CHAPTER 8

Can the IT revolution lead to a rebirth of world-class European universities?

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THE DIGITAL REVOLUTION

We have reached a critical moment in time when the digital revolution — brought on by ubiquitous personal, mobile and affordable information devices — is challenging the historical missions of education and research; a challenge for our universities that constitutes a disruptive force and an opportunity for world-class European universities.

This IT revolution has given rise to a new generation of minds and novel technologies, both bound to impose new educational paradigms on our universities. In education, the iconic manifestation of the digital disruption is the MOOCs (Massive Open Online Courses). And, in research, the IT disruption is represented by MOORs (Massive Open Online Research projects), which feed on open access science, collaborative research and the development of simulation-based research. Both MOOCS and MOORS, whose impact and challenges are the subject of this paper, are undoubtedly changing the face of education and research — a change that should be welcomed and nurtured to ensure the future of the European academic tradition.

A long History of Online Education, and then a Tsunami

Computers, information technologies and online/off-site technologies have been biting at the edges of education for over 50 years: Computer-assisted Instruction was introduced in 1960; Computer-Based Learning was all the rage in 1980; Educational telematics appeared in 1988; followed by Online Education (1993); e-learning (1993); open learning (1995); the Virtual University and Learning Management Systems in 1999; and, for Switzerland, a national Virtual Campus in 2000. Yet, all these initiatives were only modestly successful. In 2008, the first recognizable massive open online course was developed in Canada (Massive Open Online Courses, 2013), and then a Tsunami hit in late 2011: one on-line class, "Introduction to artificial intelligence", by Sebastian Thrun at Stanford University, attracted 160,000 students of whom 22,000 completed the course. Of these there were 420 students with perfect scores — and legend has it that none of these students were from Stanford.

One short year later, a number of world-class universities integrated MOOCs in their portfolios, and thus acknowledged the impact of online education on the academic landscape. In this first year, MOOCs had a great start: rigorous backing by academic leaders, seamless technical capacity, strong technical platforms and amazing media coverage. The momentum of this online learning is considerable: in this first year over 3 million students have enrolled in MOOCs at Coursera — one of the leading platforms — with over 60 participating universities.

What happened this time that was different from the attempts over the past 50 years to harness IT for education?

A phase transition: a new generation of learners

We argue that this tidal wave of MOOCs is different because we are experiencing a new generation of minds in a particular context, and not only novel technological advancements; a *phase transition* that has been brought about by the confluence of economic, demographic and technological factors. With the crisis in tuition costs and student debt, there are necessary economies of scale to be made. There is also a crucial need to accommodate the growing demand in higher education: the number of students enrolled in higher education around the globe is forecast to more than double to 262 million students by 2025. Half this growth will be in China and India, which plan to build thousands of universities. Lastly, recent IT trends, including high bandwidth, social networks and cloud computing, are facilitating this transition. Global Internet Device Sales (PCs, smartphones, tablets) have exploded: there were no more than 150 million devices sold in 2000, and the sales are estimated to reach 2.5 billion in 2016. In 2015, the G-20 countries alone will have over 2.5 billion consumer broadband connections. We have definitively entered a mobile, hyper-connected world.

But while it is true that the technology has matured to a critical point — Internet, mobile access, bandwidth and novel IT platforms are taken for granted — we are also in the presence of students with a completely new mindset, the "Facebook and iPhone" generation, made up of digital natives. For this generation, IT technologies have become the central, normalized means with which to interact socially, to gather news and information … and to learn.

MOOCS

Things take longer to happen than you think they will and then they happen faster than you thought they could.

Ruedi Dornbusch (MIT)

Novel Features of MOOCs

We summarize the main new features of MOOCs in the following way:

1. Open access: the content of MOOCs is freely accessible ("free" as in "free beer");
2. Personalization: the content is segmented in short modules, typically consisting of short videos, quizzes and assignments; this segmentation allows for adapting speed to individual learners;
3. (massive) Synchronization: the student is an empowered participant: learning tasks are crowd-sourced, grading is done by peers (and everyone is a peer), discussion forums lead through the course module by module.

Having tens of thousands of students in your class makes teachers reinvent teaching. The enthusiasm, both from teachers and from students, is real. The best knowledge produced in our universities is sent out for free, because it is the right thing to do. And there is a lot of experimenting and variety at this stage. For the moment, providers of MOOCs make their courses available to anyone — there is no admissions process. Similar to an online video game, anyone can begin, but you then have to master levels that can prove very difficult. "For the 10% who get to the end, the learning is real" (Allen, 2013).

Networking between students, a trademark of the MOOC experience, is a crucial feature. It's "rubbing minds via the computer", in the words of Coursera co-founder Daphne Koller. Though important, student engagement in a MOOC forum is not (yet) widespread: the median percentage of students — taking only the best students — who contribute more than one post is 21.7, with a range of 10% to 68% across all Stanford MOOCs (Manning & Sanders, 2013). Grading by peers is another important — and controversial — MOOCs feature. In one careful analysis, student grading appears to be as accurate as grading by teachers or TAs (Lewin, 2012).

Impact on teaching

Enlarging the student base. MOOCs broaden the impact a university has by recruiting from a student population unable or unwilling to spend a full-time studentship on a physical campus. The first impact is clearly on lifelong learning or continuing education, especially continuing education in technical fields — over 40% of the students of the first MOOCs in machine learning course were already employed in the software industry. Likewise, for EPFL's top hit in MOOCs, "Functional Programming Principles in Scala", about 45% of the 10,000 students who took the final exam already had a Master degree (and 5% had a PhD). This first MOOC was a fantastic experience: "More than classes, these are vast networks of knowledge," says Martin Odersky the course instigator (Perrin, 2012). Incidentally, with about 50,000 registered students, and 10,000 final exams, this MOOC also holds a record completion rate of 19.2% (Parr, 2013).

The fever has spread from IT subjects — where MOOCs where born — to social sciences and humanities. Professor Mitchell Duneier (Princeton) says, "I had more feedback on my ideas in [Introduction to Sociology] than during my whole career." And Professor Al Filreis (U Penn) calls his class "Modern and Contemporary American Poetry," with 36,000 students enrolled and 2,000 students completing the course, an "outreach for poetry" (Lewin, 2012).

Improved teaching: A seemingly paradoxical impact of MOOCs. Since professors invest a great amount of energy to prepare these courses, where they are "judged" by the entire planet, the quality of the course material is very high. Do not be mistaken, MOOCs are not replicating in-class instruction. MOOCs — even in the absence of formal credits — are, in fact, less "laid back" than traditional courses, with continuous testing and strong involvement of faculty. MOOCs might even have a positive effect on in-class teaching, since lecturing can be moved out of the classroom. When given the choice, students will indeed opt for the online version of a course and transform the classroom into a site of active-learning; this has been called the "flipped-classroom", where students come to class better prepared and teachers can then engage in active interactions. This, of course, will also entail a major effort by faculty.

Teaching as a research object: MOOCs are also a valuable source of data for pedagogical research. We will learn a lot from the massive data on learning we can collect to answer questions like: What are students confused about? How do they go about solving their problems? We should however acknowledge a lack of hard evidence today to produce the best courses. As a collateral effect, MOOCs will also surely transform the textbook industry, with professors making their "traditional" textbooks freely available to students, like Martin Odersky did in his MOOC on Scala.

In short, teaching becomes suddenly attractive with worldwide exposure for the teachers, course materials are of excellent quality because there are scrutinized by thousands, and students contribute to the teaching material. Finally, traditional, on-campus students seem to like the additional flexibility and adaptability of having an online course.

European Angle

Specific European angle: There are few European universities among the early adopters of MOOCs. On the Coursera Platform there are (as of June 2013) 11 universities (all top tier). As example, the University of Edinburgh has published a first report on its MOOC experience (MOOCs@Edinburgh Group, 2013). A recent survey (Kolds, 2013a) at the first European MOOC Stakeholders Meeting at EPFL indicates that universities in 13 European countries have started MOOCs, on Coursera or edX platforms, or national ones. MOOCs adoption is faster in the U.S. since it is linked to the intense discussion on cost containment. In Europe, student fees still play a minor, albeit increasing role in university budgets; so the pressure to adopt a "mass model of instruction" for economic reasons is weaker. We solicit Europe to seize this chance and develop a crop of MOOCs that build on our strengths, in the tradition of exchange and mobility, of open and free access to education. European universities, by developing their *brand* of MOOCs — while still sharing global platforms — can build on these pillars:

1. The "**global ladder of opportunity**" (Gordon Brown): Europe's best universities can be proud of their courses and can contribute to "build a better world through knowledge," with generous access and good credentialing for all;
2. A rich **landscape of cultures**: Europe can build on its rich history and long tradition in the humanities; there is no risk of uniformity through massive courses; on the contrary, students will benefit from various approaches in social sciences and humanities. Europe, we think, has a lot to offer in the area of digital humanities (see below);
3. A **variety of languages**: Europe should make use of the richness of languages, build strong partnerships with continents that are close to us, namely Africa;
4. **Good framework conditions**: thanks to public support of our universities, and to the existence of Europe-wide initiatives like ECTS (transfer of credits between universities), Bologna (common degree structure) and ERASMUS (student mobility program), we can maintain a world-class university system. However the excellence — or reputation — of the MOOC providing institution will play a decisive role.

Problems & Challenges

Many questions remain open: the credits to attach to the courses; the openness of platforms; the ownership of course material and student data; ways to verify the identity of students; the business model (a conundrum for all stakeholders: platforms, teachers, students, universities); standardization and accreditations; completion rates.

1. **Drop out rates**: MOOCs have been launched with an exploratory, some may say zealous, spirit: there aren't many formal requirements for students who get to peek in and then decide to complete courses or not. The ease of non-completion in online MOOCs can be viewed as an opportunity for risk-free exploration (Koller *et al.*, 2013). This analysis indicates that in 2012, the typical Coursera MOOC enrolled between 40,000 and 60,000 students, of whom 50 to 60% returned for the first lecture. Of these around 15 to 20% submitted an assignment for grading. Of this group, approximately 45% successfully completed the course and earned a Statement of Accomplishment. In *fine*, roughly *5% of the students* who signed up actually completed the course.
2. **Managing both internal & external students**: Universities are not bare "information-dispensing" enterprises, but, unless universities respond to the rising tide of online courses, new players will emerge to displace them, or so thinks Wikipedia founder Jimmy Wales (Coughlan, 2013). The *boring* university lecture might be the first casualty of the rise in online learning in higher education (Coughlan, 2013), since professors can be freed from "grading and repeating the same lecture." However, the synchronous existence of onsite and online student groups will require major redesign of courses to guarantee the vital "organic" link between these online and on-site activities. Students also typically fear the loss of direct contact with a professor.
3. **The workload frightens teachers**: MOOCs are demanding for students and for teachers. MOOCs will test both the loyalty of faculty to their institution, should for-profit platforms arise, and reduce the need for faculty to teach entry-level courses (often of "massive *on-site*" nature) because universities in the second and third tier will likely succumb to the pressure of "buying" excellent quality MOOCs provided by first-tier universities. With faculty generally reluctant to teach what they do not own, recognizing MOOCs from other universities will also put university governance, especially presidents, to the test. In addition **flipped classes** are difficult to set up and require deep rethinking of one's course than the MOOC per se. For our on-campus students, watching MOOCs in small teams is an ideal solution.
4. **Plagiarism** is widespread and will require a better understanding of the MOOC student population and their motivation. This is a crucial question to resolve in the likely event that eventually, students will be credited if they successfully follow a MOOC.
5. **Intellectual property (IP) and privacy issues.** Students criticize the fact that their "pedagogical data" and academic performance are owned by the platforms. Indeed, legal issues are a growing concern, notably concerning the IP of course content, the security and pri-

vacy of data storage and the possibility to reuse contents with university partners and networks.

EPFL — Strategy & Experience

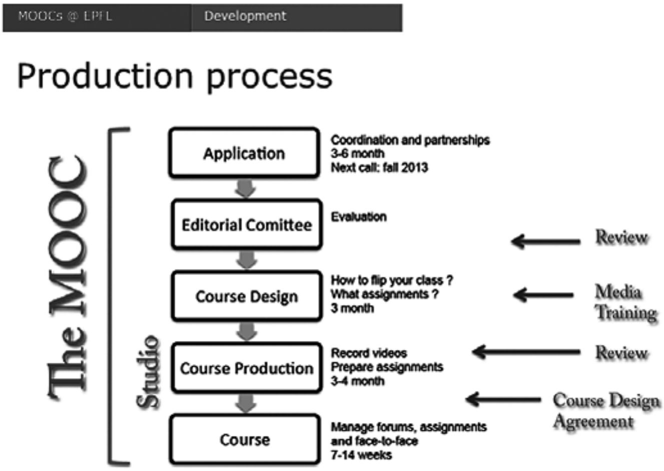
Better be an Actor than a Spectator: In its first year of MOOCs activity, EPFL (Ecole polytechnique fédérale de Lausanne) reached out to 150,000 students with five MOOCs. The geographic repartition of the students was variable, and depended on the offered course: 20%-50% from Europe, 20%-35% from the Americas, 15%-30% from Asia and 3%-16% from Africa. To date, 21 MOOCs (EPFL, 2013) are produced or in production, including 10 in French. Four are on edX and 17 on Coursera.

Why invest in MOOCs? The main objectives of our MOOC strategy:

1. **Visibility** and outreach: Enhance EPFL's global reputation; be a member of leading platforms (Coursera, edX); reach out to science-minded citizens; and be a promoter of MOOCs in Europe.
2. Engage **on-campus teaching:** ameliorate first-year teaching; introduce flipped classrooms; optimize courseware (we have set up a small production team with professional video/audio skills). MOOCs are a complementary tool for on-campus education. Indeed, students appreciate MOOCs that are based on on-campus classes.
3. Create opportunities for **continuous technical education.** The demand is there: most students were postgraduates in the first batch of MOOCs. This is also a potential source of revenue.
4. Building networks in Europe and Africa, notably RESCIF (Réseau d'Excellence des Sciences de l'Ingénieur de la Francophonie), a network of technical universities of the Francophonie, and EuroTech: network for postgraduate education in Europe.

MOOCs are a unique tool for building networks in countries that have leapfrogged from no technology to the mobile world. First collaborations on MOOCs within RESCIF start in Autumn 2013, with invited faculty from African universities to our MOOC studio to produce first year level MOOCs (in physics and programming), and later a "lab-work" MOOC on Microcontrollers, a course run with a network of local instructors in over 50 universities covering 10 African countries.

Governance and implementation at EPFL: MOOC strategy is a management issue for the university as a whole. A steering board (provost, vice-presidents and Deans) oversees the process. An editorial committee controls quality, approves courses and allocates budgets, and synchronizes teaching calendars. Finally, a **Center for Digital Education** with a MOOC studio has been created, which supports course development and delivery, and engages in research in learning and data analytics. The production process at EPFL is illustrated in the figure above.



MOORS

Global Context: open access and collaborative research

As MOOCs challenge our teaching habits, MOORs (Massive Open Online Research projects) are shaking up the research enterprise itself. They are fueled in particular by the irreversible irruption of the “open access ethic” on the scientific-political scene, by the rise of collaborative and/or citizen-oriented research projects, and by the *invasion* of digital methods in the humanities and medicine.

Open Access: ArXiv, an open on-line archive for electronic preprints of scientific papers (mostly in the fields of mathematics, physics), owned by Cornell is already 22 years old, and today boasts 834,189 archived pre-prints, at a submission rate of over 7,000 per month. **PLOS,** the Public Library Of Science, founded in 2000 in California, is a nonprofit open access scientific publishing project. It launched its first journal, *PLOS Biology*, in October 2003 and publishes seven journals, all peer reviewed, as of April 2012. **Frontiers,** a Swiss initiative launched by Henry and Kamila Markram of EPFL in 2007, is a web-based publishing platform that offers semi-automated submission and processing, interactive peer-review, and open access publishing of research articles. 5,000 articles were published in 2012 at Frontiers and the number doubles every year. Nature Publishing Group (McMillan) acquired a controlling stake in the company in 2013. Outsell, a consulting firm, estimates that open-access journals generated $172m in 2012, up 34% from 2011. This is still a small fraction of the $6 billion generated by journal subscriptions, but open-access is clearly taking off.

Collaborative research: The second leg of the MOORs revolution is a slew of projects aiming at developing more collaborative, participative research. As a sample, three such projects are presented here. Reproducible Research (http://reproducibleresearch.net) is an online initiative to help researchers publish papers and data in a reproducible way (for anyone), thus improving research quality. The Polymath blog (http://polymathprojects.org) is a collective endeavour to launch massively collaborative mathematical projects. Citizen Science (http://www.scientificamerican.com/citizen-science) presents research projects involving teams of scientists (and curious amateurs) collaborating across continents.

Digital Medicine and Digital Humanities: Inspired by the Human Genome Project with its promise of individualized treatment, and by increasing pressure by society on the health system in terms of cost and demographics, traditional medicine will no doubt undergo a profound transformation towards *digital* medicine. MOOCs and massive data are impacting also the humanities and social sciences. For many years now, a flurry of small-scale projects have brought together scientists from humanities and IT engineers, but now a wave of ambitious digitization — national libraries, historic collections, anything ever published or written — is deeply transforming the access to our past, the understanding of the present, and projections into our future.

Simulation-based research

The IT revolution — notably in supercomputing capacity — has brought the field of computer simulation to the threshold of a new era: realistic, interactive, real-time simulations**.** **Simulation-based research** is developing as a "Third line of research", complementing theoretical and experimental science. Particle physics (CERN) with grid-based participative super-computing, and Neuroscience are fields where simulation-based research is expected to finally permit the integration of the data deluge and fragmentation into realistic models. In Neuroscience, the emblematic MOOR is the **Human Brain Project** (*www.**humanbrainproject**.eu*), a Europe-wide, 1 billion Euro research consortium of 134 institutions in 23 countries that aims at building a simulation-facility permitting to simulate the human brain in development, ageing and disease. EPFL houses its coordination and simulation facility.

Big data leads to simulation science, and this will disrupt and transform the way we do research. Experimental data will continue to be generated at a tremendous volume, but in addition there is the data deluge coming from all of our monitoring devices — from smartphones to satellites. Big Data will impact curricula, with emphasis on mathematics, computation and disciplinary knowledge. It will also change the way we organize research, with the development of "big science" projects, based not just on single labs, but on large-scale, ad-hoc consortia with armies of mobile researchers.

Europe should continue to bet on simulation and systems science. It has already started with the EU "Future Emerging Technologies (FET) Flagship" initiatives, where the core strategy is integration of information, knowledge and know-how through simulation. The FuturICT proposal, integrating ICT, complexity science and the social sciences, was a finalist of the competition, and the Human Brain Project, whose ambition is to integrate experimental and clinical data about the brain in models through simulation, was a winner. Simulation science will become a strong component of science in this century and Europe is well positioned.

CONCLUSIONS

If Europe intends to continue to be competitive in the international economy, our schools need to ride the tidal wave of open access learning and research. As George Siemens, a Canadian innovator in the field, writes, "Much of today's economy is knowledge-based. In a knowledge economy, we need to be learning constantly. Universities have failed to recognize the pent-up demand for learning as the economy has diversified and society has become more complex and interconnected. As a consequence, the Internet has contributed by creating a shadow education system where learners learn on their own and through social networks. MOOCs reflect society's transition to a knowledge economy and reveal the inadequacy of existing university models to meet learner's needs," (Kolt, 2013b)**. It is time to harness the potential of this shadow educational system found in social media and citizen-based initiatives, or be left behind.**

But MOOCs and MOORs should be approached as a key to opening the door of novel forms of online education and research. According to Bonnie Stewart, "MOOCs are a symptom of change in higher education, not its source.…So if we are to envision a future for higher education that values more than the bottom line, we need to get beyond the illusion of the simple divide between markets and education as we've known it. If we close ourselves off to the possibilities of open, online learning, it's not marketization we undermine, but our own capacity to experiment with new models for higher education" (Steward, 2013).

Massive online education and research will transcend the boundaries of our institutions. MOOCs and their kin will be, for most students and researchers, "booster shots of education" needed to expand their minds or enhance their credentials for jobs. Let us practise massive online academia with a "let's do it" spirit, understanding that we will evaluate things while we are doing them. As Europeans, looking at international rankings of our universities can be depressing. But if we play our strengths right and engage the IT revolution cleverly, European world-class universities will once again be among the best.

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