the peaceful surroundings needed for real learning and is strongly demotivating excellent people to choose the educational profession.
- The number of *student dropouts* has been increasing steadily. They stand at 30 % in Italy or the Netherlands for university education, although they are lower in countries with stricter entrance requirements, such as the UK where it is 16 % [18]. This high rate is taking away resources needed for the students that strive for excellence and hence it is lowering the quality of education.
- There is growing *teacher unrest*, with national strikes and many teachers leaving the system early in their careers. There are growing difficulties to recruit new teachers, particularly for mathematics, computing and science, with significant shortages, even in countries such as Germany where the educational system is under less stress [4]. One side-effect of this trend is that courses (for example

¹ Here are two interesting data sources for education in Europe and comparisons to the rest of the world: <http://ec.europa.eu/eurostat/web/education-and-training/overview> and <http://www.nationmaster.com/country-info/stats/Education>

computing) are taught by teachers who have hardly any knowledge nor training in the fields that they are teaching.

- There are persistent complaints from the industry that they cannot find enough people with the right qualifications. Particularly in the domain of science and engineering the situation is dramatic. For example, in Germany alone there are 14 000 vacancies for electrical engineers. Not enough qualified students are graduating and those that graduate are lacking essential skills.

Despite these undeniable trends, and despite significant expenditure (for example, on average 7780 EUR is spent per student per year in France), many educational reforms have failed. Some of them because they were ill-conceived, but also because there is often resistance from teachers, who are increasingly getting tired of bureaucrats with little knowledge about what it means to stand before a classroom meddling with educational practice and causing unnecessary disruptions by the imposition of harmful policies.

The sense of a crisis is very much with us today, and for many observers the situation is only becoming worse. Whereas initially only inner city schools in the big cities were affected, problems have now spread to smaller towns and to all European countries. Moreover opportunities for ‘after school’ education in music, arts, sports, languages, etc., which were an essential part of the European public educational system in the past, have begun to dry up due to budget cuts, thus giving fewer chances to students to complete their education with skills and knowledge that used to complement the standard curriculum, which is increasingly oriented towards vocational training only.

1.2. Possible causes for the crisis

The causes of the crisis in education have been much debated. The educational system is certainly partly under heavy stress due to the significant increase in the number of students and the evolution towards a multi-cultural society in Europe. But there are some other culprits that are often cited:

1. The European educational tradition has always been based on the laudable ideal that anyone should be given maximum opportunity for reaching the highest possible level of self-development and that this should not be based on the background or financial resources of the parents. This ideal plus significant population growth have led to a massive increase of students, particularly in higher education. For example, the bachelor degree in France has jumped from 4,9 % of the total student population in 1950, to 19 % in 1970, 25 % in 1980, 43 % in 1990 and 62,7 % in 1995. This massive increase has had two side effects: (i) It is hard to believe that all these students have the skills, motivation and talents required, so that unavoidably the dropout rate becomes higher. (ii) The scarce teacher resources are spent on trying to educate at all cost a large group of students who are not at the appropriate skill level and have no interest in learning, taking away resources needed for reaching excellence with the other students. Larger classes have led to a degradation of teacher-learner contact, causing problems of discipline and student demotivation.

2. The trend towards “*everybody has to have a university degree*” has been reinforced by the European Commission’s mantra of the ‘knowledge society’, claiming that everybody has to become a knowledge worker[26]. The overemphasis on ‘academic knowledge’ has led to a scarcity of skilled plumbers, carpenters or manufacturing workers but an overabundance of people with ‘higher’ degrees—often of doubtful value—but

without any prospect of work. It has accelerated the demise of manufacturing in Europe, a high unemployment rate, and an increasing number of young people working below the level supposedly granted according to their degree. It has also reinforced the sense of crisis in education, where schooling no longer prepares you for later professional and cultural life.

3. The Bologna reorganisation of the higher educational system has had a very negative impact on the level and quality of teaching in several European countries. The reorganisation was again based on a laudable objective: Leveling the different paths of higher education (e.g. between technical engineering schools and academic engineering faculties) and thus giving greater opportunity to all. In practice it meant that students with educational programs with lower challenge levels were upgraded (a lot of vocational engineering and arts degrees were from one day to the next declared to be at a university level), but, unavoidably, the programs that targeted higher challenge levels, specifically academic degrees, were downgraded because students were allowed to move between degree programs practically without entry barriers.

4. The Bologna reform also made students more responsible for their own educational trajectories and gave them enormous flexibility to choose. This has led to student classes with very unequal backgrounds and competences, making it difficult to keep the necessary level of excellence. In the end, it has become almost impossible to ensure that students have the level of competence supposedly guaranteed by their diploma. Many students now slide through the system, seeking out the 'easiest' way to reach the desired diploma and avoiding the hard work that would normally be required. Attempts to bureaucratise this process (specifically through the European Credit Transfer and Accumulation System [http://ec.europa.eu/education/tools/ects_en.htm] set up in the Erasmus framework) are not satisfactory because they assume that it is easy to define learning outcomes and that education can be easily decontextualised.

5. The central role of the state in education started in the 19th century in Europe. Education became compulsory with state funding provided directly to state schools or indirectly to religious organisations that set up 'private schools', which were however to a large extent still controlled by the state [5]. Curricula became standardised and levels and requirements were nationally defined. Teacher education and qualification became centrally organised and regular quality controls were introduced in the schools. This has certainly led to a tremendous improvement of education for the largest possible segment of the student population.

However, the centralised state-wide management of education has also led to a very slow adaptation to the profound changes in the educational needs of society (for example a very slow inclusion of computing skills in standard curricula). There is a growing mismatch between the needs of a particular community or of the industry in a particular region and the national objectives. Clearly, a highly multi-cultural and multi-lingual class in an urban environment should be allowed to function in a very different way from a class in a rural mono-cultural context. Technical schools in a region with a lot of industry specialised in mechanical engineering need to cater to different learning objectives compared to a technical school in a region specialised in the financial service sector. The mismatch between local needs and global state-imposed requirements is often cited as one of the causes for a high drop-out of students who feel curricula and pedagogical methods are not adopted to their needs.

2. Personalisation and decentralisation

There is certainly no magic wand that will make all these problems go away, and top-down bureaucratic intervention has only seemed to make the situation worse. Every European country has tried to combat the crisis in education in different ways and inspirational educators have taken many, often very valuable, initiatives. Generally speaking, we see a trend towards *personalisation* and *decentralisation*.

Personalisation means that independent actors (private companies or governmental institutions) are stimulated to provide educational opportunities and the students themselves (with their parents) are stimulated to actively choose and shape their educational trajectories for their own good and adapted to their own needs. As we will see, MOOCs fit entirely within this trend.

Decentralisation means that decision-making is no longer entirely controlled by a central educational bureaucracy but devolved to local governmental organisations who can operate within an envelope of financial means and requirements provided by the state [32] or even to small groups of individuals that band together to learn about a particular topic. Local actors are in this case regions, cities, networks of universities and schools, or semi-governmental non-profit organisations.

2.1. Provisioning by private actors

One radical response to deal with the crisis has been to introduce in Europe a market approach to education, thus following the American example [29]. This approach is being tried out most strongly in Britain, which, since the Thatcher era, has veered towards an American style capitalist system that relinquishes the role of the state as much as possible in favor of the private sector.

The basic principle of this model is to stimulate private actors to produce educational materials. Students and their parents are viewed as consumers that buy education the same way they buy a car or a smart phone. The providers go into competition with each other, both to attract students and to prove the worth of their diplomas with employers, which in turn ensures (at least in theory) that future students select the best provider. A school that produces successful graduates will attract more or better students and thus get the income to sustain itself. According to the market logic, competition should lead to an improvement of what is on offer, greater efficiency in creating or supplying education, and an improvement of consumer choices, i.e. it should force students to choose more carefully what they want to study based on their talents and the prospects of a later job.

Today there is certainly a willingness to consider contributions from the private sector in education. In fact in some domains private tutoring has always been very common. For example, music teaching is traditionally done by private teachers that interact with students on a one-on-one basis and if music education is organised by the state, it follows closely a highly personalised pedagogy. Intensive sports training is also done within the context of private clubs and with trainers that give a highly personalised attention to talented individuals. Many companies organise their own continuing education to keep their workforce up-to-date and highly skilled and most of them make heavy usage of external companies that are specialised in offering specialised education.

In all European countries we see a growing trend towards public-private partnerships, for example to provide and take care of schoolbuildings. There is also a timid rise

in fees for higher education, except in the UK where the rise in tuition fees has been dramatic. There is also a growing number of private actors which are providing some form of higher education, as the ‘monopoly’ of state-funded institutions to hand out certified degrees has been broken in several countries, such as Belgium for example. So these developments are paving the way for a greater involvement of private actors, such as MOOC providers, in higher education.

But the application of the market principle to education on a grand scale is seen in most European countries as a bridge too far. Here are some of the problems:

- As in any capitalistic market-based system, the value of a product is translated into how much it costs and private actors only invest if there is a profit to be made, i.e. if the price of the product is sufficiently high to cover at least the cost. This poses a problem for education because there is a basic unavoidable cost for the knowledge-intensive teaching model that is generally believed to be necessary for true learning and knowledge creation. So the price for education, assuming no state support, is necessarily high.

Such a high cost means in practice that the financial means of the parents determine the quality of the education of their children or that students have to take on loans which they have to pay back during a significant part of their life, trapping some of them into a cycle of poverty. Privatisation of education in the UK is already beginning to show signs of this. The average price of the university tuition fee in Britain is now 12,000 eu/year. Although this may still sound reasonable compared to American university tuition, which goes up to 50 000 EUR/year, it is still viewed as extraordinary high from the viewpoint of Europe, where parents pay on average between 500 and 1 000 EUR/year and the state funds the rest. Moreover, even if the US private-sector model has led to elite universities, “among developed countries, the United States is 55th in quality rankings of elementary math and science education, 20th in high school completion rate and 27th in the fraction of college students receiving undergraduate degrees in science or engineering.” [12]. In other words, privatised education reinforces existing inequalities and thus not ensure a sufficiently high educated workforce.

- It has proven difficult to create a ‘market for education’ in Europe, partly because the traditional providers (i.e. universities and technical schools) all ask the same price when they are given the right to set the price themselves. Moreover the choice by the student is often not based on supposed quality (which in many countries is guaranteed by the state to be the same across all institutions anyway) but on other factors, such as proximity or family tradition.
- Universities have a broader task than education. They contribute to the common good through research and service to society and this is generally acknowledged to underpin the economic viability and societal functioning of the regions in which they operate. By pushing universities to compete in an optimised and privatised educational market, many critics believe that we will see a ‘tragedy of the commons of knowledge’, i.e. a general shrinking of the knowledge base from which companies and government institutions can draw.

2.2. Provisioning by governmental actors

The trend towards personalisation is not only motivated by adepts of a liberal and capitalistic organisation of society. In the seventies there were educational theorists, such

as Ivan Illich with his influential book “Deschooling society” [10], which were advocating the same, except that they believed that provisioning should happen through public channels rather than by privately owned for-profit companies. Illich argued for example for the need to create computer-based learning webs, where individuals could access reference services that describe educational opportunities for formal learning, and skill exchanges, which are peer-to-peer services where those with skills offer to teach others. Many of these ideas are beginning to become reality in the context of MOOCs.

Governmental and non-profit infrastructures that come closest to providing personalised educational approaches are the ‘open’ universities that were created in the seventies. Open universities allow students to take single courses independently and at their own pace. They thus provide access to higher education for those who have to (or want to) mix education with work. It creates new opportunities for continuing education after a degree, and allows those who dropped out from a traditional courseprogram to restart their educational trajectory.

The largest example of this kind is the Open University in the UK, but there are similar institutions everywhere in Europe, such as the Fernuniversität Hagen in Germany, the Open Universiteit in the Netherlands, the Universitat Oberta in Catalunya, Uninetto in Italy, etc. The ‘open university’ courses are often produced in collaboration with professors and their teaching assistants at existing universities. Additional resources are provided by a central organisation that helps to define the course objectives and assists in designing and developing tutoring materials, exercises, and evaluation methods that can be used without physical proximity.

The open universities offer certified degree programs which are equivalent to those offered by ‘brick-and-mortar’ institutions. This implies that they have strict assessment procedures comparable to regular universities. They include personal tutors that provide also academic expertise, guidance, and feedback, although students are primarily supposed to work on their own and at their own pace. There are opportunities for social interaction with others, possibly through online media, study networks and course forums, as well as through occasional physical meetings at open university centers. Students pay per course. Although the price is usually lower than that of the normal universities, it is still much higher compared to the almost free education on offer in MOOCs.

Open universities are clearly the real pioneers of distance education and millions of students all over Europe have participated in their courses with great satisfaction. They have worked out novel pedagogies and techniques for courseware that are (or should be) of great value to MOOC developers. Open universities have also pioneered many of the information and communication technologies for distance education on which MOOCs are based, as discussed more fully in the next section. Open universities have proven most valuable for continuing education and they have certainly not replaced the traditional higher education institutions that are still teaching the bulk of students. Moreover the open universities draw for a lot of their course material on ‘brick-and-mortar’ universities.

3. The role of Information and Communication technologies

Information and communication technologies (ICT) have progressively come on the educational scene since the mid-20th century. It started with the ‘school radio’ in the fifties

and the ‘school television’ in the sixties. Initially most households did not have radio or television and students listened to the radio or watched broadcasts inside classrooms, providing examples of so called *blended education*, but as radio and TV became consumer products, and audio and video playback became widespread, educational technologies for self-teaching started to take off and were adopted enthusiastically by the open universities or other organisations such as EuroPACE offering continuing education.

The next step came with the introduction of computing technologies, gradually slowly becoming available in classrooms and school administrations in the seventies and then in the home in the nineties. At the same time, the Internet took off, again at first slowly in the seventies, but then progressively propagating like a huge wave, shortly after the World Wide Web protocol made information transfer and access straightforward and scalable.

Today ICT has in many ways become crucial in education. First, the most basic impact comes from *Learning Management Systems*. They are used by schools and universities to organise the curricula, deliver content, identify and assess learning goals, and collect data about the individual or a class. They are also used by students themselves in order to register for courses, download course materials, upload exercises, and see their grades. MOOCs had to support all these activities, but they needed to scale up the technology of Learning Management Systems to handle hundreds of thousands of students.

Second, attempts have been made from the sixties onwards to go much beyond administrative purposes, and to build systems that assist in the educational process itself. A whole series of information and communication technologies have resulted from these various efforts. Most of them have often not gone beyond small-scale academic experiments, although there are quite a few companies that are marketing already concrete applications.

The developments towards the use of computers for teaching can be grouped into three main trends: Computer-assisted instruction, intelligent tutoring, and open learning environments.

3.1. Computer-assisted Instruction

The first use of computers for teaching, already in the sixties, applied the *programmed instruction* pedagogy developed by behaviorist B.F. Skinner. This pedagogy strictly streamlines course materials in small chunks and suggests students to incrementally go through units, each time doing the exercises associated with a small chunk. Students have to check their own answers and can only advance further after answering correctly. Soon richer forms of computer-assisted instruction were developed, such as the PLATO system, where PLATO stands for Programmed Logic for Automated Teaching Operations. In addition to computer-assisted instruction in the Skinnerian style, PLATO grouped functions that we now find in Learning Management Systems, such as managing course content and student participation. The system also allowed the inclusion of a variety of additional learning materials, such as texts, videos, computer simulations, and it provided ‘courseware’ tools for creating online lessons [22]. The PLATO system is therefore an important forerunner of the MOOC.

Many of the currently successful computer-based teaching systems, such as Rosetta stone (www.rosettastone.com) for language learning, are still following the pedagogical format pioneered by Skinner’s learning machines. And many large-audience MOOCs,

such as the ones for Artificial Intelligence and Machine Learning developed by Udacity and Coursera, are essentially based on the same behaviorist pedagogical principles offering as well the added functionality of early pioneers like PLATO, but now made more attractive with better interfaces, faster multi-media savvy computers, and delivery through the internet rather than through floppy disks or CD-ROMS.

3.2. *(Intelligent) Tutoring Systems*

When Artificial Intelligence started to mature in the seventies, the objectives of developers became more ambitious [17]. They started to target systems that had three capacities: (i) to be (automated) problem solvers themselves in the domain in which they were tutoring, for example, be able to parse or produce sentences, solve mathematics problems, compose music, (ii) to build a student model that would explain student errors, and (iii) to actively plan a course of action based on particular tutoring strategies. Although a lot of work was done by many AI researchers, the technology needed to achieve intelligent tutoring was—and still is—too complicated for widespread adoption. But it is clear that if online education through MOOCs is ever going to come anywhere close to human teaching, it will have to integrate aspects of intelligent tutoring [1].

3.3. *Open learning environments*

The Skinnerian behaviorist pedagogy is most effective for a particular type of knowledge, such as the rote learning of words. But many psychologists, such as Piaget and Vygotsky, and educators, from Steiner to Malaguzzi, have argued that for many subjects learning is much more effective in an open environment in which learners are offered a variety of materials which they can explore and from which they can discover solutions themselves. In the mid-seventies, several researchers started to investigate how computers could help to put this constructivist learning approach into practice. One of the main advocates was Seymour Papert, who devised the LOGO programming language and Turtle geometry as open learning environments for mathematics and computing [15].

The most well-known MOOCs so far tend to lean towards programmed instruction and therefore stick to rather rigid educational lesson plans and immediate testing, but it is possible to conceive of MOOCs that pursue a constructivist pedagogy, for example, by providing rich simulation environments that stimulate students to construct in a game-like environment their own models of particular phenomena and test them out [11], or by heavily integrating social media to make up for the isolation of the individual learner and thus stimulate collective knowledge construction [3], [14].

In fact, the term MOOC was originally used to describe experiments in 2008 by George Siemens, Stephen Downes and others in Canada to implement a so called ‘connectivist’ pedagogy [20], that is closer to the constructivist learning in open environments that Papert had been advocating than to the programmed instruction approach, although it targets other subject domains, primarily in the humanities, such as thinking or writing.

From the viewpoint of the connectivist approach, content within some domain of knowledge (i.e. facts) is not the most important thing that needs to be learned, because this content is shifting rapidly and abundantly available today through web resources such as Wikipedia. Rather learners should acquire the skill to access, aggregate and navigate through content and teachers are facilitators that should guide this process.

The MOOCs built with a connectivist foundation are now called connectivist MOOCs or cMOOCs to distinguish them from the behaviorist MOOCs (now sometimes called xMOOCs) that follow primarily the programmed instruction format.

Instead of tutors, the connectivist pedagogy talks about facilitators. Students are presented with an overwhelming amount of materials (instructions, texts, interviews, videos, blogs, etc.) through which they have to browse and skim through, just like you have to do when exploring a new subject through the web. They are expected to bring order and aggregate these materials, remix them, and feed them back to others through blogs, email, streaming, chat channels, message boards, screen sharing, and blogs, as well as Internet-driven social media such as Twitter and Facebook. In the next step students are expected to go beyond the knowledge already out there and present and share it, thus adding to the big pool of content accessible to the other students so that the cycle can start again and new connections and content can be learned and created. Advocates of the connectivist pedagogy argue that this mode of operation teaches students to participate in life-long learning communities which are essential in this fast moving digital age.

4. The rise of the MOOC

Although we have seen that there have been many precursors for the development of MOOCs, they grabbed world-wide attention only in 2011. What sparked world-wide attention was that MOOCs not only addressed a key challenge which was not explicitly addressed before by online learning systems, namely how can online courses be designed and distributed so as to reach a very large number of students using a very small team of educators (typically one professor with technical assistance), but that they actually achieved their goal of attracting and coping with these high numbers of students (usually tens of thousands and sometimes a lot more). The challenge to deal with such a high number has required several important novel technical and pedagogical ideas on how education can be structured and delivered online.

The key properties of MOOCs are as follows [8]:

- Most MOOCs consist of a series of very short video lectures (much shorter than a normal class) immediately followed by exercises that can be checked before moving on, thus going back to the Programmed Instruction pedagogy. There are additional supporting materials (for example articles, software, links to web resources) and final assignments that are graded.
- Grading is done by other course participants or by computer programs in order to cope with the huge number of participants.
- MOOCs are in principle delivered free of charge over the internet and there are no admission criteria. Students who sit out the complete course and do all the assignments receive a certificate of participation, often after paying a fee.
- MOOCs are participatory: They have facilities for bringing students together so they also create a social context, which has been shown to be important for motivating learning. Like social media, MOOCs try to establish links between individuals, creating foundations for life-long future interactions, similar to the way that class mates in residential schools form a social network that is important for the rest of their life.

- MOOCs collect student data that is then used by data mining algorithms to study and improve learning efficiency or student engagement [2].
- Although a MOOC is said to be ‘open’, this does not mean open in the sense of open software, but rather that all materials and student discussions are open for everybody. For the rest, MOOCs are entirely closed. They are designed by a professor and his or her team and they cannot be altered or distributed by anyone else. MOOCs provided through the Free Technology Academy (<http://www.ftacademy.org/about>) are an exception. Its courses are open, in the same sense as open software: They can be edited and remixed by anyone for further distribution.

MOOCs are not based on any top-down state initiative. They introduce innovation entirely in a bottom-up disruptive fashion. Most MOOC providers subscribe to the competitive market model of education. Because courses from suppliers are publically available, they can be compared and presumably the reputation of the best courses will progressively attract more students, the same way better products become dominant in the market place. Although courses are now mostly free, this might change as the venture capitalists that currently fund MOOCs request the (high) returns on their investment they are accustomed to.

4.1. The starting phase

The first MOOC that attracted a very large audience appeared in the fall of 2011. It was based on the Introductory Artificial Intelligence course taught at Stanford University by Sebastian Thrun and Peter Norvig. The course setup was quite similar to courses offered by the various open universities or televised course providers such as Uninetto in Italy or EuroPACE. What was new was the sudden influx of an unexpectedly huge number of students: 160,000 took the course, purely based on hear-say through the web.

This success was partly due to the fact that the course was already well-known beforehand, as it was based on an earlier Berkeley course developed by Stuart Russell and Peter Norvig which was already used in 1200 institutions (<http://aima.cs.berkeley.edu/>). I used the textbook myself in my introductory AI class.

Sebastian Thrun, a roboticist without any prior involvement in educational technology, was also known as the leader of the team that won the DARPA self-driving car challenge, and, together with Peter Norvig, he was increasingly involved with Google. But after this powerful kickstart, the ball got rolling and soon courses which did not have already a prior reputation or which were not proposed by a university with a strong brand like Stanford became available and attracted an important audience. Time magazine declared 2012 “the year of the MOOC” and interest skyrocketed. By 2014 more than 6 million students had registered for a MOOC course.

Based on the unusual success of this educational format, Sebastian Thrun and colleagues founded a start-up company in 2012 called Udacity, soon followed by other start-ups, such as Coursera, also initiated by two Stanford AI professors, edX, set up as a non-profit consortium by Harvard and MIT, and Khan Academy, created by Salman Khan. These companies targeted university-level education. Quickly other companies such as Udemy or Canvas, sprung up that were teaching any subject (from yoga to guitar playing) and accepted courses by anyone who wanted to be an instructor.

Increasingly MOOC providers began to ask payment, with income shared between the instructor and the company, and some success stories started to circulate that money could be made by creating a successful MOOC. Meanwhile MOOC aggregators appeared, such as, <http://www.curricu.me/>. They survey and provide links to MOOCs that have been developed by different individuals and institutions. Also general platforms for building MOOCs were launched, such as <http://mooc.org/>, which is a cooperation between Google and EdX initiated at the end of 2013.

The well-established European long-distance organisations were somewhat caught by surprise. They had been delivering high quality course materials but always to smaller groups and therefore without ever reaching large audiences. Nevertheless, the European open universities are the natural competence centers for creating MOOCs in Europe. And indeed the UK Open University launched futurelearn.com in October 2013 and other European open universities banded together to create <http://www.openuped.eu/>.

A few start-ups for delivering MOOCs have sprung up in Europe as well, such asiversity (in Germany). Nevertheless, many European universities (such as Edinburgh university or Delft university) are delivering their MOOCs through American platforms (primarily Coursera) and it is getting more and more difficult for European platforms to compete, given the much bigger resources available to American providers thanks to venture capital. This is disappointing because Europe has a long tradition in distance education and engaged in a lot of research towards online courseware in the eighties and nineties.

4.2. *Beyond the hype*

In 2012, the first commercial MOOC providers made big claims that they were going to solve the crisis in education. Sebastian Thrun of Audacity proclaimed in Wired magazine that only 10 institutions would be needed to create all the educational materials required for the whole of the United States and that most colleges and universities would cease functioning within the next 50 years. Coursera announced that they would provide Ivy-league level education online for free and that this would not only solve the escalating cost of college education in the US but also allow developing nations to close the knowledge gap. Some of the critical issues for scaling up education to sustain hundreds of thousands of course participants seemed to be highly underestimated. For example, Daphne Koller (CEO of Coursera) claimed that “*With some effort in technology development, our ability to check answers for many types of questions will get closer and closer to that of human graders.*” [12].

Exaggerated claims are a familiar feature of Silicon Valley start-up companies and they are accompanied by smart public relations that push these claims through the media. In this case the strategy worked again. Venture capitalists began to see a tremendous market opportunity, based on the belief that MOOCs might come to dominate education the way other companies such as Google have managed to dominate world-wide information access and thus control significant chunks of electronic commerce as a consequence. Thus, Coursera already raised (end of 2014) 80 million Dollar in capital—leaving competitors including the timid initiatives in Europe far behind in terms of available resources. This level of investment provides resources for speedy development so that some of the claims for MOOCs, which at first look exaggerated, could actually be made true.

On the other hand, the claims also generated a serious backlash, leading to an ‘existential crisis’ for (commercial) MOOCs by early 2014. University administrations saw a

great opportunity for cutting cost, and hence possibly lowering tuition fees, by replacing or getting rid of their own courses and faculty. Some state governments began to work on legislation so that MOOC providers would be able to give official course credits, the same way existing private or public universities could. It was therefore to be expected that the faculty in colleges and universities that had been declared to become soon obsolete rose up against this development. One widely publicised case involved the San Jose State university philosophy department which refused to accept MOOCs as substitute for some of their own courses and challenged the (Harvard) course professors who had helped to create the MOOCs [9]. Partly as a result of these protest movements, efforts for accreditation of MOOCs in California were quietly dropped after a lot of debate.

What are the criticisms laying bare some of the serious limits of MOOCs in their current state of development and deployment? Are some of these limits inherent to MOOCs? Here are a few issues that have widely been debated in the blogosphere:

1. **Drop-out rate** Although the number of students that subscribe to MOOCs is huge, the drop-out rate is also very high (usually 90 %), which is much higher than any degree program in the regular higher education system. In defense of MOOCs, we have to say that there is no cost and no barrier to subscription and hence it is just as easy to give up. Many subscribers are simply curious. They want to see what the course is like, hope to find the time to study the subject, underestimate the difficulty, find a better course for their needs, etc. It is still amazing that tens of thousands do finish some of the high level engineering courses.

2. **Assessment and Grading** The most obvious critical problem for MOOCs is how to assess students. MOOC providers propose two vehicles: peer-to-peer grading and assessment through computer programs. For peer-to-peer grading, there is clearly a major problem, partly because students most of the time do not have the knowledge and experience themselves to come up with a decent evaluation of the work of others and partly because it is extremely difficult to get standardised grades across all students taking the course. Assessment through computer programs works for the basics in technical and scientific domains where the answers to tests are objectively known and unequivocal, but it is a very different matter when moving to human-related subjects such as history, music, writing, etc., or when creative answers are called for.

And how can cheating be avoided? Plagiarism is already rampant in the regular education system and technologies have sprung up to detect the unreferenced appropriation of texts. But in the case of distance learning, there is no way to be sure that the student who claims to follow a course actually does all the assignments him or herself. This is less of an issue in the case of continuing education where one might assume that the student is motivated to follow the course for his or her own benefit and certified credit is not the main objective, but it is a real issue for basic higher education (18-22 year olds) who are often mainly interested to pass a course with the least effort.

3. **Contextualisation** The claim that the MOOCs developed in the United States can simply be transferred to the rest of the world has also been criticised. Again, for very basic subjects, such as algebra or programming, it might be possible to come up with a 'universal' course. But for most other subjects, adaptation to the local context is one of the crucial ingredients to make a course relevant and successful to a particular group of students.

4. **Business model** At the moment MOOCs are mostly free. But many argue that this is bound to change as soon as there is a captive market. The typical *modus operandi*

of Silicon Valley style companies is to provide at first services for free to gain market share and wipe out possible competitors, but then at some point the balance tilts. We can expect the same pattern as with music, books, videoclips or other media content. At first these materials were also provided for free (possibly pirated) but once everybody was equipped and accustomed to electronic distribution and the traditional delivery channels (music stores and vinyl or CD records, printed books and bookstores, cinemas and DVDs) had collapsed, payment became obligatory either through advertising or direct payment. Those companies that had managed to win this race found themselves in a quasi-monopoly position and could ask the price they wanted or bully content providers. The history of Amazon is a case in point. Amazon managed to get a near monopoly on the electronic delivery of books, leading to a demise of book stores, decreasing income for publishers (and therefore less risk-taking) and a drop of income for most authors. This does not mean that electronic publishing is a bad idea, but somehow the creation of monopolies has to be avoided. For education this is even more true. It would be a tragedy for the richness of intellectual life if only 10 universities would remain in the US and, presumably, only a handful in Europe as well.

Given the cost of developing course materials (effective MOOCs require investments of several 100 000 EUR), it will not be straightforward to recuperate the investment and MOOC companies are already trying to find ways to monetise, such as by selling data about students to companies, by advertising textbooks, by acting as recruitment agencies bringing the best students in contact with companies seeking new applicants, etc.

Not all MOOCs are privately produced. Public universities and university consortia see the creation of MOOCs as part of their public service because it helps them to contribute to education as a public good. But that implies of course that the universities can continue to exist, and that MOOCs are not seen as a way to slash the resources available for higher education.

5. The Future of MOOCs

Today MOOCs are both praised as the future of education and heavily criticised as potentially having a disastrous effect on the quality of education and the commons of knowledge that is supporting it. But I believe we should not throw away the baby with the bathwater too quickly. On the positive side, the sudden rise and world-wide spreading of MOOCs is giving a tremendous boost to educational innovation and online distance learning. Distance education was already well under way in many countries, including in Europe. But it was seen as marginal and never reached the same large world-wide audience as MOOCs. This has clearly changed and so there are now resources leading to the development of exciting, more effective online learning environments [30] and tools for building them [7].

I believe that the following are realistic targets we can expect from MOOCs in the future:

- MOOCs are so far mostly used for continuing education. But this is nevertheless of the greatest importance. The time knowledge acquired in formal education remains valid is getting shorter and shorter, except perhaps for the very basic skills such as mathematics or writing. So everyone needs educational resources to keep up and expand their skills and MOOCs are ideally suited for this.

- MOOCs appear an excellent replacement for the classical textbook, even for textbooks that are online and are intended for self-study. It is therefore no surprise that libraries see a new role for themselves. For example, the New York Public Library organised in august 2014 the viewing of a MOOC with additional in-person help.
- MOOCs support blended learning. Educators can use the materials provided by MOOCs in their own courses and thus get more time and resources to emphasise the interactive and social aspects of education. An extreme form is known as the *flipped classroom*, where the lectures normally given by the instructor are replaced by a MOOC and the class itself is focused on motivating students, discussing the lecture material, doing additional exercises, social interaction between the students, and assessment and grading [27].
- MOOCs stimulate educators to create (more) attractive courses, simply because examples of excellent courses are now easily accessible. The demands of students also go up because they see what a good course look like.
- Search engines were in the past decade the ‘killer app’ for Artificial Intelligence technologies, specifically machine learning and natural language processing. MOOCs can play a similar role for the many valuable technologies that have been experimented with by AI researchers and educational technologists in the past decades, particularly technologies for developing student models and thus very accurately assessing the level of competence of students, integrating automated sophisticated problem solvers to customise challenges posed to students, and allow active adapted strategic planning how course materials are presented to the individual student.
- There are many domains that are currently falling outside the realm of ‘official’ education channels in many countries, particularly arts education. Many students who are eager to learn how to play instruments or participate in orchestras or bands are pushed towards private tutoring which their parents often cannot afford. Here MOOCs can have a major beneficial impact by giving access to novel learning resources [13]. The many technical challenges that need to be dealt with in order to achieve this properly are already pushing the technological development of MOOCs in exciting new directions [30].

One of the biggest challenges for MOOC developers is to escape the paradigm of instructional teaching, which is relatively easy to implement, and move towards the open-ended learning environments that are much more appropriate for a wide range of subjects from music learning to learning how to think and write. This implies going back to the original concept of cMOOCs [20]. I believe this can happen by striving to achieve *social MOOCs*: MOOCs that foster the self-organization of small communities of learners that collaborate over the internet and are supported by novel resources: learning materials to be explored in an open-ended way, peer assessment and feedback, automated feedback, easily navigatable links into information resources, a.o. Several papers in the present volume show very significant progress in this direction.

But in the end, education is more than acquiring practical skills or knowledge. Particularly the 18-22 year old segment of the population, which is the primary population for higher education, is not only acquiring specific skills and competence. These students are still in the process of learning about life, how to work, how to get organised and live harmoniously with others. Teachers play an important role in this process, picking up

where parents left off, and a lot of learning is peer-to-peer. The social relationships that are established in college settings are the first really useful social network for succeeding later in life. This task cannot be done at a distance by MOOCs. It requires being together, engage at a human level, and getting access to educators with a rich life experience.

From this perspective, a recently started experiment by Black Mountain College in North California is intriguing. Black Mountain College was already famous in the nineteen forties for its innovative approach to education with teachers such as Buckminster Fuller and John Cage. Recently the college started a MOOC campus (<http://moocampus.org/>) which does completely away with the regular teaching by faculty and replaces that aspect of education with MOOCs. It argues that “*many of the best lessons from school come from the social aspects, relationships, connections, and extracurricular activities that have traditionally been part of the college experience.*” And so the school brings together motivated individuals which do not necessarily want a diploma (although degree-seeking students are welcome as well) but want a DIY (*Do It Yourself*) education, motivated and supported by like-minded peers. The role of faculty is similar to a team of coaches. They provide resources and organise to some extent what MOOCs have to be studied, but they focus mostly on the personal growth of the individual students and on the stimulation of a healthy social climate within the group. Is this a possible future of education?

6. Acknowledgement

This research was supported by the FP7 Technology Enhanced Learning Program Project: Practice and Performance Analysis Inspiring Social Education (PRAISE) and by an ICREA research fellowship from the Catalan government supporting the author at the Institut de Biologia Evolutiva (UPF-CSIC) Barcelona.

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