View metadata, citation and similar papers at core.ac.uk

brought to you by CORE

provided by PORTO@iris (Publications Open Repository TOrino - Politecnico di Torino)

POLITECNICO DI TORINO
Repository ISTITUZIONALE

Massive on-line learning: moving from web to mobile

Original
Massive on-line learning: moving from web to mobile / Mezzalama, Marco; Venuto, Enrico. - ELETTRONICO. - (2016), pp. 749-766. ((Intervento presentato al convegno The Online, Open and Flexible Higher Education Conference tenutosi a Roma nel 19-21 October 2016.

Availability:
This version is available at: 11583/2654497 since: 2016-10-27T19:07:11Z

Publisher:
EADTU

Published
DOI:

Terms of use:
openAccess

This article is made available under terms and conditions as specified in the corresponding bibliographic description in the repository

Publisher copyright

(Article begins on next page)

04 August 2020

Massive on-line learning: moving from web to mobile

Marco Mezzalama
Politecnico di Torino, Italy
marco.mezzalama@polito.it

Enrico Venuto
Politecnico di Torino, Italy
enrico.venuto@polito.it

Abstract

Nowadays, web and mobile technologies and new communication paradigms offer many opportunities to improve services within University Campuses.

Politecnico di Torino has developed various approaches to on-line (distance) learning, using a set of tools and methodologies to follow the rapid evolution of teaching paradigms: from traditional distance learning models to hybrid and blended models, up to the most recent flipped and MOOC approaches.

The on-line learning system is designed to be used by both face-to-face and remote students for a total of 33.000 people organized in 51 bachelors and master of science programs. Today it shows 1.000.000 logins/month and it provides access to 430.000 files of teaching materials for a total of 80.000.000 downloads/year.

Particularly relevant is the service of video recorded lectures with its 80 courses for a total of about 3.000 recorded, one hour lessons per year; this generates over 1.200.000 video streaming/downloads per year.

In this scenario, the use of mobile technologies is quickly growing, becoming the favourite medium to access services and information in the University context. According to the technological evolution, Politecnico di Torino improved its services moving from a traditional Web approach to a mobile APP model via the intermediate steps of web responsive and mobile web models.

This paper describes the strategies and the technical choices to design and implement the teaching portal of Politecnico including the new PoliTO App, the official App to step into the campus, providing learning, streaming, logistic and administrative services to student and teachers.

The paper also includes the efficiency analysis of the model which correlates the access to the video-lectures and the students' achieved performances.

Keywords: learning technologies, mobile learning, blended learning

1. Introduction

The ever more increasing diffusion of mobile devices in the last six years forced universities to adapt themselves to the change, making the deployment of their services evolve in the direction of mobile users.

Figure 1 shows the evolution of mobile access to online services for didactics of Politecnico di Torino in the last eight years. We can see that the accesses through mobile devices grew from 0.2% in 2008 to 15% at the beginning of 2013, more than doubling in the following three years reaching 32% of the total in 2016. In Figure 1 the blue line plots the aggregate percentage of mobile accesses, the other ones plot the distribution per operating system.

This intense growth forced to redesign the methods of production and distribution of the information in order to allow for optimal fruition from any kind of devices, from small mobile phones to powerful workstations [Castaldo et al, 2013].

The lowering of the curve starting March 2016 depends on the introduction of the Athenaeum mobile APP "PolitTO App" (see section "From Web@desktop to App@mobile" below) that embeds direct access to services and didactic materials instead of the traditional web browsing from mobile devices.

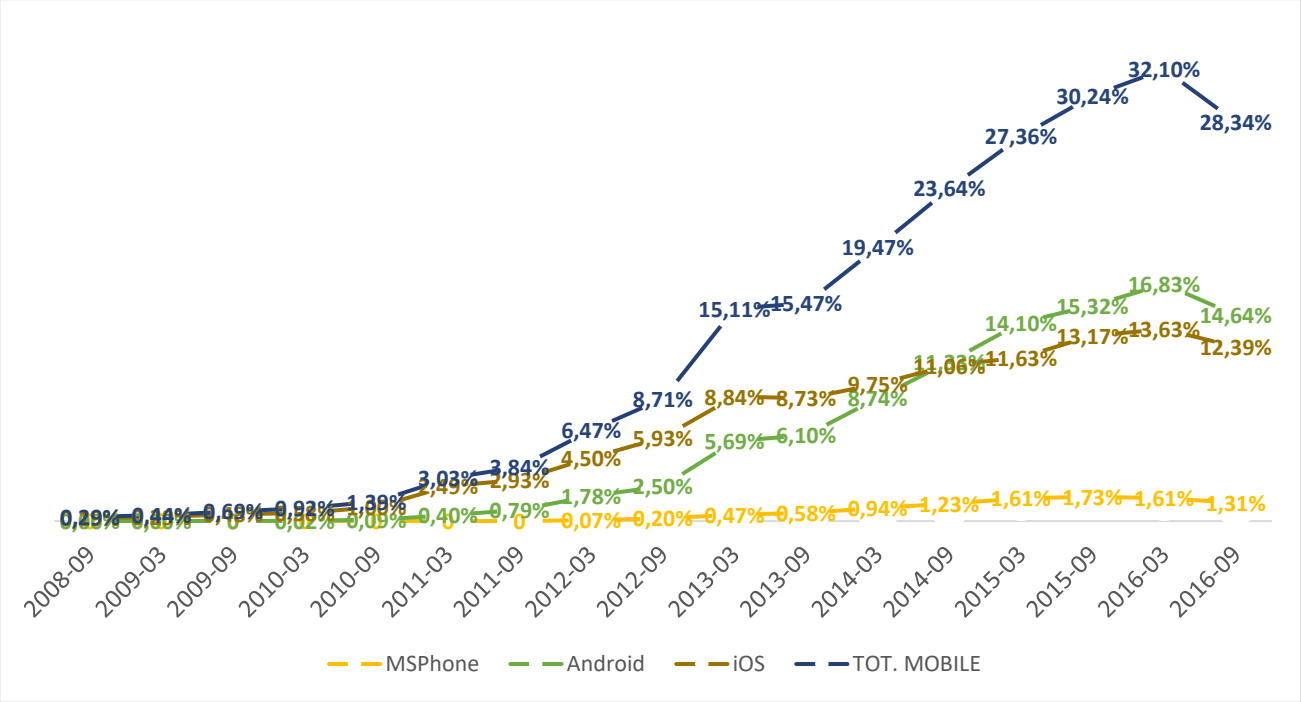

Figure 1: Evolution of mobile access to web services for didactics

Special attention should be paid to the access to multimedia materials like video-lectures (lectures fully video recorded in class) available in streaming for all web-enabled devices (including mobile).

Comparing the plots of Figure 1 and Figure 2 it is evident that the general average mobile access to teaching materials is greater than the mobile access to multimedia objects (computed on the total accesses to multimedia objects): in fact in 2012 the generic materials accessed from mobile devices represented 9% of the total, but the access to multimedia objects from mobile devices was only the 3% of the total accesses to multimedia materials.

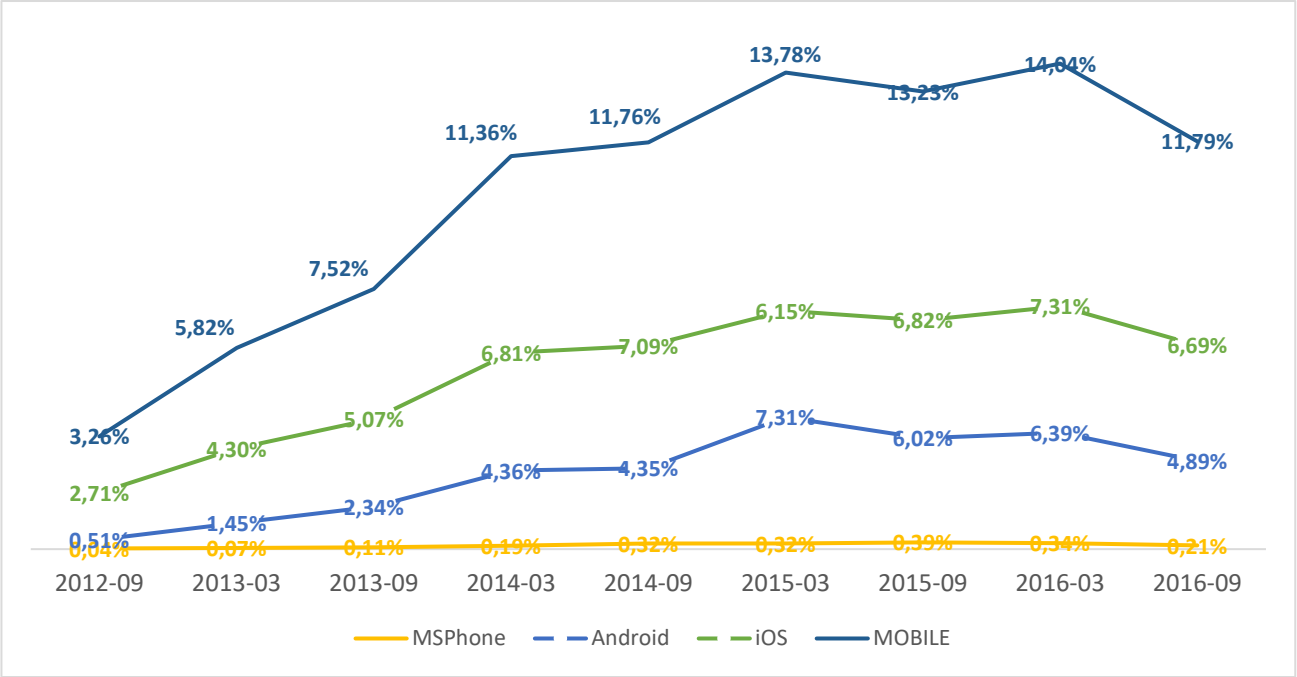

Figure 2: Mobile web access to multimedia objects (% of the total access to multimedia objects)

However in 2015 the quota of generic materials accessed from mobile device tripled (from 9% to 27%), but the quota of multimedia materials grew more than fourfold (from 3% to 14%).

This acceleration in the growth can be explained from a technological point of view with the increased availability of powerful devices, the rise of broadband connectivity, a lower cost of data communications and a higher number of ways to distribute rich multimedia objects, but also from a social point of view: students and young people have a different approach to the access to the Net, also for multimedia contents [Gedera, D., 2014].

A recent survey targeting the students of Politecnico di Torino (about 6.000 responses evaluated) shows their peculiar habits in using their mobile devices: first of all they have the tendency to use their smartphone for more than two hours per day. In Fig.3 their favourite devices are also shown: smartphones and laptops are the first choice; tablets are not so used (students were asked to sort their preferences with a value of priority from 4 to 1) [Moser et al, 2015].

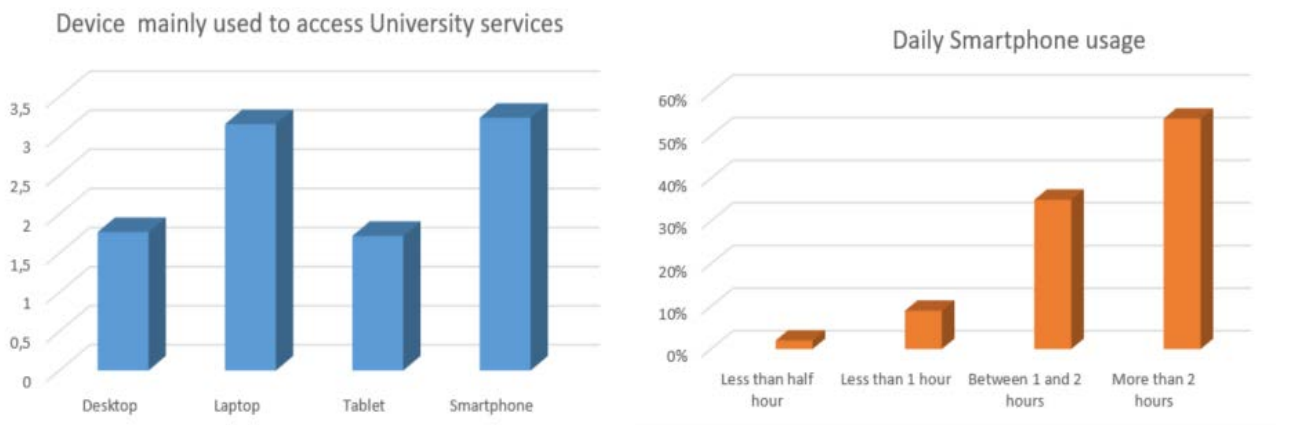

Figure 3: Students' habits in device usage

However, even if the smartphone is one of the preferred device, Figure 2 shows that the access to multimedia objects from mobile devices didn't increase in percentage after 2015. The curve reached his equilibrium and the preferred device for multimedia components remains a personal computer. Figure 2 shows also the incidence of the introduction of PolitoApp starting from March 2016 (-2.25 percent points).

2. Context

Politecnico di Torino, with its 31 Bachelor-level, 32 Master of Science-level, 16 PhD courses and with around 35,000 engineering and architecture students, is one of the most important Tech University in Italy.
Every student has access to a Teaching Portal (Portale della Didattica), a virtual space where students and teachers meet each other playing proactive roles [Dominic et al 2014]. There they can find about 400,000 file of full text, indexed didactic materials like slides, notes and examination papers; they can take part to forums, deliver homework, find stage and job opportunities, perform exam booking and access to the contextual areas of the single courses.
Building on these bases, starting from 2010 the Athenaeum removed the rigid border between traditional front-side, in-class didactic and distance learning, starting to record all the lectures of the courses of the first year of engineering (6 programs), all the lectures of the Bachelor's programs in Mechanical Engineering, Electronic Engineering, Computer Engineering and the Master's Degree in Computer Engineering [Castaldo et al, 2011].
Every year over 60 full courses are recorded in class, for a total of about 3,000 lectures per year, giving the opportunity to 15,000 students to access their curricular courses in video streaming.
Even though Politecnico di Torino - for organizational and pedagogical reasons - chose a fruition methodology like MOC (Massive Online Courses) limiting access to its students, it also tested for several years a completely different fruition method, totally free and very similar to the MOOC (Massive Open Online Courses) model one [Castaldo et al, 2014] for two teachings of the first year (Computer Science and Chemistry). For the course of Computer science, forty 90-minute lectures were published for free access. Even with no dedicated advertising, 50.000 accesses per year were detected coming from users outside the Politecnico di Torino students community [Abeer et al, 2014].

Figure 4 shows the number of accesses during the last six academic years for the six teachings of the first year of engineering. These teachings are the same for all 7,000 first year engineering students. The yearly total video-lecture streaming accesses for the first year is about 700,000: every student accesses an average of about 100 lectures.
To correctly understand the data portrayed in Figure 4 it's important to know that, although all the students of the first year of the Bachelors in Engineering are grouped into 22 parallel classes with 22 different teachers, only one professor is video-recorded and his video-lectures are deployed to all the students of all the groups.
Fig.4 shows that the video-lectures are valued from all the students, regardless the fact that the lectures aren't always from their own teacher. This result was achieved through a hard work of standardization of the

programs and of the course content so that each parallel group of students shares the same contents, the delivery modes and the assessment and grading criteria.

However, accesses to video-lectures have different trends depending on the frequency at which the recording happens: courses recorded every year (es. Computer Science) have a lot of accesses, increasing in the years; courses recorded once or a few times (es. Mathematical Analysis I) have less followers, decreasing in time.

Students seem to appreciate more video-lectures of the current academic year even from another teacher rather than lessons from previous years.

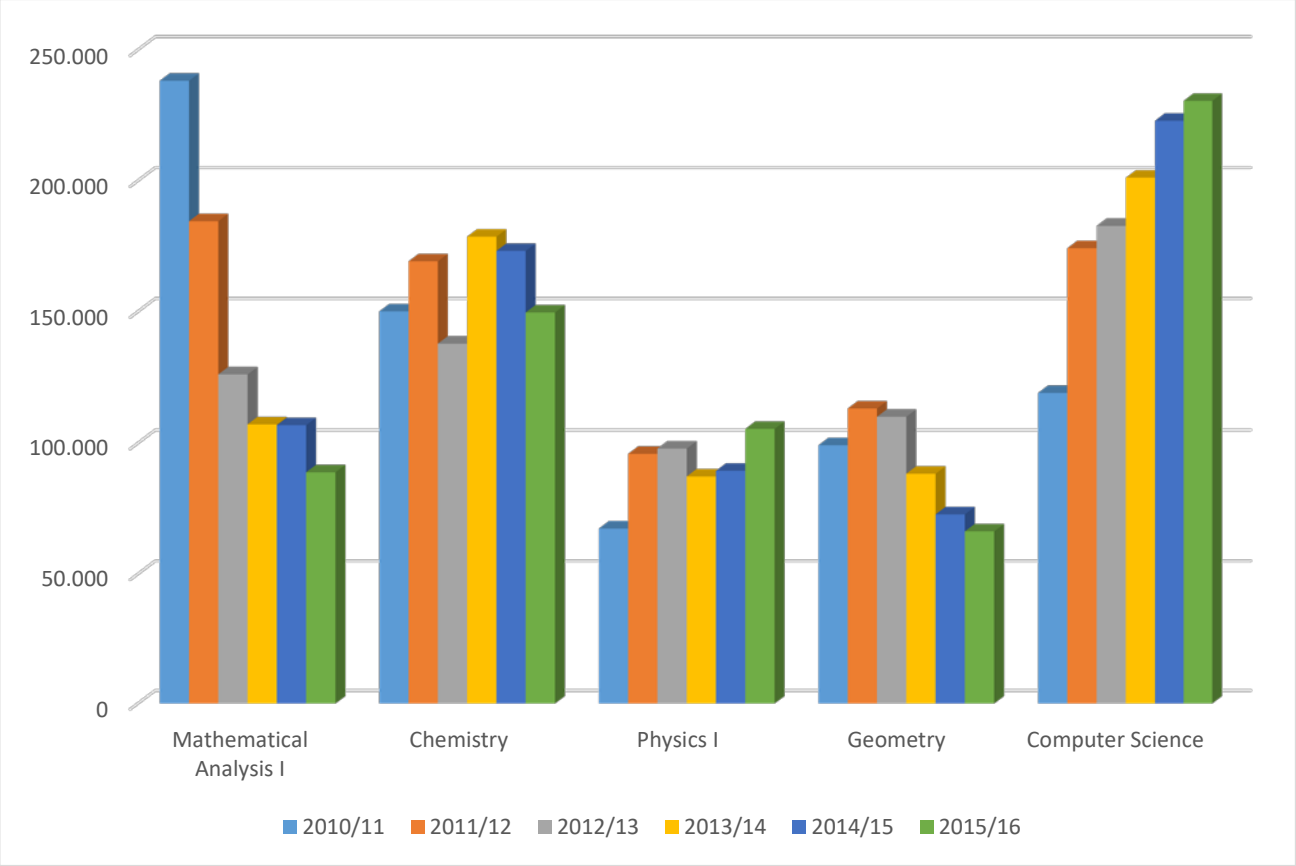

Figure 4: Video-lecture streaming accesses for the teachings of the first year of Engineering

Politecnico di Torino chose so far a blended didactic model with a deploying methodology typical of the MOC model (limited to their students) [Barbagallo et al, 2012].

Contrary to the MOOC model characterized by a lot of accesses at the beginning of the course and by a lot of drop-offs, with an inverse exponential access chart, the access charts to video-lectures of Politecnico di Torino testify the success of the model through forms repeated in the years for all the teachings, similar to a Gaussian curve with the maximum near the first exam session; also recognizable are the peaks corresponding to other exam sessions (see Figure 5) [Onah et al, 2014].

Focusing on the case of Computer Science, we found evidence that the trend of the accesses to the video-lectures is growing constantly, both during the period of the course and in the whole in the years. Politecnico di Torino has also experienced, keeping the same course contents, the deploying of the same recordings for

many years. This approach has been proposed for example for the teaching of Mathematical Analysis I. By comparing the two curves in Figure 5 it can be seen how students prefer the video-lectures of their own academic years.

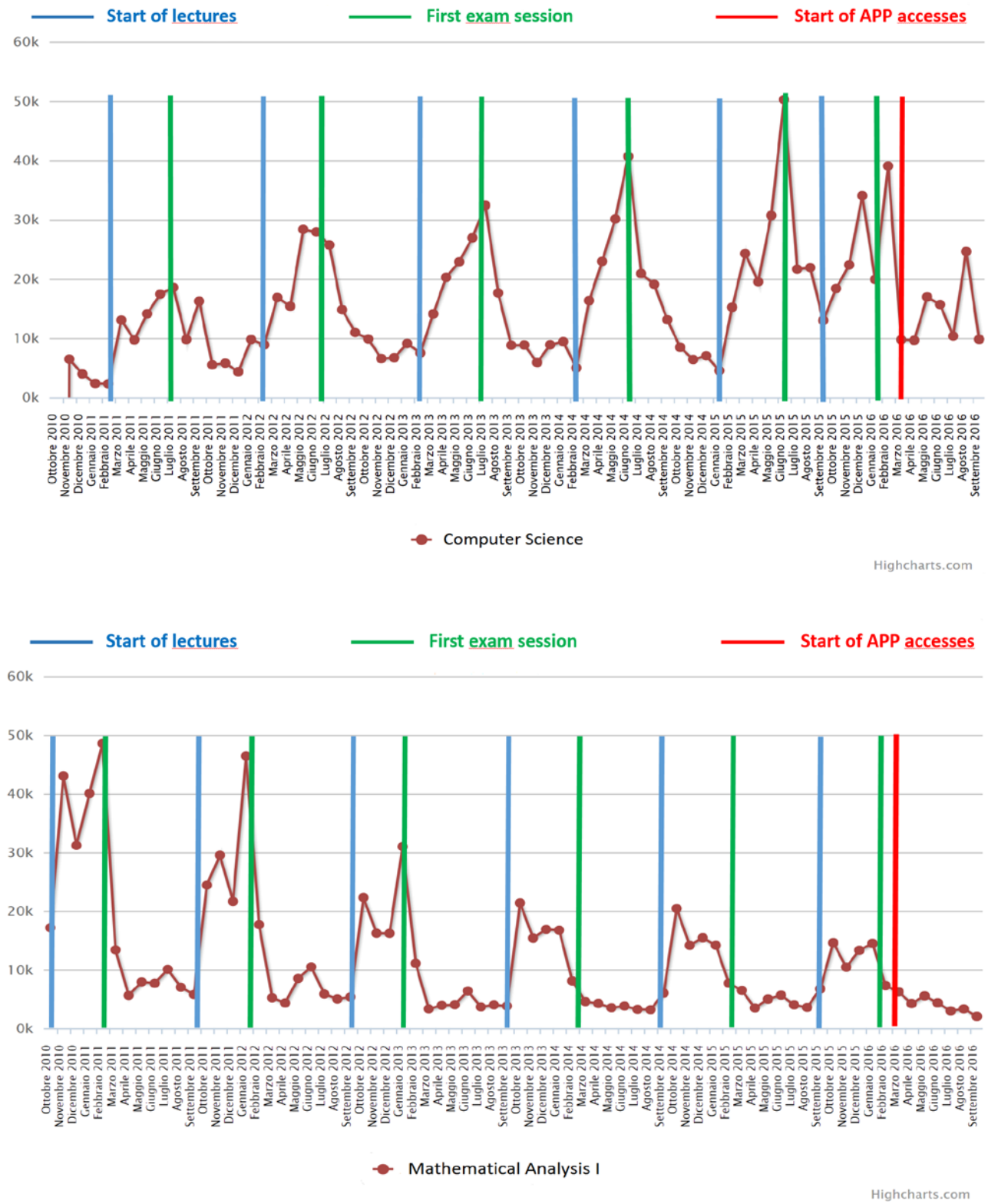

Figure 5: Video-lectures monthly web accesses charts

Some efficiency analysis of the blended model based on video-lectures have been performed to correlate the access to the video-lectures to the success in the studies. A brief review has been carried out on the teachings of the Master's Degree in Computer Engineering. In this environment all the lectures have been recorded every year and each student could access his own teacher's video-recording. The average student accesses has been tracked for each teachings (blue bars in Figure 6) and compared with the average accesses of the students that successfully passed the exam (green bars in Figure 6) and with the average accesses of the students that failed (red bars in Fig.6). So for example the students in Computer Architectures viewed in average 25.5 video-lectures; students that passed that exam viewed an average of 31.25, while those who failed only viewed 14.7. There is an evident correlation between the average number of video-lectures viewed and the success in the exam; this fact proofs the effectiveness of the methodology also in presence of some anomalies that are probably due to different arrangement of the teachings or of the assessment and grading criteria.

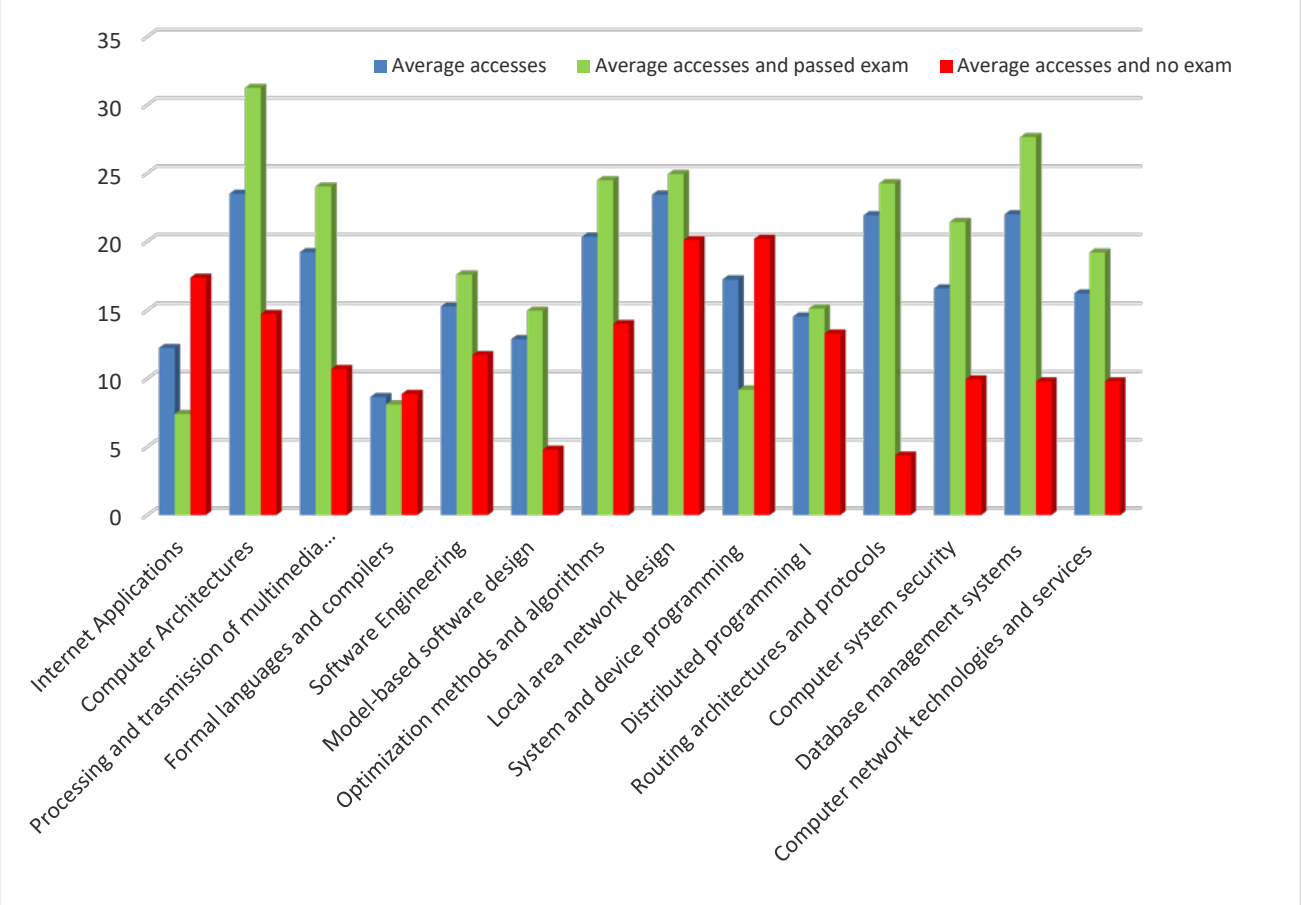

Figure 6: Average accesses per student – Video-lectures Master Degree in Computer Engineering 2013/14

3. From Web@desktop to App@mobile

In order to support the rapid migration of its students to mobile devices in accessing its services, Politecnico di Torino began a path in the direction of the mobile APPs that started with the making of websites and applications based on the "Web Responsive" paradigm: services able to use different styles of visualization

depending the device in use [Castaldo et al, 2015].

In the Web Responsive model the content and its presentation on the display could be generated client-side, server-side, or both: content is stored and managed in just one repository, but a lot of different visualizations are possible on different devices, depending on their own dimensions and graphics capabilities.

However, even if the Web Responsive model allows the deploying of web contents on most of the mobile devices, the navigation model, the access to information and the data input are based on the browser and designed for "legacy" devices like desktop or laptop. [Serrano et al, 2013]

The following step in the path to mobile APPs was the adoption of the "Mobile Web" model that overcomes some of the limits of the Web Responsive model: it ensures a user experience for mobile users very similar to the mobile APP's. Web applications are specifically developed for mobile devices and require the management of another set of web services that complement the "traditional" ones. The usage of web connector (API) to the pre-existent web-sites allow the realization of application servers for Mobile Web services not as "copies" but as "interpreters" of the same contents, usually in JSON format, coming from APIs and as distributor of these contents within a graphic and navigation framework that is specific for the mobiles [Richardson et al, 2013].

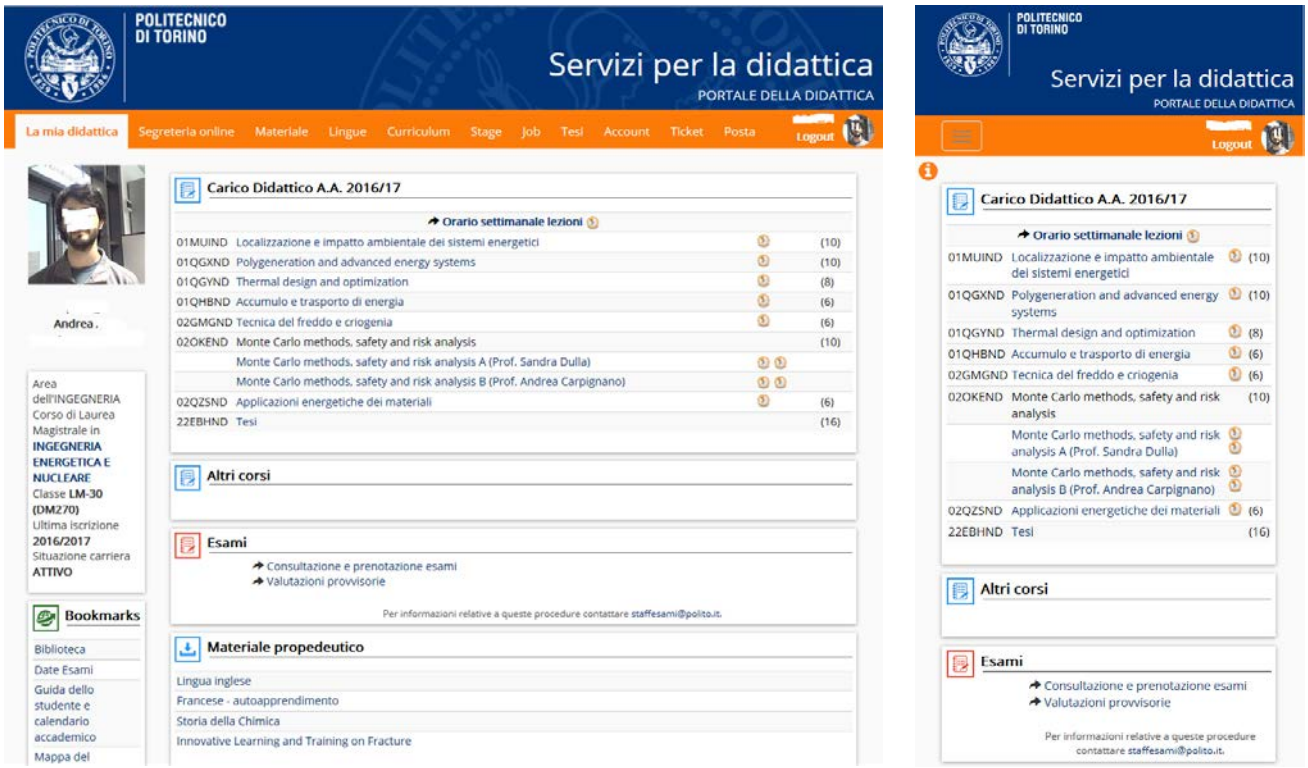

Figure 7: Screenshots from the Teaching Portal

This approach builds the basement of API's and JSON web-services that are mandatory for the development of Mobile APPs for accessing University and territorial services [Hussain F., 2013].

Mobile Web model allows for rapid and powerful response to the increase of mobile accesses; faster than APPs and more effective than Web Responsive. The mobile version of the teaching portal of Politecnico di Torino offers only the essential and frequently used services of the portal, but all of them can be used quickly and

using only one hand. Figure 7 shows two screenshots from the Teaching Portal of the Politecnico di Torino taken from a laptop and from a mobile device: the design of the portal is Web Responsive.

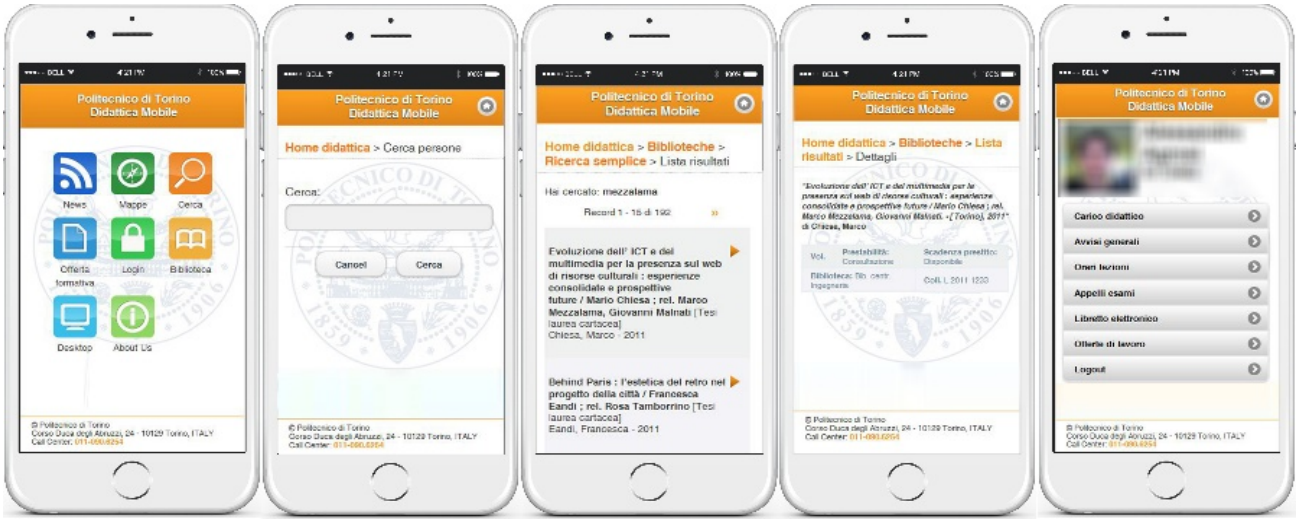

Fig. 8 – Screenshots from the mobile version of the Teaching Portal

Figure 8 shows some screenshots from the mobile version of the same Teaching Portal: the contents are similar, but the approach used in the interface design is very different.

The rapid and massive growth of mobile users connected to the services of the Athenaeum made the limits of the Mobile Web approach emerge [Sin et al, 2013].

The need to redesign the communication paradigm in order to take full advantage of the capabilities, the peripherals, and the sensors of the mobile devices leads to a new model. In fact new generations ask to be able, for example, to search the voice/social contact of a teacher and call/message him with only a few taps.

The Mobile web model is a rapid development model that allows for a rapid transition from traditional web to web for mobile users, however it can't be considered a permanent solution. Figure 9 shows that in the long run the Native/Hybrid APP approach is a winning model against the Mobile Web one.

Average Time Spent per Day with Mobile Internet Among US Smartphone and Tablet Users, In-App vs. Mobile Web, 2011-2017

hrs:mins

	2011	2012	2013	2014	2015	2016	2017
In-app	**1:04**	**1:40**	**2:28**	**2:51**	**3:05**	**3:15**	**3:23**
—Smartphone	0:35	0:56	1:24	1:35	1:43	1:49	1:52
—Tablet	0:29	0:44	1:04	1:16	1:22	1:27	1:31
Mobile web	**0:29**	**0:38**	**0:50**	**0:51**	**0:51**	**0:51**	**0:52**
—Tablet	0:15	0:19	0:24	0:25	0:26	0:27	0:27
—Smartphone	0:14	0:20	0:26	0:25	0:25	0:25	0:24

Note: ages 18+; time spent with each device includes all time spent with that device, regardless of multitasking; for example, 1 hour of multitasking on a smartphone while on a tablet is counted as 1 hour for smartphone and 1 hour for tablet
Source: eMarketer, Oct 2015

196859 www.eMarketer.com

Fig. 9 – Growth of APP model vs. Mobile Web model

One of the main reasons for developing a mobile APP in a campus with many Web Responsive and Mobile Web services was the requirement to take advantage of the use of mobile features that are not available on other communication channels, first of all the ability to receive notifications: a system that enables the students to receive real-time notifications on general info or security warnings, but also personal messages profiled for individuals or groups of users without the need to access web sites to receive them.

4. Architecture and development of PoliTO App

The PoliTO App was developed, as much as possible, over a stack of open source components and software. The architecture is based on a central node hosting a database and an application server that performs the connections with all the information system of the Campus and the territorial services, but also with all the mobile devices running the APP. It is the unique end point for PoliTO App [Castaldo et al, 2016].

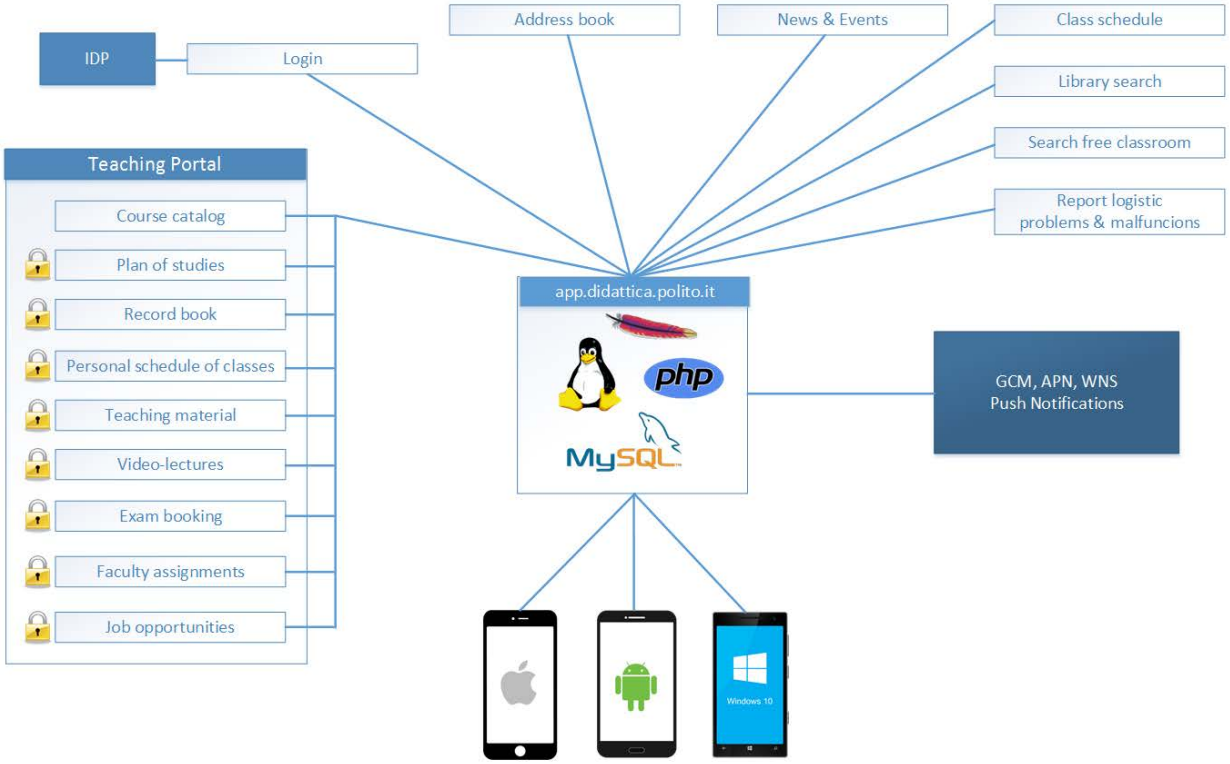

Figure 10: PoliTO App general architecture

4.1 Server-side architecture

The Central node is based on a LAMP architecture (Linux Apache MySQL PHP) and it hosts the application server: it is the heart of the architecture of the APP and it deploys all the information and the services to the mobile devices running the APP. All the API, written in PHP, reside there and are directly called from the APP. Every API performs a transparent connection to one or more of information system of the university and to the territorial ones, also managing, transforming and aggregating all the data needed by the APP and sending them in a packet [Venturini et al, 2015].

The same node hosts the database that stores all the info on the devices that downloaded the APP and that

are required for authentication and for push notifications operations.

4.2 Authentication

The authentication in performed, through the application server, on the Politecnico di Torino IdP (Identity Provider). Each user inputs her credentials - the same used to access the traditional web services and mail account. In case of success, the APP receives a token that will be included in all subsequent data exchange with the application server, so that the PoliTO App is always connected and authenticated up to the closing of the session (logout): the exit from the APP or the reboot of the device do not invalidate the authenticated state.
Authenticated users have access to profiled and personalized services like lesson scheduling, exam booking, (exam management if teachers), plan of studies, didactic materials and also video-lectures.

4.3 Client-side architecture

The PoliTO App is a hybrid App developed using the Apache Cordova framework that, using its plugins, allows the reuse of the same source code for all the target devices (Android, iOS and Windows based). The client-side part of the APP is developed in HTML5, CSS, and JavaScript, using Onsen and Angular frameworks [Phuc Huy et al, 2012]. To reduce the network bandwidth usage, the APP has been designed to perform a minimum number of requests to the server and to work for some service also in offline mode. Contents to be displayed are searched in the local storage and, only if needed, requested again to the server.

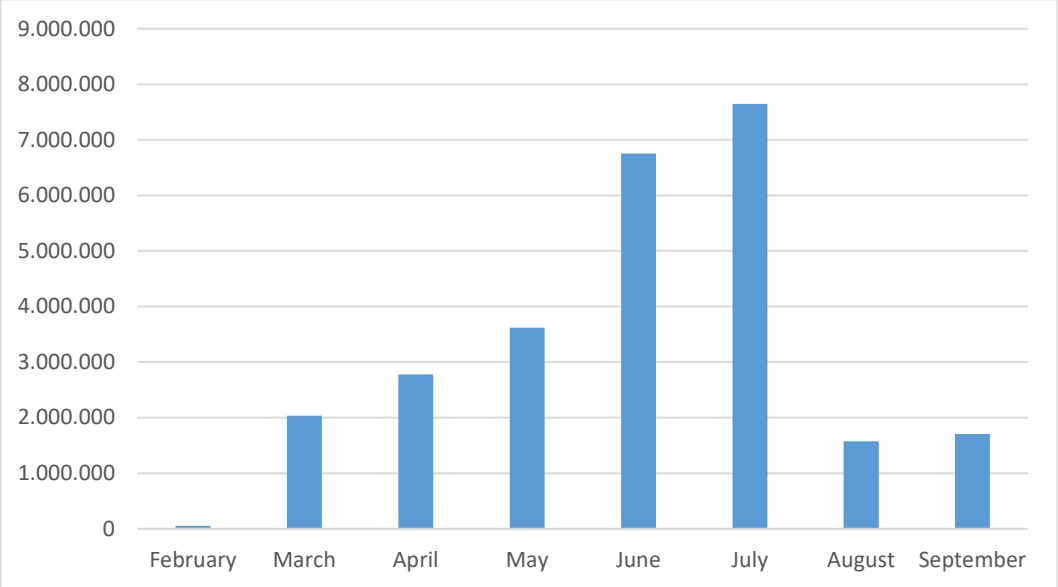

Figure 11: Monthly requests to PoliTO App PHP APIs

When the APP starts for the first time on a new device, all the info about the device and the APP (ex. operating system and version, APP version, unique registration ID), needed for succeeding use are recorded on the central database. Then a public data package with for example course catalog and contacts is sent to the device and stored in the local storage for off-line usage.
When the user logs in, another data set is sent to the device and saved in its internal storage, including that

user's information about his career. Every time the APP is started, in presence of network connectivity, a check for update is performed; although many of the services are real-time and are available only in on-line mode (ex. research in the library catalog, search for free classroom, bus-stop timetable)

Finally, PoliTO App is able to accept and manage push notifications.

Figure 11 shows the monthly requests performed by the APP to the APIs: although PoliTO App has been designed to reduce the network requests, the number of requests is very high, up to over a quarter of million per day: students use the APP very much, especially during the most intensive part of the academic year like the July exams session.

4.4 PoliTO App services

The services and functionalities of the APP have been defined through a process that involved also interviewing some students, the evaluations of their works in mobile APP context, and some surveys on universities in collaboration with research groups with specific expertise in mobile phenomena.

PoliTO App provides information and customized services to students, faculty and administrative staff, such as news and events, educational and job opportunities, search class schedules, maps transport information, library search, report logistics problems and malfunctions, view Personal Study Plan, access to teaching material and video-lectures, electronic credits booklet, exam booking, feedback on teaching quality, notifications of key announcements, access to student e-mail account and finally, notifications of the principal events and info. Figure 12 shows some screenshots of some of the services provided by PoliTO App (menu, credit booklet, video-lectures, class schedules, notification settings).

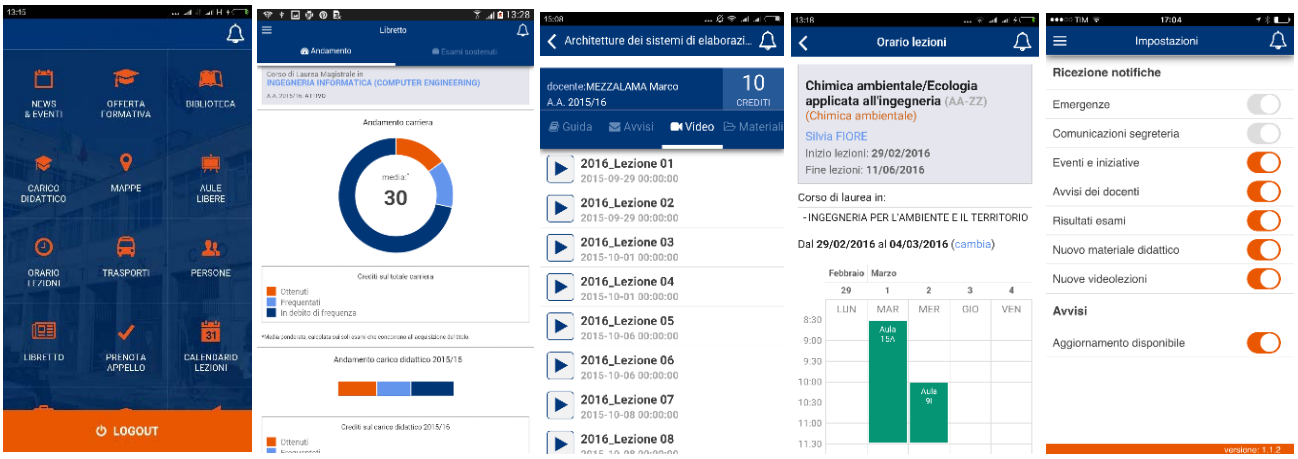

Fig. 12 – PoliTO App Screenshots

4.5 Notifications

The notifications and the persistence of the authentication are the true value added of the APP that other models of mobile communications like web responsiveness or mobile web normally don't offer.

Together they realize the "always logged-on and on-line" paradigm. Notifications overcome the restrictions of the "pull model" in which the user had to go and look for the info he needs, towards the "push model" in which the info, as soon as available, is sent to the students without any user intervention.

APP notifications have been categorized and split up in public and private. Each user can choose what kind of notifications he wants to receive (emergency warnings and secretariat messages can't be refused).
Everyone installing the APP can receive public notifications such as news and events. Authenticated users can receive also personal notifications for example for exam grading, new didactic materials or video-lecture made available.
Emergency warning notifications allow Politecnico di Torino to communicate in real-time with a huge numbers of students: this is an indispensable feature in emergency management and in ensuring security to its own members. Figure 13 show the daily notifications sent to devices based on Android (the grey bullets represent new version publications).

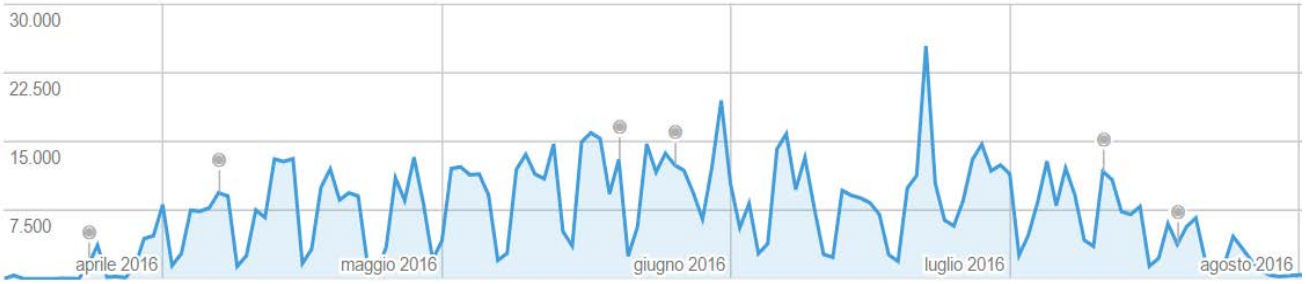

Figure 13: Daily Notifications for Android devices

4.6 PoliTO App in numbers

PoliTO App is the first official APP of Politecnico di Torino. It was released in the evening of February the 26th 2016 on Google Play. One month later the iOS version was released on the AppStore; the Windows 10 version was released at the beginning of September. Today the PoliTO APP is installed on about 15,000 Android devices and on about 9,000 based on iOS. The Windows mobile devices hosting the APP are currently a few hundreds (the Windows10 version runs both on mobiles and laptop/desktop devices).
The score of the APP is fairly high: 4.3 stars on Google Play (based on more than 400 reviews), 4 stars on App Store and 5 stars on Microsoft Store.

5. Conclusion

The paper depicts the experience made by Politecnico di Torino in the last six years building a collaborative environment for the deploying and the exchange of teaching materials. Particular evidence has been given to the experience of the video-lectures. These initiatives are characterized by a high adoption factor and in general by a large number of users, so they can be considered massive, involving methodologies designed to follow the rapid evolution of teaching paradigms and the transformations of the devices used for the learning processes: increasingly powerful, multimedia enabled, smaller and mobile.
The article also reports the experience in the development of the first official mobile APP of the Politecnico di Torino, a hybrid APP for services mainly in the didactic and teaching contexts. The APP is the last (but not least) step of a path that, starting from traditional web sites and e-learning services, saw them evolve following the

Web Responsive paradigm, passing for the Mobile Web and finally approaching the Mobile APP model. The hybrid APP is the right give-and-take between the native APP and the know-how and the competences acquired during the previous phases: the result is a product native for each device developed by the same team developing all the Politecnico web applications.
The success of the initiative is evident: in the first six months 25,000 people are constantly connected out of a base of about 35,000 students.

References

Abeer, W., & Miri, B. (2014). Students' Preferences and Views about Learning in a MOOC, ERPA 2014, Procedia - Social and Behavioral Sciences 152, 318 – 323.

Barbagallo S., Bertonasco R., Corno F., Farinetti L., Mezzalama M., Sonza Reorda M., Venuto E., E-Learning at Politecnico di Torino: Moving to a Sustainable Large-Scale Multi-Channel System of Services, in Pumilia-Gnarini P. M., Favaron E., Pacetti E., Bishop J., Guerra L., Handbook of Research on Didactic Strategies and Technologies for Education: Incorporating Advancements / Information Science Reference (an imprint of IGI Global), Hershey PA, 2012, pp. 690-702.

Castaldo, U., Mezzalama, M., Venuto, E., Mobile Web App: technologies and services in a Campus environment. In: Didamatica 2016 "Innovazione: sfida comune di scuola, università, ricerca e impresa" - Trentesima edizione della conferenza AICA sulla informatica per la didattica, Udine, 19, 20 e 21 Aprile 2016. pp. 1-10.

Castaldo, U., Mezzalama, M., Venuto, E., Dal Web alle APP: esperienze nei sistemi MOOC e MOC. In: STUDIO ERGO LAVORO - dalla società della conoscenza alla società delle competenze 29° EDIZIONE, Genova, 15, 16 e 17 Aprile 2015. pp. 381-388, 2015.

Castaldo, U., Mezzalama, M., Venuto, E., Experimenting MOC & MOOC in technical university. In: Nuovi Processi e Paradigmi per la Didattica 28° EDIZIONE, Napoli, 7, 8 e 9 Maggio 2014. pp. 78-88, 2014.

Castaldo, U., Mezzalama, M., Venuto, E., Multicanalità e e-learning: nuovi scenari tecnologici e didattici. In: Didamatica 2013, Pisa (Italia), 7-8-9 Maggio 2013. pp. 359-368, 2013.

Castaldo, U., Mezzalama, M., Venuto, E., La formazione a distanza al Politecnico di Torino: nuovi modelli e strumenti, in: AICA in Didamatica 2011, Torino (IT), 4-6 maggio 2011 - ISBN 9788890540622 March 4, 2011

Dominic , M., Francis, S., & Pilomenraj, A. (2014). E-Learning in Web 3.0. International Journal of Modern Education and Computer Science, 2, 8-14.

Gedera, D. (2014). Students' experiences of learning in a virtual classroom: An Activity Theory perspective. International Journal of Education and Development using ICT, 10(4), pp. 93-101. Open Campus, The University of the West Indies, West Indies.

Hussain, F. (2013). E-Learning 3.0 = E-Learning 2.0 + Web 3.0?. IOSR Journal of Research & Method in Education (IOSR-JRME), 3(3), 39-47.

Moser, S., Bärtele, S., Wunderlich, K., Gröger, G., Slomka, F., Schumacher, H., Learners' Requirements on E-Learning Platforms from a Technical Perspective Supported by a Survey-Based Study. In: The Online, Open and Flexible Higher Education Conference 2015 – Proceedings, Hagen (Germany), 29,30 October 2015. pp. 232-249.

Onah, D., Sinclair, J., Boyatt, R., Dropout rates of massive open online courses: behavioural patterns, in: EDULEARN14 Proceedings. pp. 5825-5834

Phuc Huy, N., Van Thanh, D., Developing apps for mobile phones, in Computing and Convergence Technology (ICCCT), 2012 7th International Conference on, 907 – 912, 978-1-4673-0894-6, 2012.

Richardson, L., Amundsen, M.,& Ruby, S. (2013). RESTful Web APIs, Sebastopol CA: O'Reilly Media.

Serrano, N. ; Hernantes, J. ; Gallardo, G., Mobile Web Apps, in Software, IEEE (Volume:30, Issue:5), 22-27, 2013.

Sin, D., Lawson, E., Kannoorpatti, K., Mobile Web Apps - The Non-programmer's Alternative to Native Applications, in Human System Interactions (HSI), 2012 5th International Conference on, 8-15, DOI:10.1109/HSI.2012.11, 2012.

Venturini, I., Oliviero, R., Lifelong Learning in Web 3.0 Environments in In: The Online, Open and Flexible Higher Education Conference 2015 – Proceedings, Hagen (Germany), 29,30 october 2015. pp. 360-378.

Waßmann, I., Schönfeldt, C., & Tavangarian, D. (2014). Wiki-Learnia: Social E-Learning in a Web 3.0 Environment, WJEIS, 4(1).

Zöserl, E.,, Reif, J.,,Improving Flexibility by Enriching Courses with Web Conferencing – Three Case Studies, in The Online, Open and Flexible Higher Education Conference 2015 – Proceedings, Hagen (Germany), 29,30 october 2015. pp. 389-400.