Educational video services in universities: a systematic effectiveness analysis

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***Abstract*— Our university has offered a massive educational video service since 2010, as part of a blended learning model that allows students to balance active participation in the classroom with remote access to video-recorded lectures. In these years, we have collected a huge amount of very detailed data about the students' access to the service. Together with additional information that characterize a university system (e.g. students' performance or course population), these data represent a precious ground set to assess the educational model. The paper describes an experimental set to profile the use of the educational video service, whose results will contribute to improve the model. Specifically the paper analyzes the students' service use relatively to different transversal course characteristics, such as level, main topic, population, success rate. As a result, it outlines the profile of the "ideal" courses for which students highly appreciate the service. This information will help educational designers to select the future courses to be included in the service, but it will also give directions on the sectors where improvements are necessary. Finally, the paper experimentally demonstrates a positive impact of the educational video service on students' performance, and specifically on the exam success rate.**

Keywords—blended learning; learning technologies; learning analytics; educational video; massive online courses

I. INTRODUCTION

Our university has adopted a blended learning model since 2010, when we have started to video-record a large number of lectures in the classroom, and we have launched a massive educational video service. Every year over seventy courses of B.S. and M.S. curricula in several branches of Engineering have been fully recorded, resulting in about 3,000 videos yearly available for the 15,000 students involved. Unlike traditional MOOCs, our service was not designed to provide open courses, but to support students in a blended learning environment. The chosen model has the advantage of maintaining a strong link between the presence and the distance activities, allowing their synchronization: all videos are available few hours after recording thanks to a lean production process, and the familiarity of the situation guarantees a very good acceptance level. It also adapts very well to today's trend of user preferences in terms of access: videos are accessible via every kind of electronic device and they are likely the most suitable and educationally effective content for smartphones' users. The main reason for this service, however, was the need to offer a flexible learning environment, capable of accommodating different users' needs and distinct learning models, where distance education merges with presence education in different levels of balance. Our users are traditional students as well as full-time workers, and they use the educational video service for different learning purposes: studying, reviewing, practicing for exams, and recovering from exam failures. In these years, we have reached the operation capacity, and we are now interested in understanding and optimizing the actual educational value of the designed service. Since the launch of the service, we have collected a huge amount of very detailed data about students' accesses, relative to several academic years and a large number of courses, more than one hundred. We have recorded every single access of every single student, creating the ground for answering to many questions regarding users' preferences and users' appreciation of the service.

The paper presents the results of a number of analyses aimed at profiling the use of the educational video service according to several aspects. Service characterization is driven by the measures of students' accesses and it uses extra information related to courses, teachers, and students, thanks to the large amount of available information that characterize a university system (e.g. students' performance or course population). Amongst others, we will consider as key analytical features the course level, the course main topic, other course characteristics such as population and success rate, the academic year of last video recording, and the students' average performance. The objective of the analysis is to extract information necessary to tailor the system to our potential users, to provide them with an optimized, flexible and effective learning tool, designed specifically for our blended learning environment.

II. RELATED WORK

With the diffusion of e-learning platforms, distance learning has become an established way of transferring knowledge. Blended learning entails combining online digital media with traditional classroom methods [1] [2]. Beyond in-class instructions, learners take advantage of online resources through web-based or mobile applications. These extra supports provide an overall improvement in educational outcomes. In this context, the importance of video-based activities in blended learning is established [3] [4] [5]. Specifically, video-recorded lectures provide students with more control over their schedules and learning [6]. In [7] and

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[8] the authors have overviewed the main video-based learning experiences to highlight the pedagogical contribution of videos in different contexts of engineering education. The university-level video-recording service we analyze in this study is blended because the lecture video records are available as additional materials to all students enrolled to the corresponding course. However, unlike traditional blended learning systems (e.g., [9] [10]), lectures are also given in presence and the interaction between learners and teachers mostly happens in classrooms (without the aid of any digital media). Hence, video records and in-class lectures complement each other to achieve effective learning. A somehow related approach relies on the use of flipped classrooms [11], where learners use in-class time to work on learning materials that were previously explored by the students on their own. Even though flipped classrooms can be classified as "blended learning", their rationale is opposite to those adopted in our learning system, where students are provided with video-recorded lectures only after in-class time to revise the lesson learnt or to retrieve missing information.

Massive Open Online Courses (MOOCs) is an alternative distance learning paradigm, where learning activities exclusively rely on remote services and typically require real-time interaction between teachers and learners [12]. MOOCs are often open access with unlimited participation to foster learning initiatives in developing countries [13] [14] [15]. Unlike traditional MOOCs, the video service considered in this study (i) is offered to a limited number of learners with similar background knowledge, and (ii) requires no real-time student engagement as in active learning [16], since it is not aimed at substituting classroom activities.

Learning analytics entails the measurement, collection, analysis, and reporting of data about learners and their contexts [17]. Many research efforts have been devoted to analyzing data related to distance learning system usage, especially in case of MOOCs. They analyzed learners' interaction with distance learning services to (i) investigate the reasons of student drop-off from MOOCs (e.g., [18]), (ii) offer personalized blended services according to student's competence [19], (iii) assess the perceived quality of MOOCs and compare them with traditional services [20]. With respect to MOOCs analyses, our main concern is to evaluate learning effectiveness and flexibility of use not for a single course but as a systemic approach for supporting university students in their whole curriculum, course after course. With MOOCS, in fact, we share the massive number of users. However, we are also able to relate usage with the large amount of information that characterize a university system (e.g. students' performance or course population).

The behavior of the students who accessed video-recorded lectures has already been studied in [21] and [22]. Specifically, in [21] the authors categorized users based on the temporal distribution of their accesses to the video records, while in [22] the authors evaluated the students' level of satisfaction using video-based Open Education Resources. Unlike [22], in our context video resources are not open, but selectively shared to the students enrolled to each course. Therefore, to ensure service efficiency and effectiveness our goal is to analyze service usage related to different types of university-level courses in order to optimize service provision according to the kind of offered courses. To the best of our knowledge, this problem has never been addressed in literature.

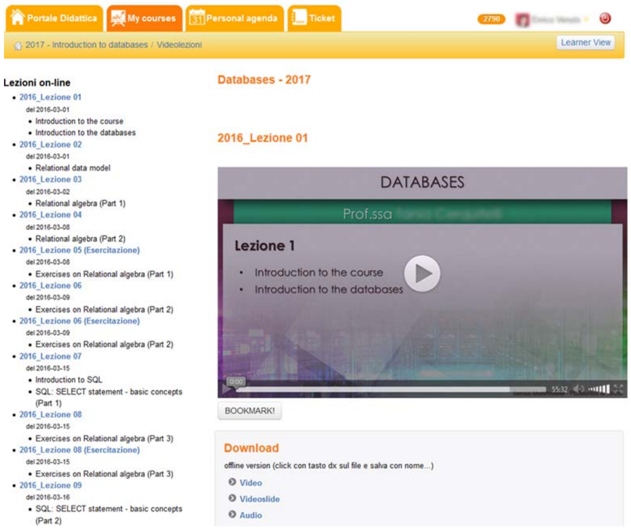

Fig. 1. Interface for accessing the educational video service – course example

III. THE EDUCATIONAL VIDEO SERVICE

The educational video service builds on the video recording and the delivery of face-to-face teaching lectures in the classroom. Every year over seventy courses are fully live recorded, for about 3,000 videos available for streaming or download to the 15,000 students involved in these curricula, which represent about 50% of the total number of students in our university. The videos, accessible through the university educational portal (see Figure 1 as an example) represent a massive effort to support students in their learning process: the service generates about 1,200,000 video accesses (streaming or downloads) per year. The appreciation of the service is evident by the monthly accesses to the educational videos. Figure 2 shows these data from the launch of the service (beginning of the 2010-2011 academic year) to March 2017.

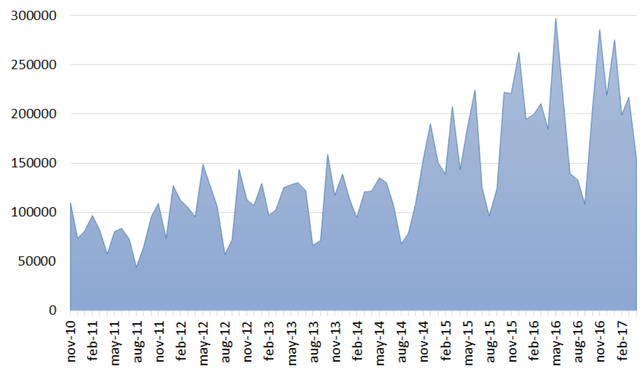

Fig. 2. Monthly accesses to the educational video service

The graph shows a constantly growing trend, both in the single academic year and across academic year; it also reflects the cycles of activities within the academic years (the access peaks correspond to exam sessions). Adapting the service to their personal learning goals, the users proved to use the service for: (a) studying a course during the whole semester, (b) reviewing concepts and practice in preparation to an exam session, (c) catching up with the exams left behind, or (d) recovering when necessary, for example after failing an exam. About effectiveness, in [19] the authors have demonstrated a general positive correlation between the probability of passing exams and the use of the educational video service. We complement this analysis by reporting a more specific example, comparing the success rate of a few courses before and after the introduction of the video educational service. The courses analyzed have been selected because they were recorded for the first time in 2015-16, and because they were the only ones for which there were no other significant changes in the course organization (e.g. teacher, credits, or syllabus changes) with respect to the previous academic year.

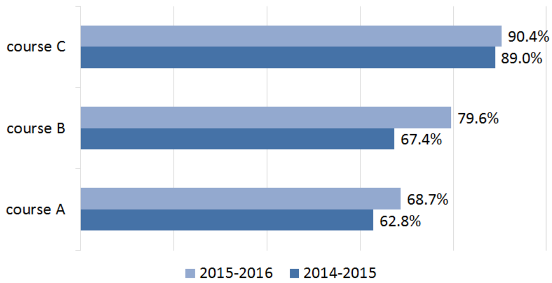

Fig. 3. Success rate of sample courses before (AY 2014-15) and after (AY 2015-16) the introduction of the educational video service

The graph in Figure 3 reports the success rate for the three courses (i) in the 2014-15 academic year (when they were not video recorded), and (ii) in the 2015-16 academic year (when they were part of the service offer). The success rate is the percentage of the students that passed the exam during the academic year in which they attended it for the first time. The graph shows that in concurrency with the introduction of the service there was an increase of the success rate, both for courses with a medium success rate (courses A and B) and for courses with a high success rate (course C). However, the main analyses reported in this paper, as described in the following section, have the objective to investigate the students' use of the service according to the different characteristics of the available courses. We have always had the feeling, in fact, that the percentage of students that uses the service greatly varies course by course, and the collected data represent a precious ground to explore user behavior. A better understanding of this phenomenon is crucial to ensure our students a customized and optimized educational tool.

IV. COURSE PROFILING AND STUDENTS' USE OF THE SYSTEM

At present the service covers all the courses of the first year of the B.S. in Engineering (the first year is common for all B.S. Engineering curricula), all the courses of the B.S. curricula in Computer Engineering, Electronic Engineering and Mechanical Engineering, and a selection of the courses of the M.S. curriculum in Computer Engineering. In addition, several other courses from different engineering curricula are recorded.

Every academic year our university educational designers decide which courses should be included in the recording list: every year new courses are recorded for the first time, others are recorded every year, still others are every two or three years. Constraints, unfortunately, exist: recording and production costs obviously matter, but the main reason that prevents the extension of the service to all courses every year is the limited number of the equipped classroom. The course selection procedure at present takes into account mainly the number of potential users, but does not consider the actual user preferences and behavior. In our intention, the results of these experiments will inform a more effective selection procedure.

The present analysis takes into account the students' accesses to the education video service categorizing the courses according to a number of independent dimensions that together give a complete description of the course. The dimensions are:

a. The course level (B.S. or M.S.)
b. The course main topic (e.g. computer science, mathematics …)
c. The course "position" in the curriculum (e.g. key course, elective course …)
d. The course population (i.e. the number of students enrolled in the course)
e. The academic year in which the course was recorded
f. The success rate of the course (i.e. the percentage of students that pass the exam in the academic year)

To work with coherent data, the analysis considers all the courses available for the students in the 2015-16 academic year (105 courses in total) and all the accesses made by the students registered for the first time to each of these courses, in the same academic year. We excluded the students that were registered to the courses in a previous academic year, because the percentage of students that fail the exam greatly varies course by course, and this factor could influence the result of the analysis. In every dimension, for each course category we extracted the average percentage of students (with respect to the total number of students that have the course in their curriculum) that used the video educational service for the courses belonging to the specific category under focus (e.g. the courses whose main topic is mathematics). The usage is quantified according to four levels, depending on the number of videos that the students accessed with respect to the total number of videos included the course. Since the videos actually are the live-recorded lectures in the classroom, their lengths are different, depending manly on the covered topics and the possible pauses made by the teacher. Therefore, the number of videos that compose the courses varies, ranging from 30 to 80. The levels used in this analysis refer to the users who (i) did not use the service, (ii) accessed less than one third of the videos, (iii) accessed a number of videos varying from one third to two thirds, (iv) accessed more than two thirds of the videos. The following sections report the result of the analysis of the user behavior under each of the abovementioned dimensions. These results will be the basis on which better and more grounded decisions will be possible in the future, to select the best candidate courses for the recording and delivery process, in order to optimize and improve the sustainability of the service.

To better compare the results reported in the next sections, Figure 4 shows the average students' usage level for all the 105 available courses. In the graph, the darker area (58.5%) represents the percentage of students who did not access any video of the course. The area above (22.5%) represents the percentage of students who accessed at least one video, but less than one third of the available ones, and the next one (6.2%) represents the percentage of students who accessed a number of video ranging from one third and two thirds of the available ones. Finally, the lighter area (12.7%) represents the percentage of students who accessed more than two thirds of the available videos. The same legend will apply to all the graphs shown in Figures 5 to 10.

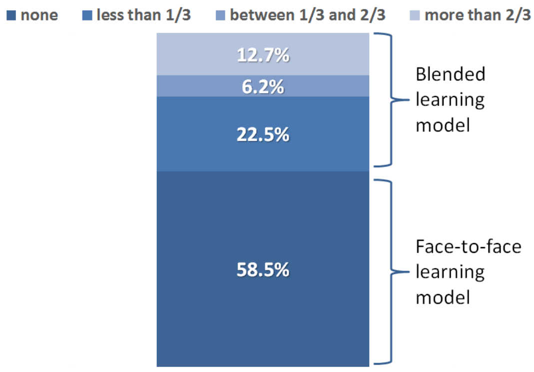

Fig. 4. Average students' accesses to videos for all courses

Figure 4 shows that the percentage of students who did not use the service is close to 58.5%, which might seem high; however, it is useful to remind that in our university the educational video service is intended to complement face-to-face education in a blended learning environment, and not to replace it. Most of our students regularly attend the lectures and use the service only in case they miss a lecture, or when they need to refresh a concept that was not clear in the classroom, or to review before the exam. All the reported graphs then put in evidence the percentage of students who actually use our proposed blended learning model, with respect to the ones that prefer the traditional face-to-face one. On average 41.5% of our students use the blended learning model, with a proportion between distance and presence activities varying from the 12.7% of users that mainly uses videos to the 22.5% that mainly attend face-to-face lectures, with a 6.2% balanced in between.

A. Course level

Politecnico di Torino offers courses at the Bachelor and the Master of Science levels. In the 2015-2016 the available B.S. level courses were 62, and the recorded M.S. level courses were 43. In the graph reported in Figure 5, the bar on the left reports the average access data for all the B.S. level courses, while the right hand-side bar considers the M.S. level courses. The graph shows that a much larger percentage of B.S. students used the educational video service, with respect of the M.S. students. In fact, almost 50% of B.S. students (43.5%) used it, compared to the 23.9% of M.S. students. However, if we consider the percentage of "systematic" users, i.e. the ones who belong to the two higher usage levels, the percentage is very similar (19.1% for B.S. students and 17.8% for M.S. ones).

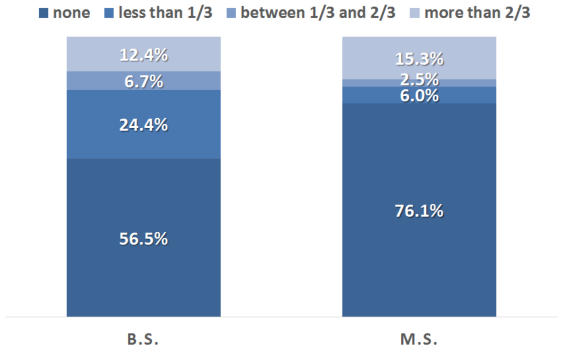

Fig. 5. Average students' accesses to videos per course level (B.S. or M.S.)

These data show a difference in students' behavior: B.S. students are new to the service, and they tend to explore it to understand its usefulness and the coherence with their personal learning preferences. Therefore, they are more likely to use the service, but often accessing a small number of videos. This is coherent with the fact that generally B.S. students (and especially the first year's ones) attend most of the lectures in presence, to familiarize with the environment and to establish social connections. M.S. students are more experienced, they learned how to use the educational service to optimize their personal learning goals and therefore they are more selective. At the same time, once they decide to use the service for one course, they generally access most of its videos. These students decide, course by course and depending on personal interests, attitudes, and course specific characteristics, whether to use a pure presence-learning model or a blended one.

B. Course "position" in the curriculum

Following the rules given by the Ministry of Research and Education, each university curriculum in Italy has to include courses belonging to different categories, balancing the credits according to given guidelines. Specifically, each curriculum must have credits from courses belonging to these four categories:

a. courses that represent the foundations of the curriculum (e.g. Calculus or Physics I for all types of Engineering); in the graph this category is labeled "foundation";

b. courses that characterize the curriculum (e.g. Distributed programming or Big data for Computer Engineering, Electronic technologies and systems for Electronic Engineering); in the graph this category is labeled "key course";

c. courses that complement the curriculum (e.g. Statistics for Computer Engineering, Cognitive psychology for Media Engineering); in the graph this category is labeled "complementary";

d. courses that can be freely chosen by the students from a list valid for all kind of Engineering (e.g. Ambient Intelligence, Marketing, Technical writing); in the graph this category is labeled "elective".

The graph in Figure 6 shows the percentage of video accesses for each of the four category of courses. It is evident that students prefer the face-to-face learning model for the choice courses (77.7% of students did not use the educational video service at all). The reasons are several: they have a genuine interest for them (they made a selection from a long and very rich list), the number of students in the classroom is generally limited, allowing a good level of interaction, and most of these courses have a strong practice connotation and involve many activities in the labs.

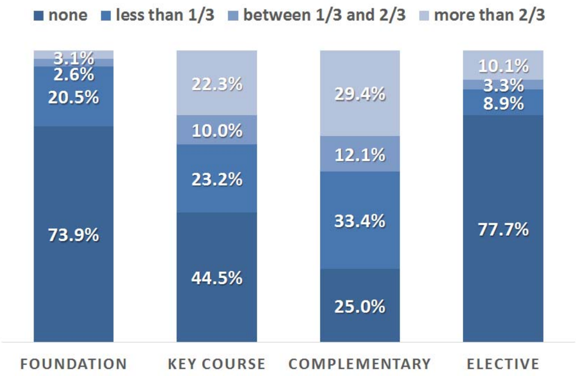

Fig. 6. Average students' accesses to video per course "position" in the curriculum

On the contrary, complementary courses are the ones where students strongly prefer a blended learning model (75% of students used the service). Since they are not central to the curriculum, students probably appreciate the possibility not to follow them synchronously but to adapt the study to their own schedule. Key courses have more accesses than foundation courses (55.5% compared to 26.1%): this is because the latter generally belong to the first two years of the B.S. level, where most students tend to follow all courses in presence.

C. Course main topic

Independently of the level, we were interested in understanding whether students' behavior varies according to the main course topic. The 105 courses available in the 2015-16 academic years cover the first year of the B.S. in engineering, and mainly courses from Computer, Electronic and Mechanical Engineering. Recently, we have started to introduce the video recording service also for courses in the Bioengineering curriculum. Considering the specificity of our curricula, we identified the following nine relevant topics: (i) Mathematics, (ii) Physics and Chemistry, (iii) Computer Science, (iv) Computer Networks, (v) Computer Communications, (vi) Electronics, (vii) Mechanics, (viii) Energy and (ix) Bioinformatics. The last category is (x) Other, that includes all the courses that are not directly related to engineering (e.g. marketing or social interaction analysis). Each of these categories includes 5 to 23 courses.

The graph in Figure 7 shows the percentage of video accesses for each of the ten topics, where the topics are ordered according to their usage rate. The category with the lowest access percentage, with only 12.6% of students that accessed the videos is the "Other" one, on the right-end side of the figure. On the other side, the percentage of students that did not use the educational video service in case of the Computer Communications courses is very small, only 1.2%.

Figure 7 shows that the behavior of the students and their preference for the blended or the pure face-to-face learning model heavily depends on the course topics. Courses from the curricula in Electronic and Mechanical Engineering, for example, have a higher access rate than the ones from Computer Engineering and Bioengineering. The foundation courses (Mathematics, Physics and Chemistry) have an even lower access rate, which is coherent with the results of section III.A: these courses are mainly at the B.S. level, where students tend to follow most of the courses face-to-face, for the already outlined reasons.

The lower access rate of Computer Science courses with respect to Mechanics, Energy or Electronics ones is likely due to the influence of the introductory course on Computer Science included in the first year of all the B.S. curricula (which has a very high number of students). Computer Science courses are offered at every level, focusing on the basics to the most specialized issues, which is not the case of Mechanics, for example. The low access rate in case of Bioinformatics, on the contrary, is likely because the video-recording service has been introduced only in the 2015-16 academic year, and therefore the students are still new to it.

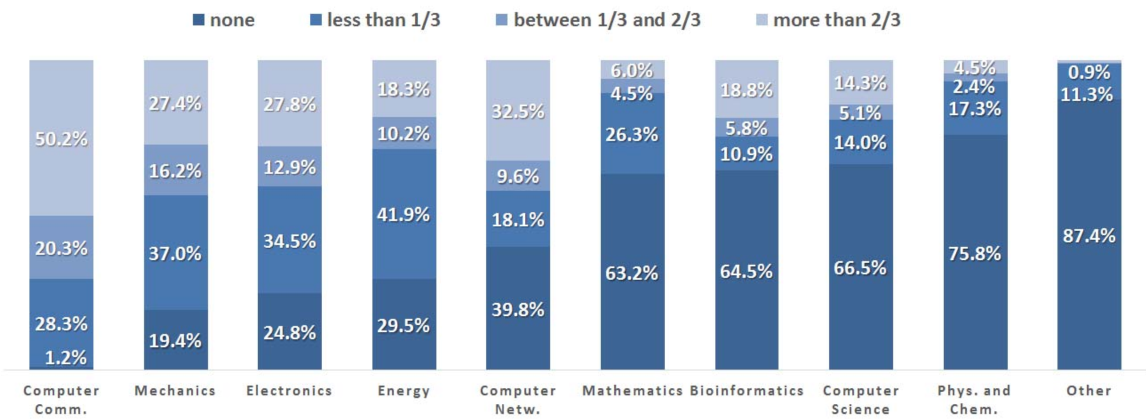

Fig. 7. Average students' accesses to videos per course main topic

The graph certainly reflects the preferred learning model of the students, but another characteristic is evident: some topics suit, more than others do, the peculiarity of the designed service model. The solution to live record the lectures in the classroom has several advantages, not only in terms of cost effectiveness. The situation is familiar to the students and besides it maintains a strong link between the presence and the distance activities, allowing their synchronization (all videos are available a few hours after recording thanks to a lean production process). The idea behind was to interfere as little as possible with the normal behavior of the teacher in the classroom. However, teachers are obviously asked not to use the blackboard but the computer and a pen tablet (a touch-screen monitor that also acts as virtual blackboard). This situation represents a barrier for some of the teachers, especially for topics where the lack of a large writing area for formulas and demonstrations required a non-easy adaptation to the new tools. This difficulty necessarily reflected on the resulting service and on the appreciation of the students, who, in general, prefer to attend these courses in presence.

D. Course population

Politecnico di Torino is a large technical university, with about 31,500 students, 26,500 of which study an engineering curriculum. The number of students per course varies from 30-35 (for very few courses) to over 350 (typically for the courses at the first year of the B.S. level). In this analysis, we divided the courses in three categories according to their population: (i) "large" courses, with more than 200 students, (ii) "medium" courses, with a number of students between 100 and 200, and (iii) "small" courses, with less than 100 students.

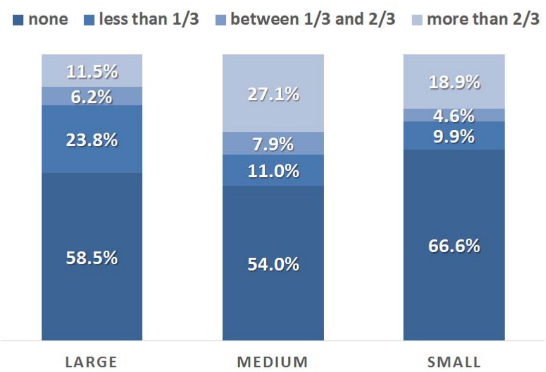

Fig. 8. Average students' accesses to videos per course population

Figure 8 shows the students' behavior for the three course categories. The students of "small" courses tend to use the educational video service less than the others (66.6% of the students do not use the service, compared to about 56%): this is reasonable, because the live interaction with the teacher and the peers is potentially much higher, and so is the added value of attending the course in presence. For the other two categories, the percentage of non-users is similar. However, in the case of "large" courses (that in general correspond to the first two years of the B.S. curricula) only 17.7% of students on average use the service in a significant way (i.e. accessing more than one third of the available videos), compared to the 35% of the "medium" category. This result is coherent with the results of the previous sections: students at the beginning of their B.S. curriculum prefer a presence-learning model, and use the service only sporadically, when they need to refresh concepts or when they were not able to attend a specific lecture. More "experienced" students start to develop their own learning strategy that implies a decision on which course to follow mainly face-to-face, and which one to follow mainly asynchronously.

E. Course recording academic year

Not every course is recorded every year, due to the limited number of equipped classroom available. To enrich the number of available courses, often the choice is to record some of them every two or three years, and to deliver the videos recorded in the most recent academic year, that not necessarily is the current one. In the reference academic year, i.e. 2015-16, most of the courses (72 out of 105) have been live recorded, while the remaining courses belong to previous academic years (2014-15, 2013-14 and even 2012-13 in a few cases).

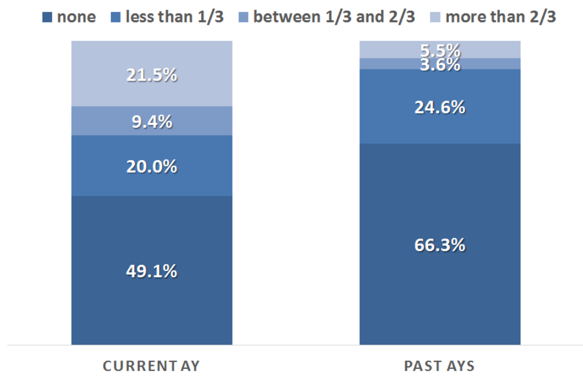

Fig. 9. Average students' accesses to video per recording academic year: current or past

The analysis reported in Figure 9 compares the students' behavior according to this dimension, comparing the courses recorded in the current academic year and the ones recorded in a past academic year. In the graph, the bar "current AY" reports the data relative to the academic year in which the students' access data have been collected, i.e. 2015-16. The graph shows an impressive difference along this dimension: students use the educational video service preferably for courses that are video recorded in the current academic year: users are 50.9% compared to 33.7%, and "systematic" users are 30.9% compared to 9.1%. The explanation is clear: the designed blended learning model has the synchronization between the presence and the distance activities as its stronger value. The videos are more significant for students that experience also the classroom environment, because they can balance the level of live and distance participation in the course according to their personal requirements and preferences, and maintain a strong link between the two situations. The peculiarity of the service is the immersion of the student in a familiar environment; in case it goes missing, the paradigm of live videos, with its limitations (direct communication, no post-processing), is not the best choice.

F. Course success rate

The success rate of a course is the percentage of the students who passed the exam during the academic year in which they attended it for the first time. The average success rate for the considered courses is 59.5% but we divided the courses in three categories: (i) courses with success rate below 50%, reported in the graph as "low", (ii) courses with success rate between 50% and 70%, reported in the graph as "medium", and (iii) courses with success rate above 70%, reported in the graph as "high".

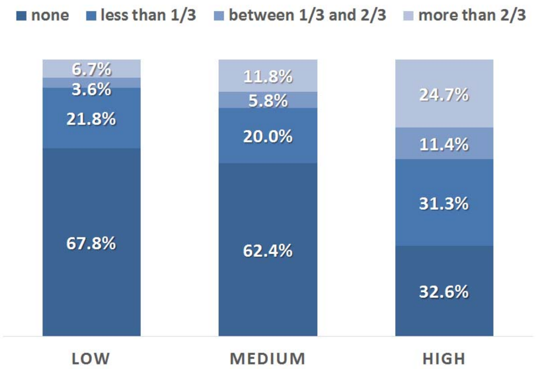

Fig. 10. Average students' accesses considering the success rate of the course

Figure 10 shows the results of this analysis, and outlines that the courses with a larger number of educational video service users are the ones where the success rate is much higher. The categories "low" and "medium" show a small difference, but the category with "high" success rate has a percentage of users that is 67.4% compared to 32.2% and 37.4%, and a percentage of systematic users (the ones that used at least one third of the available videos) that is 36.1% compared to 10.3% and 17.6%, respectively. This result suggests that the educational video service has the potential to improve the success rate of the students, and that the adopted blended learning model can have a positive influence on the students' performance.

G. Students' ranking

The results presented in the previous section did not consider the possible influence of the individual performance level of the students on the correlation between access to service and success rate. We then examined more in detail this factor, and analyzed the use of the educational video system by students with different average performance level. To measure the performance level of the students we used the same ranking algorithm that Politecnico di Torino adopts to select the students that can participate in the Erasmus mobility programs. This algorithm produces a score that depends on several factors, among which (a) the number of acquired credits, (b) the average mark, and (c) the number of years since the start of the university career. We divided the students in three categories according to this score: (i) high score: above 800 (800 is the required score for entering an Erasmus double degree mobility program), (ii) medium score: between 500 and 800 (500 is the minimum required score for entering any Erasmus mobility program), and (iii) low score: below 500.

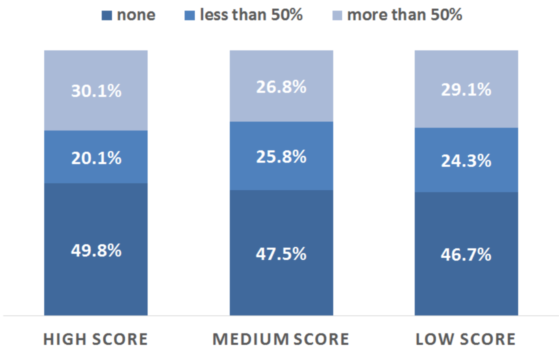

Fig. 11. Use of the educational video service by students with different average performance category (high, medium, low)

Since the selected performance indicator is relative to the whole career of a student and not directly to any specific course, in this case we did not consider the students' behavior for the single course, but rather the general attitude toward the service, in terms of number of courses for which he or she privileged a blended learning model. Figure 11 shows the number of courses the students belonging to the three identified categories used the educational video service (relatively to the number of courses for which the service is available that are in his or her yearly course selection). We assumed here that the student "used" the service for a course if he or she accessed at least 40% of the available videos for that course. For each category, the graph shows (darker area) the percentage of users who did not use the service at all ("none" in the graph), that used the service for less than 50% of the courses (medium-color area) and for more than 50% of the courses (lighter area).

It is quite evident that the percentages are very similar for the three categories of students. This means that the service is a "universal" tool, appreciated to the same extent by all the students, independently of their average performance level. This result is coherent with the requirements we had in mind when designing the learning model, i.e. to provide a tool for enriching the educational opportunities of all the students.

H. Discussion

The main objective of this research work was to understand where to invest more to maximize the use and the appreciation of the service. Considering the results of the previous sections, we can clearly describe the profile of the courses that are the best candidates for selection. These courses correspond to the categories for which the students demonstrate to use the service more intensively, i.e. the courses where the blended learning model has been adopted more frequently than face-to-face one.

Figure 12 shows the summary of the results. For all the considered dimensions (level, position in the curriculum, main topic, population, year of recording) the graph shows the percentage of students who used the service for each of the categories. The origin of the graph corresponds to the average use percentage (41.5%), therefore the bars above the horizontal axis are the categories for which the number of users is higher than the average, and the bars below it are the ones with a lower number of users. The categories above the axis, then, are the ones for which the students appreciate more the proposed blended learning model; for the other categories, students mainly prefer the presence-learning model. The graph visually outlines the profile of the ideal candidates for course selection, which are B.S. level courses in the areas of Mechanical, Electronic and Communication Engineering, positioned as key or complementary courses in the curricula, and with a large student population. It is also evident the added value of recording the courses every year, to maintain the link between face-to-face and remote activities that is so appreciated by our students. This profile will help the educational designers in two ways. On the one hand, they will know where to invest in order to maximize the outcomes. On the other hand, they will have the information necessary to start a serious rethinking of the characteristics of the service, to better adapt it to the categories of courses that now are not appealing enough for the students. The results of sections F and G are not included in the graph, because their purpose was different. Section F experimentally demonstrated the positive impact of the service on students' performance, and section G outlined its universal appreciation, independent of students' average performance.

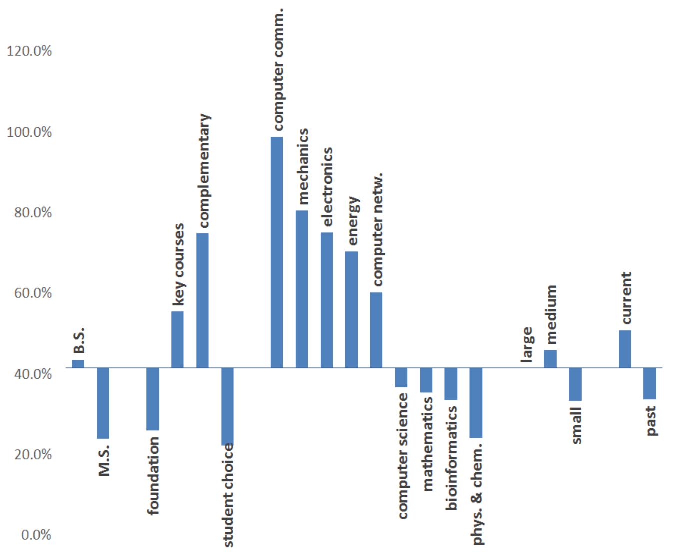

Fig. 12. Summary of course dimensions, with the educational video service usage percentage for each category, compared to the average use (41.5%)

V. Conclusions and Future Work

We analyzed data acquired from an educational video service, which provides university-level students with remote access to video-recorded lectures to complement in-class learning. We have profiled service use according to the characteristics of the recorded courses with the aim at optimizing the provision and the quality of the offered service. Specifically, based on the achieved results we can draw the following conclusions:

- The introduction of the service has increased the student's success rate (see Sections III and IV.F).
- Approximately half of the enrolled students, independently of their performance level, complement in-class lectures with the video service (see Section IV.G).
- B.S. students tend to watch fewer lectures of a larger number of video courses to complement face-to-face learning, whereas M.S. students are more selective and their service use is vertical on specific topics (see Sections IV.A and IV.C).
- Video courses on complementary subjects are accessed more than basic courses, which, conversely, are mostly attended in person (see Section IV.B).
- A higher number of accesses characterizes courses with a large number of enrolled students, because in-class interaction with the teachers is more complex (see Section IV.D).
- Videos recorded in past academic years are less appealing and typically underused (see Section IV.E).

Politecnico di Torino strongly believes in a blended learning model that uses the video-recording service as the kernel tool, and the results of the experiment encourage this feeling. Moreover, the results suggest that other educational institutions that have similar characteristics can effectively adopt the proposed model, and specifically institutions that:

- Have a very large number of students and a high students/teachers rate (in our university the average is 210 students per teacher at the B.S. level and 90 students per teachers at the M.S. level): in large courses student-teacher interaction is unfortunately very limited, and the added value of a continuous presence attendance is consequently low.
- Need a cost-effective solution (the recording and the delivery of videos exploits a semiautomatic process, with a minimal level of post-processing) but also want to guarantee a high level of educational value and of students' acceptance (the solution is familiar to students and maintains a strong link between the presence and the distance activities, allowing their synchronization).
- Want to guarantee a high level of flexibility to their students (they can balance face-to-face and remote activities according to their preference and to the course characteristics).
- Adopt an inclusive learning model: the video-recording service has a positive impact on overcoming the physical and psychological barriers related to classroom presence. On the one hand, students with motor impairment have the possibility to attend most of the activities remotely. On the other hand, the flexibility of the model allows less performant students to recover and reinforce learning with additional support. Compared to MOOCs, that have the same advantage in terms of inclusivity, our model is more "familiar" to students and fosters the feeling of being part of a classroom group.

Future works will entail the application of clustering techniques to identify groups of students with similar behaviors in service use and the recommendation of the most appealing video courses or individual lectures to students based on their profile and current needs.

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