ONELab: Online Education with Minimal Human Supervision

Marco Furini
Dip. di Comunicazione ed Economia
Reggio Emilia, Italy
marco.furini@unimore.it

Giovanna Galli
Dip. di Comunicazione ed Economia
Reggio Emilia, Italy
giovanna.galli@unimore.it

Maria Cristiana Martini
Dip. di Comunicazione ed Economia
Reggio Emilia, Italy
mariacristiana.martini@unimore.it

ABSTRACT

Many educational institutes are recording classroom lessons to improve the students' learning process. Unfortunately, a simple recording does not necessarily imply benefits. Indeed, when producing video lectures, there are different challenges that must be faced: production costs, accessibility, usability, video indexing, just to name a few. In this paper, we share our experience building ONELab, a system designed to capture, record, edit and stream video lectures. ONELab was designed to be scalable and to have low-cost implementation and maintenance. The system has been used in the 2017-18 Academic Year to manage the 49 courses offered by the five degrees available at our Department. In numbers, it supported 1,054 freshman students and produced 1,376 video lectures (for a total of 2,064 hours). The usage analysis showed that students appreciated the system and a comparative analysis between students who used the system and students who did not use the system, showed that the former passed more exams (+97.8%), had better grades (+8%) and acquired more credits (+105%).

CCS CONCEPTS

• **Applied computing** → **Distance learning**; **E-learning**;

KEYWORDS

On-line learning, video lectures, learning process

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1 INTRODUCTION

Technological and scientific advances in networking, multimedia and IoT have changed our personal and professional life [2] and are affecting the educational scenario. Indeed, in recent years, many educational institutes recorded classroom lessons and made them available through online private or public platforms. Although the numbers of private platforms are not available, the ones of public platforms are remarkable: Coursera, the public MOOC platform, has more than 2,700 active courses with more than 30 millions of registered users, EdX currently boasts a catalog of 1,800 courses and has 14 millions of users, and FutureLearn has 700 courses and 7.1 millions of users [28].

With no doubts, nowadays people have access to an incredible amount of educational contents and different studies state that this availability is affecting the learning process [29]. Indeed, on the one hand, students can access educational material regardless of location and time; on the other hand, educational institutes can easily support distance-learning students and might try to improve the effectiveness of teaching inside and outside the classroom [23]. For example, different institutes are experimenting alternative educational methods such as the so-called *flipped learning*, a pedagogical approach in which students are introduced to the learning material before class, and the classroom time is used to deepen the understanding through discussions with peers and teachers.

The benefits provided by the availability of video lectures have been widely discussed in the literature and several lecture recording systems have been developed [4, 8, 17–19]. However, the development of an effective online learning system is not easy task. There are several challenges that must be faced: keep production costs low [18], improve the accessibility to support the learning of impaired people [7], enhance the usability to speed up the learning process [25], manage the information retrieval process of educational resources in an efficient way [30], ensure a good viewing experience [18], improve the learning process [10, 12], improve the video indexing [11, 21], engage students [5, 13, 22], produce alternative material [1, 9, 24], use social media features to facilitate learning and knowledge construction [14–16, 31], just to name a few.

Motivated by the growing interest towards video lectures, by the number of students who enrolled in degree programs offered by our department, and by the need to produce video lectures while keeping production costs low, in this paper we share our experience building ONELab, a scalable system designed to capture, record, edit and stream video lectures. In particular, ONELab was designed to meet two main goals:

- **Scalable**. It must be possible to expand the system (e.g., more students, more courses and/or degrees) without having to redesign it.
- **Low-cost**. System development, maintenance and video lecture production have to be low-cost.

ONELab has been developed with off-the-shelf technologies and it allows the students of the department to watch the video lectures through streaming technologies (no download allowed). For privacy and copyright issues, ONELab grants access only to students

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enrolled at our Department. The kick off was on September 2017 and the system was used to capture, record and produce all the 2017-18 first-year classroom lessons delivered within the five degrees offered by our Department (two bachelor degrees, "Communication Sciences" - "Marketing and business organization", and three master degrees, "Advertising, digital communication and creative business processes" - "Economics and law in business and public administration " - "Management and business communication"). In numbers: 1,054 freshman students, 49 courses and 1,376 video lectures (for a total of 2,064 hours).

The analysis of the log file (as of May 31st, the end of the 2017-18 teaching period) shows the success of the initiative (e.g., the number of accesses to video lectures is remarkable) and shows that students appreciated the availability of video lectures. Indeed, the courses of the first semester were also watched during the second, the accesses to video lectures have been done also on weekends, 18% of the accesses to video lectures took place outside the classical academic time (08:00-19:00). This analysis showed that students use the system to adapt the learning process to their time-schedule and not to those imposed by the teaching schedule. With respect to the benefits introduced by ONELab to the learning process, a comparative analysis between students who used the system and students who did not use the system, showed that students who used the system passed more exams (from an average of 1.82 to an average of 3.60, which is an increment of 97.8%), had better grades (from an average of 23,79 to an average of 25,70, which means +8%) and acquired more credits (from an average of 13.85 to an average of 28.40, which means an increment of 105%).

Given the success of the initiative, in the near future, we will improve the indexing process (currently, based on simple metadata entered manually by the operator) and we will provide alternative contents to hear-impaired students (e.g., by providing close-captions).

The paper is organized as follows: in Section 2 we present background and studies focused on video lecture productions; Section 3 describes details of our proposal, where a performance analysis is presented in Section 4. Conclusions are drawn in Section 5.

2 BACKGROUND AND RELATED WORK

Although distance learning and online learning are often used as synonyms, they are actually different things. In the following, we clarify the concept and we briefly review recent studies focused on distance(online) learning.

2.1 Distance vs. online learning

Distance learning is a system to support students and teachers when they are separated. The student receives the material (today through bits and modern technologies, yesterday through tapes and snail mail), studies and takes the exam. There is little interaction (e.g., between student and teacher and among students) and the learning material is produced to replace the classroom lessons.

Online learning is a system where students and teachers are not separated, and where online technological tools are used to bring benefits to the learning process. The educational material is produced not to replace the classroom lessons, but to improve the learning process. It should be noted that some students may use these materials as a replacement for the classroom lessons, but this is not the primary goal of the system.

2.2 Scalable and low-cost learning systems

In literature, most studies focused on specific details of a learning system like accessibility and video indexing. For instance, Federico and Furini [6, 7] used the audio track of video lectures to produce alternative material such as notes and/or subtitles in order to support students with hearing impairments, Kamabathula and Iyer [20] focused on the video indexing and proposed to transform the audio transcript into document-style sentences to allows students to search for particular topics by typing keywords. Similarly, Che et al. [3] aimed to improve the indexing of video lectures by transforming the slideshow of the video lectures into textual data by using OCR technologies.

With respect to the design of systems from scratch, there are relatively few papers in the literature. Rui et al. [26] proposed a system to automate the capture and the broadcast of lectures to online audiences. The system is based on different tracking cams (one follows the teacher, one points the students and one captures the slideshow), on different computers and on one audio/video mixer. One of the system's goal was to develop the system with reasonable costs, but nothing is said about scalability. Hulens et al. [18] proposed a system that automates the process of recording video lectures in classrooms. The approach uses special hardware (e.g., lecturer and audience facing cameras and microphone arrays) and records multiple points of view of the lecture. By using sound source localization, face detection and body tracking algorithms, the system digitally zooms in and out to improve the viewing experience. Scanlon [27] discussed learning at scale from the perspective of two UK Universities that use technologies to improve learning. In essence, these universities rely on popular MOOC platforms.

Our approach is different from the ones presented in literature. Our goal is to develop a platform that is scalable, has a low cost development and a low cost of maintenance. Furthermore, for reasons of privacy, security and copyright, the produced video lectures cannot be uploaded on MOOC platforms.

3 ONELAB SYSTEM

The production of video lectures does not just mean installing a webcam in a classroom and uploading the recorded file on a video sharing platform. Video lectures produced in this way do not improve the learning process [7, 18, 25, 30].

ONELab is an online learning tool developed to improve the student learning process. Indeed, the provision of video lectures wants to adapt the student learning process to their own pace and not to those of the class. Therefore, video lectures are not an alternative to classroom lessons, but represent an opportunity to review what has been understood in class in order to deepen the study, clarify and/or understand the topics covered during the classroom lesson. In this way, students might prepare themselves for the successive classroom lessons and/or for the final exam of the course.

The system has to meet three constraints, scalability, low-cost development and low-cost maintenance, and has to capture, record, edit and distribute video lectures through online technologies.

In the following, we present details of the system architecture and of the features of the produced video lectures.

3.1 Architecture

The system architecture has been designed to be scalable and low-cost. As shown in Figure 1, scalability is achieved by providing dedicated hardware in each classroom, by centralizing the editing/collection process and by using a video streaming platform to distribute the video lectures. The production flow is the following: after recording, the file(s) is(are) automatically sent to the editing center, which is in charge of doing a minimal editing (i.e., removal of small parts, insertion of promo and privacy warnings). Then, the produced file is uploaded to a video streaming platform (i.e., Vimeo) and it is made available only through the department's learning platform (i.e., no direct access through the Vimeo platform).

Figure 2 shows details of the recording hardware. Each classroom is equipped with an overview camera pointed at the teacher's desk, a projector to show the teacher's slideshow and an audio system to amplify the teacher's voice. To capture these signals, each classroom has been equipped with Ephipan pearl, a video production system able to capture and record multiple media channels. Figure 3 shows how the two signals (teacher and slideshow cams) are combined into a graphical layout that gives more relevance to the slideshow. At the end of the recording, the file is automatically sent to the editing studio, where an operator removes some parts (usually located at the beginning and/or at the end of the recording) and attaches one short clip at the beginning (i.e., ONELab promo and credits) and one at the end (i.e., ONELab privacy). Then, the video lecture is moved to the Vimeo video sharing platform and a direct link is provided through the department's learning platform.

To be low-cost, the system has been implemented with off-the-shelf technologies and only one full-time person runs the system. No dedicated staff is present in the classrooms: the teachers are in charge of starting and ending the recording by pressing a specific button located on the desk. The use of an external streaming platform was necessary to ensure scalability (i.e., the number of simultaneous streams is managed by Vimeo and not by ONELab) and to keep low the production cost (i.e., an internal solution would have increased hardware, bandwidth and human labor costs).

3.2 Video Lectures

Video lectures are produced to provide a good viewing experience. Indeed, as shown in Figure 3, the system produces video lectures with a particular graphical layout that shows the teacher and highlights the slideshow content. Technically speaking, video lectures have a resolution of 1280x720 pixels, 25 frames per second, and are encoded with h.264 with a maximum bitrate of 2 Mb/s. The audio signal is encoded with AAC with a maximum bitrate of 160 kbps. To keep the production cost as low as possible, the two video signals are mixed by the Epiphan pearl and not by the human operator. Therefore, the operator has just to do minimal video editing like removal of small parts (usually located at the beginning and at the end of the video lectures produced by the Epiphan pearl), insertion of promo and privacy warnings. FFMPEG[1], an open-source command-based audio/video editing software and Adobe Premiere

[1]FFMPEG: available at www.ffmpeg.org

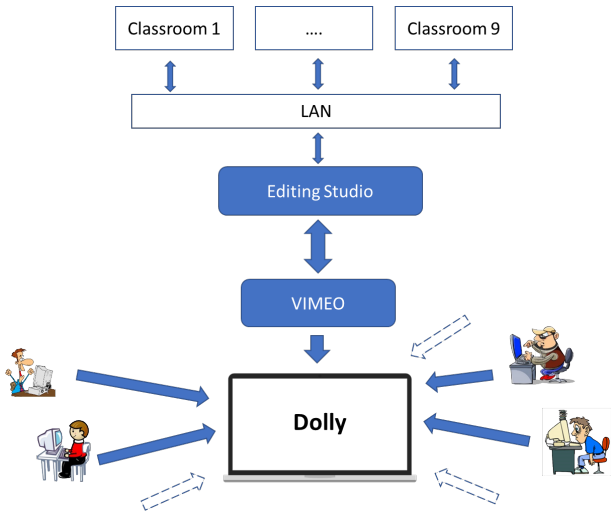

Figure 1: ONELab system. The lecture is recorder and edited before being uploaded to the Vimeo video sharing platform. For security reasons, the access to video lectures passes through the department's learning platform.

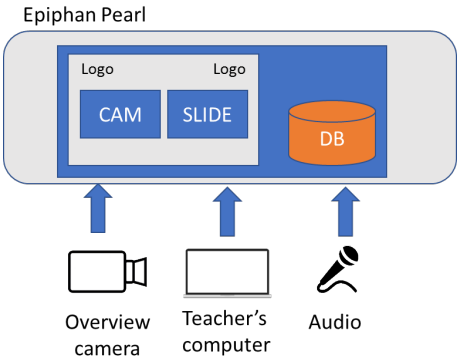

Figure 2: Video lecture recording: overview camera, teacher's slideshow and audio are captured and recorded with Epiphan pearl.

Software are the two video editing software available at the editing studio.

The choice of using a command-based audio/video software is to speed up the production process. Indeed, before uploading the file to Vimeo, the recorded lesson must be edited. Usually, a video editing software re-encodes all the pieces of video that compose the video lecture, whereas the command-based audio/video software directly acts on the encoded files and produces the video lecture without re-encoding all the pieces of video that compose it. For instance, with an off-the-shelf computer (Core I7 6700HQ - 16 GB RAM - 256 GB SSD), the coding time of a 90-minute lesson varies from 20 to 30 minutes, whereas through a direct editing, the time goes down to a few tens of seconds.

Figure 3: Video lecture layout: overview camera (left) and slideshow (right)

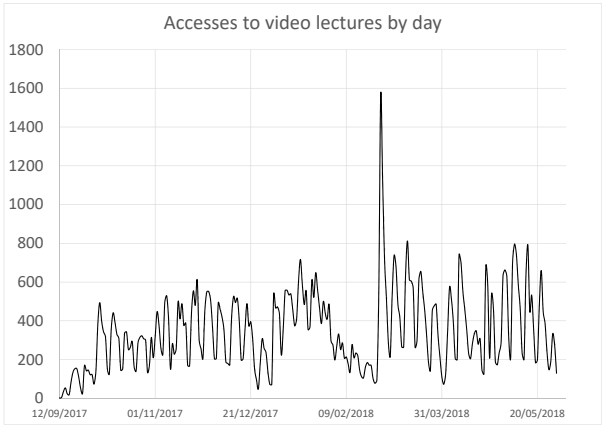

Figure 4: Absolute number of accesses to video lectures.

4 ONELAB EVALUATION

ONELab has been used in the Academic Year 2017-18 to capture, record and produce the first-year classroom lessons delivered within the five degree courses offered by our Department. This resulted in 49 courses, 1,376 video lectures produced for 1054 freshman students.

In the following, first we present quantitative data to show the students' use of the system; then, we analyze the benefits introduced by the system to the learning process.

4.1 Usage

Figure 4 shows the absolute number of accesses to video lectures grouped by day from Sep 12 to May 31. Before analyzing the graph, it is worth recalling that classroom lessons are held from September to mid December (first semester) and from March to May (second semester), whereas the period January-February is used to hold exams. Not surprisingly, the number of accesses is higher in the second semester. Indeed, the number of courses available on the platform has increased and students got familiar with the system. From de-structured interviews, we observed that students followed an incremental approach while using the system: at the beginning they spent some time to understand the usefulness and the best way to approach it and, after that, they got familiar with it and began using it.

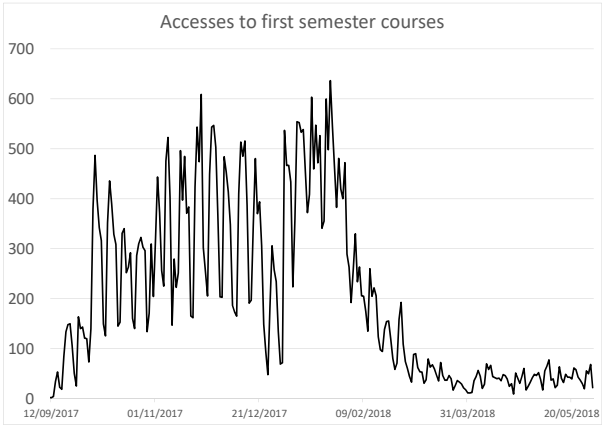

Figure 5: Absolute number of accesses to video lectures of the first semester courses.

To deepen the analysis, it is worth focusing on the video lectures released during the first semester. Figure 5 shows the number of accesses to these video lectures. It is not surprising that during the examination period (i.e., January and February) the number of accesses is very high, but it surprises that students kept watching these lectures also during the second semester. The number of accesses during the first semester indicates that students try to keep updated on course topics, either by deepen topics and/or by watching video of lessons that they did not attend. The number of accesses during the second semester confirms that students have different individual learning model and that the provision of video lectures is a way to adapt the student learning process to its own pace and not to those of the class.

Figure 6 shows the absolute number of accesses to video lectures grouped by days of the week. Not surprisingly, the number of accesses drops in the weekend, but it should be noted that the percentage remains considerable (8% on Saturday and 7% on Sunday). This confirms the different learning habits of the students.

Figure 7 shows the hourly accesses to the video lectures. Morning and afternoon are the most popular periods used to access video lectures. During the lunch break, the number of accesses drops considerably. However, it is to note that 18% of the accesses to video lectures has been done during evening and night (i.e., from 19:00 to 07:00). Once again, this confirms that the system meets the different learning habits of the students.

4.2 Benefits

To investigate whether the system introduces benefits to the students learning process or not, we performed a preliminary investigation focusing on the students enrolled to the "Marketing and business organization" degree. This undergraduate program has 549 enrolled freshman and it extensively outnumbers the other degrees offered by our Department.

First, we compared the performances of students enrolled in Academic Year 2016-17 (no ONELab) against the ones of students

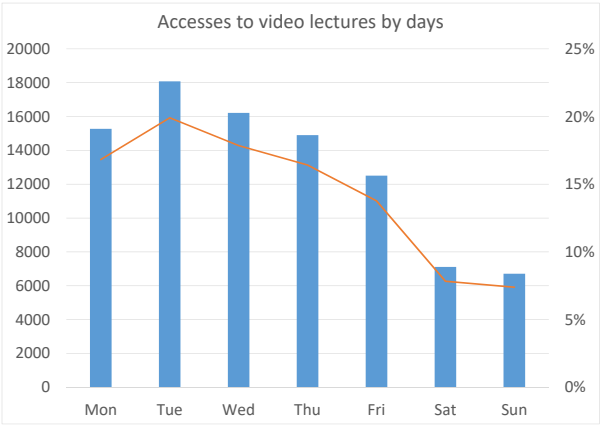

Figure 6: Absolute number (and percentage) of accesses to video lectures grouped by days of the week.

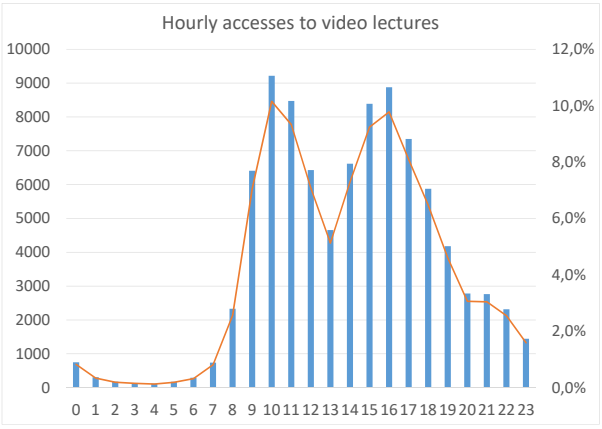

Figure 7: Absolute number (and percentage) of accesses to video lectures grouped by time of viewing.

enrolled in 2017-28 (with ONELab). In the same period, from January to July, 2016-17 students passed on average 2.63 exams, whereas 2017-18 students passed on average 2.93 (T.Test, P=0.001). Therefore, ONELab might have helped students in improving their learning process.

To deepen the analysis, we focus on the 549 enrolled students and we cluster them using the Ward's method with the following indicators:

- *D_abs*: percentage of browsed courses;
- *D_rel*: percentage of played video lectures with respect to the student who has played the highest number of video lectures.
- *C*: percentage of played video lectures regarding the most viewed course.

The cluster analysis produced four different groups that we labeled as follows:

Table 1: Performance comparison among groups of students

Group	Average number of passed exams	Average grade	Acquired European credit
Non-user	1.82	23.79	13.85
Irregular	2.75	23.67	21.15
Regular	3.51	24.74	25.21
Assiduous	3.60	25.70	28.40

- **Non-users**. [*D_abs*=0%, *D_rel*=0%, *C*=0%]. Students who have never used ONELab. They represent about 19% of first year enrolled students.
- **Irregular-users**. [*D_abs*=32%, *D_rel*=3.22%, *C*=8.4%]. Students who have seldom used ONELab. They represent 34,5% of first year enrolled students.
- **Regular-users**. [*D_abs*=83%, *D_rel*=10.27%, *C*=17.43%]. Students who have regularly used ONELab. They represent 40.15% of first year enrolled students.
- **Assiduous-users**. [*D_abs*= 88%, *D_rel*=45.83%, *C*=77.07%]. Students who have assiduously used ONELab. They represent 6.4% of first year enrolled students.

We analyze the learning performances of these groups according to the average number of passed exams (APE), the average grade (AG, min=18, max=30) and the average number of acquired European credit (EC). Table 1 shows the differences among the groups of students. The "non-users" group shows the worst educational performances, whereas the "assiduous-users" group shows the best performances. In general, as the use increases, the benefits for learning process increase.

Although this preliminary investigation cannot guarantee that ONELab improves the students learning process, it provides evidences that the system might help students. Indeed, the comparison between 2016-17 students (no ONELab) and 2017-18 students (with ONELab) supports this hypothesis. Moreover, performances significantly improve as ONElab accesses increase; this can be due to the high commitment of students belonging to regular and assiduous clusters, who particularly appreciated this new opportunity.

5 CONCLUSIONS AND ON-GOING IMPROVEMENTS

In this paper, we shared our experience regarding ONELab, a system designed to capture, record, edit and distribute video lectures through online technologies. Designed with off-the-shelf technologies, ONELab is scalable and low-cost. During the Academic Year 2017-18, ONELab has been used to support 49 courses, resulting in 1,376 video lectures. As of May 31st, the analysis of the log file highlighted the success of the initiative and showed that the system might meet a learning need that goes beyond classical academic time (e.g., 18% of the accesses to video lectures has been done from 19:00 to 07:00). A comparative analysis between students who used the system and students who did not use the system, showed the benefits introduced by ONELab to the learning process (more passed exams, better grades and more acquired credits). In the near future, we will cover all the courses offered by our Department, we will improve the indexing process (currently, based

on metadata like date of lecture, name of degree, course module and professor) by introducing deeper analysis of the video lectures (e.g., Automatic Speech Recognition, OCR, etc.) and we will provide alternative contents to hear-impaired students (e.g., by providing closed captions).

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