MOOCs ANNUAL REPORT 2015

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

MOOCS ANNUAL REPORT
- 2015 -

Center for Digital Education

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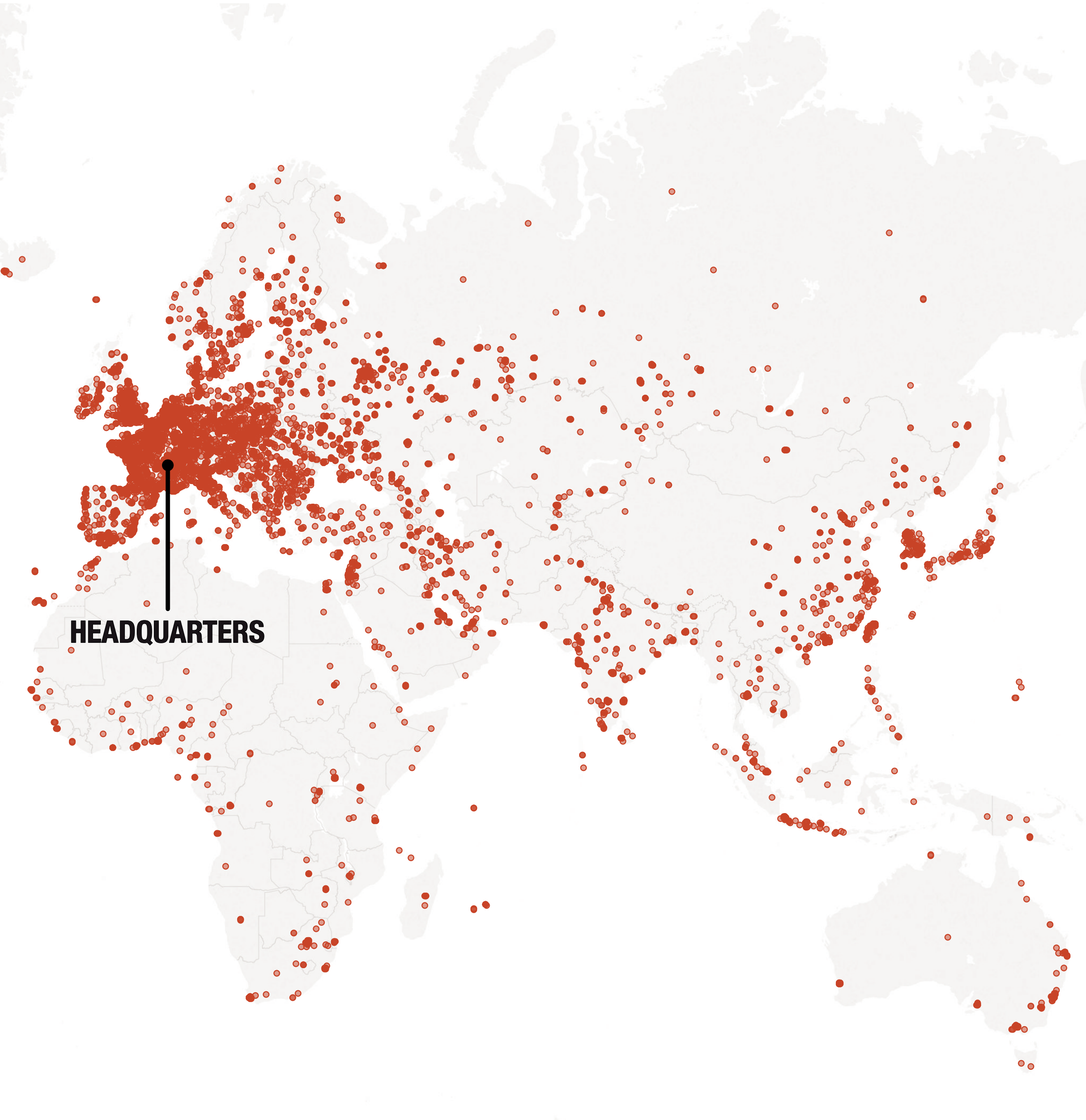
CLUSTER OF USERS
WHO SIGNED UP
FOR AN EPFL MOOC



EPFL **MOOCs Campus**

Contents

Introduction

MASSIVE OPEN ONLINE COURSES (MOOCs) are a new embodiment of Digital Education that has been gaining momentum around the world since 2012. These are courses presented as video lectures—that professors record at their own universities—with integrated assignments that students can submit and receive a grade for (often automatically). If students receive a series of sufficiently high grades on their assignments, they are considered to have passed the course, and therefore are eligible to receive an electronic statement of accomplishment.

The Ecole Polytechnique Fédérale de Lausanne (EPFL) was one of the first universities to experiment with MOOCs, and among the few in Europe to integrate the use of MOOCs on its own campus. Some of our professors have been actively using MOOCs as an integral part of their classroom teaching. The MOOCs are authored by professors themselves, and recorded at the Center for Digital Education (CEDE) of EPFL—the new center responsible for in-house production of MOOCs.

From 2012 to 2015, the MOOCs deployed by EPFL amassed more than 1 million registrations from 186 countries, of whom 58,000 passed the course with a statement of accomplishment. On the EPFL campus alone, 5,300 students registered for an average of 2 MOOCs—about half of the students on the entire EPFL campus.

Other universities in Europe have started to follow suit by recording their own MOOCs. But few have successfully integrated MOOCs into their own educational systems as we have, and even fewer have achieved the massive global reach that EPFL has achieved in the span of 3.5 years. With the MOOCs initiative, EPFL has effectively grown into a 1-million strong "global campus" with 186 nationalities.

This report describes the main activities and results related to the EPFL MOOCs program in 2015, and the main challenges our team and instructors have faced in an effort to maintain EPFL as the undisputed European leader in MOOCs production and integration.

In **Chapter 1**, *Production for the Masses*, we present the MOOCs creation process at CEDE, as well as its main challenges in terms of production and scaling. We describe how videos are recorded and edited, how self-grading assignments are developed—including remote experiments that students can interact with—and how data analytics are used in quality control.

In **Chapter 2**, *Teaching Innovations at EPFL*, we present statistics that show how EPFL students have embraced the use of MOOCs as a means of learning new subjects, as well as additional material that helps them complete their EPFL coursework. We also present case studies of EPFL professors who have applied the "flipped classroom" model to their classes, using MOOCs created by themselves.

In **Chapter 3**, *MOOCs: Empowering the World*, we go beyond EPFL and show how our MOOCs have a global reach and are making a difference in people's lives. We provide statistics of user engagement and achievement, user demographics, and vital signs that provide a global picture of the current vitality of our program.

In **Chapter 4**, *Impact in Africa*, we address a specific division of our program called *MOOCs for Africa*, which focuses on promoting the use of MOOCs in technology universities in sub-Saharan countries. We describe how African students can benefit from the use of MOOCs, and how our efforts in the continent are already starting to make a difference.

In **Chapter 5**, *Targeting Professionals*, we describe how our MOOCs are serving the needs of an important sector of the population: employed professionals. We present numbers that show how large this market is, what type of companies these people work for, and how we can target them effectively through the use of social media marketing.

In **Chapter 6**, *Latest Research*, we show how MOOCs Big Data is being used at EPFL to conduct research on Learning Analytics and the Psychology of Learning. We provide a summary of our published results, describing the outcome of psychological studies we conducted based on the statistical analysis of massive behavioral data sets.

1. Production for the Masses

«Educate and inform the whole mass of the people; they are the only sure reliance for the preservation of our liberty.» – Thomas Jefferson

THE MOOCS EXPERIMENT at EPFL officially started on September 2012 with the launch of the course "Functional Programming Principles in Scala", by Martin Odersky, on the Coursera platform. The course amassed an outstanding 65,000 registrations, of whom 18,800 solved and submitted for grading at least 1 assignment among the 7 proposed in the course curriculum. An equally staggering 9,500 participants—about the same number of students on the EPFL campus—finished the MOOC with a statement of accomplishment.

Next in line were the courses "Digital Signal Processing" by Martin Vetterli and "Linear and Discrete Optimization" by Friedrich Eisenbrand, both of which were launched on February 2013, and attracted 48,400 and 32,600 participants respectively. In these two courses combined, 2,300 users obtained a statement of accomplishment.

Today, with 48 MOOCs in our catalog, more than 1 million people from 186 countries have registered for a course offered by EPFL; around 230,000 have actively participated in the course, and at least 58,000 have passed with a statement of accomplishment.

The success of our MOOCs program has been made possible by the creation of a dedicated team—the Center for Digital Education (CEDE)—specifically entrusted with the tasks of designing, producing, and deploying online courses in collaboration with EPFL professors. This team comprises experts in all areas relevant to the creation of a MOOC, including course design, video production, and data analytics, who together allow the CEDE to operate as a fast and efficient MOOCs production machine.

In effect, the CEDE operates as a startup company on the EPFL campus, and we are starting to open up our production services to external institutions who do not wish to go through the enormous hassle and costs of building up their own MOOCs production process. Some of our clients include the Hoffmann Foundation, the World Health Organisation (WHO), the Interna-

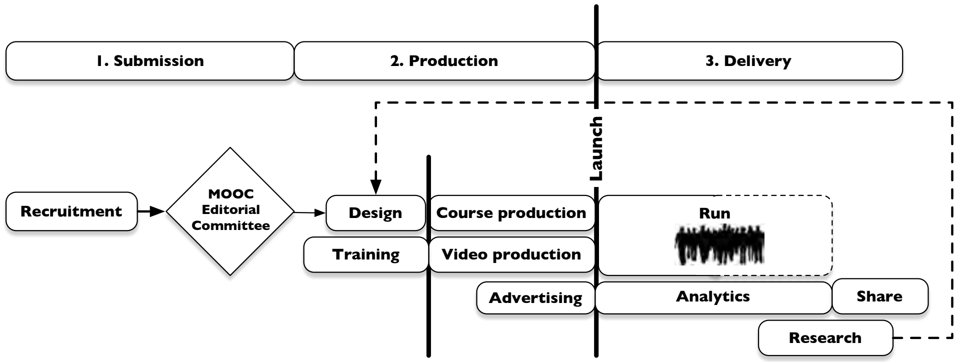


Figure 1: MOOC Production Process. The production comprises three phases (submission, production and delivery) and usually lasts 12 months.

tional Organization for Standardization (ISO), the Bühler Group, as well as CoorpAcademy, a startup located in the EPFL Innovation Park and active in the corporate eLearning sector.

1.1 MOOCs Production

Producing a MOOC usually takes 12 months and includes three phases. It is a collaborative effort with a course team (professor and assistants) and the staff of the CEDE. The production process is illustrated in Figure 1.

In the **submission phase**, instructors submit a project for their course to an EPFL internal MOOC Editorial Committee. Two calls for proposal are organized every year in spring and fall. The CEDE is a valuable partner in the preparation of the project since it has accumulated solid experience in coordinating pedagogical, technical as well as business related aspects. EPFL is encouraging the creation of a series of courses which add a strong academic dimension to the preparation of the projects. Instructors have to obtain the support of their deans and their director of curriculum before submitting to the committee. The coordination between partners also becomes an essential part of the preparation.

In the **production phase**, instructors start by designing the course as a sequence of activities and lectures. The next step is to produce the videos and prepare the assignments on the learning platforms. As the course launch date approaches, some courses are advertised to boost the number of registrations. We provide more details about this critical phase in Section 1.3.

In the **delivery phase**, the course team follows the users' on-line activity by monitoring discussion forums and grading the assignments. Recently, MOOC platforms have switched to an on-demand delivery model (or self-paced) that allows users to start the course whenever they want and progress at their own pace. This new model requires a higher level of commitment from the course teams to monitor the course. We are currently looking for alternative models where professors can focus their attention during a limited period of time and where community tutors (e.g., MOOC alumni) could perform the base service.

The collection of users' expectations and level of satisfaction through questionnaires allows course teams to reflect on the course design and adapt the course accordingly. Behavioral user data lends itself to research activities by partners of the CEDE.

Lastly, there is one other, relatively new, dimension introduced by the advent of online courses: the use of Big Data in learning analytics. When people register for a MOOC in a platform like Coursera or EdX, their behavior on the website is continuously logged. This means that, by the time a user has finished the course, we have access to his or her entire history of actions—from the exact time he or she submitted the assignments, to how many forum posts were viewed, all the way down to every mouse click on the video navigation bar.

This exhaustive recording of users' learning activity requires a dedicated data management system on our side, capable of collecting the Giga-bytes of data that we receive every day, and storing them securely. We take special care in protecting user privacy, by storing all data on secure servers within EPFL with restricted access.

Such data also requires a team of researchers—in our case, the Computer-Human Interaction in Learning and Instruction (CHILI) lab—who can go through the data, find relevant patterns of behavior, and use their conclusions to help professors improve their online teaching methods. Data analytics is essentially the feedback loop in our MOOC production process. It can be used to progressively improve everything from course development to production quality, as well as provide valuable insights about our target users.

1.2 Challenges in Scaling Up Teaching

The acronym MOOC stands for "Massively Open Online Course". As the name suggests, a MOOC can be any online course that is open to an unlimited number of participants. It should therefore be expected that a course is self-contained, with all lectures and exercises required for the mastery of a particular subject, as well as partially self-operating (at least in the long-term), so that the massive number of users can be graded and guided throughout the course with minimal intervention from the instructors. In other words, the cost of operating a course must not grow proportionally with the number of users.

These requirements are harder to meet than it seems. For a start, instructors are typically not as comfortable in front of a camera as they are in front of an audience. To become reasonably comfortable such that their lectures are not awkward, our team provides training in the art of engaging large audiences through video. More often than not, this training has to be continued throughout the recording sessions, since it requires changing some hardwired habits.

As a consequence, it takes about 2.5 days of recording time and editing work to produce 2 hours of lecture (8 videos = 4 recording sessions = 2 days), since most of the raw video footage must be cut out. To meet this demand, our team currently has 7 professionals working full-time on video editing and production tasks alone, with several others working part-time

Figure 2: Automatic control remote experiment. Users connect to an activity that is linked directly to a servo motor in an EPFL lab, and are able to control its parameters and observe the machine's behavior in real-time through a live camera feed. The following steps in the activity consist of mathematically modeling the response of the system. The experiment was developed by Christophe Salzmann in collaboration with Denis Gillet, who have both been conducting research on remote experimentation for many years.

during periods of large demand.

Secondly, the course assignments have to be adapted to a massive number of participants. It would be unthinkable for an instructor to go through thousands of assignments submitted by users every week. In order for the course to work on this scale, assignments have to be either automatically graded or peer-graded (where users grade each other's assignments). This introduces challenges for different types of assignments, such as:

- laboratory experiments,
- non-textual responses, like chemical formulas and mathematical proofs,
- programming and typesetting assignments that require a functional code,
- open-ended questions that can be answered in multiple ways.

At CEDE, we are constantly developing new ways of adapting traditional classroom assignments to an online environment that supports a large number of users. For instance, in the context of laboratory work, some of our professors have created remote experiments that users can control from a dashboard on a website. Three experiments are currently available: a hydraulic machine where the water flow is regulated by a slider on a website and a live video is streamed back to the user ("Fluid Mechanics" MOOC), a micro-controller that users can program remotely and see the result through live video ("Microcontrollers" MOOC), and a servo-motor that is controlled remotely to move to a given position ("Automatic Control" MOOC). The last one is illustrated in Figure 2.

Some professors have developed auto-graders for programming assignments in Java, C++ and Scala, that allow users to submit their code and then verify if the correct output is produced. Others have created peer-graded assignments, where users submit their answers for grading to

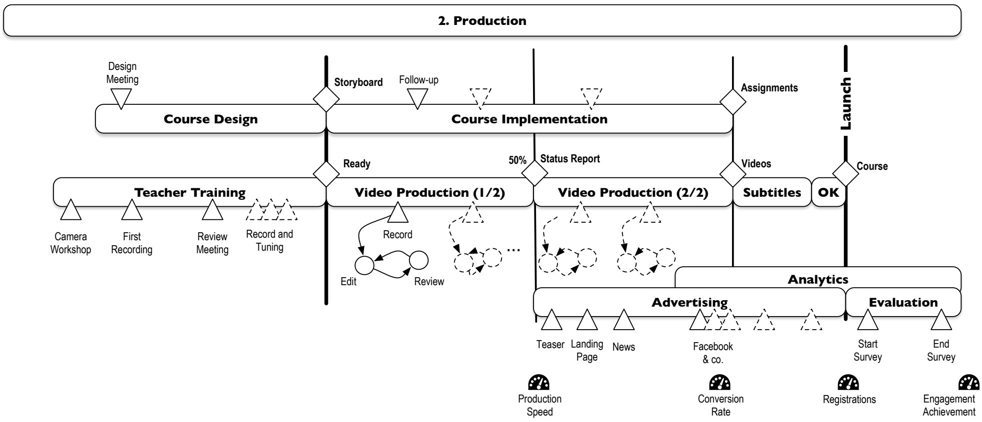


Figure 3: MOOC Production. Assignments and lectures are produced as two parallel and complementary tracks. Triangles represent services offered by CEDE. Diamonds represent milestones.

other participants, thus removing the instructors' burden of grading thousands of submissions.

Creating self-grading assignments that replicate the learning experience of a traditional classroom course is perhaps the biggest challenge we face in the MOOC production process, and one that CEDE pays very close attention to. In the future, we will emphasize the seamless integration of external experiments and graders into the learning platforms, while at the same time retaining control over these added-value components, for instance, via a standard called Learning Tools Interoperability (LTI).

1.3 The Production Process: Step-by-Step

Let us now look in more detail at the production phase, and how CEDE and instructors address the challenges inherent to preparing a MOOC (as illustrated in Figure 3).

Production efficiency and course quality rely on thorough preparation. When planning their MOOC, many teachers think first about recording videos before thinking about their course as a whole. **Course design** is the starting point for MOOC creation. The traditional 2 x 45' lecture format instructors are used to in the auditorium cannot be transposed directly to the MOOC format. We are helping teachers to think of the course as a sequence of resources, lectures, activities and experiences. The approach combines best practice from instructional design as well as a sense of keeping learner motivation and interest high. The initial design meeting is accompanied by a series of follow-up meetings to refine design and implement activities on the platforms.

Teaching in front of a camera comes with new challenges. The CEDE proposes a series of **teacher training** sessions to help get them acquainted with teaching an unknown audience, that potentially includes novices as well as colleagues from other institutions. There is no feedback and it is difficult to tune the message. A workshop about the art of presenting on camera is organized with a professional coach, and teachers are invited to discover the studio during a first recording session. Such sessions are organized until the instructors feel proficient (see "record and tuning" in Figure 3).

While it is important for students to see the instructors speaking to them, we have chosen to focus the video presentation on the content. During a 12 minute video, instructors appear on screen for 1 minute at the beginning to introduce the topic of the lesson and 1 minute at the end to sum up the main points. The remaining time is used to dive into the content. Accordingly, during the review meeting that follows the first recording, we mostly address the design of visual resources, how to perform gestures, what to write on the tablet, how to best use pictures, schemata and video-clips to illustrate the explanations.

Once instructors are ready to record, we start the **video production**. Teachers make appointments for half-day sessions in the studio. We have observed that a 4-hour session is enough to produce 2 videos on average and that the production of a MOOC requires 20 sessions on average. The preparation of the material is the most time-consuming aspect of video production. It is not unusual for instructors to spend half a day preparing for 15 minutes of video. We recommend rehearsing the delivery of the lectures before coming to the studio and, if this is not possible, we ask instructors to warm up before recording with the cameras. After the recording session, video editors from CEDE produce a first version of the lecture which is sent to instructors for review. This step is critical for quality control since it allows instructors to check that the academic content is adequate. Most often a single review step is enough before the final version of the video.

The total video production duration is difficult to predict in advance because it depends a lot on instructors' availability and reaction to do reviews. We estimate the productivity of each course team by observing the number of videos produced in the first few weeks. We start **advertising** once we have a clear estimation of the delivery date. Advertising includes the announcement of the course on the platforms as well as publication of short news articles that are spread on social networks. Section 5.2 provides more details on the conversion rate of such initiatives.

Finally, in 2015, two brand new recording studios were inaugurated. The Center now operates three studios with identical equipment and capabilities. An impressive total of 485 half-day recording sessions were organized during the year for teachers to record their courses. In addition, 34 official visits have been hosted by the team from the Center in the studios. In parallel, CEDE has also developed a mobile version of the studio that is used for field recordings and could be used as a basis for such a facility in developing countries.

1.4 Production Costs and Revenues

The biggest cost of creating and operating a MOOCs Production Factory such as ours—both in terms of time and money—is by far the initial cost of building the factory itself. This includes building the recording studios from the ground up, setting up a video production team and infrastructure, and programming a data analytics pipeline that keeps track of all the

Figure 4: Jürgen Brugger (MEMs and nanofabrication) records his MOOC in one of our studios at CEDE.

usage numbers and statistics. Table 1 shows a summary of the initial costs that were involved in setting up the Center for Digital Education (CEDE)—the EPFL MOOCs Factory.

Table 1: Initial setup costs for the MOOC Factory

	Material Cost	Salaries
Recording Studio Infrastructure	85,000 CHF	18 Man Month
Video Editing Infrastructure	55,000 CHF	4 Man Month
Data Analytics Pipeline	25,000 CHF	12 Man Month
Total	**165,000 CHF**	**34 Man Months**

Production costs for a single MOOC are much lower in comparison to the initial investments that are necessary to produce a state of the art course (approximately 8% for a 5 week long course). Table 2 summarizes the production effort incurred by MOOC production. Instructors obtain a subsidy to help them develop the content. They often use the subsidy to hire students to redraw figures, check copyrights, transpose quizzes, etc. We consider that 1 MOOC week corresponds to 5 videos each lasting 15 minutes accompanied with an assignment.

In terms of revenue, different types of courses have different commercial potential. So far, only a few courses have generated revenue: "Functional Programming Principles in Scala", "Digital Signal Processing", "Villes Africaines", and "Launching New Ventures". The basic principle is that MOOCs that provide income should subsidize less profitable MOOCs. Users

Table 2: Estimation of the production effort in MOOC preparation. 1 MOOC week $\simeq$ 5 videos of 15 min.

Preparation (1 month)	
Course design meetings	minimum 3 meetings
Storyboard development	1 week to specify the course structure
Content development (2 month)	
Content creation by professor	at least 1 week of work for 1 week of MOOC
Graphical resources and copyrights	1 day for 1 week of MOOC
Course implementation on platform	1 day for 1 week of MOOC
Video Creation (6 month)	
Production management	1 week per MOOC
Teacher training	first recording session and review meeting
Studio recording	20 half day studio sessions
On-site recording	2 crew members for half a day for each session
Post-production	1 day editing and reviewing for 15-minute video
Subtitles and translation	cost depends on language
Marketing and Analytics (1 month)	
Social networks	advertising campaign
Teaser video	cost depends on complexity

seem to be willing to pay for a certificate when the acquired skills have a clear value on the job market.

On-campus education. Propaedeutic MOOCs (e.g. Algebra, Physics and Chemistry) are a valuable complement for first-year students on campus, but do not generate income. Several reasons can be identified. The courses do not attract a wide audience because they are taught in French. Universities usually offer these basic courses by themselves. Students are not willing to pay for online credentials because progress in their academic studies depends on academic credits. The financial benefit of those courses is indirect. They are an important component of sponsored programs for developing countries and they have the potential of increasing efficiency for first-year students pursuing on-campus education.

Continuing education. More specialized courses (e.g. Plasma Physics, Brain Mechanisms, Synchrotron, Finance, etc.) attract a relatively small number of participants (< 1,000 active students) for whom the value of a continuing education program results as much from the online content, as from sharing experiences with peers and experts. The development of specializations (collection of 2-3 courses) that facilitate admission to on-campus Master's programs is an avenue that is currently being explored. Blended education models can also be created for a regional audience. These courses also generate an indirect value in terms of worldwide visibility of the school in cutting edge domains.

Worldwide campus. When Bachelor and Master level courses (programming courses, "Villes Africaines", "Aires Protégées") meet a market demand for technology and business skills, learners are willing to pay for certificates that enhance their CV and employability (e.g.

Coursera statements of accomplishment are visible on the LinkedIn profile of participants). Other universities and sub-licensors are primarily interested in these courses since they allow them to offer the courses in a specific geographical region and academic programs (e.g. Russian or Chinese translations of courses). In addition, new business models are currently being developed and tested by platforms, such as the provisioning of tutoring for a fee.

2. Teaching Innovations at EPFL

«We cannot know ahead of time how far our predisposition might be developed by which education method. This can only be ascertained by trying and assessing different methods.» – Immanuel Kant

THE SUCCESS of the MOOCs initiative has been particularly notable on the EPFL campus. Between September 2012 and December 2015, more than 5,300 EPFL students registered for at least one of our MOOCs, among whom 26% passed with a statement of accomplishment, and 61% of those who were *very active* (solved at least half of the assignments) passed the course. On average, each student signed up for 2 different MOOCs.

Since the beginning of the program, EPFL students have been consistently active in our MOOCs. Close to 48% of our students have tried to submit at least one assignment for grading, compared to 22% in the rest of the world. The figure is even higher for MOOCs that have been recommended by professors as complementary material, particularly in classes that have a direct MOOC counterpart. In fact, most of the MOOCs offered by EPFL were created as an online version of existing courses, and therefore are widely used internally.

Central to the EPFL MOOC strategy is a teaching method called "flipped classroom". This method is defined by an inversion of the types of events that happen inside and outside the classroom. For instance, teachers may require students to learn the material before arriving to class. Then, rather than giving a traditional lecture, they can use their class time to solve exercises and engage students in discussion.

This pedagogical approach is not new; it has been progressively developed in various universities across the world, but became increasingly popular when students began having access to video lectures. The success of Khan Academy[1] is a great example of the adoption of the flipped classroom model[2]. With its massive collection of video lectures and learning analytics tools, teachers in high schools and elementary schools can rely on Khan Academy to provide

[1] www.khanacademy.org

[2] "Research on the Use of Khan Academy in Schools", SRI Education, Research Brief, March 7, 2014.

pupils with the course material they need, analyze their progress on each student's dashboard, and then the time in class can be used for interactive activities.

The advent of MOOCs has provided a similar opportunity to university professors, and in particular to EPFL. The fact that we produce every MOOC in-house, and any professor can create one if he or she wishes, gives us the freedom to push the flipped classroom model to any degree we like. We could, theoretically, package all the support material of an EPFL course into a MOOC, for students to learn at home, and leave only the social and interactive aspects of the course for the classroom.

This is harder than it seems. Although the principles of a flipped classroom are straightforward, its execution requires a substantial amount of effort by the instructors in transforming their classes. Yet, some of our professors have indeed done so, and their efforts were eventually rewarded (see Section 2.2).

The creation of MOOCs based on EPFL courses has had a number of positive side-effects. For a start, lectures are now broadcast to the rest of the world, giving professors a previously non-existent exposure outside the classroom walls. This inevitably increases their motivation to improve the quality of their teaching, both in terms of content and delivery. In a way, professors become public figures; it provides an opportunity to take advantage of their massive reach, and ultimately improve the lives of thousands of students they would never meet otherwise.

Furthermore, the influence of MOOCs is starting to be felt in terms of academic credibility. The same way h-factors[3] and publications in high-impact journals are accepted measures of research output, launching a MOOC with thousands of registrations is becoming a credible indicator of excellence in teaching.

2.1 Engagement of EPFL Students

The main purpose of the MOOCs program is to improve the teaching experience of our students at EPFL. For this reason, it is not surprising that EPFL students have been among our biggest early adopters. At least 5,300 EPFL students registered for one of our MOOCs (the campus has about 10,000 students), among which 48% were more or less active in the courses they registered for. Among these active users, the number of those who passed depended on whether or not finishing the MOOC was encouraged by professors in their respective courses (see the top of Figure 5).

For instance, in courses such as "Numerical Analysis", "Linear Optimization", and "Scala Programming", the students were advised to solve and submit all assignments in addition to watching the video lectures. In other courses, such as "Mechanics I" and "Geomatics", the teachers' recommendations were more relaxed, simply encouraging students to watch the videos.

[3] The h-factor (or h-index) is a metric that measures the productivity and citation impact of the publications of a scientist or scholar.

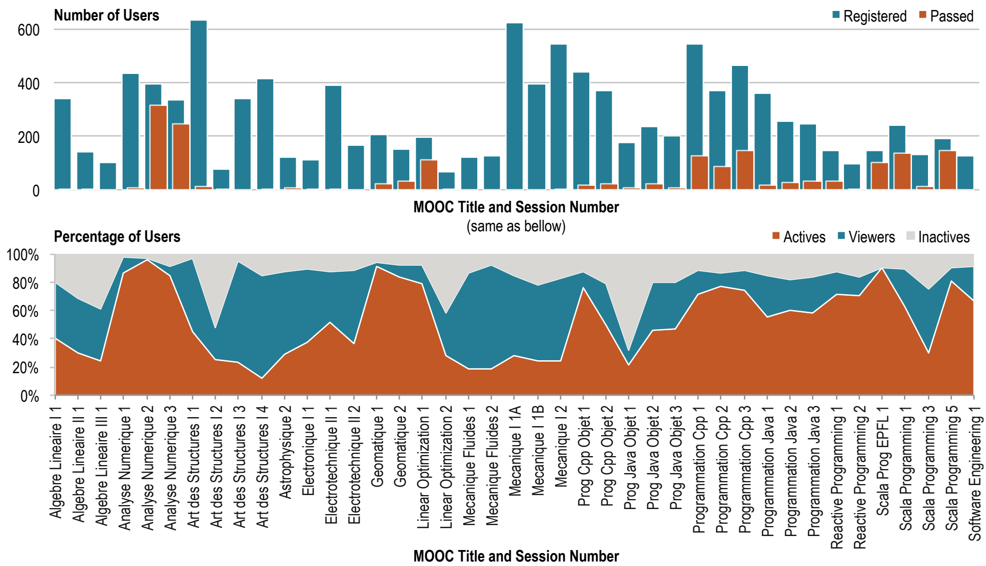


Figure 5: Top. Number of EPFL students who registered and passed each MOOC session. The horizontal axis is sorted alphabetically by MOOC title and session number. **Bottom.** Engagement of EPFL students in each MOOC session. The *actives* are those who submitted at least one assignment; the *viewers* are those who viewed at least one video, but did not submit assignments; the *inactives* are those who did neither. The horizontal axis is sorted alphabetically by MOOC title and session number.

This can be confirmed by the percentages of actives, viewers, and inactives for each MOOC session, illustrated at the bottom of Figure 5. Courses with a high number of active students (those who solve assignments) have—with a few exceptions—a higher passing rate. In contrast, most of the courses where students are less active have nonetheless a high percentage of viewers (those who only watch videos). These viewers cannot pass the MOOC without submitting the assignments, which explains why the passing rates of are lower[4].

Overall, EPFL students tend to be more actively involved in our MOOCs than the rest of the world: 48% of EPFL students are active *versus* 22% in the rest of the world. This does not necessarily mean that our students are better achievers. In fact, the average grade among active users is relatively uniform across the world, regardless of a user's country or educational background. It does mean, however, that MOOCs are successfully fulfilling one of its initially stated missions: to benefit the students of EPFL.

2.2 Are MOOCs Helpful in the Classroom?

The role of MOOCs in teaching on campus depends on teachers' pedagogical choices. One model consists of using the MOOC as a complement to live lectures in class, similar to a textbook. Students watch the videos either before the lecture to prepare themselves or

[4]It should be noted that EPFL students take a local exam.

after the lecture to reinforce the content. Another model, called "flipped classroom" consists of switching learning activities performed in the classroom and at home. Following the flipped model, students acquire basic knowledge by watching videos at home and deepen their knowledge by solving problems in class with the teacher.

There are no clear rules about how to best implement the textbook and the flipped models. To try to shed some light on the conditions under which MOOCs are beneficial for learning, we conducted an analysis to compare students' engagement with the MOOC and their grades on the EPFL exam for 26 on-campus courses. We analyzed 6,000 grades from courses that roughly fall into the two categories we just outlined. Twelve first-year physics courses and eight second-year courses simply used the MOOCs as complements to the lecture. Six first-year courses used the MOOCs following a version of a flipped classroom.

Before looking at particular courses and the way they integrated MOOCs, we wanted to know whether watching videos and solving problems were related to the grade that students obtained (N=2,887 EPFL students who signed up for a MOOC in parallel to their course). A two-way analysis of variance showed that both watching videos ($F[1,2883]=22.7$, $p<.00$) and solving problems ($F[1,2883]=9.0$, $p<.00$) were related to a higher grade in the course (see Figure 6).

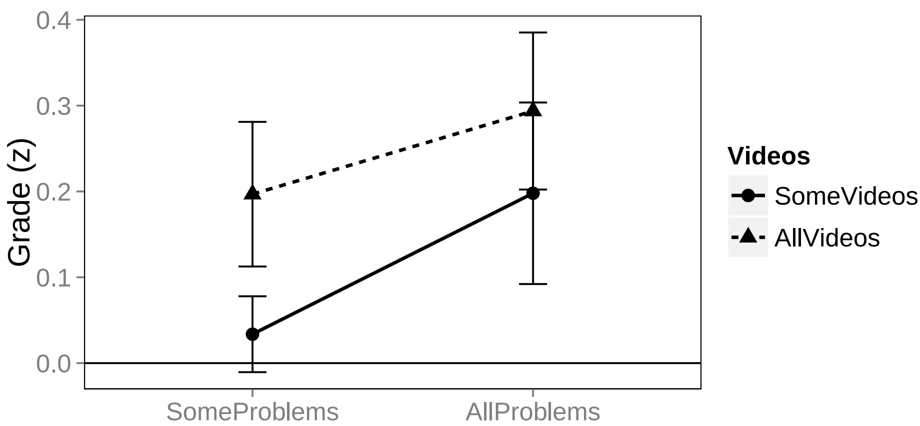


Figure 6: Normalized grades (z-scores) and MOOC activity. Students who watch all videos obtain better grades than those who watch only few videos ($F[1,2883]=22.7$, $p<.00$). Similarly, students who complete all assignments obtain better grades than those who solve only some problems ($F[1,2883]=9.0$, $p<.00$).

Because we analyzed these data post-hoc, we cannot tell whether the positive association between MOOC usage and grade is due to the fact that stronger students simply use resources more or whether active MOOC participation results in better grades. A controlled study, where students are randomly assigned to different treatment groups (textbook model versus flipped classroom model) will be conducted to provide more reliable answers.

Textbook model

Let us first look in detail at the "Mécanique" MOOC (Physics 101) that was created by Prof. Jean-Philippe Ansermet. Rather than requiring students to watch the MOOC video lectures beforehand, Prof. Ansermet simply offered the MOOC as reference material to his class. The basic material was still taught in the traditional *ex cathedra* style, but was equally available in the form of video lectures and quizzes that students could refer to at home (in addition to their lecture notes).

The same **first-year physics course** is taught in parallel by twelve professors to our 1,500 first-year students but not all of them rely on the MOOC. We observed a wide variation of using the MOOC by students ranging from 0% to 77%. The highest level of participation was in Prof. Ansermet's class, who is the creator of the MOOC. The MOOC was used in 8 classes as a complementary resource to the face-to-face lecture and was not used at all in the remaining 4 classes.

We compared the grades (normalized as z-scores) of students who signed up for the MOOC and the students who did not sign up. In half of the cases, the grades of students who used the MOOC were higher than the grades of students who did not (see Figure 7 and Table 3).

Is this difference simply due to the fact that the stronger students use available resources whereas weaker students do not? To find out, we used students' grades on the linear algebra exam as an indicator of their academic level to isolate the MOOC effect. The score in algebra and introductory physics are highly correlated (r=.64) and adding the algebra score to our statistical model allows placing the MOOC effect in competition with the academic level. A two-way analysis of variance revealed that MOOC participation had a small positive impact on the grade ($F[1,2125]=6.6$, $p<.01$) *in addition* to the huge effect of the students' academic level ($F[1,2125]=1502$, $p<.0001$).

Table 3: Comparison of normalized grades (z-scores) for students who participated in the MOOC (yes) and students who did not participate (no). See Figure 7.

Course	t	df	p	MOOC(N)		Course (z-score)			d
				yes	no	yes		no	
PHYS-101 (T4)	-1.94	18.2	0.07	16	223	-0.41	=	0.02	-0.43
PHYS-101 (T3)	-0.18	8.5	0.86	6	108	-0.03	=	0.00	-0.04
PHYS-101 (T1)	0.04	91.3	0.97	50	152	0.00	=	0.00	0.01
PHYS-101 (T6)	2.05	36.0	0.05	30	202	0.39	> *	-0.05	0.44
PHYS-101 (T10)	2.43	10.3	0.03	10	198	0.62	> *	-0.04	0.66
PHYS-101 (Anser.)	2.78	95.7	0.01	212	63	0.16	> *	-0.23	0.39
PHYS-101 (T8)	3.23	180.5	0.00	84	99	0.26	> *	-0.20	0.46
PHYS-101 (T9)	4.42	289.5	0.00	138	204	0.29	> *	-0.19	0.48

We repeated a similar analysis for eight **second-year courses**. In three courses, the MOOC was used by nearly all students, which makes a comparison impossible between students who take the MOOC and those who do not. Among the five remaining classes, the MOOC was not mandatory. Only 1 course out of 5 showed a positive impact of MOOC participation.

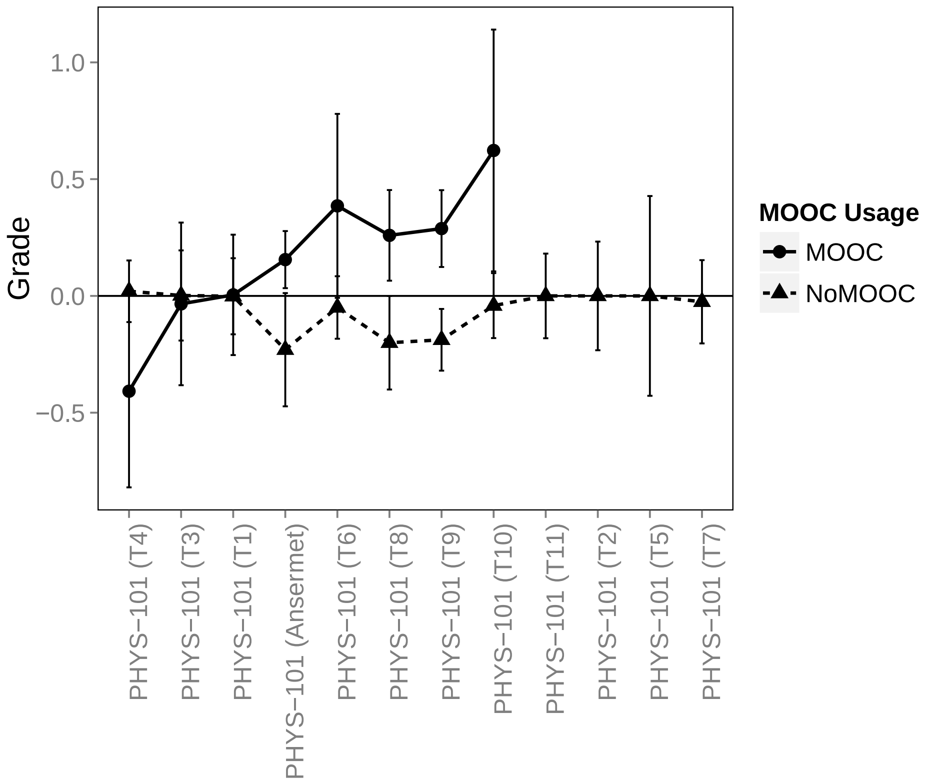


Figure 7: Normalized grades (z-scores) obtained by first-year students in their PHYS-101 course. In 4 courses the MOOC was not used at all. In 4 out of the remaining 8 courses, students who signed up (and participated) in the MOOC obtained a better grade than those who did not. See Table 3 for statistics.

Motivated students always welcome any additional material they can get their hands on. The downside of such an approach—with respect to a true flipped classroom model—is that it puts little or no pressure on unmotivated students to become more engaged in the class. The analysis of students' grades supports this conjecture, as it shows that high-performing students tend to engage more in the MOOCs than low-performing ones.

All in all, one can safely say that the experiment conducted by Prof. Ansermet was a success. A course evaluation survey showed that 91% of his students appreciated the availability of the MOOC as a complement to the class. And, in fact, students from parallel classes referred to the same MOOC as an extra resource, despite the fact they were following a class with a different teacher. This leads us to conclude that MOOCs are a legitimate source of study material.

Figure 8: Jamila Sam and Jean-Cédric Chappelier, lecturers of computer programming at EPFL, have successfully applied the flipped classroom model to their classes, "Introduction to Java and C++ Programming".

Flipped classroom model

Jamila Sam and Jean-Cédric Chappelier are two EPFL lecturers who have successfully applied the flipped classroom model to their classes, "Introduction to Java and C++ Programming"—an initiative for which they received the Credit Suisse Award for Best Teaching in 2015, which recognizes the best contribution to the area of teaching at EPFL.

In the teaching of computer programming languages, teachers often spend the bulk of their lecture time on the foundation of coding theory and syntax. Although this is a necessary component of teaching computer programming, it leaves less time for other activities that are equally (or more) important in the development of students' coding skills—such as practical use cases, common errors, and exercises.

By "flipping" the classroom, the teachers shifted all the basic material to a MOOC format, comprising video lectures and quizzes. Students were required to watch the video lectures prior to each class, and solve all the related quizzes at home. In class, they were encouraged to ask questions about what they had learned at home, and participate in the various class discussions.

As a result, students arrived to class much better prepared, with concrete and profound questions about the material and valuable insights to share with each other. Classes became less of a monologue about theory and more of a "field training" for the students (and much more fun as a result). Moreover, the fact that the MOOC was open to anyone else in the world gave EPFL students the opportunity to ask for help and feedback from tens of thousands of other students, through the use of MOOC forums. In all of the Java and C++ MOOC sessions combined, more than 200,000 students produced 50,000 forum posts.

Unsurprisingly, Jamila Sam and Jean-Cédric Chappelier found the students were more motivated, and ultimately performed better on the exams—particularly those students who were initially struggling to follow the course. The results speak for themselves: 16% more students received a passing grade during an exam given in 2014 compared to the same exam in 2007.

We now look at students' grades (normalized as z-scores) in six first-year courses that all integrated the MOOC in their on-campus teaching in some form of a **flipped classroom**. In 4 out of 6 cases, the students who did not participate in the MOOC obtained a lower grade compared to the students who participated (see Table 4). When the MOOC is a central component of the teaching, not participating has a detrimental effect on the grade. It also clearly appears that the majority of students followed the instructors' indications by signing up for the MOOC.

Table 4: Comparison of normalized grades (z-scores) for students who participated in the MOOC (yes) and students who did not participate (no).

Course	t	df	p	MOOC(N)		Course (z-score)			d
				yes	no	yes		no	
Electrotechnique	2.0	16	.07	226	15	0.04	=	-0.54	0.58
Structures	2.0	15	.06	292	15	0.04	=	-0.70	0.73
Prog. C++ (I)	2.9	63	.00	468	49	0.04	> *	-0.34	0.38
Géomatique	3.0	32	.01	322	31	0.07	> *	-0.73	0.80
Prog. Java	3.6	402	.00	435	230	0.11	> *	-0.20	0.31
Prog. C++ (II)	4.3	36	.00	434	32	0.05	> *	-0.73	0.79

Conclusion

It difficult to establish a systematic causal link between MOOC participation and grades since many other factors affect performance. We were able to demonstrate such a link with first-year physics courses, showing that MOOC usage helps students regardless of their academic level.

The results are also encouraging for courses that integrate the MOOC in a flipped classroom. Teachers redesign their course so as to spend a larger part of their time solving problems with students, demonstrating expertise and discussing content. This model requires self-discipline from students since it is necessary to come to the lecture well prepared.

The question of the "effect of MOOCs" has to be addressed by taking into account the context of MOOC usage on campus. Careful guidance by the teachers about how to use resources as well as active engagement by students are the foundation of successful learning.

3. MOOCs: Empowering the World

«Give me a lever long enough and a place to stand on,
and I shall move the Earth.» – Archimedes

THERE ARE TWO MAJOR FORCES in human achievement. The first one is *leverage*—the power to produce a large result from a small effort applied. The second one is *compounding*—the effect of multiplying small results and growing them exponentially. Because these concepts are not intuitive, people often underestimate the effects of taking small initiatives—which, no matter how small, can quickly grow into outstanding results.

Critics of online education often fall into this trap, by dismissing MOOCs as less worthy than, say, an Ivy League education. In a sense, they are correct. MOOCs are not a replacement for a university degree; they serve a different purpose. While an institution like Harvard can propel a young student to the top very quickly, an education based on MOOCs requires students to build their own path to the top. Under such circumstances, only those who understand the power of *leveraging and compounding knowledge* will prevail in an unprescribed self-educating world.

Perhaps for this reason, the positive effects of online education are still not fully apparent to the mainstream. There is a myth that says MOOCs have a less than 10% completion ratio. Even though this number is false—as we show in this chapter, the true completion ratio is closer to 73%—the re-enforcement of the myth by critics in the media has plagued the reputation of MOOCs, and delayed their adoption since the beginning of our program.

Furthermore, the market is still skeptical about MOOCs. It is not guaranteed that companies will accept a MOOC certificate as proof of mastery of a subject[1]. Yet, 10 years ago, few would have imagined that institutions such as EPFL, Harvard, and Stanford would be competing to put out their best courses available online for free—courses that were once only available

[1] Positive signs are beginning to emerge in that direction: Coursera reported in 2015 that 26% of their users have found a job as a result of taking a MOOC, 9% started a business, and 6% received a raise or promotion. Udacity, another MOOC provider, is reimbursing its users if they fail to get a new job within 6 months of paying for one of their courses.

to a tiny elite of students. Some of these top institutions are starting to offer credits to those who complete their courses online, and it is only a matter of time until they start offering full degrees as well. This is a strong indication that MOOCs are here to stay, and that we are starting to see a world where common people have more leverage than ever to take control of their education, and build their own way to the top.

3.1 Here's to the Fearless Ones

Olga Reznikova (pictured), a young woman from Korsakov—a small island-town in Far-East Russia—never got the chance to obtain a proper college education. She began working at the age of 18, and was forced to live off a modest income doing web development. "The quality of IT education in that part of the world wasn't very good," she recalls, "it was a place of oil miners and fishermen."

In a bid to improve her prospects, Olga taught herself computer programming and moved to St. Petersburg. Coming from a humble background, she was suddenly faced with the fierce competition of a big metropolis, and the abuses of unscrupulous employers. "[In St. Petersburg] there are lots of people like you from all over the world, and your employers know that, so they will take advantage of you when they can," she lamented.

Olga Reznikova, a MOOC enthusiast from Russia.
www.linkedin.com/in/olga-reznikova-3b76661a

When the first MOOCs came out, Olga grabbed the opportunity and immediately signed up for EPFL's first online course, "Functional Programming Principles in Scala", which she completed with a 100% flat score—a feat she would repeat many times in the near future.

Empowered by a new form of education, she embarked on a mission to get herself into college by leveraging her MOOC certifications, but not before landing a job as a Scala programmer. "In the company I've applied to, one of the interviewers turned out to be one of my course-mates [in the EPFL Scala MOOC]", she said excitingly, "and I finally got the job!"

Today, Olga is certified in more than 20 MOOCs, and has finally fulfilled her goal of getting into college; she describes MOOCs as one of the leading causes for her recent achievements. "I am greatly thankful to EPFL and all its professors, and to all the MOOC movement", she concludes.

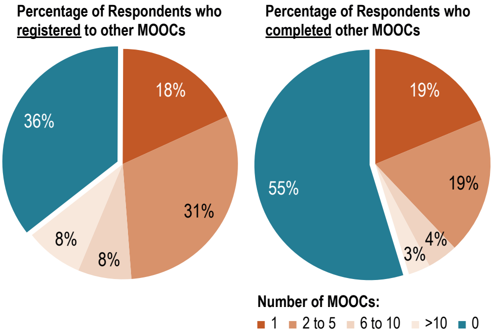


Figure 9: Distribution of users who followed and completed other MOOCs—including those from other institutions—prior to registering for one of our MOOCs. Users are grouped by number of MOOCs they followed or passed.

Stories like these are not unique. Every MOOC session we launch attracts thousands of self-education enthusiasts, who graciously share with us their inspiring stories of achievement. We send out surveys on a regular basis, so that our users can give us feedback on their objectives and level of commitment, and we exchange e-mails with our most outstanding MOOCs *alumni*.

Most of our users are, in fact, people who follow MOOCs on a regular basis. Take, for instance, the survey results depicted in Figure 9. The survey showed that 64% of our users have registered for at least one other MOOC before signing up for one of ours, and an equally impressive 45% have completed at least one MOOC before. Furthermore, 16% of our users have registered for at least 6 MOOCs prior to ours, and 8% have registered for more than 10—an impressive percentage of highly committed users.

The motivation that drives people to follow an EPFL MOOC varies according to the MOOC subject. One of our surveys asked users to specify their motivation for registering for a given course, by providing the following options: (1) to get a new job; (2) to get a promotion or a status change; (3) to earn a higher salary; (4) to solve specific problems in their current job; (5) to help pass a class to get a degree; or (6) to meet the expectations of their family. The results are shown in Figure 10.

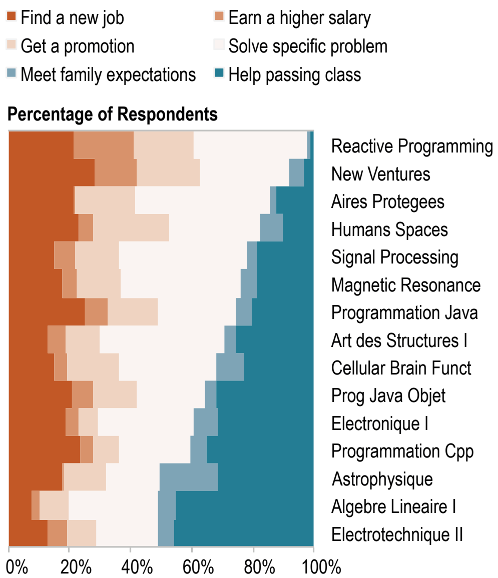


Figure 10: Reasons cited by users for registering to our MOOCs. The courses are sorted by decreasing percentage of job-related motives.

These answers are allusive to the fundamental motivations that drive human beings, such as the need for resources, status, and appreciation. Although some of the answers are correlated (*e.g.*, "earn more money" *vs* "get a promotion") they are intended to reveal the deep motivations (*e.g.*, money *vs* status) that lead to the more superficial ones.

At the same time, the answers are representative of the context within which a user follows our MOOC: at school or at work. It is clear that basic-level courses, such as linear algebra and electronics, tend to attract students who just want to complete their university coursework, and therefore follow the MOOC to help them pass a specific class. This trend is reversed for advanced-level and extra-curricular MOOCs, where job related motivations are more prominent.

Programming courses in particular are associated with job related ambitions, as well as solving specific problems at work. The same is true for our entrepreneurship course, in which 92% of users are primarily motivated by improving their careers or businesses.

An example of such a user is Job van de Kieft, the winner of the Best Business Proposal prize for our "Launching New Ventures" MOOC. Mr. van de Kieft, an entrepreneur from Delft, Holland, was developing his own startup company Scoozy[2] when he signed up for the MOOC taught by EPFL business professors Christopher Tucci and Marc Gruber. The MOOC, he said, helped him structure some of his fragmented ideas about business into a concrete and executable strategy.

Job van de Kieft, winner of the Best Business Proposal in our entrepreneurship MOOC. Founder of the startup company Scoozy.
www.linkedin.com/in/jobvandekieft

"The course helped me create a bigger picture of all the separate aspects I had already looked into", he said. "It helped me understand my customers better, and led me to negotiate a paid pilot project with a particular customer who could very well be the one that makes my business take off". This is an exemplary case of a small initiative that has led to a big and unexpected result.

These, and other examples are the precise reason why MOOCs work. People do not need to be "spoon fed"; if they are motivated, they will recognize the value of what we offer and they will benefit from it. The next section will reinforce this conclusion by presenting the latest key performance indicators of our MOOCs.

3.2 Status Report: 2012 to 2015

The year 2015 has come to an end, and after more than 3 years of operation we can proudly say that the EPFL MOOCs program has been serving its purpose beyond all expectations. In addition to the overwhelming adoption of MOOCs by EPFL students, and the success stories we receive from our users abroad, all of our international indicators suggest we are moving in the right direction—despite the increasing competition from other institutions, and the settling of the initial "MOOCs euphoria".

[2]www.scoozy.nl

At the Center for Digital Education (CEDE), new MOOCs are being produced and deployed every semester, allowing us to acquire hundreds of thousands of new users every year. Many of these users are actively engaging in our courses, and successfully completing the required coursework, even though our MOOCs are as challenging and difficult to pass as our classroom courses.

This means that, every year, thousands of people are receiving an EPFL-grade education on a variety of subjects from the comfort of their distant homes, including many homes in developing countries. This is a remarkable achievement for EPFL and its professors, which we intend to preserve in the years to come.

In this section, we analyze the evolution of our main indicators from September 2012 (when our first MOOC was launched) to December 2015. These indicators include what we call the "vital signs"—number of registrations, active users, and certified users—as well as demographic data, including age, gender, and country of origin. With this goal in mind, the various graphs presented next depict the main vital indicators as a function of either *time* or *date of launch* of our MOOC sessions. These graphs will hopefully provide the reader with an intuitive "temporal overview" of our entire MOOCs program to date.

Engagement and achievement

On the 24th of August 2015, EPFL reached **1 million MOOC registrations**. This number has since grown to an estimated 1.17 million, with a total of 58,000+ certified users (those who passed) from 186 countries and 28 territories. Out of all the registered users:

- 218,000+ (23%) submitted at least one assignment (those we call *actives*), of whom 26% passed;
- 77,000+ (8%) submitted at least half the assignments (those we call *very actives*), of whom 73% passed.

There are two lessons that can be taken from these simple numbers: (1) users who commit at least one step towards following the course—in this case, submitting an assignment—more than double their chances of success (recall the 10% passing rate myth); (2) users who seriously try to follow the course, by regularly submitting assignments, normally pass.

In terms of registrations, the number has been remarkably stable each year: *321,882* in 2013, *362,547* in 2014, and *329,908* in 2015. That is a variation of little more than 6% from one year to the next. This stability can be observed in the vital signs graph of Figure 11—a graph that we call the MOOCs "heart beat". It represents the weekly number of registrations for all of our open[3] MOOC sessions combined.

Looking at the graph, one can easily notice that every "heart beat" corresponds to a registrations cycle of 1 semester, when most of our MOOCs are deployed. Although some "beats" are clearly stronger than others (depending on the popularity of the courses involved) the overall pattern is relatively stable, hence explaining the small yearly variation.

[3] In both Coursera and EdX, every course accepts new registrations for as long as a session is open.

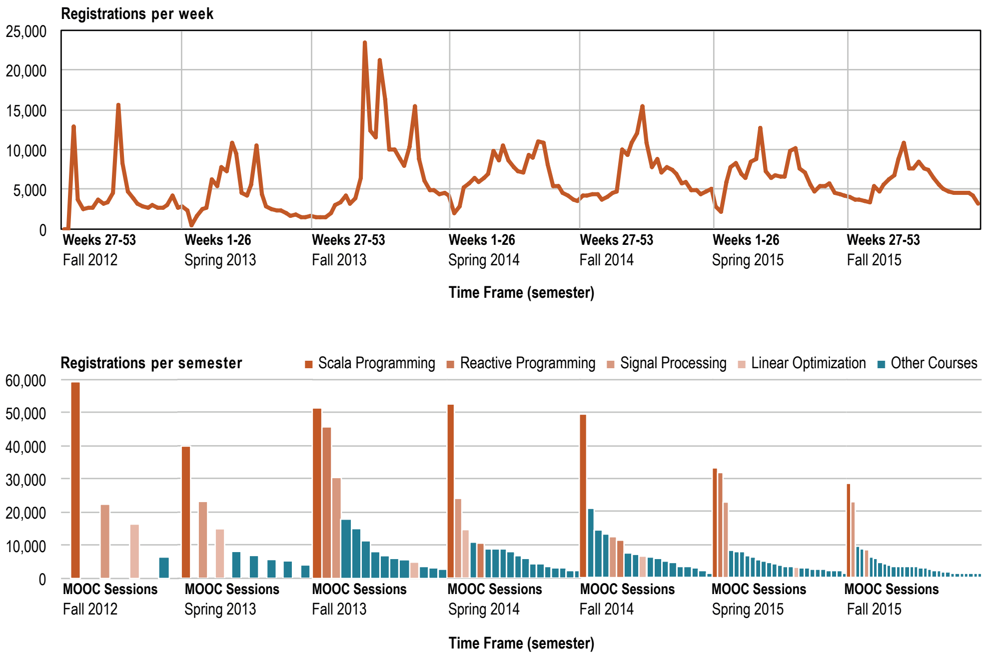


Figure 11: MOOC Vital Signs I: Number of registrations. **Top.** Number of registrations over time. The graph shows the weekly number of registrations on a linear time frame, and includes registrations from all open MOOC sessions each week. **Bottom.** Number of registrations per MOOC, per semester. The graph shows the number of registrations that each MOOC received during each semester, sorted by decreasing number of registrations. Note that, from 2012 to 2015, the number of open MOOC sessions progressively increases, even though the number of registrations per MOOC decreases. This helps to preserve a high and stable number of registrations each semester.

This will change in the future, as we drop the old session-based MOOCs in favor of the on-demand model—currently being adopted by Coursera and EdX—where users are allowed to follow the courses whenever they want, at their own pace. As a result, once all of our on-demand courses have been deployed, the oscillatory pattern of Figure 11-(top) will most likely converge to a flat line[4].

Another useful look at the temporal progress of our MOOCs program is the vital signs graph of Figure 12, which depicts the number of *active users* (those who submitted at least one assignment) together with those who passed the course. This graph, however, should be analyzed with caution, since it does not follow a linear temporal flow.

In fact, the horizontal axis of the graph represents the **start date** of the MOOC sessions, which implies that each point incorporates the entire population of users who followed the respective course over the following weeks—all compressed into a single point. As a result, the impression that the curve is decreasing with "time" is only illusory.

[4]We hypothesize that, in an on-demand environment, new users will sign up for our MOOCs in accordance with a Poisson process, just like other human behavioral phenomena in which events occur continuously and independently at a constant average rate.

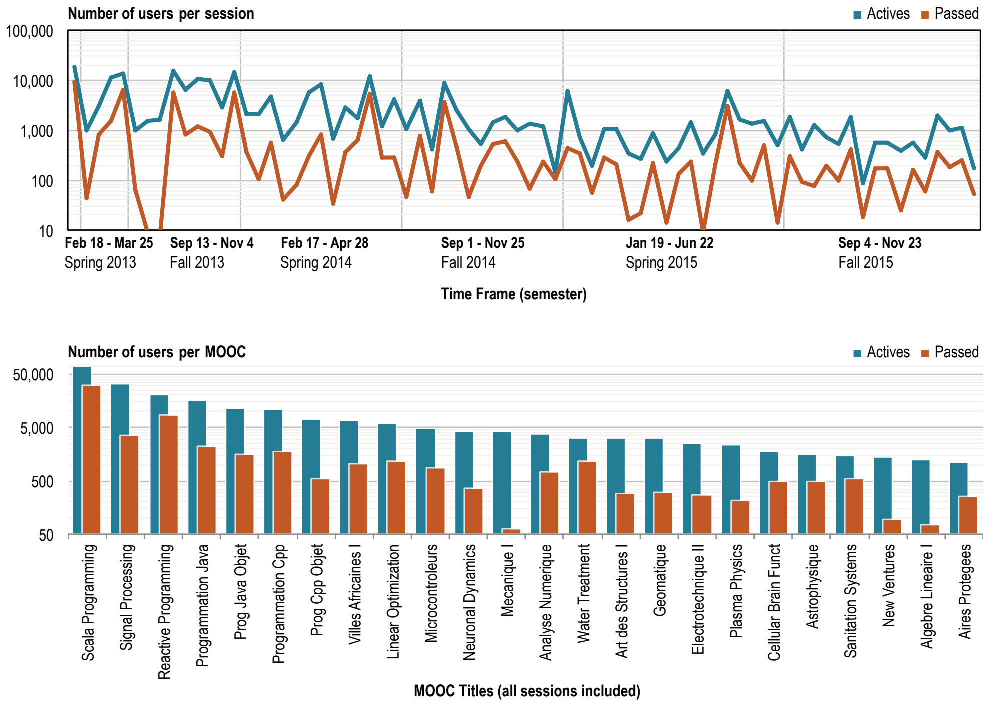


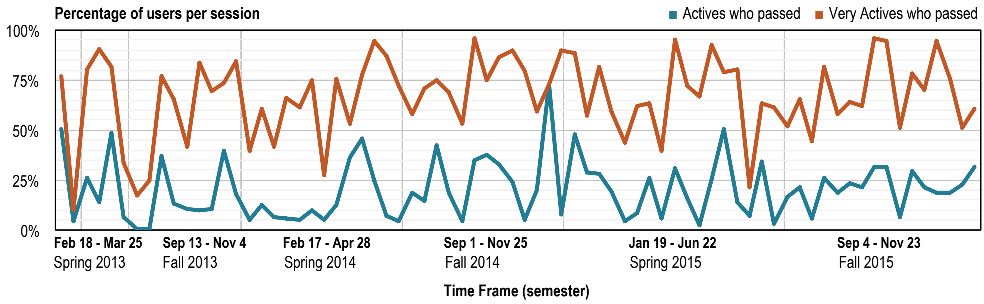
Figure 12: MOOC Vital Signs II: Number of active and certified users. **Top.** Number of active and certified users over time. The graph shows the number of users who submitted at least 1 assignment (actives) and those who passed the course, on a vertical log scale. The horizontal axis is sorted by start date of MOOC sessions, in order to give the impression of temporal evolution. **Bottom.** Number of active and certified users per MOOC. The graph shows the number of active and certified users that each MOOC amassed during all deployed sessions, sorted by decreasing number of actives. Note that this ranking favors older courses that went through multiple sessions (such as "Scala Programming" with 5 sessions) against those that launched only once (such as "Launching New Ventures").

Nevertheless, it is interesting to observe that whenever a new session of our most popular MOOCs is launched—such as "Scala Programming", "Reactive Programming", and "Signal Processing"—there is a peak in both the number of active users and the number of users who pass the course.

This type of graph allows us to precisely determine which MOOC sessions were the most popular, and which ones failed to attract a satisfactory following (in comparison to our global historical performance). Several decisions are made as a direct result of such analysis, particularly when choosing subjects for future MOOCs.

The third vital signs graph that we use to evaluate the general health of our MOOCs program is illustrated in Figure 13. This graph shows the percentage of engaged users who pass each MOOC session as they are launched over time. We distinguish between two levels of engagement: *active users* (those who submit at least one assignment) and *very active users* (those who submit at least half of the assignments).

As the graph shows, the passing rates among *active* and *very active* users has been relatively



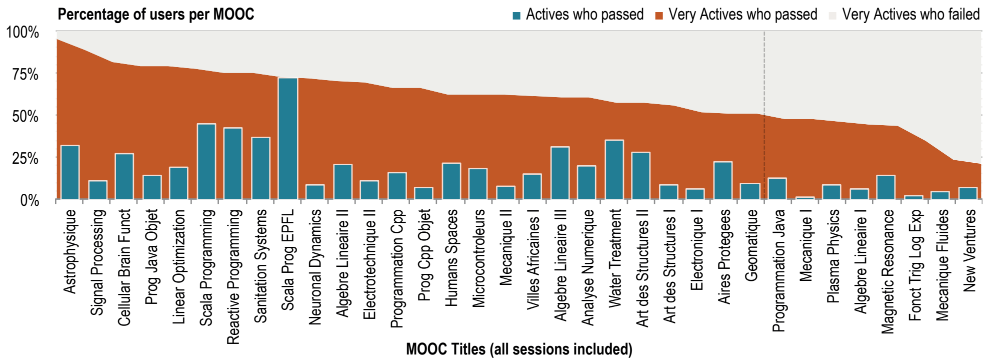


Figure 13: MOOC Vital Signs III: User performance. **Top.** Percentage of active and very active users who passed over time. The graph shows the percentage of users who passed the course among those who submitted at least 1 assignment (actives) and those who submitted at least half of the assignments (very actives). The horizontal axis is sorted by start date of MOOC sessions, in order to give the impression of temporal evolution. **Bottom.** Percentage of active and very active users who passed each MOOC—all sessions included. In this ranking, since it is shown on a percentage scale, there is no bias favoring MOOCs with more than 1 session. It is, however, affected by the grade that instructors have chosen as the passing threshold. The vertical dashed line separates the courses that had more than 50% passing rate among very actives from those that had less.

steady for the last 3.5 years. It also shows a high effectiveness of our professors in educating engaged users online: only 13 of the 71 MOOC sessions launched by EPFL saw less than 50% of *very active* users passing the course. In the remaining 58 sessions, more than 50% have passed. In fact, by this measure, 2015 was our best year: only 4 sessions out of 31 finished below the 50% passing rate threshold.

Assuming we are able to maintain this steady performance, increasing the number of certified users at the end of each year is a matter of attracting more registrations—a problem that can be solved with better marketing (see Chapter 5).

Country of origin

Among the 193 countries recognized by the United Nations, there are only 7 which EPFL has not yet reached with the MOOCs program. These are: Nauru, Palau, Solomon Islands, South Sudan, Timor-Leste, Tonga, and Tuvalu. All other 186 countries—and an additional 28

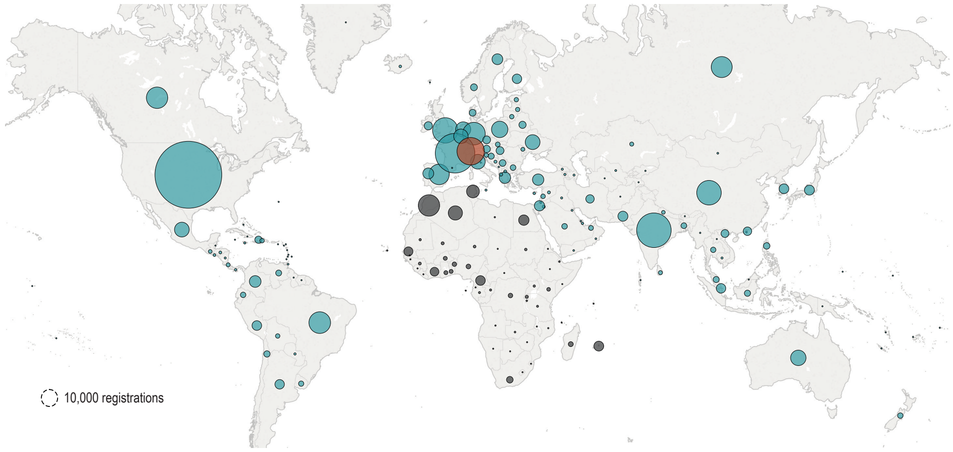


Figure 14: World map of registrations. The radius of each bubble (equivalent to a linear scale) is directly proportional to the number of localized users in the country. The orange bubble represents the number of registrations in Switzerland, and its size is scaled accordingly. The grey bubbles represent African countries, and the blue ones represent the rest of the world.

non-sovereign, unrecognized, or disputed territories—have had members of their population register for an EPFL MOOC. Metaphorically speaking, EPFL has turned into one giant world-wide campus (see Figure 14).

In Switzerland alone, we had an estimated 28,191 registrations from 15,678 users—although the real numbers are probably much higher[5]. As in previous years, it is still clear that the vast majority of registrations—nearly 64%[6]—come from the Western world, including Europe, North America, and Oceania. About 20% originated in Asia, 9% in Africa, 5% in South America, and 2% in other regions.

India accounts for 7% of the total registrations, while China accounts for only 3% (less than Switzerland, with 4%). The United States is still the biggest client for our MOOCs, with 25% of the total number of registrations.

Another fact worth mentioning is that 60% of all African users are from North African countries (mostly Morocco, Algeria, Tunisia, and Egypt), followed by 24% from West African countries (mostly Cameroon, Senegal, and Côte d'Ivoire).

However, not all MOOCs are created equal. Each course tends to develop its own regional base, which remains relatively unchanged from one session to the next. These regional bases—illustrated in Figure 15—show that the origin of users is highly correlated with the instruction language of each MOOC.

English courses are mostly popular in Europe, North America, and Asia. French courses, in

[5] We only have country/location information for about 69% of our registration records. This makes the number of registrations in Switzerland probably closer to 40,000.

[6] Percentages are calculated based on the number of localized users (N = 679,733) rather than the total number of registered users, and therefore represent only estimates of the real percentages.

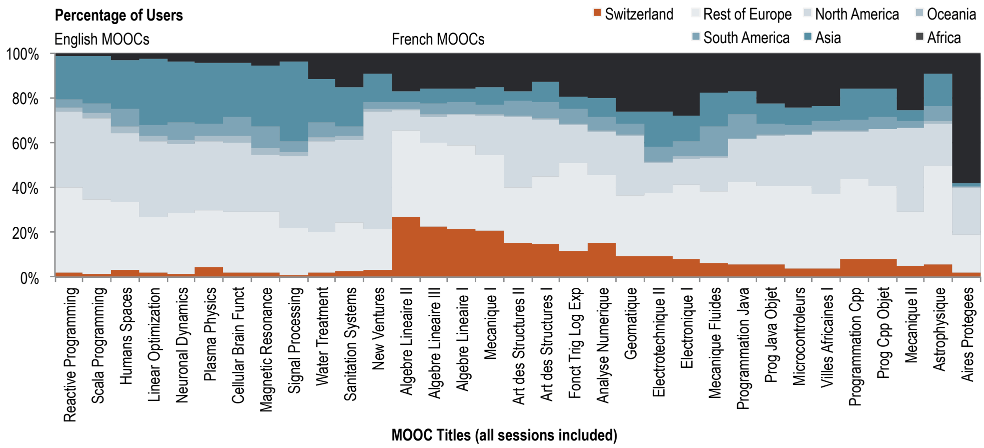


Figure 15: Distribution of users across regions and continents for English and French MOOCs. The chart shows the regional base developed by each course for the whole duration of its existence online. The high percentage of users in Switzerland for propaedeutic French MOOCs can be partially explained by the fact that instructors at EPFL encourage their use as additional material (but it could also be a result of these courses having a low number of registrations).

contrast, are dominated by African and European users (including a large proportion from Switzerland), even though all French MOOCs have English subtitles. Among our French MOOCs, in particular, those that are targeted to EPFL students attract a high percentage of users from Switzerland.

It should be noted, however, that the language dimension is not independent from the course level, as most basic courses at EPFL are taught in French, while more advanced courses are taught in English. Moreover, almost 70% of European users who take our French courses are from French-speaking countries (such as France, Switzerland, Belgium, and Luxembourg). In contrast, only 15% of European users who take our English courses are from French-speaking countries.

The specific subject area covered by MOOCs can also influence their geographical distribution. Courses such as "Water Treatment", "Sanitation Systems", and "Launching New Ventures", even though they are taught in English, are particularly relevant in the African continent.

Demographics

From a demographics standpoint, the profile of our users has not changed significantly from 2012 to 2015. For this reason, there is no point in discussing the temporal evolution of demographic indicators, such as age, education, and background. Instead, we will discuss the aggregated numbers of the past 3.5 years.

The simplest demographics indicator we use is the users' **gender**. As Figure 16 shows, our courses have different proportions of male and female users depending on the subjects being taught, much like the gender ratios observed in traditional colleges.

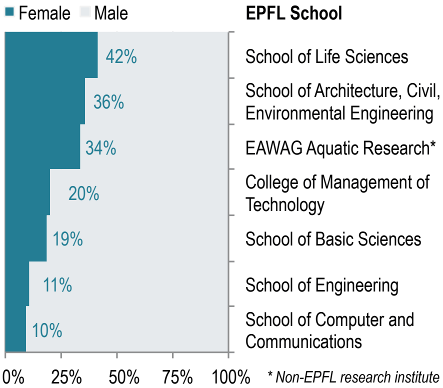


Figure 16: Gender distribution in MOOCs authored by each EPFL school (except EAWAG).

On the one hand, male users tend to dominate courses in the areas of basic sciences, engineering, and information technology. On the other, courses in the areas of life sciences, architecture, and humanities have a more balanced ratio, with the percentage of females going up to 42%.

The gender ratio also varies with the **age** of our users. Figure 17-(top) shows that our MOOCs are taken mostly by young people between the ages of 22 and 28 (peaking at age 25) with a female-to-male ratio of 1:5, followed by people between 29 and 34 with a 1:6 gender ratio, and 45 to 54 with a 1:8 gender ratio. In general, the ratio between females and males tends to decrease for older age groups.

In terms of user **education**, the higher number of registrations for ages 22 to 28 is consistent with the age group of typical academic programs. By age 25, students have finished their Bachelor's and Master's degrees, and resort to MOOCs as part of their continuing education. This is confirmed by the academic degrees held by users of our MOOCs, illustrated in Figure 17-(bottom). The chart demonstrates that most registrations come from people with Bachelor's and Master's degrees. This is true for both males and females, who have a nearly equal distribution of academic degrees.

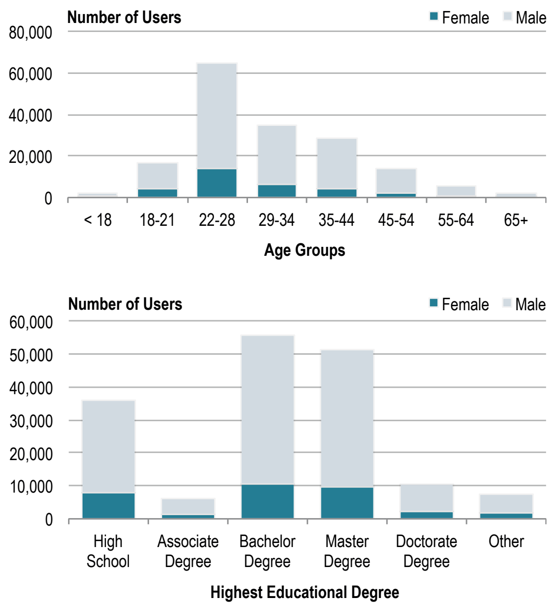


Figure 17: Top. Number of MOOC users by age group and gender. **Bottom.** Number of MOOC users by level of education (highest degree obtained). Note that the graphs only account for users who filled out the demographics survey, which are no more than 15% on average.

Continuing education is a key concept in evaluating the target audience of online courses. While common sense would suggest that full-time students represent the largest group of clients for online courses, our data shows that only 34% of registered users are, in fact, enrolled in an educational program. An astounding 66% of users are not students (see Figure 18). These statistics, which are important in defining the future strategy of our MOOCs program, will be discussed in more detail in Chapter 5.

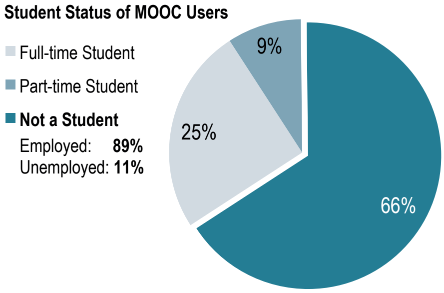


Figure 18: Percentage of MOOC users who are currently enrolled in an educational program.

In this context, it is equally important to understand the educational **background** of our user-base. Figure 19 illustrates the percentage of users who have studied (or are currently working on) a particular class of subject areas.

The chart shows that our MOOC catalog appeals to users with a variety of backgrounds, depending on the subject and level of specialization of the course. For instance, "Functional Programming in Scala", "Principles of Reactive Programming", and "Digital Signal Processing"—our 3 most popular MOOCs—are highly technical and specialized, and therefore attract a higher percentage of engineers and computer scientists. On the other end of the spectrum, courses like "African Cities", "Sanitation Systems", and "Water Treatment" attract users from a variety of other backgrounds.

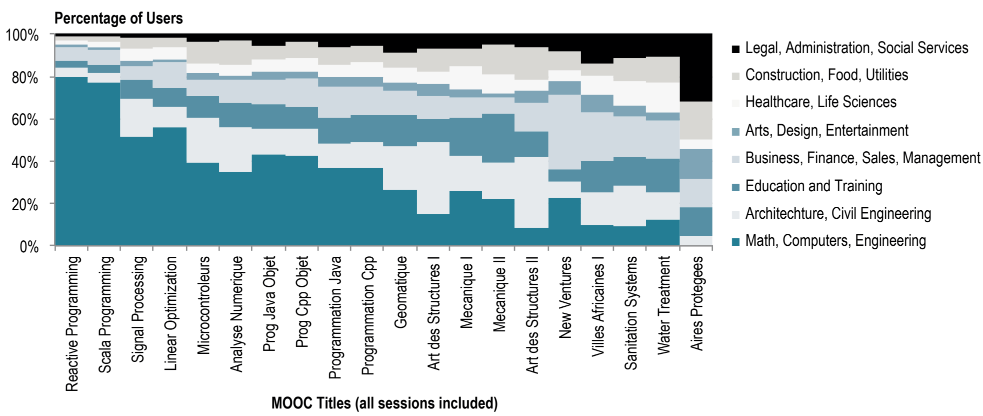


Figure 19: Background of users who followed our MOOCs. The courses are approximately sorted by percentage of users with a highly technical background to a less technical one.

4. Impact in Africa

«I showed my friend the windmill I was building that would produce power for my home. He asked me where I got such a cool idea. I said: the library!»
– William Kamkwamba, 15-year-old author from Malawi

USING THE WORD "REVOLUTION" to describe the advent of Massive Open Online Courses (MOOCs) has long been avoided by EPFL. The paradigm of online education is not new, at least to the Western world, and has been implemented in many different forms ever since the advent of the Internet. Yet, if there is a place in the world where MOOCs can potentially be revolutionary, that place is Africa.

With the exception of a few countries—particularly in the north—the continent of Africa is still largely under-educated. In central Africa, the adult literacy rate is estimated to be as low as 15-40%, despite the region having the highest birth rates in the world[1]. How to provide a high-quality education to such a large population of young people is one of Africa's main challenges for the 21st century, and one that MOOCs (powered by the Internet) can help solve.

Never in the history of the region has Africa had such wide-spread access to first-rate educational material like it has today. In the last decade alone, the percentage of the population with access to the Internet in sub-Saharan countries has grown from 2% to 20%. Although most of these connections are low-bandwidth, they provide unprecedented access to the educational system of developed societies.

However, access to knowledge is not enough. Students still need a well-organized local institution that can guide and motivate them throughout their studies. This is why partnerships with local African schools and universities are so important to help Africa adopt a modern and efficient educational system. It is with this sense of responsibility that EPFL decided to launch the *MOOCs for Africa* program—a long-term initiative to bring MOOCs into the heart of Africa.

[1] All social-economic indicators in this chapter are obtained from the World Bank Organization, unless stated otherwise.

Specifically, the initiative aims at building partnerships with universities of technology in sub-Saharan African countries, and producing MOOCs with direct interest to those universities. As a result of adopting these MOOCs into their own curriculum, we expect African universities to act as regional hubs for the dissemination of our courses among the rest of their student population.

The next step of this initiative, which is already being put into action, is to offer EPFL certificates to Africans who complete our MOOCs with a proctored exam. This will provide a significant amount of leverage when applying to jobs, universities, and foreign institutions.

4.1 Higher Education in Africa

Despite the dramatic growth of higher education in Africa in recent years, only 6% of students of suitable age are enrolled in a higher education program—compared to 20–40% in most developing countries, and 72% in North America and Western Europe. In French-speaking Africa, the enrollment is estimated to be 3-4%.

To make matters worse, at the current population growth rate, the population of Africa is expected to double by 2050 (possibly sooner)[2]. If the situation does not improve by then, Africa risks being left with an estimated 178 million young adults without access to higher education[3].

This presents a formidable challenge for the continent in the time to come. And despite the genuine attempts of some African countries to modernize their educational systems, the question remains of how to effectively educate such a massive new generation of people that will soon be approaching working age.

The role of MOOCs

One of the answers—certainly among many—is to encourage the adoption of MOOCs in African universities. There are many advantages of doing so, particularly in terms of quality, cost, and scalability.

By using our MOOCs, Africans will have access to some of the best educational material in the world, taught by world-leading experts in each field. In the past, such a possibility would have been available only to a small elite group of students who could pursue their studies in Europe or the United States. With MOOCs, they can get a share of that education from their own home country.

For the university, the additional cost of hosting MOOCs is negligible in comparison to its scalability. If only low-bandwidth connectivity is available to the university, as is often the

[2] "World Population Data Sheet", Population Reference Bureau, 2013.

[3] According to projections by the United Nations Department of Economic and Social Affairs, 8.5% of the population in Africa will be aged 20-29 in 2050. With a population increase from 1.1 to 2.2 billion, the number of college-age adults will be 187 million, of whom only 9 million will have access to higher education.

case, a local server is required to host the video lectures. Yet, the advantages in terms of scalability are immense.

While one teacher alone can manage a class of 100-200 students, a MOOC can potentially teach thousands—as long as computers or smartphones are available. Fortunately, the GSM Association estimates that, by 2020, 90% of all African students will be equipped with a tablet computer or smartphone.

By using a hybrid educational model, combining classroom teaching and MOOCs, African universities will be able to massively increase the number of students. Local teachers will be able to record their own lectures, and broadcast them outside the classroom. If no experts are available in a specialized subject, the university can still offer the subject for credits in the form of a MOOC.

Collaboration with EPFL

In the last 3 years, the *MOOCs for Africa* team has been helping African institutions implement a mature and sustainable MOOCs program, not only with courses from EPFL, but also with courses developed in close collaboration. We call these "collaborative MOOCs".

Collaborative MOOCs are an important step in the cross-cultural relationship between European and African institutions. Although universities in Africa can already benefit from MOOCs created at EPFL, they can benefit even more from MOOCs that are tailor-made to fit their curricular needs.

The process of creating such MOOCs, besides defining a specific subject and a target audience, requires identifying relevant teachers who can present the material, and working together with them in both course design and video production—typically under the leadership of one of their peers. This type of collaboration helps promote the exchange of academic best practices, as well as joint research, between African teachers and institutions.

These MOOCs are currently being implemented in 10 partner universities of French-speaking Africa, plus 20 additional institutions, including the following:

- Institut National Polytechnique Félix Houphouët-Boigny de Yamoussoukro, Côte d'Ivoire,
- Ecole Nationale Supérieure Polytechnique de Yaoundé, Cameroon,
- Ecole Supérieure Polytechnique, Université Cheikh Anta Diop de Dakar, Senegal.

As a result, more than 100 African teachers have been trained in the pedagogical approach of MOOCs. They created their own network of MOOC experts, and have begun sharing their experiences with their peers.

In addition to producing MOOCs together, we have also taken steps to improve the accessibility of MOOCs for students in our partner institutions. As mentioned before, high-bandwidth connectivity is still rare in Africa. To solve this issue, we implemented solutions such as installing satellite antennas, creating dedicated MOOC computer rooms on-campus, and uploading our MOOC videos to their internal servers (or just sending them a DVD with all the videos).

Lastly, we made efforts to obtain the support from political and academic leaders in Africa. Efforts such as lobbying and communicating with key stakeholders, meeting with African ministers, receiving state delegations at EPFL, and participating in forums and conferences. We also gave a number of interviews, which boosted our program's coverage in both written and broadcasted media.

MOOCs Certification

If MOOCs have the potential to transform higher education in Africa, they are even more impactful in training adults. In several professional sectors worldwide, human resources are starting to accept MOOC certificates as an important element for job applications. This is no different in African companies and institutions, especially for candidates who hold certificates from prestigious European universities such as EPFL.

The *MOOCs for Africa* team is working on core business subjects with strategic importance to the African labor market—subjects such as urbanism in Africa. One of the pilot experiments already in place is the "Villes Africaines", by Jérôme Chenal. In this course, participants are required to take a proctored exam at the end. If they pass the supervised exam, they receive an official EPFL "Certificate of Open Studies".

Additional MOOCs of direct interest to Africa—both in French and English language—are under consideration, or already in development. These courses aim to train specialists capable of managing the complex issues in science and engineering that are being faced by Africa today. At the same time, EPFL is putting in place the necessary legislation that will regulate the issuing of official certificates.

4.2 MOOCs Usage in Africa

Ever since the *MOOCs for Africa* program took off, the reach of our courses in African countries has been close to our initial goal. At the date of writing, an estimated 86,000 African users had registered for one of our MOOCs, 3,500 of whom passed with a statement of accomplishment. In comparison, the EPFL campus has only 377 students of African origin.

Although the continent started with a low pace of adoption, with a mere 6% share of the world's registrations, it has started to catch up. Of all regions in the world, MOOC adoption in Africa has grown the most in relation to 2013. In the years 2014 and 2015, Africa's share of registrations grew to 11% and 12% respectively—a definite upwards trend. This is illustrated in Figure 20.

Furthermore, the number of registrations in Africa necessarily needs to be considered in light of Internet connectivity. The percentage of Internet users within the population of sub-Saharan Africa is—with few exceptions—no more than 10-20%. As a result, the map in Figure 14 gives an unfair view of the success in our MOOCs program in Africa. A more realistic view is given by the map in Figure 21, which shows the number of registrations among the population of Internet users in each country.

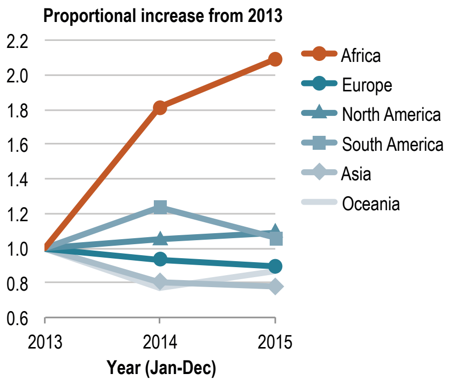


Figure 20: Proportional increase or decrease in registrations with respect to 2013 in each continent. The values are normalized according to the formula $f(y,c) = \frac{R(y,c)}{R(2013,c)} / \sum_c \frac{R(y,c)}{R(2013,c)}$, where $R(y,c)$ is the number of registrations for year y and continent c.

The map demonstrates that African countries where we have been actively promoting our MOOCs—countries like Senegal, Côte d'Ivoire, Benin, Togo, Cameroon, and Madagascar—have an effective adoption rate among Internet users comparable to that of European countries, and even higher than the United States, India, and China.

From a success point of view, African users do not lag behind the rest of the world. The **passing rate** among "very active" users (those who submitted at least half of the assignments) is 60% in Africa, compared to 74% in the other continents combined. Moreover, the **average grade** among users who passed is 83/100 in Africa compared to 88/100 in other continents, which is remarkably close.

Where Africa still lags behind is in terms of **user retention**. Only 6% of registered users from Africa can be considered "very active", compared to 11% in the rest of the world. This could be happening for a variety of reasons, including students using the MOOC as a complement to their lectures—in which case, they have no motivation to submit assignments for grading. However, as the achievement numbers show, once African users commit to solving (and submitting) the assignments, they tend to pass with a good grade.

In terms of **demographics**, the percentage distributions of age, gender, and education in Africa do not differ much from other continents. The analysis in Section 3.2 can therefore be used as a reference.

4.3 Case Study: *Launching New Ventures*

A good example of a MOOC that embodies the strategy of the *MOOCs for Africa* program is the entrepreneurship course entitled "Launching New Ventures". This course was created by Professors Marc Gruber and Chris Tucci, from the College of Management of Technology (CDM) at EPFL, with the purpose of teaching entrepreneurship to people who are interested in starting a new venture, and especially tailored for a audience of entrepreneurs (or aspiring entrepreneurs) in emerging economies in Africa.

The course features interviews with many African entrepreneurs, which help students see real applications of the course material, experience positive inspiration, and realize that

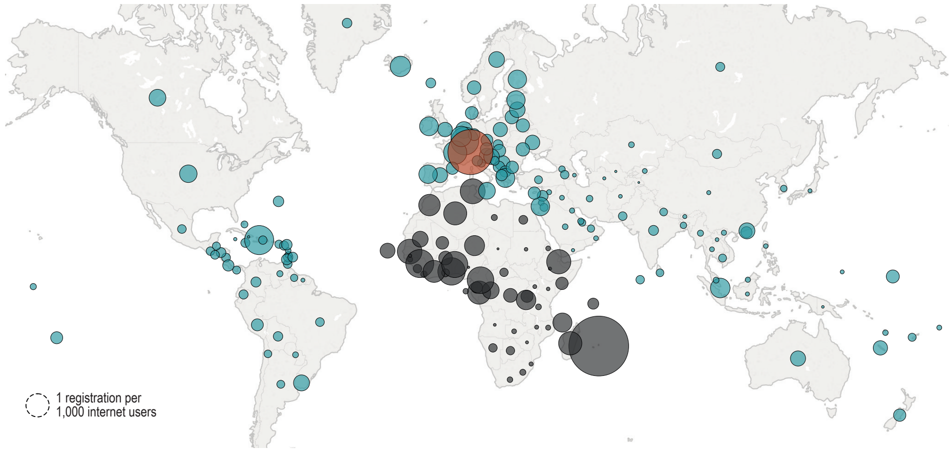


Figure 21: Number of registrations per 1,000 Internet users in each country. The radius of each bubble (equivalent to a linear scale) is directly proportional to the number of localized users in that country. The orange bubble represents the number of registrations in Switzerland, and its radius is scaled accordingly. The grey bubbles represent African countries, and the blue ones represent the rest of the world.

entrepreneurship is not just a Silicon Valley phenomenon. It also included a contest, where five of the top performing new venture teams were invited to an intensive entrepreneurship workshop in Switzerland, hosted at EPFL and CERN, in late 2015.

However, what made the experience of launching this course particularly interesting is that it was distributed in refugee camps in Africa, and followed by people within the camps with a remarkable level of engagement.

The initiative took place at the Ampain Refugee Camp and the Krisan Refugee Camp, both in Ghana (see Figure 22), and was organized by the Open University of West Africa (OUWA)—an open university which runs courses based on MOOCs. Refugees were given smartphones with shared headphones where they could watch the MOOC videos and solve the exercises together. At the end of the course, the refugees were expected to come up with their own venture idea, and pitch their proposal in front of a camera.

In the end, more than 90% of the participating refugees completed the MOOC successfully. Those who completed the MOOC earned a joint certificate of completion signed by Chris Tucci and OUWA president John Roberts[4]. Those who participated but did not attain completion were issued a certificate of participation.

At the time of writing, the course had amassed over 12,000 registrations, 42% from emerging countries, and an estimated 1,600 from Africa. In addition, two startups have been launched by participants in the refugee camps, with financial aid and coaching support from OUWA.

[4]No ECTS credits were given, however.

Figure 22: Participants in a refugee camp in Ghana following the MOOC "Launching New Ventures". The participants were given smartphones where they could watch the video lectures, and expected to pitch a venture proposal in front of a camera at the end of the course.

5. Targeting Professionals

«The illiterate of the 21st century will not be those who cannot read and write, but those who cannot learn, unlearn, and relearn.» – Alvin Toffler

A SURPRISING REALIZATION we had, the moment demographics data started flowing from Coursera and EdX into our servers, is that an overwhelming percentage of our MOOC users are not students in the traditional sense—they are not enrolled in any educational program. They are, in fact, either employed by a company or working as self-employed professionals.

Upon further investigation, we discovered that many of these professionals are employed by some of the biggest and most profitable companies in the world, with annual revenues on the order of 1 billion USD. They also have a higher passing rate compared to the rest of the population, as we shall see.

The immediate consequence of this realization, from a strategic point of view, is that we cannot separate our target audience only into EPFL and non-EPFL students. Instead, we need to consider an additional third group of non-student professionals which forms an important (and potentially more profitable) part of the MOOC user population.

On many fronts, this third group requires a completely different approach from the first two. While students can benefit from courses that focus on academic material, such as basic sciences and engineering, that help them pass their classes, the employed professionals are more interested in courses that can provide them with concrete skills that will help them solve specific problems at work, get a promotion or raise, or find a new job entirely (see Figure 10).

Furthermore, the way we reach these two populations and promote our new courses to them is also different, requiring the use of different marketing channels—particularly, social media channels. For instance, a recent study[1] on the demographics of social networks shows that 32% of American teenagers consider Instagram their most important social tool. In contrast,

[1] "Social Media Update 2014", M. Duggan et al, Pew Research Center, Jan 9, 2015.

LinkedIn is used by 44% of American adults with income of 75,000 USD or more.

The importance of offering continuing education to professionals, coupled with the appeal of our MOOCs to this group of users, has motivated the creation of an EPFL Extension School—a partially online school that will bring together all extra-curricular courses and MOOCs offered by EPFL into a single program.

The EPFL Extension School will bring our continuing education program to a whole new level. It will trigger a breadth of new innovations, both in teaching methods and technology, as well as in our marketing and branding efforts. It will amplify our visibility world-wide, exposing us to new markets that were never reached before. It will bring about important sources of revenue, not only from Switzerland but from other countries that will access our MOOCs *en masse*. All these developments will inevitably accelerate our transition into the digital world.

5.1 MOOCs in the Corporate World

When we talk about monetizing the EPFL MOOCs program, we think primarily of the corporate world. There is a large population of professionals who are yearning for new training opportunities—something that can help them solve specific problems for which they lack the skills, or that can help them earn more money or achieve a higher status in their company.

Fortunately, our MOOCs have proved appealing to this group of users. In a survey completed by 62,908 of our MOOC users, only 25% reported to be full-time students, and 9% part-time students. The remaining 66% said they are currently not enrolled in any educational program. Among those who are non-students, 89% are fully or partially employed, which means that an estimated **59% of our entire MOOC user-base** (about 690,000 people) are, in effect, employed professionals.

In addition, our users are highly educated: the survey shows that 72% have either a Bachelor's, Master's, or Doctorate degree (see Figure 17). While it remains one of our ambitions to attract young and unprivileged people to our MOOCs, we cannot ignore the needs of such a high percentage of users who are educated professionals. Therefore, the purpose of this section is to analyze this important section of our user-base, by characterizing the companies they work for, and evaluating their performance in our MOOCs as compared to other parts of the population.

In the following analysis, we use a population of 2,286 professionals from 206 companies and organizations. We selected only companies (or organizations) where at least 5 employees registered for an EPFL MOOC. The results are presented next.

Company profiles

In the corporate world, the most popular MOOCs taken by employees were the following:

1. "Functional Programming Principles in Scala", used in 86% of the companies;
2. "Digital Signal Processing", used in 11% of the companies;
3. Other programming courses, such as "Introduction to C++", "Introduction to Java", and "Linear and Discrete Optimisation", used in 11% of the companies.

Non-governmental organizations (NGOs) have also used our MOOCs. Some of the courses we created with an African audience in mind—such as "African Cities", "Water Treatment", and "Sanitation Systems"—were particularly popular, and used by at least 3 NGOs and other institutions in the areas of construction and sanitation.

In terms of location, the companies we identified are mostly based in Western countries (see Figure 23). Nearly half have their headquarters in the United States, with the other half in Europe and other countries. Switzerland is relatively well represented, with 4% of all the companies.

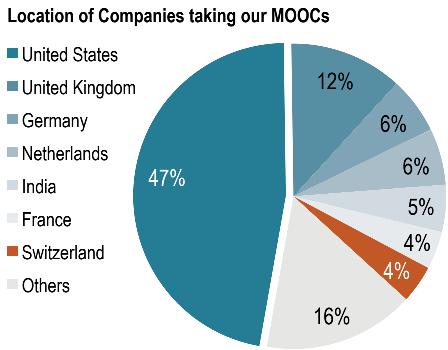


Figure 23: Headquarters' location of the companies where at least 5 of its employees signed up for an EPFL MOOC.

The profile of these companies covers a wide spectrum, both in terms of sheer size and area of activity. As Figure 24 shows, companies where employees take our MOOCs are medium to large in size, peaking at 1-10 billion USD in annual revenue.

However, there is no correlation between the number of employees in a company and the number registrations (the correlation coefficient was 0.12), which suggests that most of these registrations are spontaneous, rather than the result of company policy.

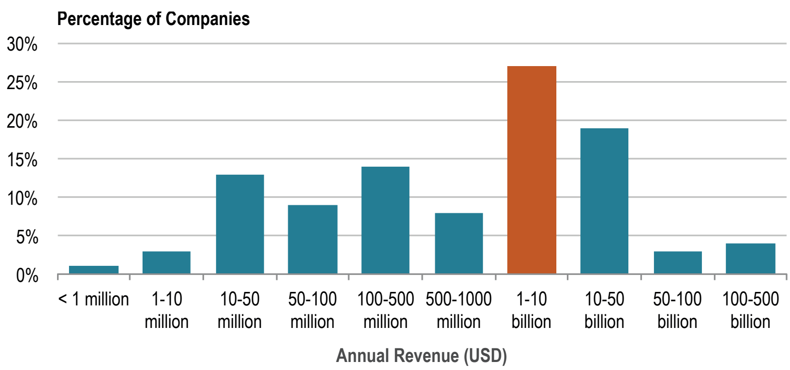


Figure 24: Annual revenue distribution of companies where at least 5 of its employees signed up for a particular EPFL MOOC.

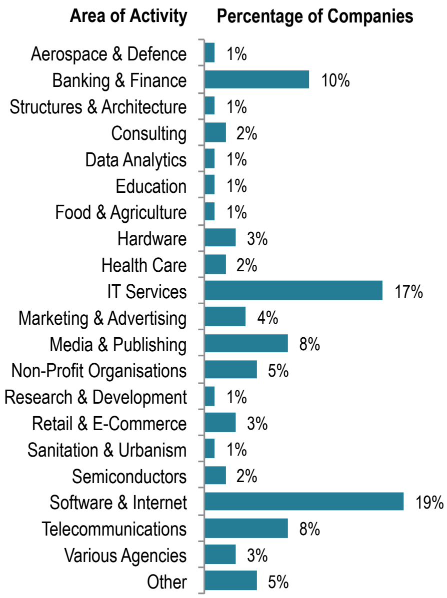


Figure 25: Area of activity of companies taking our MOOCs.

The area of activity of the companies we identified (see Figure 25) is as diverse as their size and annual revenue. It ranges from technology companies to non-profit organizations.

The main industries where our MOOCs have been the most popular are Software, Internet, and Information Technology (IT) services, especially due to our Scala, C++, and Java programming courses.

Banking and Finance are also prominent in the list of industries, not only due to our programming courses, but also due to our course on Digital Signal Processing (DSP), which is a critical tool in the analysis of markets and the science of wealth management that banks and hedge funds have specialized in.

Other industries of interest include Telecommunications (such as network providers and equipment manufacturers), Hardware and Semiconductors, and Media and Publishing.

Performance of company users

Professionals who are currently employees in a company are not only using our MOOCs in large numbers, but also performing better than others. This is demonstrated by the chart in Figure 26.

With no constraints on their engagement, company users are nearly 3 times more likely to pass the course than other users (19% *vs* 6%). If we consider only the population of active users (who solved at least 1 assignment) those working for a company are nearly twice as likely to pass the course than others (48% *vs* 26%).

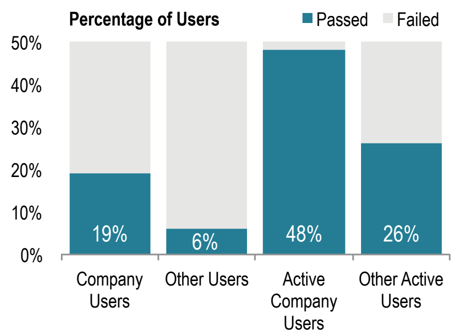


Figure 26: MOOC completion rate among company employees compared to other users, and compared to other levels of engagement.

In other words, we are discussing a group of users who have a near 50% passing rate when they are minimally engaged. Such a high performance does not necessarily mean that company users are fundamentally more engaged than others; it only means that they are potentially more motivated to obtain a statement of accomplishment, which can be included in their CVs or posted on their LinkedIn profiles.

As we have seen in Section 3.1, many users are motivated by results that are directly related to their jobs. These results include getting a promotion, earning a higher salary, solving a specific problem, or finding a new job entirely. On some level, any of these ambitions has a higher chance of being realized if the user completes the course. Thus, if we want to reach more of these users, we ought to touch on these ambitions and propose MOOCs that can help them achieve their specific professional goals.

5.2 Targeted Advertising

One way of reaching more professionals to whom we can sell our MOOCs is through the use of targeted advertising. This is a type of advertising that is directed towards a specific niche audience, with specific interests that can be identified and used to isolate them from the rest of the world. Once we identify those interests, we can communicate in a language that speaks directly to them.

There are many strategies and technologies we can use for targeted advertising, some more modern than others. With the advent of the Internet, digital marketing has become one of the most important tools for advertising in the modern world.

Yet, we should not forget that, on a fundamental level, and regardless of which marketing channel we use, we are dealing with human psychology. The deeper motivations of our users, such as the need for achievement, status, and appreciation, do not change over time. Only the platforms where users spend their time change.

In 2016, it is reasonable to say that social networks are almost synonymous with "time spent on the Internet". More than 1.59 billion people spend an average of 20-40 min a day on Facebook. If we count all 5 social networks that people use on average, they spend 1h40min every day browsing these networks[2] (accounting for 28% of the total time spent online). That is a considerably large time-window we can use to advertise our MOOCs.

The challenge with social media marketing (SMM) is that the marketing channels are networked, rather than hierarchical like traditional marketing channels (such as billboards and television). This means that, in order to reach a potential lead, one has to cross through a network of intermediary people—typically their friends—who we depend on to pass the message.

But this is also an opportunity. Many SMM platforms provide paid tools that allow us to bypass the network and advertise directly to a very narrow target audience, based on specific demographics and interests. As an experiment, we used one of these tools—the Facebook SMM platform—to promote the launch of our course "Management of Protected Areas in Africa", by Dr. Geoffroy Mauvais.

The campaign was a success, resulting is an estimated 30% conversion rate among African

[2] "Quarterly report on the latest trends in social networking", GlobalWebIndex Social, Q3 2015.

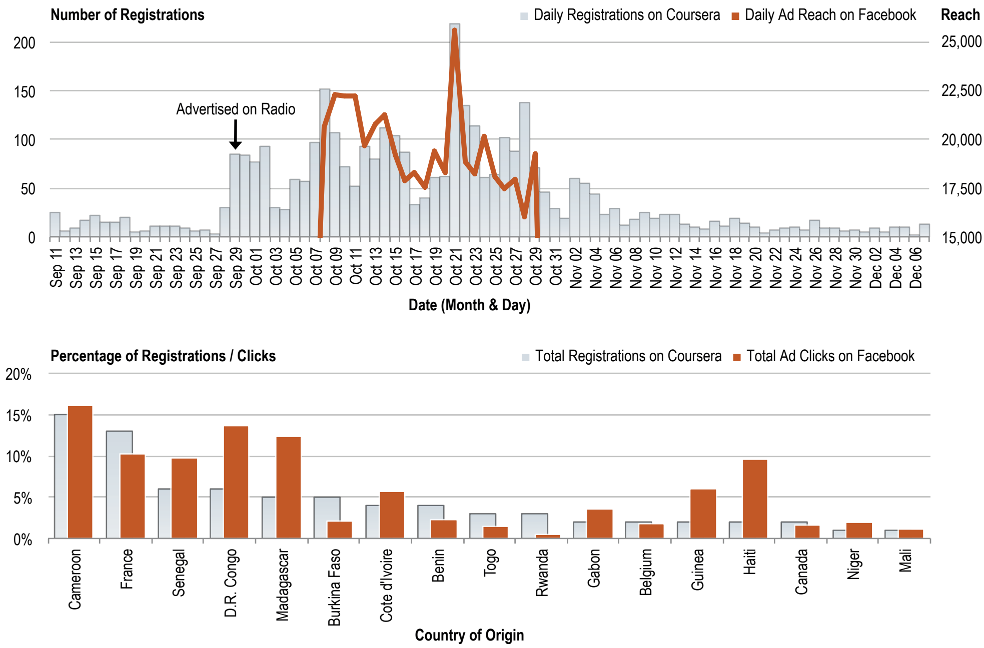


Figure 27: Effects of Facebook advertising on MOOC registrations. **Top.** Number of Facebook users to whom the ad was displayed every day (daily reach) compared to the number of daily registrations on Coursera. **Bottom.** Percentage distribution among different countries of the Facebook ad clicks and the Coursera MOOC registrations.

Facebook users, where 1 out of 3 people we reached registered for the course[3]. This helped boost the number of registrations from 907 to 3,097, by attracting 1,000 additional users who would not have otherwise learned about the existence of the course.

The effects of our Facebook advertising campaign are illustrated in Figure 27. The graph on top suggests that there is a high correlation between the daily reach of our "ad" on Facebook and the number of MOOC registrations on the Coursera website; whenever one peaks, the other peaks as well. The graph also shows an additional peak in registrations right after an announcement made on the Swiss radio.

The graph at the bottom shows the correlation between the countries where the Facebook ad was shown (and clicked) and the number of registrations on Coursera coming from those countries. As the graph suggests, there is a reasonable match.

Another piece of evidence that the Facebook campaign was successful is the result of a survey that asked users the question "Where did you learn about our course?". The survey offered several possibilities, such as the Coursera and EdX websites, search engines, and various social networks. The results, shown in Figure 28, demonstrate that an unusually high percentage

[3]This estimation is based on indirect proof, by comparing the daily reach on Facebook for each country with the number of registrations in those countries, and by asking users directly (though a survey) how they learned about us. Direct proof would be possible only if we could track every person from the moment he/she clicked the ad, all the way to a MOOC registration—a functionality that neither Coursera nor EdX provide.

(28%) of users for the MOOC "Protected Areas" found the course through Facebook. The only other course that comes close to this number is "Introduction to Astrophysics", which we also advertised on Facebook.

The survey reveals other interesting facts. Namely that: (1) most of the traffic still originates from the Coursera and EdX websites; (2) basic programming courses in languages such as Java and C++ get a high percentage of traffic from search engines (14-18%); (3) the course "Principles of Reactive Programming" has a significant amount of traffic (8%) originating from Twitter—most likely a result of Martin Odersky and his team's active presence on Twitter.

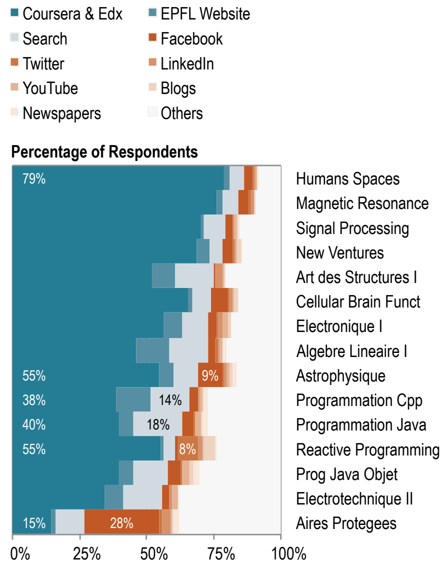


Figure 28: Result of a survey that asked users the question "Where did you learn about our course?".

The last thing worth mentioning about the Facebook advertising campaign is that (as an expected side effect) it increased the number of followers of the IUCN Papaco[4] Facebook page from 2 users to 516. These are users who IUCN Papaco can now reach organically, without the need for paying—meaning that any content, such as articles, videos, and photos, that is posted on their Facebook page has a high chance of showing up directly on their users' newsfeeds.

Any long-term SMM strategy ought to use network effects[5] such as this one to its advantage, allowing the advertisers to amplify their reach while reducing costs. In SMM, the need for paying exists only in the first stages of the campaign. Eventually, once a critical mass of followers has been amassed on a Facebook page (or any other social network), the communication becomes increasingly organic rather than paid.

5.3 The EPFL Extension School

The success of the MOOCs program has prompted EPFL to consider joining forces between the CEDE MOOCs program and the continuing education department. A first step has already been taken in this direction: in late 2015, the EPFL board approved the creation of the EPFL Extension School—a purely online school that will offer extra-curricular training in the form of MOOCs to anyone in the world.

[4] International Union for Conservation of Nature - Programme Aires Protégées pour l'Afrique du Centre et de l'Ouest.

[5] "Network effects" is a theoretical concept believed to be the main determining factor for the success of a social network. It quantifies the strength of a network based on the density of connections between people.

The Extension School will work in close collaboration with the CEDE, in an effort to produce new and profitable MOOCs, in addition to monetizing existing ones. These purely online courses will most likely be offered in the form of specializations, each consisting of a small curriculum of 3 to 4 MOOCs. They will be hosted on partner platforms such as Coursera and EdX, as well as our own private platform, depending on the technical and legal needs of each specialization.

One of the specializations about to be launched is the one on Scala programming. It consists of 4 MOOCs: (1) Functional Programming Principles in Scala, (2) Functional Program Design in Scala, (3) Parallel Programming, and (4) Big Data Analysis in Scala and Spark. These courses are offered by the EPFL Scala Center—an EPFL-based foundation dedicated to the development of the Scala programming language—the language invented by EPFL professor Martin Odersky.

New developments on the EPFL Extension School and its future specializations will be announced during 2016.

6. Latest Research

«In God we trust; all others must bring data.»
– W. Edwards Deming

THE MASSIVE AMOUNTS of behavioral data collected by the MOOC platforms (and made available to us) has boosted the development of learning analytics, a recent field that brings learning sciences to the era of data sciences. In our database alone, we have 100 million user actions describing every single "mouse click" a user has made while following a MOOC, including video navigation, assignment submissions and forum browsing. Such massive data—which we store securely at EPFL—is changing the way we conduct educational research.

One of the EPFL goals is to take full advantage of MOOCs Big Data from a research standpoint, by sharing it[1] with the various research groups at EPFL that conduct research on educational Big Data—groups such as the Artificial Intelligence Lab, the Automated Reasoning and Analysis Lab, the Audiovisual Communications Lab and the Computer-Human Interaction Lab for Learning and Instruction (CHILI).

Research at the CHILI Lab concerns the behavior of MOOC students and the factors that affect their success, such as how to select learning methods, how students succeed, what motivates them and what grabs their attention. Such knowledge is important for understanding how people learn with MOOCs, but also for the practical use of instructors, who can judge the quality of their teaching material by the way students navigate the videos or re-submit assignments. It can be used to improve the way we design MOOCs as well as to improve the platform's technology, by making it adaptive to each student's learning style, and to build recommendation systems that can point students to other courses they may be interested in.

Thus, even though our research only touches the tip of the iceberg, it is potentially game-changing. In this section, we describe a few selected studies conducted by the CHILI Lab

[1] We only share data within EPFL, and the data is fully anonymous. The CEDE takes all the necessary steps to protect any information that may reveal the identity of our users.

in 2015. Such studies exemplify the types of conclusions we can reach from the analysis of MOOC data.

6.1 Identifying Successful Activity Patterns

One of the difficulties we have in evaluating student performance in MOOCs is in defining good metrics of engagement that account for the different motivations that lead students to show different activity patterns, such as solving all assignments, only watching videos, or only watching 1 video. Take, for example, a student who is able to master the entire course material just by watching lectures. By definition, a zero means the user failed the course. But can we conclude that the user did not benefit from the MOOC, even though he or she mastered the material? The creation of broadly-accepted engagement metrics that enable comparisons across MOOCs and across platforms is an important challenge for the MOOCs community.

One way to address this question is to consider time dynamics. Until recently, MOOCs followed a rather rigid weekly structure that probably explains the social richness of MOOC life: the message a learner reads in the forum has been posted by other students who also need to deliver their assignment in a couple of hours. One measure of engagement is hence the extent to which MOOC users follow its time structure, including the release time of videos and the assignment deadlines. This measure can be described as some kind of "procrastination index": the delay between the times when a resource (lecture, quiz or assignment) is made available on the platform and the time the student actually accesses the resource, i.e, watches a lecture video or submits an assignment. Not surprisingly, this index is predictive of success: the more the students procrastinate, the less likely they are to score passing grades at the end of the MOOC. The global MOOC time span (time difference between the first and last activity of a student) is also predictive of final score, but these results are influenced by the fact that some participants discover and join the MOOC later than the official starting date, which is a rather difficult situation. In an on-going study, we analyzed in more detail when in the day/week MOOC users interact with the MOOC and how these time profiles differ from those who have a job and those who are students.

These results concern the balance between the freedom required for adapting MOOC activities to individual time constraints and the social benefits of a shared time structure. The current evolution of MOOCs consists of exploring new time structures that optimize this balance, such as on-demand MOOCs (always open) and multiple cohorts (one session starts on a regular basis).

Reference: Pending publication.

6.2 Predicting Success from Programming Assignments Strategies

Generally speaking, assessments play a key role in defining success in MOOCs. In the case of programming courses, assessments become even more important, as they constitute the prime way to provide feedback to learners. In a preliminary analysis for 120,000 programming assessments, we observed that the main disengaging factor for the active students (who submit at least one assignment) is failure in these programming assignments.

One specificity of programming courses is that the use of automatic graders allow MOOC users to submit their code several times for the same assignment. In some MOOCs, the maximum number of submissions is limited; in other MOOCs, it is not. It is hence interesting to discriminate different strategies used by learners for fulfilling their assignments. We identified 3 major problem-solving strategies: "one-timers", "thinkers" and "trial-and-error". "One-timers" submit the assignment only once, and accept the first grade they get. "Thinkers" re-submit their assignments more than once, but they do so moderately. "Trial-and-error" is a strategy where students re-submit an assignment multiple times with small changes, until they get the grade they want.

Do some strategies lead some to quit after a failure while others lead to a better score? Not surprisingly, students who followed a **trial-and-error strategy** had a higher score, since their score should improve every time they submit a corrected version of their code. Conversely the **one-timers** who failed their single attempt tended to quit the MOOC. This is actually also the case for both **thinkers** and **trial-and-errors** after their second trial. In other words, failing an assignment seems to be a huge blow to the motivation of students, causing them to drop-out in many cases. Letting learners upload their solution multiple times is hence rather positive, especially if the code is complex enough to discourage random variations that lead to success.

Reference: "Towards Predicting Success in MOOCs: Programming Assignments", Kshitij Sharma, Łukasz Kidzinski, Patrick Jermann, Pierre Dillenbourg, Proceedings of the European MOOC Stakeholder Summit, 2016.

6.3 Regulating Students' Gaze

In last year's report, we discussed the advantages of using the instructor's own gaze as a pointer on the lecture slides. Our research has shown that doing so improves the students' video navigation patters. They pause the video less frequently, and tend to navigate forward more frequently than backwards. This year, we tried to evaluate if there was actual improvement in their learning gain if we redirect their gaze whenever the student loses focus on what the teacher is talking about.

To do so, we recruited 27 Bachelor students from EPFL and equipped them with eye tracking devices. The students were shown 2 video lectures on the subject of "resting membrane potentials", at the end of which they were given a test to evaluate their knowledge. In the course of each lecture, the instructor's gaze was displayed in the video whenever the students were not paying attention—judged by the students' own gaze. The process is illustrated in Figure 29.

The results of this study included the following. By redirecting their focus:

- students significantly **increased** their attention, and the extent to which they followed the teacher;

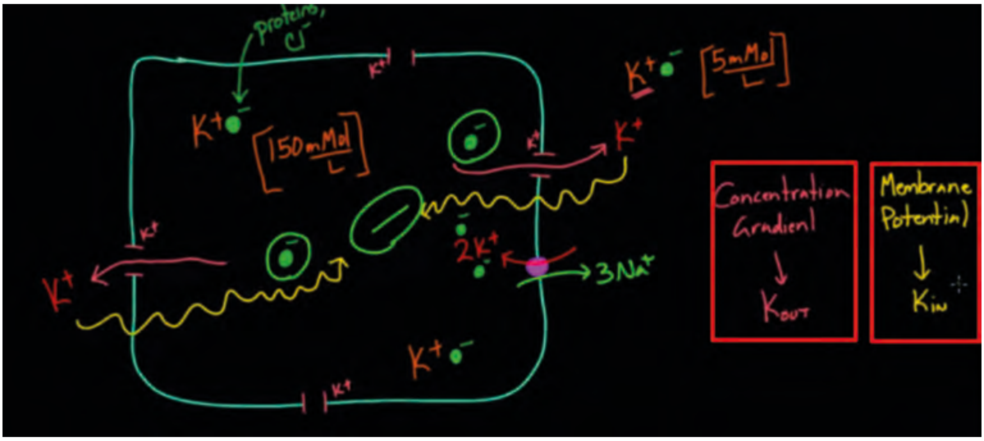


Figure 29: Example of the feedback used in the experiment. The circumscribing red rectangles were shown if the attention of the participant went below the baseline (estimated by the average attention of other students) at any given instant in the video.

- students significantly **increased** their learning gain, consequently scoring higher on the post-test.

The results showed a significant learning gain when redirecting the attention of students with a feedback system. Such a system, however, requires measuring the gaze of the students in real-time, while they are watching the videos. At the CHILI lab, we have ongoing projects trying to do this using a standard computer webcam.

Reference: "A Gaze-based Learning Analytics Model: In-Video Visual Feedback to Improve Learner's Attention in MOOCs", Kshitij Sharma, Hamed Alavi, Patrick Jermann, and Pierre Dillenbourg, 6th international conference on learning analytics and knowledge.

6.4 Ongoing Research Projects

Simulation of MOOC users

Analytics from MOOCs are often considered Big Data, since we collect behaviors from thousands of students. However, after filtering students relevant to the context of a specific study, sample sizes may not be sufficient for detecting some of the effects we are seeking. Estimating the required sample size is a key factor of experimental design.

To explore this problem, we generated cohorts of (highly simplified) simulated students and used a Monte Carlo simulation. We modeled students' actions with several Semi-Markov chains and we implemented an expectation-maximization algorithm to fit the model. Running these models with sets of simulated students allowed us to determine the distributions of MOOC features for various sample sizes.

This approach differs from the learning analytics method that mostly focuses on recorded data, while the modelling effort described here aims to simulate students even before a MOOC starts. If we succeed at improving the validity of our model, we could predict some features of a course, such as the success rate or the evolution of the number of assignment submissions.

Reference: "Semi-Markov model for simulating MOOC students", Louis Faucon, Łukasz Kidziński, Pierre Dillenbourg, submitted.

Forum analysis

One of the main differences between MOOCs and previous forms of e-Learning is the intensity of social interactions in MOOCs. The analysis of forum posts is the main source of information on social interactions among users. Yet, this analysis requires laborious and costly periods of manual coding or classification, for instance to decide if a post is a question, an answer, feedback, etc.

Methods from natural language processing allow us to extract information from the forum in order to classify the posts accurately and to estimate the relevance of the posts with regard to the topic of the MOOC. The potential benefits of this classifier are twofold. For MOOC practice, we will be able to support teaching assistants by detecting threads that require their intervention (e.g. because the average level of relevance is too low). For MOOC research, the automatic classification allows us to apply content analysis to large data sets within a reasonable amount of time. For instance, we found that students who answer questions on the forum perform better than those who ask them.

Reference: "Semiautomatic Annotation of MOOC Forum Posts", Weizhe Liu, Łukasz Kidziński, Pierre Dillenbourg, State-of-the-Art and Future Directions of Smart Learning

Learning styles

Educational research has identified so-called "aptitude-treatment interaction laws", which predict the fact that a specific method will be more effective with learners that correspond to some profiles. Conversely, learning analytics establish a posteriori that a method has been more effective for some learner categories. Can we integrate these two sources of information to create the best pedagogical decision: the a-priori probabilities inferred from MOOC-independent laws can be progressively updated with a-posteriori analytics, using a Bayesian framework.

A Swiss NSF grant has been awarded to answer this question and will start in summer 2016. In the meanwhile, a Master's student, Farah Bouassida, ran a short pilot study with Lukasz Kidziński. They built a small learning platform in which they identified two student profiles (introvert vs extrovert) and provided two learning activities (video vs texts). Their system detected that extrovert students obtained higher learning gains when they were given video materials, whereas introvert students were performing better when given text.

The effects of gamification

Gamification refers to the use of game mechanisms (lives, badges, scores, etc.) in a non-gaming environment. We collaborate with a MOOC-providing company, CoorpAcademy, located in EPFL Innovation Park, to understand the effects of gamification. We studied a gamification feature available on their platform, called "Battle Mode", when two learners asynchronously compete on a set of quizzes related to a specific learning module.

We analyzed the anonymized data from different MOOCs developed for four companies by CoorpAcademy, which represents a total of more than 20,000 learners. We found that the battle feature was adopted by up to 37% of learners and up to 83% of battle invitations were accepted. We also found that battle players covered up to 14% of the modules and battled against an average of 4.5 peers in some companies. Globally, engagement was higher among battle players as compared to non-players, but we do not know which of these two features is the cause of the other. In any case, they illustrate that some gamification mechanism may enhance social interaction on MOOC platforms.

Reference: "Gamified Competition Features for Corporate MOOCs: The Battle Mode", Jessica Dehler-Zufferey, Hamed Alavi, Łukasz Kidziński, Pierre Dillenbourg, eMOOCs 2016.

7. Closing Remarks

Another year has gone by and EPFL's commitment to Digital Education remains unshaken. Three and a half years after the beginning of our MOOCs initiative, we have produced 48 MOOCs and attracted over 1 million registrations from all over the world. Although several European universities have produced MOOCs, only few have integrated these as a core part of their educational strategy (as we have).

The engagement of EPFL combines global trust with fragmented uncertainty. The trust refers to the belief that MOOCs will change the European academic landscape. Who could predict that EPFL courses would be taken all over the world? MOOCs are more than a variation of e-Learning; they are game-changers.

Now, building on this kernel of confidence, we have numerous points of uncertainty. We are pushing MOOCs forward not because we know whether or not they will work, but because we want to discover the possibilities. Is it not the role of universities to explore unknown territories?

EPFL MOOCs target 3 major audiences: (1) on-campus students, (2) worldwide professionals, and (3) French-speaking African universities. The year 2015 provided us with experiences with each audience.

For the first audience, we have seen that the impact of MOOCs depends on two variables: the role that the teacher allocates to a MOOC in his or her own course, and the students' level of engagement. For the second audience, worldwide professionals, this report examined their profile and sought to clarify the market opportunities. For the third audience, 2015 has seen new developments, especially the fact that partners from Africa recorded MOOCs segments at EPFL.

New audiences and markets have emerged in 2015, such as the desire to include MOOCs in the long term relationship with EPFL alumni, the production of MOOCs and other services for external companies and institutions.

The EPFL MOOCs strategy is constantly adapted based on what we learn from the data. Early on, we found that the worldwide use of MOOCs actually constitutes continuing education. We are therefore launching the EPFL Extension School.

In 2015, it has become clear that a bottom-up approach is not sufficient. Most EPFL MOOCs have been proposed by professors driven by personal motivations. This allowed us to start rapidly and learn a lot. Now, the set of 48 MOOCs that we have produced does not constitute a consistent whole; our MOOCs are scattered across most EPFL curricula.

A major evolution in 2015 has been to promote a sequence of 4-5 MOOCs on the same topic—so-called "specializations", "tracks" or "nano-degrees". This ambition requires more top-down coordination.

We have launched two specializations: one on protected areas in Africa, and one on African cities. We will soon launch the specialization in Scala programing as well. Other specializations in the pipe include: quantitative finance, embedded systems, water in developing countries, and brain simulation.

For our own students, the EPFL doctoral school has decided that Ph.D. students will be allowed to take MOOCs from other universities as part of the credits they have to acquire. The underlying assumption is that, since this will be done on an individual basis, the Ph.D. supervisor probably knows the MOOC teacher, and may therefore judge the relevance of the MOOC as well as the assessment format.

Our next step is to offer the same possibility at the Master's level for a limited set of MOOCs, selected from top European institutions. The CEDE is collaborating with the best MOOC producing universities in Europe to elaborate on the rules that will allow credits to be shared. This second top-down trend could lead to something equivalent to a virtual Erasmus, but at the level of specific courses.

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Massive Open Online Courses

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