Master Thesis on the Academic Master of Information and Communication Electronic Systems

LEARNING ANALYTICS: DEFINITION OF INDICATORS OF STUDENTS’ BEHAVIOR IN REMOTE LABORATORIES

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Summary

LEARNING ANALYTICS: DEFINITION OF INDICATORS OF STUDENTS' BEHAVIOR IN REMOTE LABORATORIES

This Master's Thesis aims to define indicators of the students' behavior content-based on the course *Circuits Fundamentals and Applied Electronics*, a Massive Open Online Course (MOOC) developed under the *edX* platform, with *YouTube* as video provider and linked to the electronic remote laboratory *VISIR* (Virtual Instruments a System in Remote) with a booking system. The course has been developed by the Electrical and Computer Engineering Department (DIEEC) of the National University for Distance Education of Spain (UNED).

The definition of indicators is part of the Learning Analytics processes of selection, capture and processing of data that will be helpful for improving the course from the point of view of the students and instructors at the course or individual level.

KEYWORDS: Learning Analytics, indicators, MOOC, VISIR, remote laboratories

Resumen

ANALÍTICAS DE APRENDIZAJE: DEFINICIÓN DE INDICADORES DE COMPORTAMIENTO DE LOS ESTUDIANTES EN LABORATORIOS REMOTOS

Este Trabajo Fin de Máster tiene como objetivo definir indicadores de comportamiento de los estudiantes, basados en el contenido del *Curso Bases de Circuitos y Electrónica Práctica*, un Curso Online Masivo Abierto (COMA) desarrollado bajo la plataforma *edX,* con *YouTube* como proveedor de video y vinculado al laboratorio electrónico remoto VISIR (Sistema Virtual de Instrumentos en Remoto) con un sistema de reservas. El curso ha sido desarrollado por el Departamento de Ingeniería Eléctrica, Electrónica y de Control de la *Universidad Nacional de Educación a Distancia* (UNED).

La definición de indicadores es parte de los procesos de Analíticas de Aprendizaje de selección, captura y procesado de datos que serán útiles para la mejora del curso desde el punto de vista de los estudiantes e instructores a nivel de curso e individual

PALABRAS CLAVE: Analíticas de aprendizaje, indicadores, COMA, VISIR, laboratorios remotos

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i Acronyms

AJAX	Asynchronous JavaScript And XML
API	Application Programming Interface
ASP	Active Server Pages
A/D	Analog to Digital
BCEP	Bases de circuitos y electrónica práctica
BTH	Blekinge Institute of Technology
CD	Compact Disc
CFAE	Circuits Fundamentals and Applied Electronics
CPLD	Complex Programmable Logic Device
D/A	Digital to Analog
DAQ	Data Acquisition Card
DIEEC	Departamento de Ingeniería Eléctrica Electrónica y de Control
DMM	Digital Multimeter
DSP	Digital Signal Processing
DVD	Digital Versatile Disc
FPGA	Field-Programmable Gate Array
GPIB	General-Purpose Instrumentation Bus
GUI	Graphical User Interface
HTML	Hypertext Markup Language
HTTP	Hypertext Transfer Protocol
IEEE	Institute of Electrical and Electronics Engineers
IIS	Internet Information Services
I2C	Inter-Integrated Circuit
IVI	Interchangeable Virtual Instruments
JSP	Java Server Pages
LA	Learning Analytics
LabVIEW	Laboratory Virtual Instrumentation Engineering Workbench
LAN	Local Area Network
LMS	Learning Management System
LXI	LAN eXtensions for Instrumentation
MIT	Massachusetts Institute of Technology
MOOC	Massive Open Online Course
xMOOC	offline MOOC
cMOOC	connectivist MOOC
MT	Master Thesis
NI	National Instruments
PC	Personal Computer
PCI	Peripheral Component Interconnect
PhD	Doctorate (from antique Philosophy Doctor)
PHP	Pre Hypertext -processor
PLC	Programmable Logic Controller
PLD	Programmable Logic Device
PXI	PCI eXtensions for Instrumentation
SMOC	Synchronous Massive Online Course
SPOC	Small Private online Course
SQL	Structured Query Language

SSOC	Synchronous Small Online Course
TA	Teaching Assistant
TCP/IP	Transmission Control Protocol/Internet Protocol
UNED	Spanish University for Distance Education Madrid, Spain
USB	Universal Serial Bus
VISIR	Virtual Instruments System in Reality
VME	VERSAModule Eurocard
VXI	VME eXtensions for Instrumentation
XML	eXtensible Markup Language

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1. Introduction

Being aware of one's own situation is a three level process and a prerequisite for making decisions and effectively performing the task: the perception of elements in the current situation is followed by the comprehension of the current situation which then leads to the projection of a future status [1, 2].

The same applies to educators. In order to support students within a course, teachers should be aware of what the students are doing, how they are interacting with the course material, where comprehension problems arise [3, 4]. Especially if the number of students in a course is high and the tasks the students are engaged in are not trivial, teachers need assistance for keeping track of the students' activities, e.g., with the help of activity-based learner-models [5].

Among the information deemed most important are the students' overall success rate, the mastery level of concepts, skills, methods and competencies as well as the most frequently diagnosed mistakes. Such information is also needed for the evaluation of a course, i.e., didactic concept, materials, contents, tools, and tests. Awareness and reflection support for educators are thus also highly important aims of Learning Analytics [6].

In 2013, DIEEC-UNED launched the first Massive Open Online Course (MOOC) that, besides the usual features of these courses, includes the extensive use of a real remote laboratory dedicated to practices in electronic circuits. The MOOC was named "Circuits Fundamentals and Applied Electronics" (CFAE) and has been re-edited every year since then [7].

Although the nature of this MOOC is completely open, the course targets especially people with at least basic circuits knowledge, because in no case the course addresses teaching the laws that govern the behavior of electronic component and circuits: the main objective of the course is to learn practical competencies in basic electronic circuits and provide to students a work philosophy.

The core of the MOOC is the remote laboratory VISIR (*Virtual Instrument Systems In Reality*), which has been given the leading role in the course: evaluation and activities spin around the remote laboratory and the objectives and evaluation are focused on handling the instruments and the interpretation of the measurements obtained from the remote laboratory, knowledge on electronics are on no account evaluated despite being necessary to understand the behavior.

The main advantage of VISIR, when comparing with other electronic remote laboratories, lies in his concurrent access: multiple users interacting with the remote laboratory simultaneously, designing the same or different circuits and monitoring the same or different signals in real time, as in an in-person laboratory with several workbenches. This feature provides the remote laboratory VISIR two colliding aspects: VISIR is well suited to courses with massive access needs because of its concurrent access; and the intrinsic limitations of a real laboratory such as VISIR collide with one of the most relevant features that any MOOC should achieve: scalability.

The interaction between MOOC CFAE and remote laboratory VISIR is not carried out as a whole but as two separate entities. The remote laboratory booking system is integrated into the MOOC platform with the purpose of easing the identification and registration process for students.

The MOOC work philosophy proposes the students these sequential steps:

1) Theoretical analysis of the circuit.
2) Performing an analysis of the circuit using a simulation tool with the purpose of monitoring the time-dependent signals.
3) Experimenting in a real environment (laboratory).
4) Analyzing the behavior and comparing the limitations, advantages, differences, etc. between methods.

As any course this MOOC is improvable and here is when the Learning Analytics have a major role. Learning Analytics (LA) remains a relatively new term and, as a result, several definitions exist in the literature today. A practical and concise definition is [8]:

"Learning analytics is the measurement, collection, analysis, and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs."

In order to improve the course the application of Learning Analytics techniques may result determinant for:

- Identify patterns of behavior in student learning
- Identify students at risk of abandonment, dropout
- Custom the learning
- Improve the student engagement and their collaboration
- Predict assessment and behavior of students in learning
- Better understand the learning process
- Take action to improve course outcoming

The aim of this work is to define indicators of the students' behavior, content-based. Low-level data indicators can be found in various places. Therefore methods and materials used in this MT consist of the description and analysis of the environments, architectures, platforms, methodologies, documental, media contents and assessments of the MOOC "Circuits Fundamentals and Applied Electronics" (CFAE).

The work focusses on the general concepts MOOC and remote labs, the course platform edX and the central core VISIR, passing through YouTube as video provider and touching obliquely MicroCap as simulating software. The bibliography is reviewed and a VISIR demo and an UNED MOOC demo are used as approximations to the course. <u>Access to the original course has not been possible,</u>

with the consequent limitations to this work. Once low-level indicators are found, may be defined derivatives high-level indicators. Fig. 1 shows the conceptual framework of the course and its indicator sources.

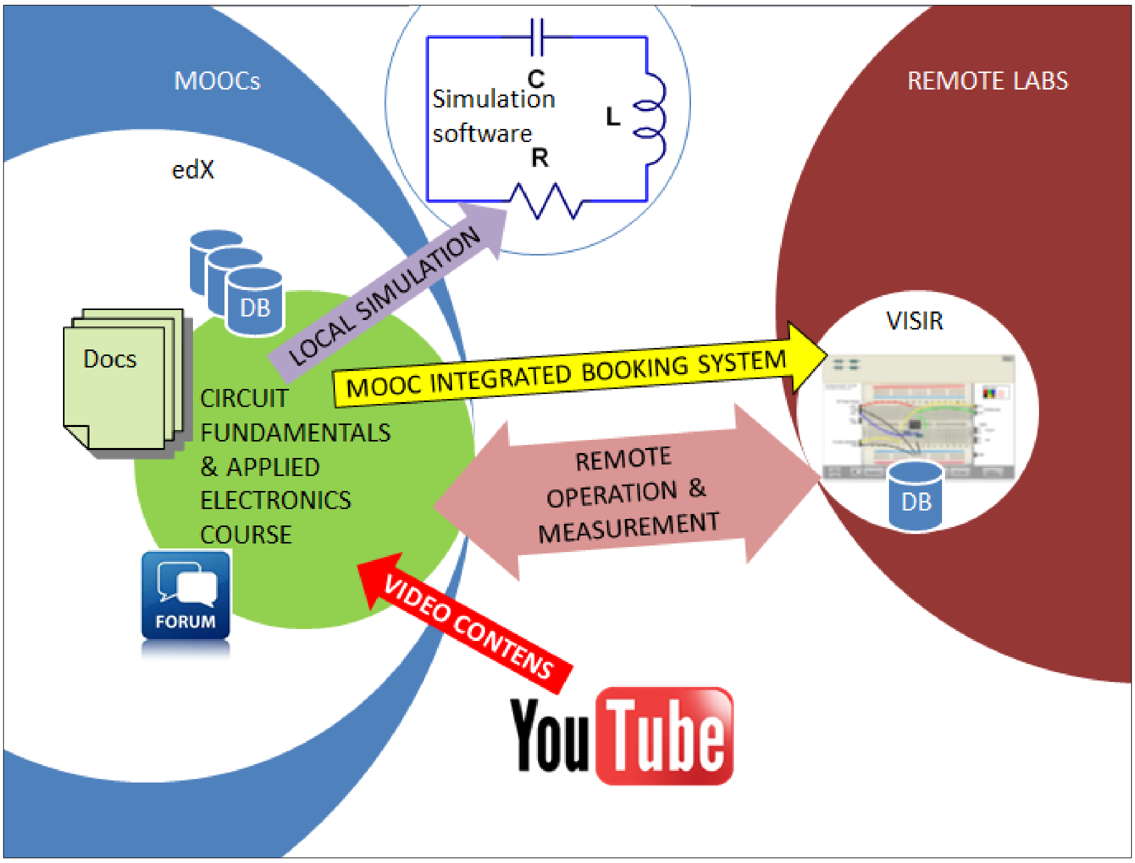

Figure 1. Conceptual framework of the course and its indicator sources (Own elaboration)

2. VISIR

VISIR (Virtual Instruments System in Reality) is a remote laboratory, core of the MOOC course object of this work, so for a better understanding of this concept, a short literature review will be done.

2.1 Remote laboratories

Remote labs appear in literature from various perspectives. To characterize the different modalities of all available experimentation environments, two criteria were proposed in [9]:

1. According to the way resources are accessed for experimental purposes, environments can be remote or local.
2. According to the physical nature of the lab, environments can be simulated or real plants.

By combining those criteria, there can be four types of experimentation environments (Fig. 2):

1. **Local access-real resource**. This combination represents traditional hands-on labs, where the student is in front of a computer connected to the real plant.
2. **Local access-simulated resource**. The whole environment is software and the experimentation interface works on a simulated, virtual and physically non-existent resource, which together with the interface is part of the computer. This configuration could be defined as a mono-user virtual lab.
3. **Remote access-real resource**. Real plant equipment is accessed through the Internet. The user remotely operates and controls a real plant through an experimentation interface. This approach is named remote lab.
4. **Remote access-simulated resource**. This form of experimentation is similar to the one above, but replacing the physical system with a model. The student operates with the experimentation interface on a virtual system reached through the Internet. The basic difference is that several users can operate simultaneously with the same virtual system. As it is a simulated process, it can be instantiated to serve anyone who asks for it. Thus, we have a multi-user virtual lab.

		NATURE OF THE RESOURCE	
		Real	**Simulated**
ACCESS TO THE RESOURCE	**Local**	Hands-on lab.	Mono-user virtual lab.
	Remote	Remote lab.	Multi-user virtual lab.

Figure 2. Experimentation environments [9]

According to [10], the virtual lab is a program that allows the students to carry out their experiments from a PC anytime and anywhere, without going out from home or from his study place. These virtual labs can be classified into three categories: Software Labs, Web Labs and Remote Lab (Fig. 3).

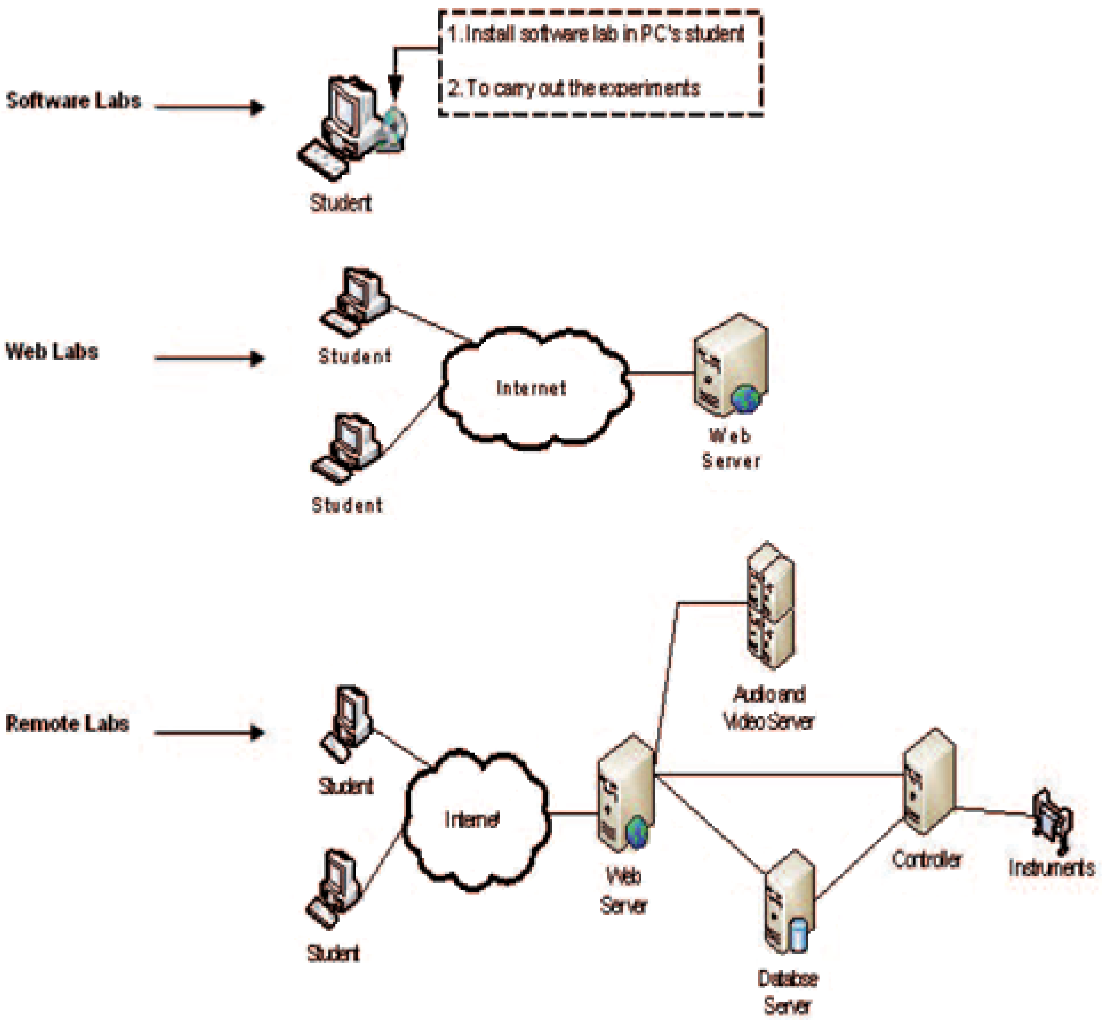

Figure 3. Software Labs, Web Labs and Remote Labs [10]

Software Labs are based on simulation software programs executed by the student's computer. The student's computer must fulfill the hardware and software requirements but an Internet connection is not required.

Advantages:

- The students can carry out their experiments at any time from their home. It is only necessary to switch on a computer.
- When the real instruments are very expensive, it is a good solution to use simulation programs.

Disadvantages:

- The teacher has no information about the student's progress (problems that the student has found, time he has spent, etc.)
- Version problems. The software programs use to be stored in a CD or DVD. In many cases, it is necessary to update them in further distribution media.
- They don't include collaborative tools.
- The students don't work with real instruments.

Web Labs are simulation programs that use web resources. The student's computer must have an Internet connection with a wide bandwidth connection.

Advantages:

- The students can carry out their experiments at any time from their home. It is only necessary to switch on the computer and having available an Internet connection.
- When real instruments are very expensive, the use of simulation programs is a good solution.
- When compared with software labs a Web lab allows the student to download the updates of the programs from Internet.
- The web server allows the student to work with collaborative tools.

Disadvantages:

- The students don't work with real instruments.
- The students must have a good Internet connection.

Remote Labs are programs that allow the student to carry out his experiments with real instruments. It is necessary a driver for managing the instruments.

Advantages:

- The students can carry out their experiments with real instruments. The students can work from home, although the physical instruments are in a real laboratory whose door is locked.
- The teacher can have information about the student's progress (problems that the student has found, time that he has spent, etc.).
- The program allows the student to use collaborative tools.

Disadvantages:

- Every educational organization develops its own solution so it is very difficult to reuse programming code.
- It is necessary to use a good Internet connection because data, audio and video are usually going to be transmitted.

On the other hand according to the state-of-the-art described in [11] remote laboratories are those laboratories that can be controlled and administrated online. They differ from the virtual simulated laboratories as they are interacting with physical instruments. The common generic architecture design of today's remote laboratory for industrial electronics applications could be structured as shown in Fig. 4:

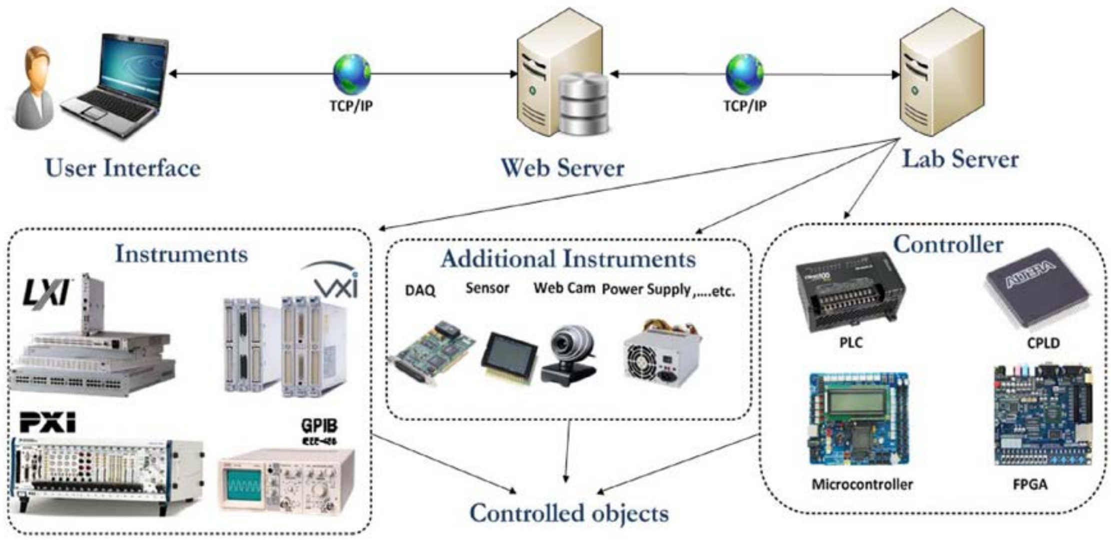

Figure 4. Common Generic Architecture design of today's remote laboratory for industrial electronics applications [11]

The user interface is a virtual end-user workbench that handles all the lab administration process. It is a website that runs on the user's web browser and usually requires a server side programming language to retrieve user's data from database such as PHP, ASP, and JSP, along with a Graphical User Interface (GUI), which is built by means of plugins and animation technology embedded in the HTML code to resemble the real lab workbench such as Flash, Java Applets and ActiveX controls. Other scripting languages commonly used are JavaScript (it adds interactive elements to the web page without relying on the server) and AJAX (it retrieves information from the server in an efficient way and without needing to refresh the web page). The website could be supplanted by a software application installed on the user-PC and connected to a database server (application server).

The web server is a server-PC that hosts the website and the database files. Apache and Microsoft IIS are the most commonly used servers, while MySQL, Microsoft SQL, and Oracle, are the most commonly used databases. The web server sends the user requests to the lab server in the form of XML messages through TCP/IP model over HTTP layer.

The lab server is a server-PC that hosts the instrumentation control software (lab server software) and it is connected directly to the instruments and the controller. The lab server software sends commands to the controller regarding the received requests or the programmed code from the user. The lab server software could be built from scratch with a multipurpose programming language such as C# and C/C++, or with graphical programming environments such as LabVIEW and MATLAB. Or else, it could be a proprietary software that comes with the controller. The instrumentation control software is connected to the controller and the instruments by standards such as USB, RS-232, Ethernet, General Purpose Interface Bus (GPIB-IEEE-488.2), serial port, parallel port, etc. depending on the controller or the equipment platform. The Data Acquisition Card (DAQ) may be needed to retrieve and convert digital and analog data signals. There are several modular types of instrumentation platforms such as PXI (PCI eXtensions for Instrumentation), LXI (LAN eXtensions for Instrumentation), GPIB, and VXI (VME eXtensions for Instrumentation).

The controller is a programmable device that directly controls the controlled objects and they are suited for all types of applications. In the literature, the controllers that have been typically used in remote laboratories are Programmable Logic Controller (PLC), Programmable Logic Device (PLD), Field-Programmable Gate Array (FPGA), Complex Programmable Logic Device (CPLD) and Microcontroller. The controller connection with the instruments and the controlled objects may entail connectors, converters (e.g., A/D, D/A), I2C-based electronic boards, etc. In some applications, a relay switching matrix is used to switch and route the connection between instruments and experiment elements. Whilst, some experiments do not require a controller, they only rely on measurements and require a measurement card such as Digital Signal Processing (DSP) card in case of real-time image processing experiments. Otherwise, LabVIEW in conjunction with commercial measurement and experimentation platforms such as NI ELVIS II, VISIR, and CompactRIO has facilitated the adoption of remote laboratories at many universities.

Remote experimentation is important [12] by presenting several labs, in special, the VISIR platform for electrical experiments. Remote labs are indispensable and cannot be substituted by virtual labs because they offer the possibility of seeing the differences between the results of calculations based on models and the actual behavior of the physical world.

2.2 VISIR technical features

The VISIR system was developed at the Blekinge Institute of Technology (BTH), Karlskrona, Sweden, in 1999, and its functionalities and user community have been growing ever since. It is currently used at several academic institutions worldwide: the Polytechnic of Porto.—School of Engineering (ISEP), Porto, Portugal; the University of Deusto, Bilbao, Spain, and the UNED - Spanish University for Distance Education Madrid, Spain; the Carinthia University of Applied Sciences, Klagenfurt, Austria, and Vienna University of Applied Sciences, Vienna, Austria; and the Madras Institute of Technology, Madras, India. Several of these institutions have reported technical and pedagogical conclusions on the operational use of VISIR laboratories. VISIR is an open remote lab designed for experiments with electrical and electronic circuits [13]. The user interface replicates a physical breadboard, showing all available components and the instrument front panels so a user can connect the desired circuit and analyze its behavior with several instruments (Figs. 5, 6)

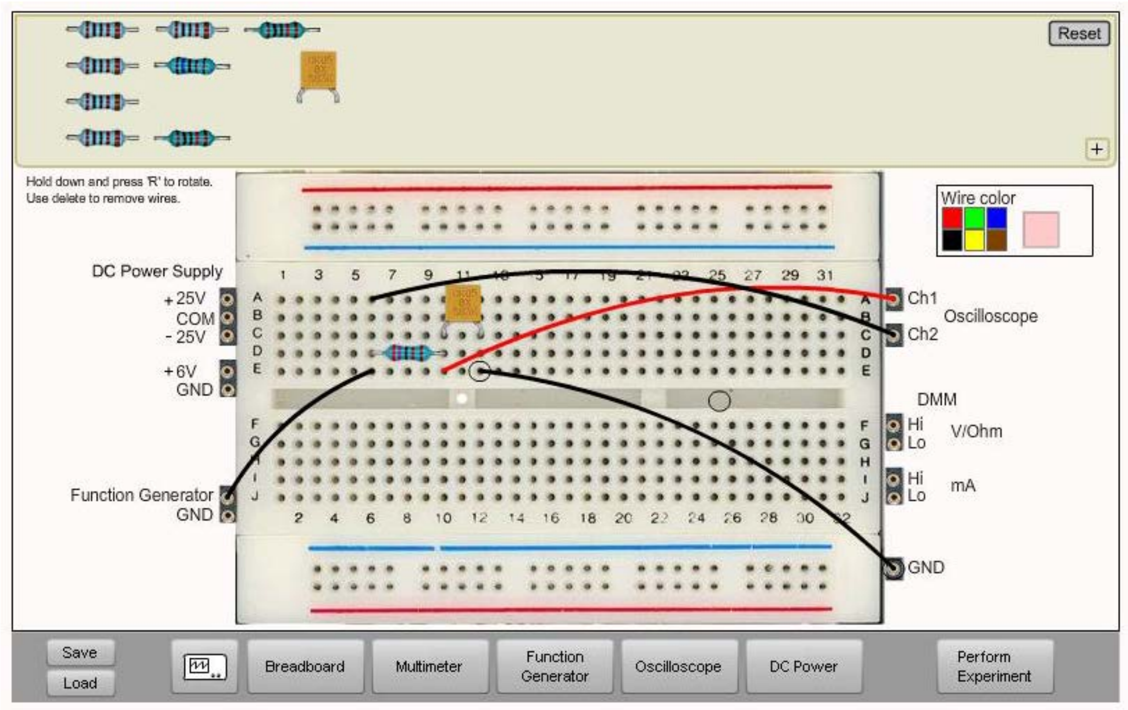

Figure 5. The VISIR Lab Client

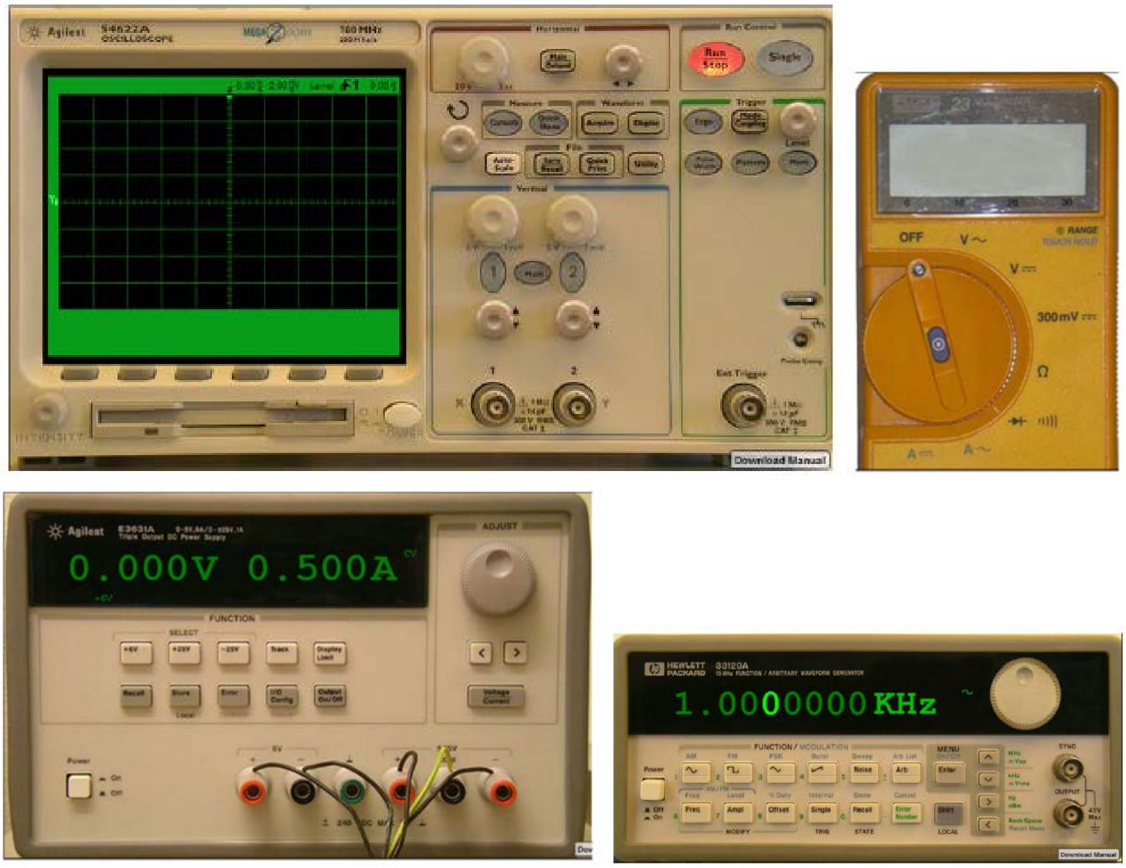

Figure 6. Remote operated instruments: Oscilloscope, DMM, Power Source and Function Generator

An identical simulation of the real equipment and instruments appears on the student PC-screen that makes him familiar with the real instrument models and types. The student starts to adjust the instruments and wires his circuit with his PC-mouse. Then, VISIR converts the student's design to a real wired circuit and sends to him, on his PC-screen, the measurement results. Thus, VISIR creates a real electronic lab environment to the student which can be accessed at any time and from anywhere as long as the student have a PC connected to Internet [12, 13].

Fundamentals of electronic circuit's practices encompass the basics of electronic circuit's components such as resistors, diodes, capacitors and inductors. As well, the adjustment of electrical instruments such as power supply, function generator, oscilloscope, and multi-meter, and wiring and building circuits in order to realize and monitor measurements. Thus, they have an intrinsic role in electrical engineering education. Remote laboratories have made this type of practices affordable and accessed at any time and from anywhere [14].

Standards for instrument drivers are already available [15]. VISIR recommends the standard IVI (Interchangeable Virtual Instrument). The IVI Foundation, http://www.ivifoundation.org, is a group of end-user companies, system integrators, and instrument vendors, working together to define standard instrument programming APIs (Application Programming Interface). The IVI standards define open driver architectures, a set of instrument classes, and shared software components. Hardware platforms such as PXI (PCI eXtensions for Instrumentation), http://www.pxisa.org or LXI (LAN eXtensions for Instrumentation), http://www.lxistandard.org/home, are recommended.

The concept will be expanded to laboratories for physical experiments in other areas which are feasible to perform experiments using remote operation. A VISIR Consortium chaired by BTH will be formed to release new extended future versions.

In [16] in given an overview on the usage and the implementation of VISIR in academic courses, a general summarized overview on its installation, however, focused on the administration and the accessibility features provided by the web interface, which facilitates the remote connection between the teacher, the students and the laboratory. Fig. 7 shows the overall operation process of VISIR with the four principal components:

- Equipment Server
- Measurement Server
- Web Server
- Web Interface

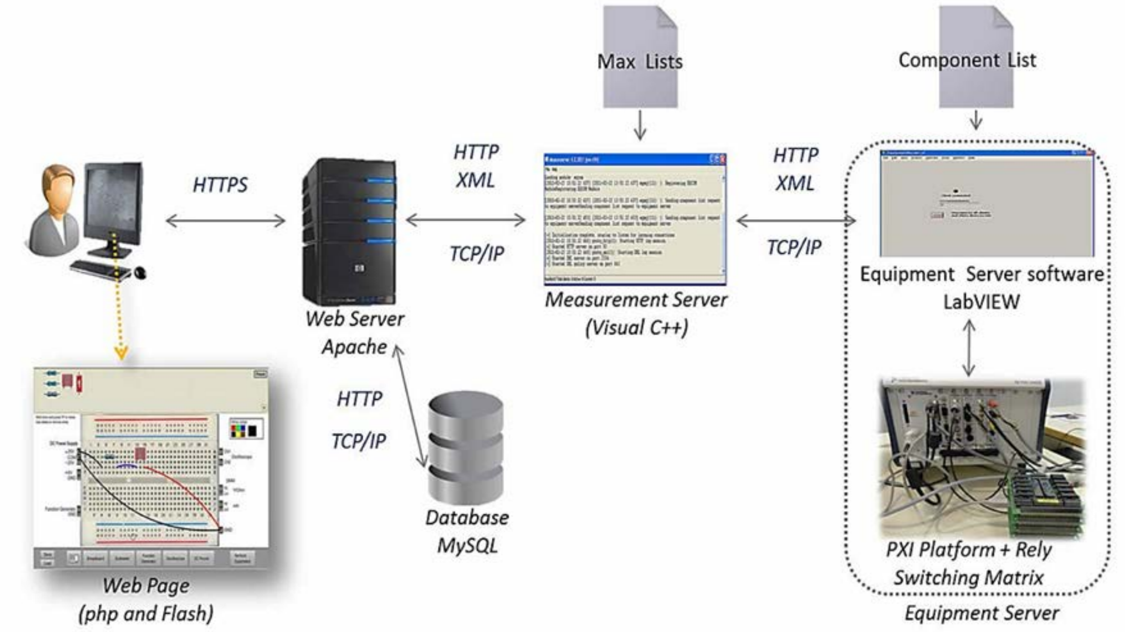

Figure 7. Overall operation process of VISIR [16]

- **Equipment Server**: It comprises all the lab equipment; the PXI platform connected to the relay switching matrix, both are controlled by a server written in LabVIEW. It receives the commands from the measurement server over TCP/IP to be executed on the real instruments. The commands are sent in form of XML-based protocol (experiment protocol) on HTTP. A "component list" file is inserted to the equipment server to define the components installed on the matrix.
- **Measurement Server**: It is a server written in Visual C++ for Microsoft. It acts as a virtual instructor that controls the commands passing from the web interface (and received over TCP/IP) to the equipment server. That is, in order to prevent hazard circuit designs and protect the instruments. It is programmed by "max list" files which contain the maximum component values and instruments adjustments for each experiment.
- **Web Server**: It is the server that hosts the VISIR web interface. The web interface is written for Apache server against MySQL Database.
- **Web Interface**: It is the website of VISIR (written in PHP) with the experiment client integrated inside (written in Flash). The student accesses the website through the secured protocol https, after getting authenticated, he/she begins to design his/her circuit in the experiment client. This design is sent to the measurement server to be verified then to the equipment server to be converted into a real wired circuit and the measurement results appear through the virtual instruments on the user PC-screen. VISIR has its own Learning Management System (LMS) as a web interface in which the lab contents are arranged and through which they are accessed.

3. The course *Circuits Fundamentals and Applied Electronics*

CFAP (Circuits Fundamentals and Applied Electronics) is the VISIR-based MOOC course, developed under the MOOC platform edX with YouTube as video provider. In order to extract indicators previously is necessary a little review of the MOOC concept and the edX platform under which the course is developed.

3.1 The MOOCs

The MOOCs (an acronym for Massive Open Online Courses) online courses are aimed at a wide number of participants over the Internet on the principle of open education and massive. The term was coined in 2008 by Dave Cormier and Brian Alexander. While not completely defined the characteristics of the MOOC, some of them are [17]:

- Massive access to hundreds of thousands of students from around the world interested in a specific topic.
- Free, open access, it does not require a previous test or be a student of the institution offering the MOOC knowledge.
- Free access it does not require payment for access to content and the platform that makes the course. However, it could be tariffed access to tutorials, evaluations or accreditations bibliographic resources.
- Fully online development that allows using the potential of Internet (audio, text, video, animation).
- Interaction (asynchronous or synchronous) online among students through forums or video conferencing tools (hangouts, for example). It is important that there is some interaction student-student and student-teachers, although this is mediated technology
- It consists of a training designed and oriented learning is evaluated in a series of tests that prove to have acquired knowledge.
- It is done online and shares with distance learning mediated Internet, features such as scheduling and planning activities, mentoring students, learning assessment, etc.
- Its structure is designed to promote independent student learning, with many resources in the form of videos, links, documents and forums for debate and communication.
- The content developed by teachers and materials or tools used in the development of the MOOC courses should be open, with a license allowing reuse them.

A very good dissertation about MOOCS is given in [18]. It focusses on two specific types of distance learning conducted online —MOOCs and SPOCs— which differ primarily in the sizes of the student populations to which they cater. An MOOC is an open-access online course (i.e., without specific participation restrictions) that allows for unlimited (massive) participation. Many MOOCs provide interactive elements to encourage interactions among students and between students and the teaching staff, although the latter is not a defining requirement. An SPOC (Small Private Online Course) is an online course that only offers a limited number of places and therefore requires some form of formal enrollment. SPOCs frequently have a competitive application process and might charge a tuition fee.

These definitions enable us to classify online distance learning applications according to two dimensions: the number of participants and the degree of time dependency (see Table 1). MOOCs, in addition to being unlimited in size, traditionally include students who are separated both by space and by time, enabling students to learn independently at their own pace without the requirement to stick to a specific schedule. Some massive online courses, however, require all students to be 'present' at the same time, for example, due to the use of live streaming or the requirement of group work done in real-time online. The term SMOC (Synchronous Massive Online Course) is used to refer to these courses. In a similar spirit, when referring to classes for which the number of participants is limited, we use the term SSOC (Synchronous Small Online Course) to refer to courses in which all students must participate in real time, and SPOC otherwise. The two dimensions of class size and time dependency can be complemented by other classification characteristics, such as the ability to earn credits (degree vs. non-degree awarding course) or whether attendance is free or fee-based.

			Number of Participants	
			Unlimited	**Limited**
Time Dependency	**Asynchronous**	*Distance Learning*	*MOOC (Massive Open Online Course)*	*SPOC (Small Private Online Course)*
		Traditional Learning	*e.g., community college offering several time slots for the same fundamentals course, which gives quasi-asynchronous choice to a student*	*e.g., individual/ small-group language tutorials with a private teacher scheduled according to student availability*
	Synchronous	*Distance Learning*	*SMOC (Synchronous Massive Online Course)*	*SSOC (Synchronous Small Online Course)*
		Traditional Learning	*e.g., undergraduate lecture in amphitheater with stadium seating*	*e.g., PhD course on a specific method or research topic*

Table 1. Classification of online distance learning applications [18]

Interestingly, a stronger focus on social media applications is also expected to impact the design of MOOCs in the future. The vast majority of today's MOOCs are structured as weekly sequences of activities in which instruction is provided by videos or filmed lectures, supported by supplementary readings and assignments. Even MOOCs that are asynchronous are usually cohort-based in the sense that they are offered over a fixed period of time (6—10 weeks on average) in which each participant is expected to complete activities within a certain time window. MOOCs based on traditional lecture formats are commonly referred to as 'xMOOCs'— a term inspired by Harvard University, which used the prefix 'x' to indicate (offline) courses in the university's course catalog for which online versions were available. Some xMOOCs have online discussion forums that allow participants to engage with one another, but, as mentioned above, such interactions are not essential or integral to the course.

Combining MOOCs with social media platforms, which facilitate the creation and exchange of user-generated content [19, 20], will lead to the emergence of connectivist MOOCs, referred to as 'cMOOCs.' Social media applications constitute a central part of the cMOOC since they allow participants to create pedagogical materials —via blog entries, tweets, podcasts, and the like— that can subsequently be commented on and further enhanced by other participants. Instead of providing a formal curriculum, cMOOCs offer a set of course materials that each student can use, repurpose, and extend as necessary. This strong focus on collaboration and cooperation among students represents a fundamentally different teaching philosophy from the one underlying the xMOOC. In a cMOOC environment, the professor no longer fulfills the key function of transmitting knowledge; instead, she focuses on facilitating interactions. Table 2 provides a comparison between these two types of MOOCs.

	xMOOC	cMOOC
Professor	*Instructor, who designs a standardized course for everyone*	*Facilitator, who animates an individual learning process*
Participants	*Passive learners*	*Active contributors*
Pedagogy	*Predetermined content, based on a formal curriculum, using lecture style and (peer) evaluations*	*Collaboratively developed content without a formal curriculum, in seminar style without evaluations*
Pattern	*Structured with regular sessions over a fixed time period*	*Unstructured based on continuous learning*
Platform	*Centralization of content in one place*	*Decentralization of content across the network*

Table 2. Comparison of xMOOCs and cMOOCs along 5Ps [18]

A notable example of xMOOC [21] is Circuits & Electronics, one of the first MOOCs offered through an MIT nonprofit spinoff called edX (https://6002x.Edx.mit.edu). This course, which has enrolled more than 155,000 students worldwide, features textbook readings, design and lab exercises, and automated grading of tests.

There are two major MOOC players. In addition to edX, there's Coursera, a Stanford University spin-off now with 33 universities participating worldwide. Coursera's vision is, in part, "to give everyone access to the world-class education that has so far been available only to a select few." Coursera boasts more than 2.5 million students and 215 courses (https://www.coursera.org).

MOOCs [22] promise to open up higher education by providing accessible, flexible, affordable and fast-track completion of universities courses for free or at a low cost for learners who are interested in learning. The popularity of MOOCs has attracted a great deal of attention from HE institutions and private investors around the world seeking to build their brands and to enter the education market. Institutions will need to look more closely at and learn from the different initiatives outside traditional institutions that are developing new business, financial and revenue models to meet the different needs of new groups of learners in an open HE marketplace. Open education brings new opportunities for innovation in higher education that will allow institutions and academics to explore new online learning models and innovative practices in teaching and learning. At a national and international level, new frameworks for HE funding structures, quality insurance and accreditation to support different approaches and models for delivering higher education will be required. Policy makers will need to embrace openness and make education more affordable and accessible for all and at the same time be profitable for the institutions in an open higher education ecosystem.

3.2 The EdX platform

Founded by Harvard University and MIT in 2012 [23], edX is an online learning destination and MOOC provider, offering high-quality courses from the world's best universities and institutions to learners everywhere.

With more than 90 global partners, it is proud to count the world's leading universities, nonprofits, and institutions as our members. EdX university members top the QS World University Rankings® with its founders receiving the top honors, and edX partner institutions ranking highly on the full list.

EdX missions are:

- Increase access to high-quality education for everyone, everywhere
- Enhance teaching and learning on campus and online
- Advance teaching and learning through research

It was founded by and continues to be governed by colleges and universities. It is the only leading MOOC provider that is both nonprofit and open source.

Open edX is the open-source platform that powers edX courses and is freely available. With Open edX, educators and technologists can build learning tools and contribute new features to the platform, creating innovative solutions to benefit students everywhere.

The Open edX platform is a free--and open source--course management system (CMS) that was originally developed by edX [24]. The Open edX platform is used all over the world to host Massive Open Online Courses (MOOCs) as well as smaller classes and training modules.

Open edX includes:

- Open edX Studio
- The Open edX LMS (Learning Management System)
- The capa_module XBlock, which implements a set of problem types that are based on LON-CAPA problem types
- The ORA2 XBlock, which implements an open-response assessment problem type
- Discussion forum
- Open edX Insights

3.2.1 Open edX Studio

Studio is the Open edX tool used to build courses, used to create the course structure and then add course content, including problems, videos, and other resources for learners.

Studio is used to manage the course schedule and the course team, set grading policies, publish each part of the course, and more.

Studio is used directly through a browser, without any additional software.

3.2.2 Open edX LMS

The LMS is the Open edX tool that learners use to access course content, including videos, textbooks, and problems, and to check their progress in the course. The Open edX LMS can also offer a discussion forum and a wiki that both learners and course team members can contribute to.

For course team members, the LMS includes an Instructor Dashboard, with options to enroll learners, produce reports, and administer a course as it runs.

LMS is used directly through a browser without any additional software.

3.2.3 XBlock

XBlock is the component architecture for the elements of an Open edX course. Software developers build XBlocks to create independent course components that work seamlessly with other components in an online course.

For example, you can build XBlocks to represent individual problems, or text strings, or HTML content. In addition, XBlocks are composable: you can build XBlocks to represent larger structures such as lessons, sections, and entire courses. By combining XBlocks that serve a wide variety of purposes, from delivering text and video content, to presenting multiple choice and numerical questions, to supporting sophisticated collaborative and interactive learning laboratories, course teams can create rich and engaging courseware.

A primary advantage to XBlocks is that they are deployable. The written code can be deployed in any instance of the edX Platform or other XBlock runtime application, and then used by any course team using that system.

3.2.4 The edX courses Life Cycle

Managing, building, and running edX courses is a process that takes time, planning, and teamwork from multiple stakeholders at institutions. As you plan your course, keep in mind the different phases that your course will go through, as a way to for you to identify where you are and where you are going in that process. EdX provides [25] a roadmap for course development (Table 3) and an MOOC development checklist (Table 4)

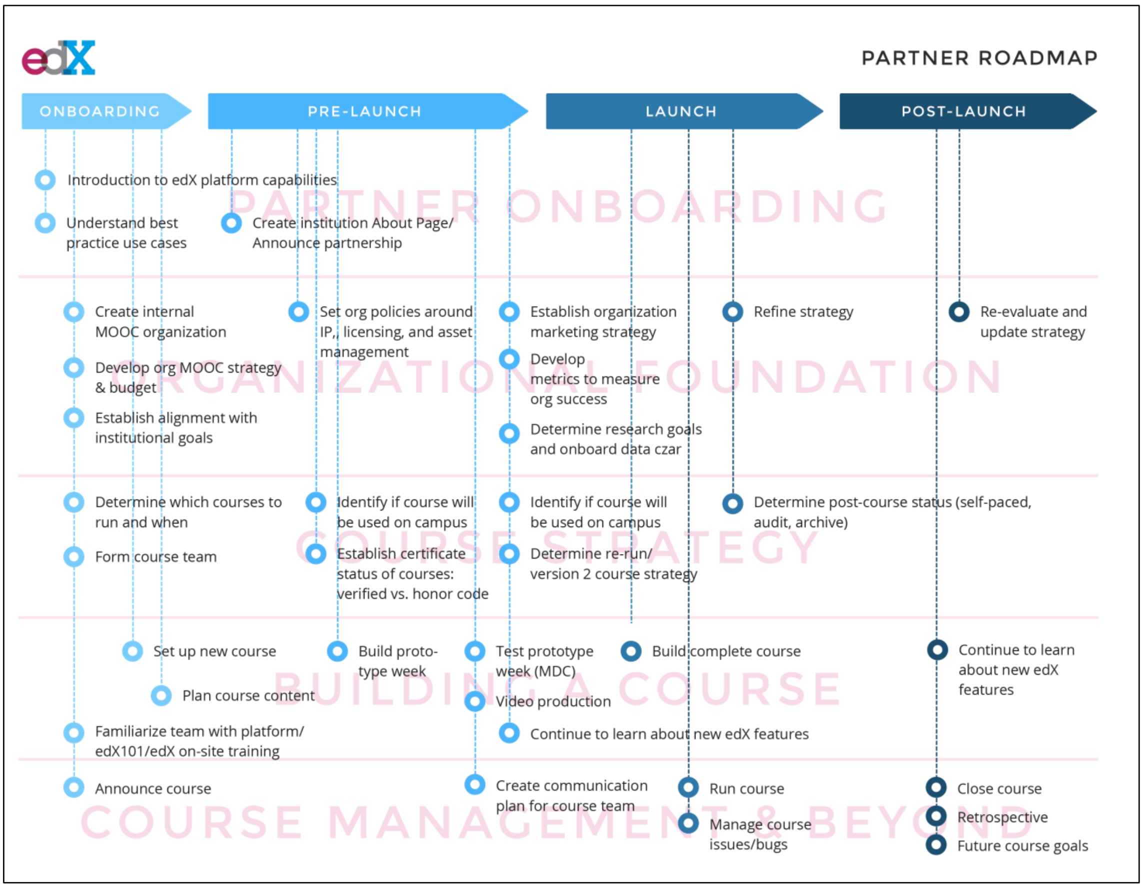

Table 3. Roadmap for course development [25]

MOOC Development Checklist

EdX is committed to delivering the best courses from the top faculty and instructors at the most highly regarded universities, colleges and other institutions throughout the world. In order to ensure that we maintain the highest degree of course quality, edX has developed the following MOOC Development Checklist ("MDC").

Course teams should use the MDC as a development tool for MOOC courses. EdX will use the MDC as the criteria for determining if a course is ready to be offered on the edx.org site.

0% **Not Passing**

Instructions

Step 1: Make a copy of the MOOC Development Checklist (File > Make a copy)

Step 2: As indicated in the "Link / Agreement" column, insert a link to the location in your course that completes the corresponding requirement or mark [x] stating your completion/intent to complete the corresponding requirement.

Step 3: Send your completed MDC review to checklist@edx.org and your edX Partner Manager. Course teams that undergo an MDC Review must submit this form 10 business days prior to the launch of their course.

Requirement	Link / Agreement	Complete?	Comments
Course Introduction	**To be completed by partner**	**This boxed section for edX use only**	
Welcome message posted on the Home page			
Learners new to edX are requested to view edX Demo101	<insert link to completed item>		
Welcome message prompts the learner on how to get started with the course (e.g. "To get started, click on the "Course" tab at the top of the page.")			
Explanation posted of how to get help with learner issues (e.g. "To get help with the course, click the Discussion tab and post a question. To get help with a technical problem, click Help to send a message to edX Student Support.")	<insert link to completed item>		
Course Syllabus			
Course syllabus is included as a separate static page or a PDF in the "Course Handouts" section			
Prerequisites for the course are clearly stated			
Time commitment for the course is clearly stated			
All course deadlines and due dates, including time zone differences, are clear			
Grading policy including the grade needed to receive a certificate is clearly stated			
Learning objectives, goals, and outcome(s) are clearly stated	<insert link to completed item>		
Academic Policy for the course is clearly stated			
Guidelines provided for discussion forum etiquette			
Expectations for frequency of learner forum participation in the course is clear			
Roles and expected level of involvement for Instructors/TAs is clear to students			
Schedule for releasing course content, and the expected frequency of course updates is clear			
Any unexpected changes to released content will be communicated clearly to students	[ ] I agree to do this.		
Course Structure and Design			
Course design intersperses instructional content such as videos and text with exercises	[ ] I have done this.		
Course has set a grading policy	<insert link to completed item>		
Course design is clear and consistent from week to week	[ ] I have done this.		
Assessments			
Course includes gradable assignments, e.g., exercises/homework/quizzes and assigns a grade	[ ] I have done this.		
Questions and prompts in assignment problems are articulated clearly	[ ] I have done this.		
Deadline for assignments are clear	[ ] I have done this.		
Course Videos			
Course includes original videos that are hosted in the edX video player	[ ] I have done this.		
Consistent and adequate video quality and audio levels	[ ] I have done this.		
Timed captions provided for all videos and audio content	[ ] I have done this.		
Other Instructional Material			
Any images used in the course are of consistent and adequate quality	[ ] I have done this.		
All content from third-party sources is integrated into the course material rather than linked to another site, if applicable	[ ] I have done this.		
All content is freely available to learners (e.g. open source, in the public domain, or cleared or paid for by your organization), if applicable	[ ] I have done this.		
Paid content is not required to achieve learning goals and is clearly marked as paid content, if applicable	[ ] I have done this.		
Off-platform content is optional and it is clearly noted that the link will take learners to a site outside of the course and the edX platform, if applicable	[ ] I have done this.		
Learner Engagement			
A welcome email message will be sent to learners on the course start date	[ ] I agree to do this.		
Email messages will be sent to learners to communicate the release of new content, provide updates on course events, and so on at regular intervals throughout the course (once a week is recommended)	[ ] I agree to do this.		
A closing email message to learners with final course details will be sent near the end date of the course	[ ] I agree to do this.		
Learners are encouraged to use the discussion forum to introduce themselves	<insert link to completed item>		
Certificate Preparation (courses ending after November 1, 2015)			
All certificate information is correct and has been uploaded in Studio	[ ] I have done this.		
Certificate templates have been reviewed by the course team and are approved to activate	[ ] I have done this.		
Reruns, Reusability, and Licensing			
All IP issues are cleared for the course and clearly documented	[ ] I have done this.		
Accessibility			
All team members have reviewed the edX Website Accessibility Policy [1]	[ ] I have done this.		
All team members have reviewed the Accessibility Best Practices Guidance for Content Providers [2]	[ ] I have done this.		

Footnotes:
[1] https://www.edx.org/accessibility
[2] https://edx.readthedocs.org/projects/edx-partner-course-staff/en/latest/accessibility/index.htm

Table 4. Development checklist [25]

3.3 The course features

According to the course itself,

https://coma.uned.es/course/bases-de-circuitos-y-electronica-practica-ii-3

Circuits Fundamentals and Applied Electronics responds to the need for open and freely access to information and knowledge of basic design of electronic circuits with real components and circuits. Access to a laboratory with the necessary equipment to analyze and evaluate circuit behavior and actual electrical and electronic components is often difficult, the cost of equipment to be used, the complexity of managing them or the organization of the teaching laboratories where they usually meet.

Experimentation allows empirical testing of the laws governing the electrical behavior of components and circuits, allowing to reproduce characteristic effects, analyze the limitations of the ideal modeling, etc. In short, experimentation can reinforce learning and build knowledge in a solid form.

The course is based on practical work on the platform of remote laboratory Virtual Instrument Systems In Reality (VISIR) housed in the Department of Electrical Engineering, Electronics and Control (DIEEC) of the School of Industrial Engineers (ETSII) of the Spanish University for Distance Education Madrid, Spain (UNED). Within the same, it will be used routinely simulation as a tool for the preparation and knowledge of the circuits with which it is going to work in remote.

3.3.1 Learning goals

Acquire practical skills in the analysis of electrical and electronic basic circuits in a laboratory with real components, in handling the equipment making up an electronics laboratory and employment and the behavior of real components. Consolidate the basic knowledge by acquiring such practical skills. Improve knowledge of the design of electrical and electronic circuits and expand the use of simulation tools in the design process of the circuits.

3.3.2 Recommended requirements

It is a course for the acquisition of practical skills in the laboratory, and although documents that support the various components and circuits will be provided, within the scope of the course is not the acquiring the basis for the analysis of electrical circuits. Therefore, basic knowledge is required in the electrical behavior of passive components (resistors, capacitors and inductors) and active (diodes, transistors and operational amplifiers).

Recommended knowledge will not be assessed at the start of the course with the idea that all students are in possession of them. For people who remain interested in the course despite not meet the recommended requirements, it is proposed the prior development and investigation of basic knowledge recommended in the large literature on the subject and / or performance is proposed COMA course (in English) created by the Massachusetts Institute of Technology (MIT) "Circuits and Electronics" (6.002x).

3.3.3 Intended audience

Grade students and postgraduates, graduates in engineering, science, physics, computer science, students and graduates in Professional Formation in technical areas, as well as anyone, that meet the recommended requirements, want to reinforce the knowledge acquired in the matter at hand the acquisition of practical skills in laboratory and electronic circuits and present concern interact with real components and equipment.

The effort required will vary depending on the competencies, skills and knowledge of each student. For those who meet the recommended requirements, a burden is estimated per module of 10 hours over the following tasks: assimilation of the materials provided, design and work with the theoretical model, design and work with the simulated model, design and work with VISIR actual model, post-practice work analyzing and comparing the results obtained in each of the previous phases and closing of completing assigned tasks module. In short, the workload of the course in hours is estimated at 80 hours which are provided two months, so it is recommended that each student performs a course of study according to their personal availability to complete the modules before the closing date.

3.3.4 Structure

The course structure consists of 8 modules:

- Module 1 is dedicated to electronics simulation: MicroCap software is proposed and several demonstratives videos and a manual are supplied to students together with documentation about the theoretical contents of the course.
- In Module 2 the remote laboratory VISIR is introduced to students, but they do not have granted access yet, demonstrative videos with the special features of every instrument and a manual are provided to students in order to familiarize with the laboratory workbench.
- From Module 3 to Module 8 students interact with lab, building real circuits with VISIR and taking measurements related to them. Every module is focused on one or more functionalities and handling of the laboratory instruments (breadboard, multimeter, function generator, power supply and oscilloscope). Module 3 and Module 4 aim especially in teaching the handling of the lab equipment, components and instruments, whereas Module 5 to Module 8 are centered on showing the behavior of real components and specific features of the instruments (coupling, trigger, cursors, measurements, etc).

3.3.5 Evaluation

The course [7] contains 97 evaluative activities, 55 standard multiple choice questions (including single-answer questions and multiple-answer questions) and 42 videos. The weight of the videos is 30% of the final grade and they need 80 over 100 to obtain the certifying badge. Besides this structure, two extra modules (one before the beginning of the course and another one once the students have completed the course) are responsible for compiling the students' profile and their knowledge level by means of optional surveys and questions about basic circuit analysis and electronics components. UNED-COMA platform doesn´t have any tool to carry out surveys, so an external tool has been used to accomplish it, therefore there is no way to identify the behavior of students according to their profile.

3.3.6 Administration and support issues

The remote laboratory reservation system is integrated into the platform of the MOOC, UNED COMA [26]. Its design allows several freedom degrees to administrators: number of slots per turn, time per turn, the number of simultaneous turns and the total number of allowed turns in the course. Adjusting these parameters, the administrators will be able to regulate the remote laboratory availability to the demand of use. In fact, this is one of the critical points for analyzing in this pilot MOOC: the adaptability of the remote laboratory VISIR to a MOOC. Unfortunately, the VISIR remote laboratory has some features that collide with a MOOC. The intrinsic limitations of a real laboratory such as VISIR collide with one of the most relevant features that any MOOC should achieve: scalability. The information collected during the course by the surveys, the VISIR performance and the demand for use will provide us the indicators about the optimal settings and the convenience of the use of VISIR from the first modules of the MOOC or delay its use until the number of participants has decreased. The initial settings allow 16 simultaneous users per turn, 60 minutes per turn, a maximum of 2 simultaneous turns booked and a limitation of 14 turns per course. With these settings, VISIR will allow up to 384 students to experiment with any of the designed practices of the MOOC every day.

To prevent students from having to manage two accounts (two users and two passwords), one for the platform of the UNED-COMA and one for VISIR, a reservation system was created on the platform of the UNED-COMA as a resource by developers of the platform. This resource is not designed exclusively for VISIR reservation system but is designed to add it as a calendar resource reservation in MOOCs teachers wishing to employ teams to bring different activities [27]. The Fig. 8 shows communication between UNED-MOOC and VISIR platforms.

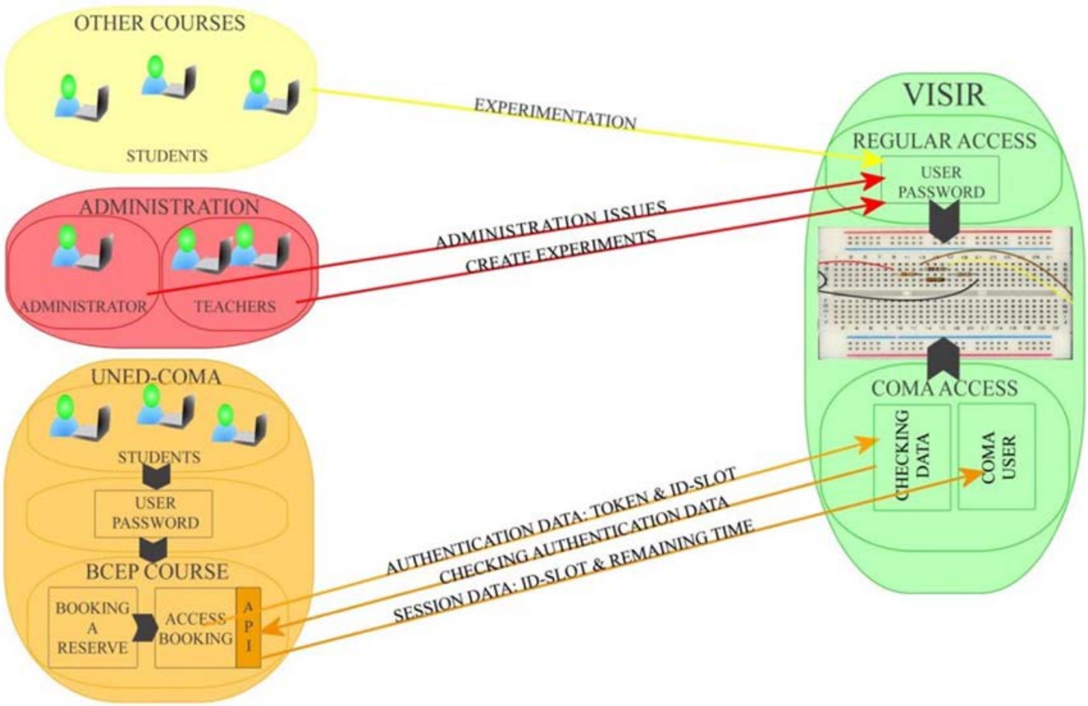

Figure 8. Communication between UNED-MOOC and VISIR platforms [27]

The MOOC has two different support levels:

- A mentor, in Spanish a "*facilitador*" that is continuously tracking any possible issue with the reservation system. Also, he helps the students trying to resolve any problem related to the documentation, the tools in the MOOC and general questions.
- When the problem is related to electronics, and although foundations knowledge is a prerequisite as commented, a teacher is accessible for helping the students.

As in many other current MOOCs, this one is almost completely based on self-learning and peer to peer collaboration.

4. Learning Analytics

As the Fig. 9 shows, the NMC Horizon Report: 2016 Higher Education Edition [28] predicts between its six key trends, six significant challenges, and six important developments in educational technology on the one hand as a Short-Term Impact Trend for the next one to two years the *Growing Focus on Measuring Learning*. Indeed, Learning analytics and adaptive learning, are a natural extension of the use of digital tools for learning.

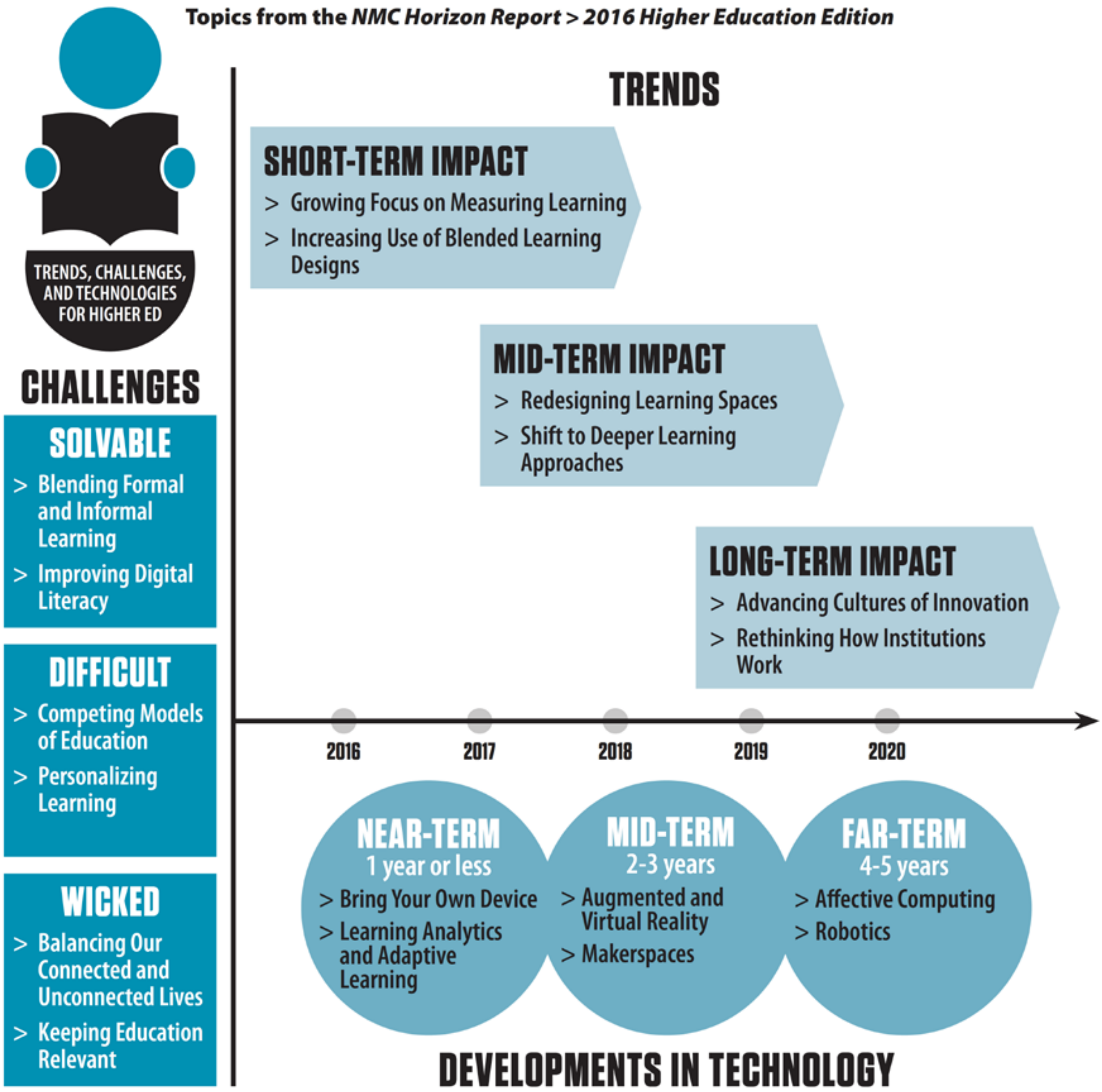

Figure 9. NMC Horizon Report: 2016 Higher Education Edition predictions [28]

With recent developments in online learning, in particular, students are generating an exponential amount of data that can offer a more comprehensive look at their learning. At the same time, the widespread use of learning management systems (LMS) including Blackboard and Moodle, which amass large amounts of data related to student activities, has generated increasing interest from universities in analyzing the available datasets. New and more robust incarnations of the LMS will be informed by a learning-centered model and rely on core functionality that includes personalization, analytics, advising, and learning assessment, as well as accessibility.

The NMC Horizon Report: 2016 Higher Education Edition [28] also predicts in a time-to-adoption horizon of one year or less as an Important Development in Educational Technology for Higher Education the *Learning Analytics and Adaptive Learning*.

Learning analytics is an educational application of web analytics aimed at learner profiling, a process of gathering and analyzing details of individual student interactions in online learning activities. The goal is to build better pedagogies, empower active learning, target at-risk student populations, and assess factors affecting completion and student success. Adaptive learning technologies apply learning analytics through software and online platforms, adjusting to individual students' needs.

By comparing and combining four models and frameworks of analytical process developed over time in a variety of disciplines (Knowledge Continuum, Five Steps of Analytics, Web Analytics Objectives, Collective Applications Model) [29] extracts seven related processes of learning analytics: Select, Capture, Aggregate & Report, Predict, Use, Refine and Share, summarized as follows in Table 5:

Knowledge Continuum	**Five Steps of Analytics**	**Web Analytics Objectives**	**Collective Applications Model**	**Processes of Learning Analytics**
		Define Goals	Select	Select
Data	Capture	Measure	Capture	Capture
Information	Report		Aggregate	Aggregate & Report
Knowledge	Predict		Process	Predict
Wisdom	Act	Use	Display	Use
	Refine			Refine
		Share		Share

Table 5. Comparison of ANALYTICS frameworks and models [29]

This work is centered on the uppers processes of the related Table 5, the selection of data for later treatment, the definition of basic indicators which by themselves or as a part of a high-level derivative indicator may help to the improvement of the course. After first stages of the upper vertex of Fig. 10 have been fulfilled then proceed that teaching staff analyzes and act to improve the course.

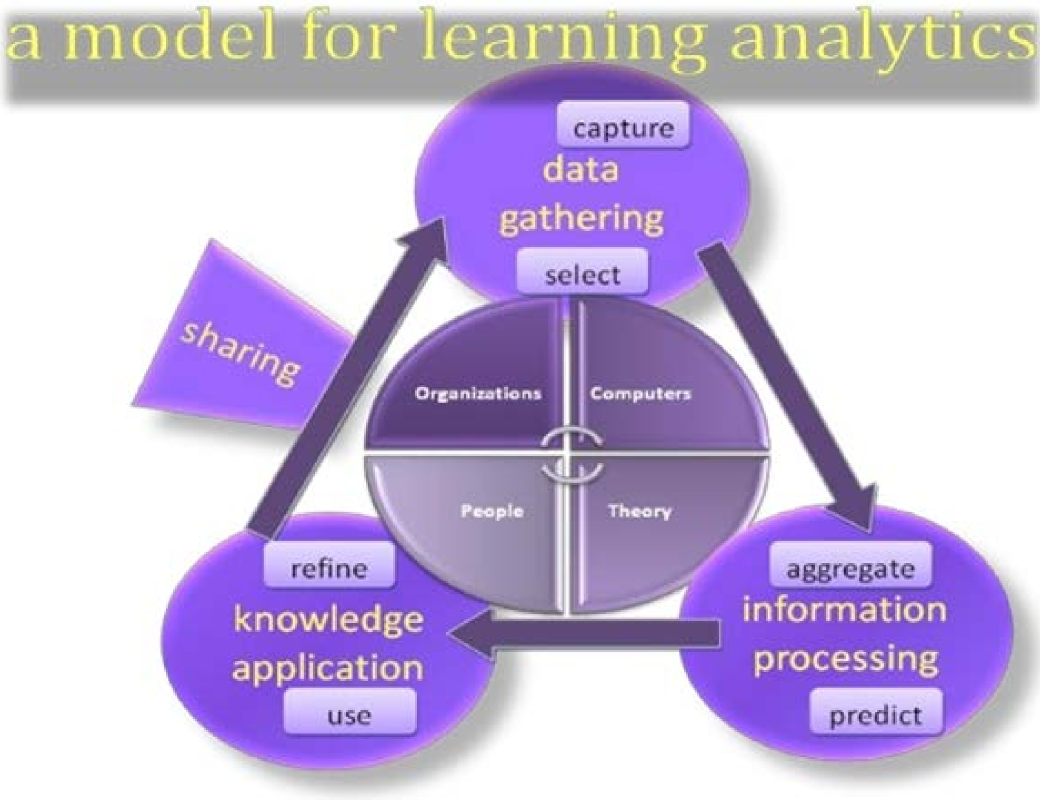

Figure 10. Learning Analytics continuous improvement cycle [29]

The standard *UNE 66175 Quality Management Systems. Guide to implementation of indicators systems* [30] defines *Indicator* as a data or data set that helps objectively to measure the evolution of a process or activity and *Control Panel* as a management tool that facilitates decision-making, and that includes a coherent set of indicators that provide to senior management and to responsible functions an understandable business vision of your area of responsibility. The information provided by the control panel allows focus and align management teams, business units, resources and processes with the strategies of the organization.

It can be understood LA as an extension of the management systems of continuous improvement (for example the model PDCA) with the process or activity to improve the MOOC course or one of its parameters.

The model PDCA (plan–do–check–act or plan–do–check–adjust) is an iterative four-step management method (see Fig. 11) used in business for the control and continual improvement of processes and products [31]:

- PLAN: Establish the objectives and processes necessary to deliver results in accordance with the expected output (the target or goals). By establishing output expectations, the completeness and accuracy of the specification is also a part of the targeted improvement. When possible start on a small scale to test possible effects.
- DO: Implement the plan, execute the process, make the product. Collect data for charting and analysis in the following "CHECK" and "ACT" steps.

- CHECK: Study the actual results (measured and collected in "DO" above) and compare against the expected results (targets or goals from the "PLAN") to ascertain any differences. Look for deviation in implementation from the plan and also look for the appropriateness and completeness of the plan to enable the execution, i.e., "Do". Charting data can make this much easier to see trends over several PDCA cycles and in order to convert the collected data into information. Information is what you need for the next step "ACT".
- ACT: If the CHECK shows that the PLAN that was implemented in DO is an improvement to the prior standard (baseline), then that becomes the new standard (baseline) for how the organization should ACT going forward (new standards are enACTed). If the CHECK shows that the PLAN that was implemented in DO is not an improvement, then the existing standard (baseline) will remain in place. In either case, if the CHECK showed something different than expected (whether better or worse), then there is some more learning to be done... and that will suggest potential future PDCA cycles. Note that some who teach PDCA assert that the ACT involves making adjustments or corrective actions... but generally, it would be counter to PDCA thinking to propose and decide upon alternative changes without using a proper PLAN phase, or to make them the new standard (baseline) without going through DO and CHECK steps.

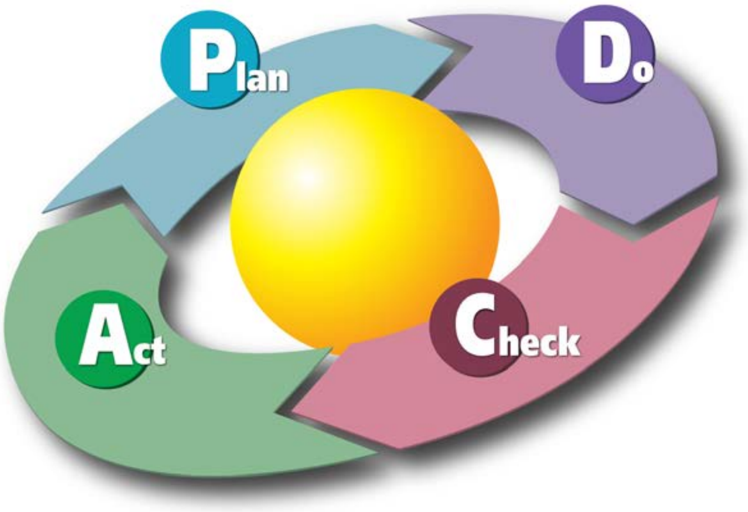

Figure 11. The PDCA cycle [31]

The information collected will be critical for deciding upon the new MOOC structure, the advisability or need of including theoretical contents as a part of the evaluative process and the depth of the contents, the stability and development needs of the MOOC platform and the performance, limitations and advantages that VISIR will provide the MOOC [26].

4.1 YouTube Analytics

There are three main parts of the YouTube Analytics dashboard [32, 33]:

- Real time – See how many people are watching your channel and views on the top few videos with estimated real-time views. This is especially helpful when you want to see how a newly uploaded video did. More details here.

- Watch time reports – Watch time is the total number of minutes of your video someone watches. Watch time is a key success metric on YouTube, and videos are ranked by how much watch time they have. Videos with higher watch times are likely to show up higher in search results and recommendations. In these reports, you can break down how many minutes people are watching, some information about who these viewers are, where they're discovering you from, and what parts of your video keep their attention or cause them to leave. Click for more tips on optimizing watch time.

- Engagement reports – See how viewers respond to your videos. Do they like or dislike them? Which ones got them talking in the comments that were shared with their friends on social media or added to a playlist on their channel? Did they click on additional features that you've added to your videos, such as cards?

Figs. 12 to 23 show examples related to videos of the course and some analytics of YouTube obtained:

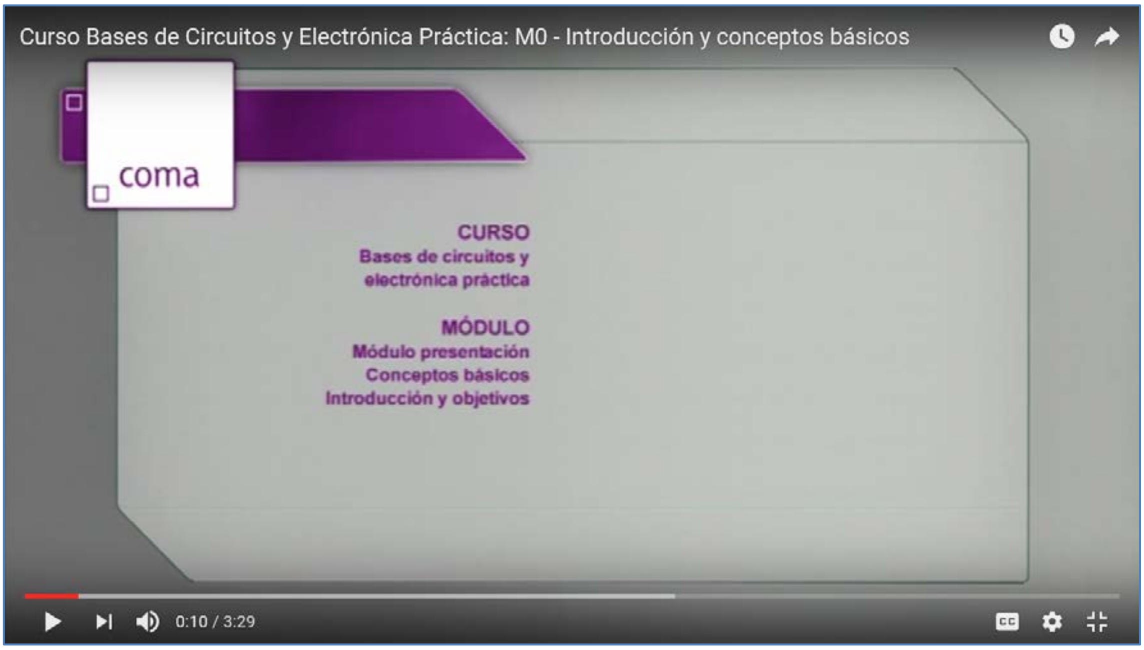

Figure 12. Video of Module 0

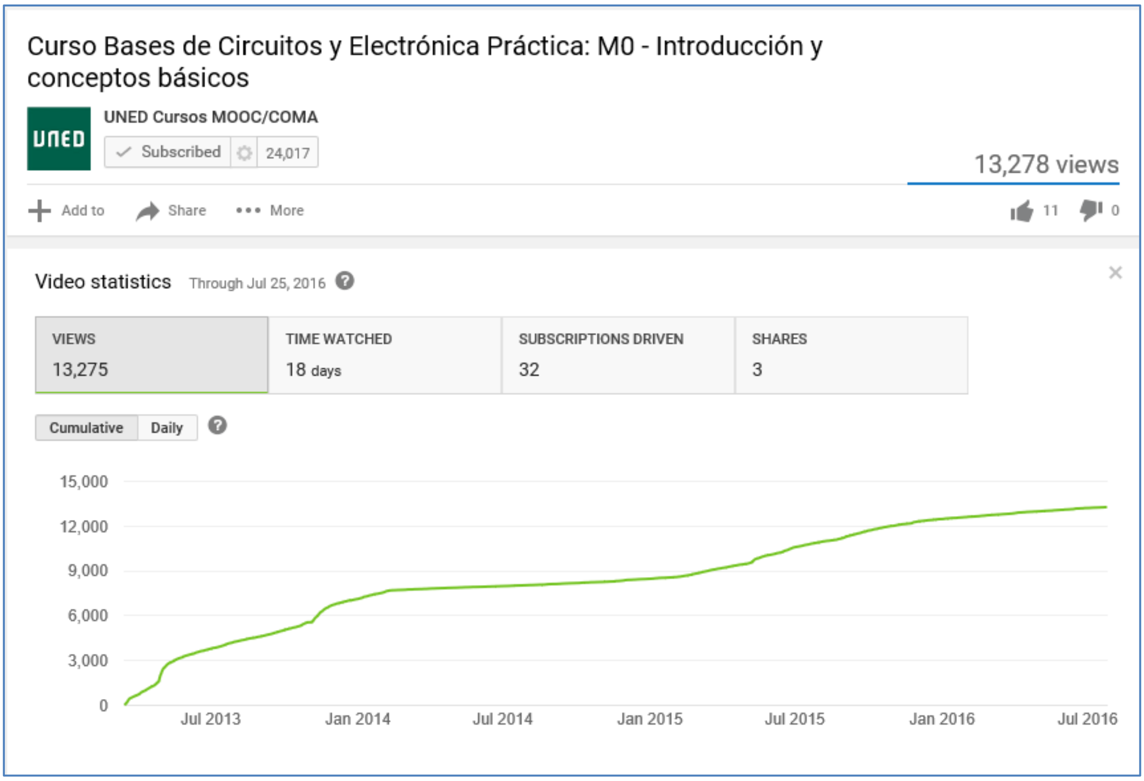

Figure 13. Video statistics of Module 0: evolution of views

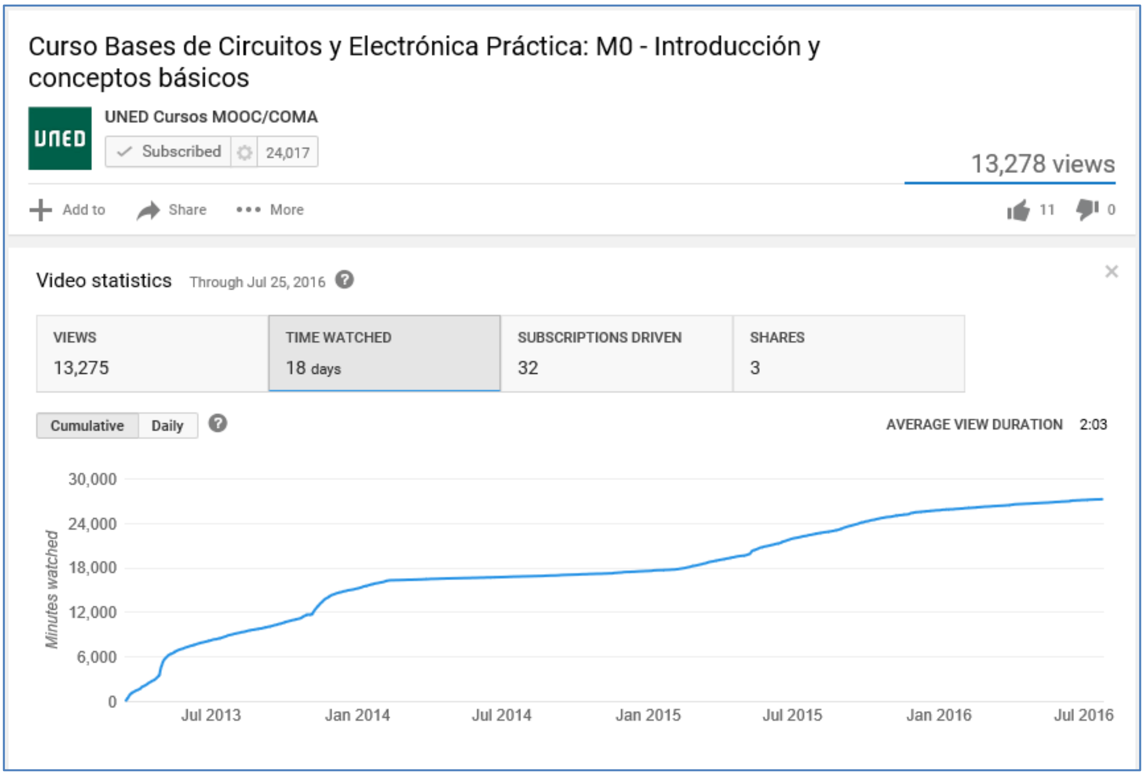

Figure 14. Video statistics of Module 0: evolution of time watched

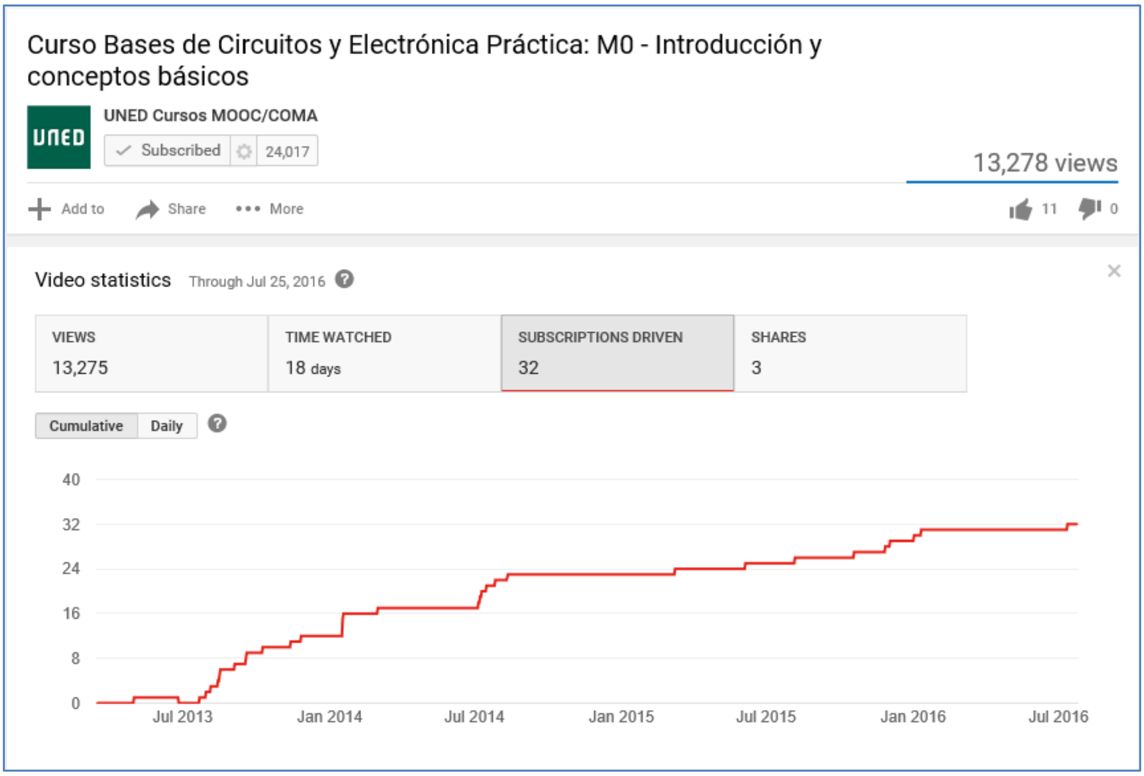

Figure 15. Video statistics of Module 0: evolution of subscriptions

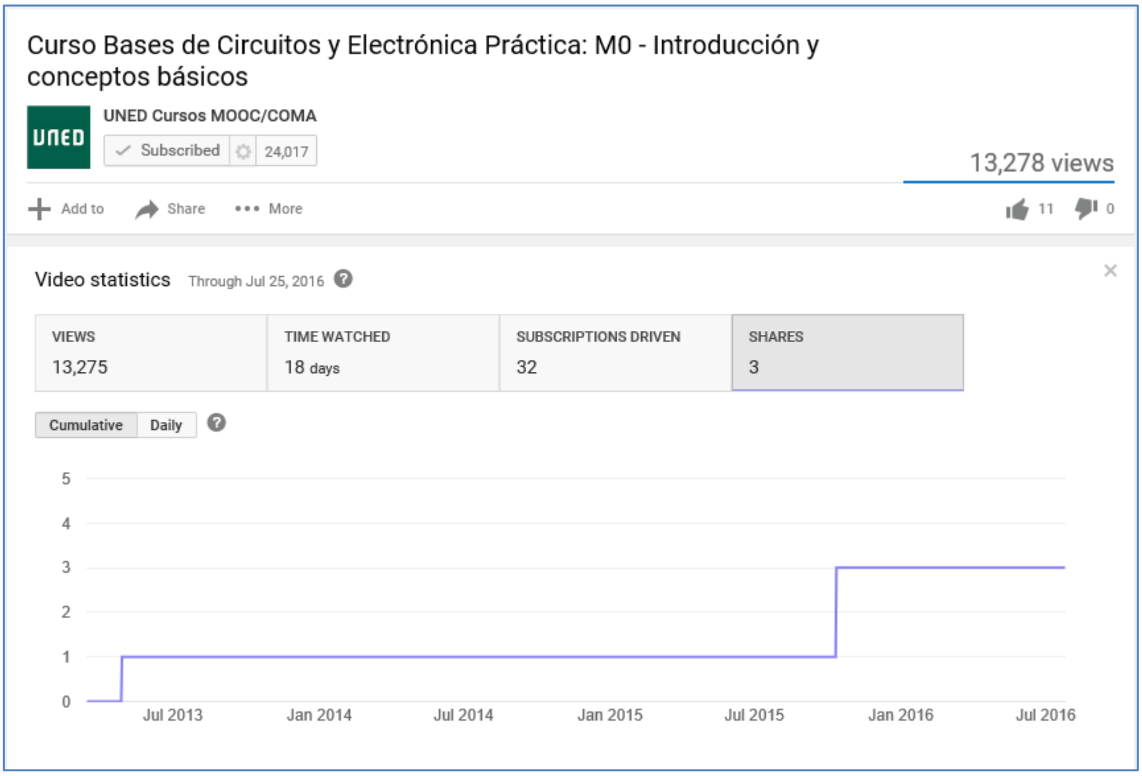

Figure 16. Video statistics of Module 0: evolution of shares

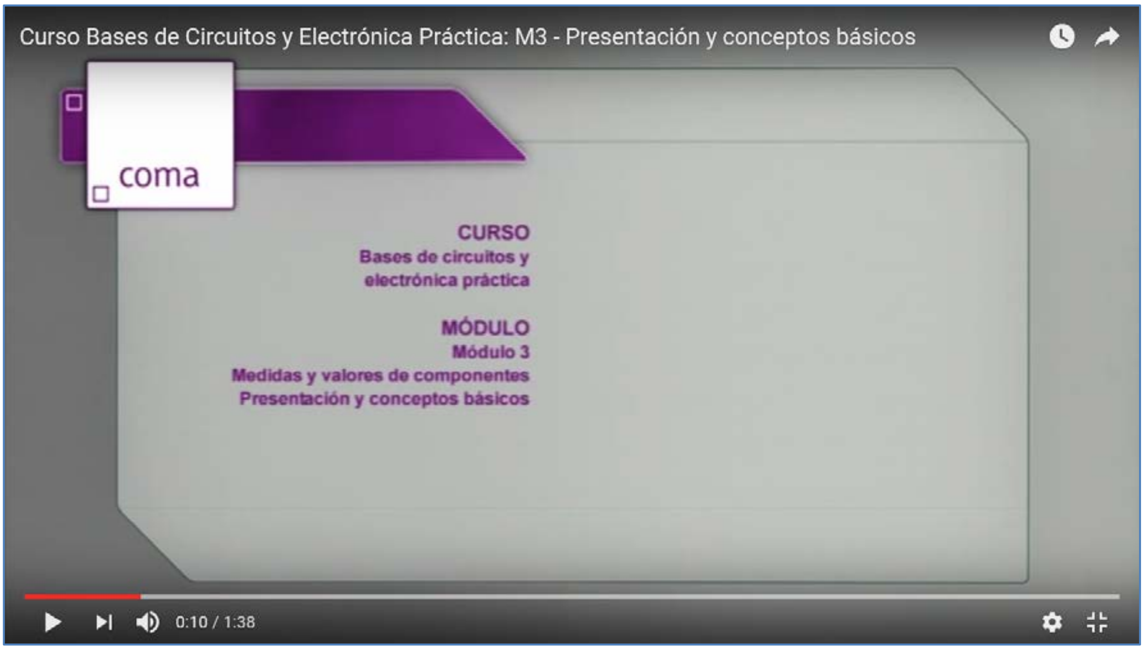

Figure 17. Video of Module 3

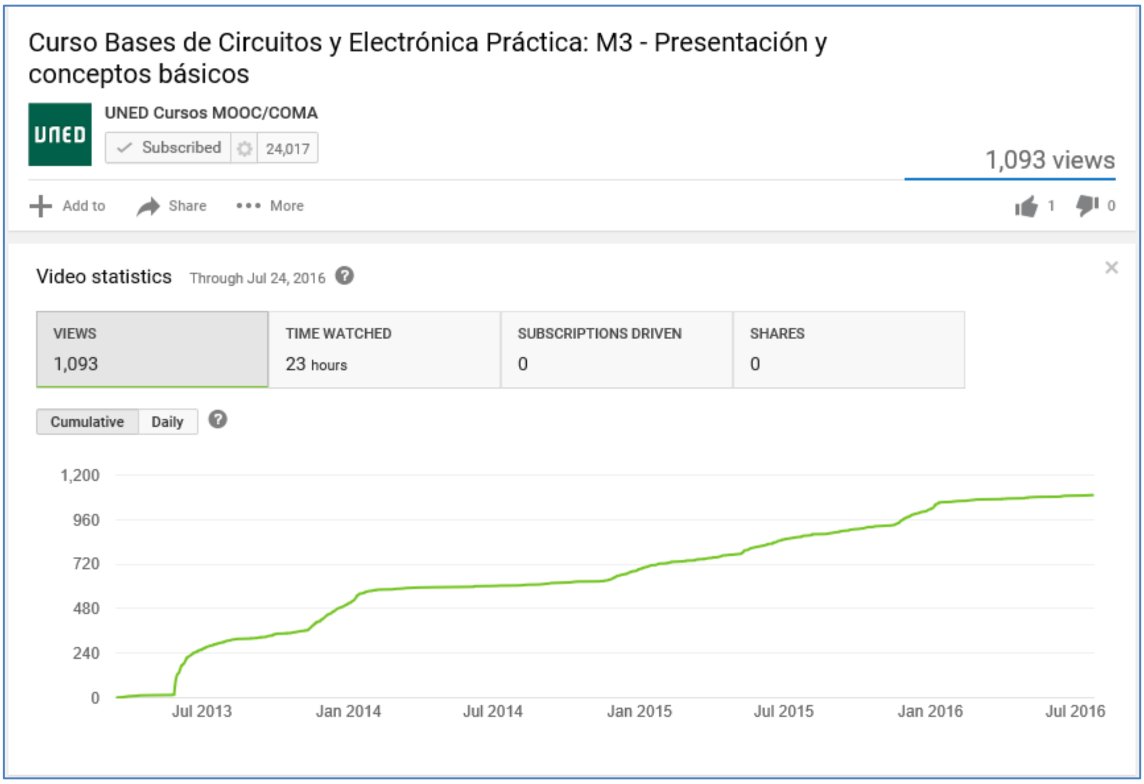

Figure 18. Video statistics of Module 3: evolution of views

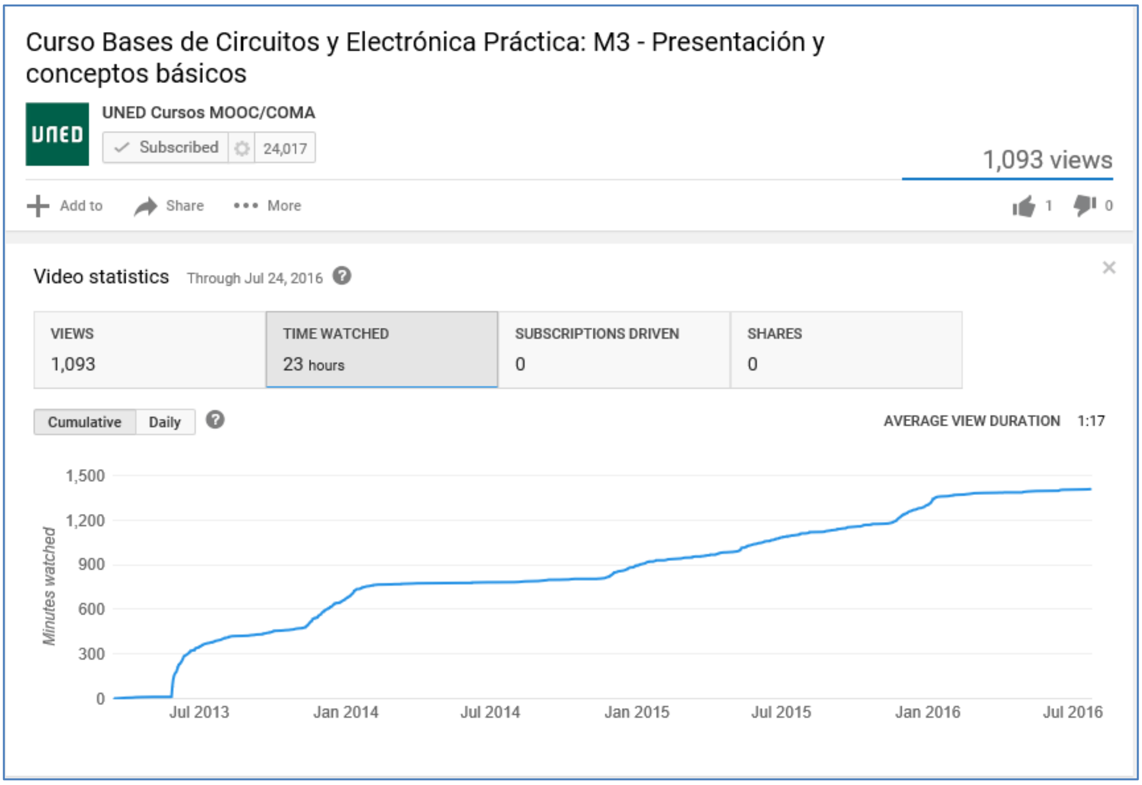

Figure 19. Video statistics of Module 3: evolution of time watched

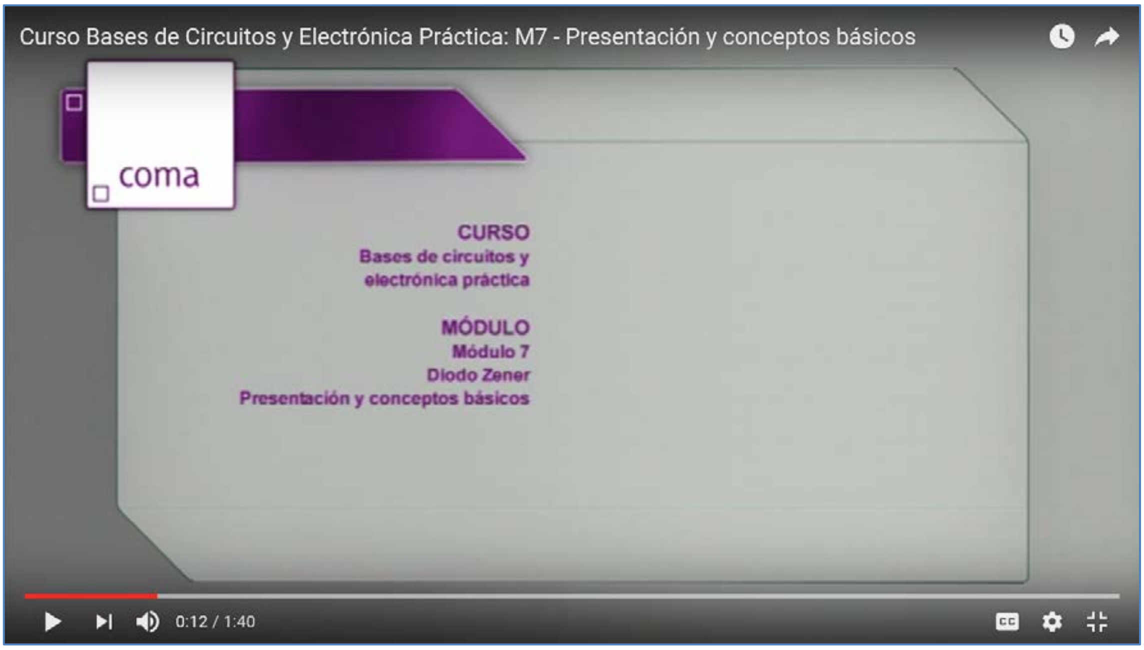

Figure 20. Video of Module 7

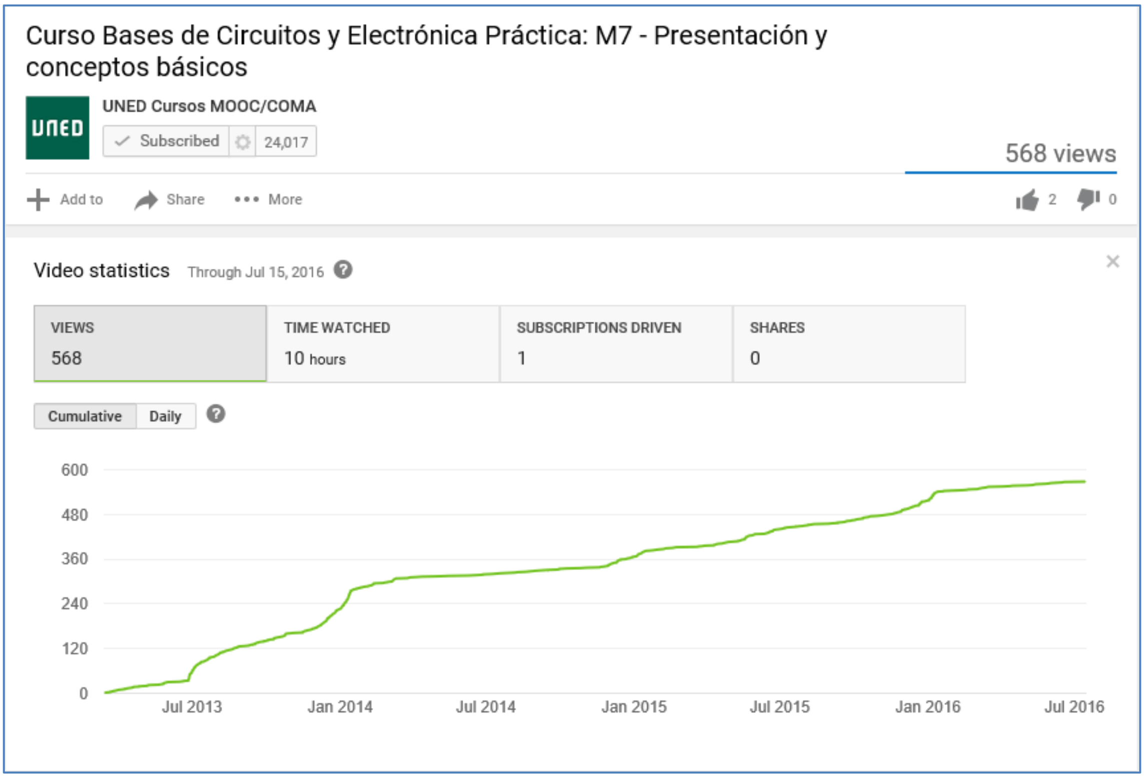

Figure 21. Video statistics of Module 7: evolution of views

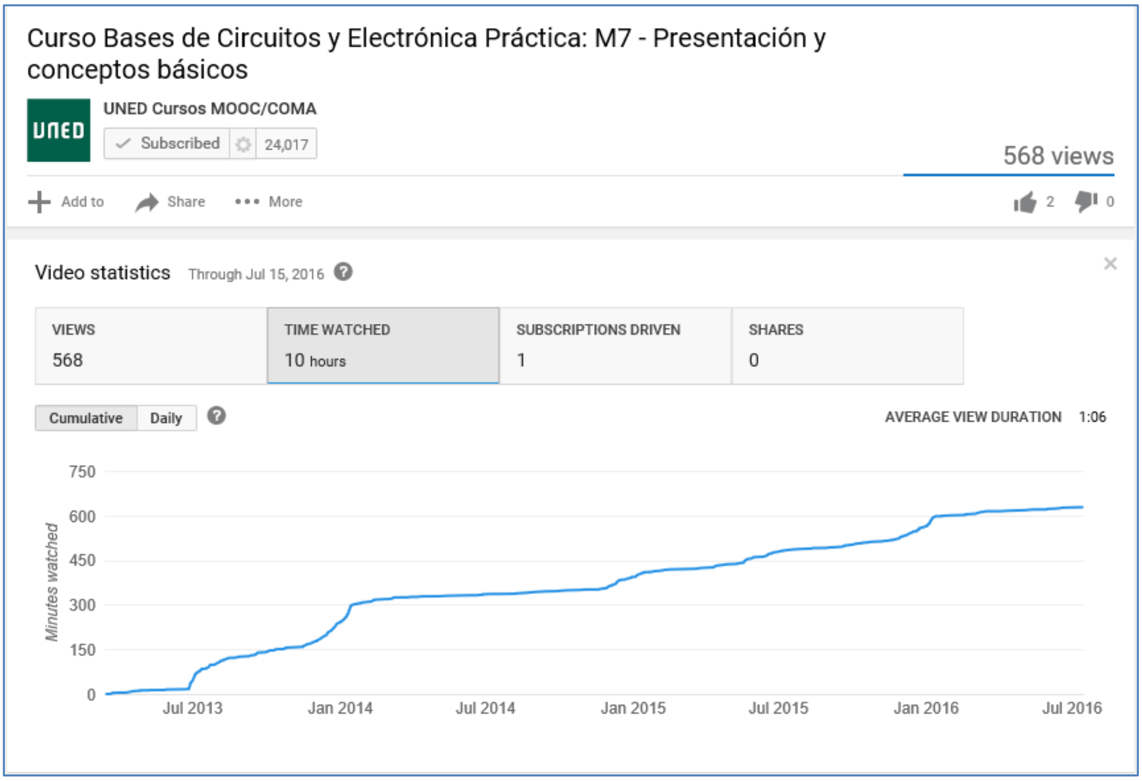

Figure 22. Video statistics of Module 7: evolution of time watched

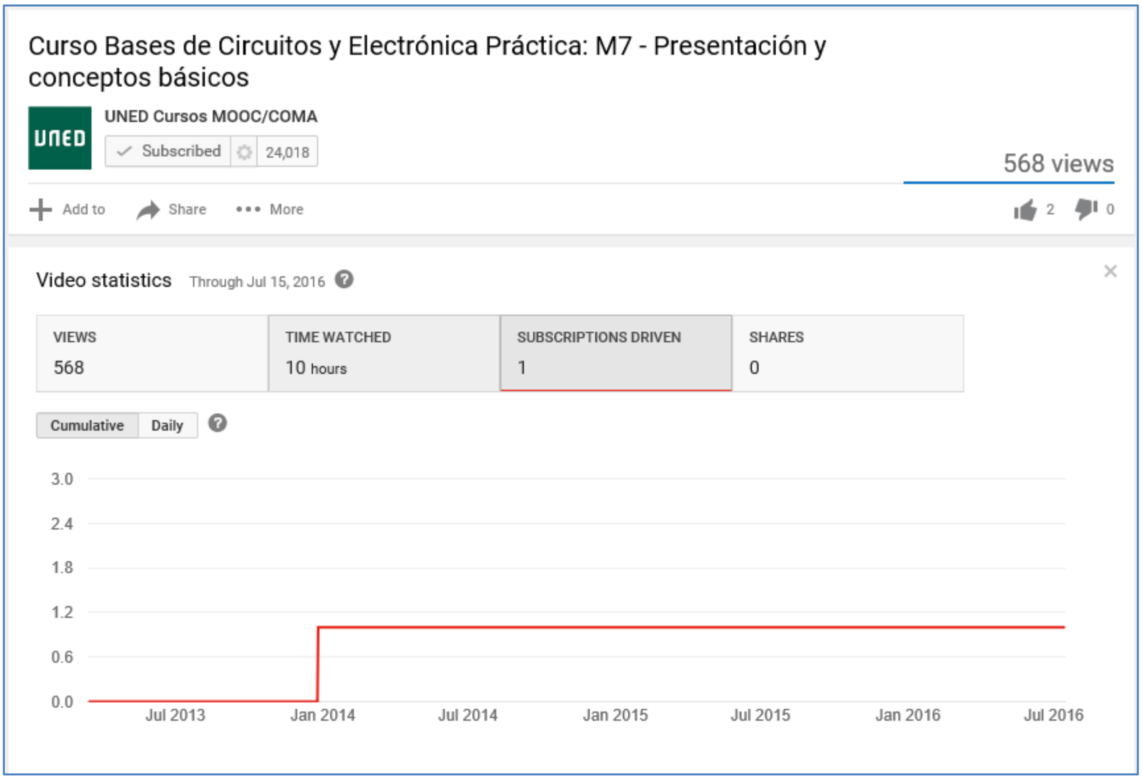

Figure 23. Video statistics of Module 0: evolution of subscriptions

4.1.1 Real-time report

Real time report can be used to see estimated views data for the last 5 published videos. For channels, it can also be used to see the total views for all videos on the channel. Real-time data is estimated and meant to provide general guidance on potential view activity on the videos. This report can give early insights into the performance of the most recently published videos. This data can be viewed in reports for individual videos.

4.1.2 Watch-time reports

Watch time helps creators understand the quality of their videos and how well different videos keep viewers engaged. Watch time is a more meaningful metric than counting just views.

YouTube Analytics displays watch time more prominently in reports. This makes it easier to check key metrics and understand what is driving success on the channel. All YouTube algorithms are also focused on watch time.

Key metrics include not only watch time but also related metrics like average view duration, average percentage viewed, and audience retention. These metrics can be used to learn how engaged viewers are and get insights into how to get them interested in watching more.

Watch time report

Watch time report can be used to see data about watch time and views. The report shows the following data collected from YouTube.com, the embedded player, and mobile YouTube apps. No personally identifiable information is collected or shared in the Watch time report.

Watch time: The amount of time that a viewer has watched a video. This gives a sense of what content viewers actually watch (as opposed to videos that they click on and then abandon).

Views: The number of legitimate views for your channels or videos.

Audience retention report

Audience retention report can be used to get an overall measure of how well your video keeps its audience:

- Average view duration for all videos on your channel
- Top videos or channels listed by watch time
- Audience retention data for a specific video for different timeframes
- Relative audience retention for a video compared to the YouTube average for similar videos

Absolute audience retention report can be used to see what parts of the video are most popular. The absolute audience retention curve shows the number of views for every moment of a video as a percentage of the total number of video views. Pay close attention to the first 15 seconds of every video — that's when viewers are most likely to drop-off.

Relative audience retention report can be used to see how the video compares to similar YouTube videos. Relative audience retention shows a video's ability to keep viewers compared to all YouTube videos of similar length. When the graph is higher, it indicates how many more viewers kept watching your video for that timeframe compared to the same timeframe in other YouTube videos.

Others reports

Although not directly related to the contents, other sources of indicators are cited, not as indicators content-based but yes as content-modifiers, that is, indicators that can modify the contents conforming to its conclusions:

- The Demographics report helps to understand the age range and gender distribution of the audience. It's based on logged-in users on all devices. Date range and geographic region can be changed to see how the audience varies by time and location. This data can be viewed in both interactive graphs and the chart at the bottom of the page.
- The Playback locations report shows the pages or sites that videos are being viewed on.

- The Traffic sources report shows the sites and YouTube features that viewers use to find the content. It can be used to get insight into the many ways viewers find videos.
- The Devices report gives information on the different devices and operating systems that viewers use to watch the videos. Device type tab can be selected to see if watch time and views are coming from computers, mobile devices, TVs, game consoles, or other devices. Operating systems tab can be selected to see the software system viewers use to watch content.

4.1.3 Engagement reports

Subscribers report

The Subscribers report shows how you've gained and lost subscribers across different content, locations and dates. Subscribers are viewers who tend to be more engaged with your content and watch your videos on a regular basis.

You can use the Subscribers report to understand:

- The effectiveness at building a base of subscriber
- What videos drove subscriptions or caused people to unsubscribe
- Where your content is popular

Likes and Dislikes report

The Likes and Dislikes report summarizes how many people liked and disliked your videos. The report shows the net change of likes and dislikes in your videos, so it adds up the number of likes/dislikes added, minus the number of likes/dislikes removed. Use the Compare metric button to compare the total number of likes/dislikes to other video metrics, including engagement metrics such as likes/dislikes added and removed, or subscribers and favorites change.

The table at the bottom of the page shows "Total engagement", which aims to help you understand which videos are attracting and engaging the audience the most. "Total engagement" includes the following data:

- likes, dislikes
- favorites added and removed
- shares
- comments
- subscribes and unsubscribes

Videos in playlists report

Videos in playlists report can be used to see how many times your videos were added or removed to viewers' playlists. This can be a default playlist, like "Watch later" or "Favorites," or any other playlist a user has created.

Comments report

The Comments report summarizes how many people are commenting on your video.

Sharing report

The Sharing report shows how many times your content has been shared through the Share button on YouTube, and what sites viewers are using to share your videos (e.g. Facebook, Tumblr, and Blogger). Click the Sharing service button underneath the Line chart/Map to view detailed information about those sites.

Annotations report

The Annotations report provides information on the performance of video annotations and gives engagement information such as click-through rate and close rate for annotations on videos.

- Impressions: Number of times an annotation was displayed.
- Clickable impressions: Number of times an annotation with the option to click further was displayed.
- Closeable impressions: Number of times an annotation with the option to close it was displayed.
- Click-through rate: The percentage of clickable annotations that received clicks
- Close rate: The percentage of annotation impressions that were closed by the viewer.
- Clicks: Number of clicks on annotations.

Cards report

Information on how viewers interact with cards on the videos in the Cards report. Cards can be used to add interactivity to the videos. Cards can point viewers to a specific URL (from a list of eligible sites) and show customized images, titles, and calls to action, depending on the card type.

4.2 EdX Analytics

EdX Insights [34] makes information about courses available to course team members who have the Staff or Admin role. EdX Insights provides these course team members with data about student activity, background, and performance throughout the course. Using edX Insights can help you monitor how students are doing, and validate the choices you made in designing your course. It can also help you re-evaluate choices and inform efforts to improve your course and the experience of your learners. Putting the data provided by edX Insights to work involves:

- Evaluating reported data against your expectations and hypotheses.

- Understanding the context of the course run: the environmental factors and choices that make each run unique.
- Deciding whether the action is called for.
- Selecting the action to take, and when.

EdX Insights includes a brief description for each reported value. To see these descriptions, move the cursor over the “i” information icons that appear at the top right of each chart or metric, as in Fig. 24.

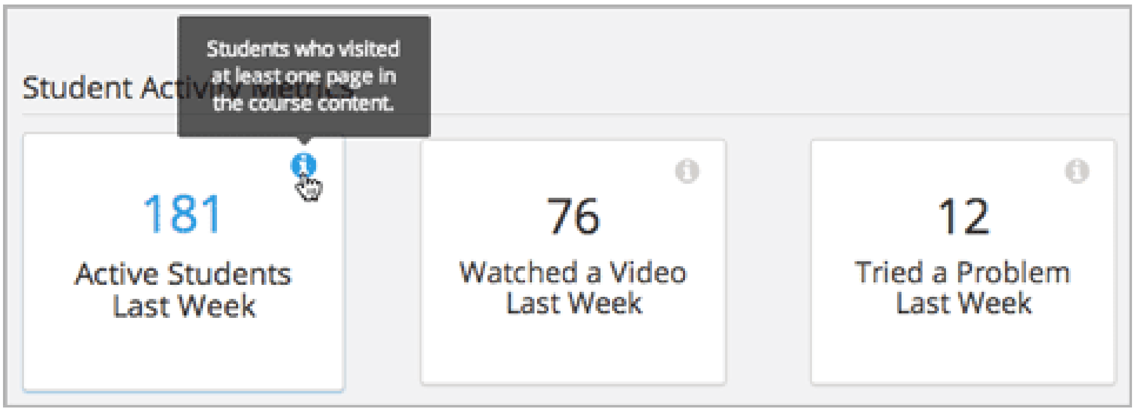

Figure 24. Student Activity Metrics

Graphs, metrics, and reports accessed in edX Insights, related with contents are:

- Learner Engagement
    - Engagement with Course Content
    - Engagement with Course Videos
- Student Performance
    - Graded Content Submissions
    - Ungraded Problem Submissions
- Individual Learners
    - Learner Activity

Insights has others sources of indicators not contents-based but yes content-modifiers, that is, indicators that can modify contents according to its conclusions:

- Enrollment
    - Enrollment Activity
    - Enrollment Geography
    - Enrollment Demographics

These indicators are not treated in this work.

4.2.1 Engagement with Course Content

How many of the enrolled students are actually keeping up with the work? What are they doing? Content engagement data helps you monitor how many students are active in your course and what they are doing.

Weekly Student Engagement Chart

The markers on this chart represent the number of unique students who interacted with course content. The graph plots three categories of engagement: an overall total of students who completed any type of course activity, and totals for students who played any course video and for students who submitted an answer for a problem. Each total is for activity completed within a one week period. To see the total count for each activity type for a given week, move your cursor over the chart to display a tooltip. Activity is included beginning with the week in which the first-page visit took place. The first-page visit is typically by a member of the course team shortly after course creation. This data is also available for review in tabular format and can be downloaded. See the Content Engagement Breakdown report.

Examples of the Weekly Student Engagement chart follow. The first example, Fig. 25, shows a course that started only a few weeks ago. Callouts provide context for the data that is shown by indicating several recent occurrences: the beginning of the beta test, the course start date, and the due date of the first homework.

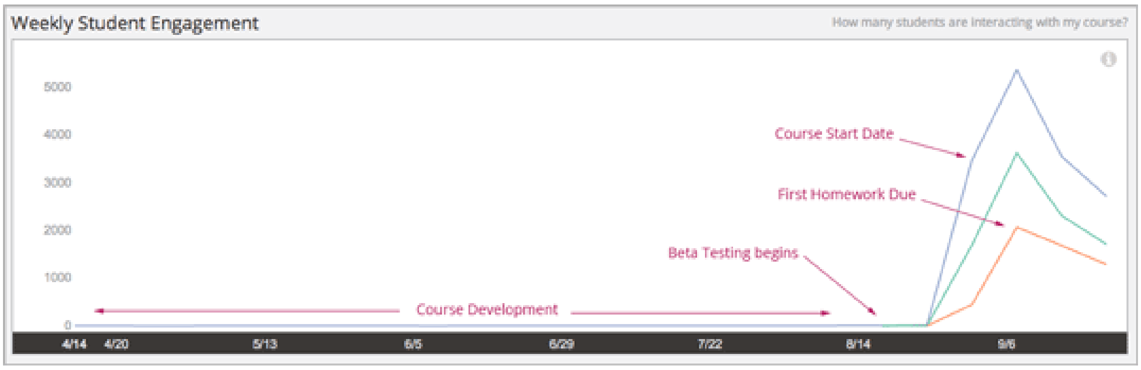

Figure 25. Weekly Student Engagement, first example

In the second example, Fig. 26, a small private online course was developed in one instance of the platform, and then exported and imported to a different instance just before the course start date. The tooltip shows the number of students engaging in different activities on the same day that the final homework was due.

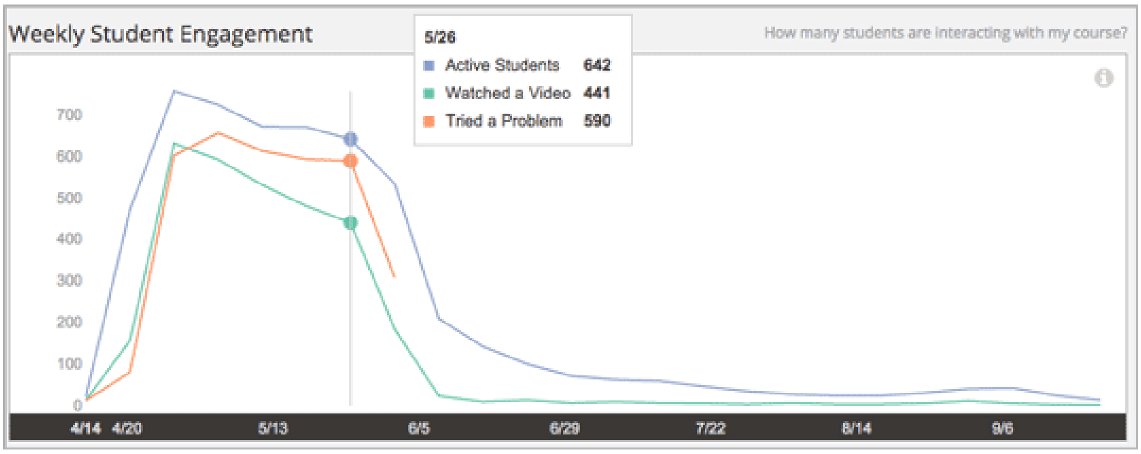

Figure 26. Weekly Student Engagement, second example

Active Students Last Week Metric

The number and percentage of students who, at least once, visited a page in the course during the last complete one week period.

Watched a Video Last Week Metric

The number and percentage of students who played at least one of the course videos during the last complete one week period.

Tried a Problem Last Week Metric

The number and percentage of students who submitted an answer for at least one problem during the last complete one week period.

Content Engagement Breakdown Report

The weekly breakdown of student engagement with course content is available for review or download. Columns show each Week Ending date and the count and percentage of active students, students who watched a video, and students who tried a problem.

You can download the Content Engagement Breakdown report in comma-separated value format: select Download CSV. The CSV file contains the following columns.

- any (active students)
- attempted_problem
- course_id
- created (shows the date and time of the computation)
- interval_end (shows the ending date of the one-week period)
- interval_start (shows the beginning date of the one-week period)
- played_video

4.2.2 Engagement with Course Videos

Are learners watching the course videos? Do they watch some videos more than others? Of those who watched a video, what percentage watched it to the end? Do learners watch certain parts of the video more than once? The video engagement data in edX Insights gives information to gain perspective on the learners' viewing patterns.

EdX Insights delivers data about learner engagement with videos in a series of charts and reports. Charts, metrics, and data are available for each of the videos in the course. A review of what learners in the course watch can lead to discoveries about the videos and about the course.

- Can be determined how many learners watch each video.
- Can be determined how many learners watch the entire video, and where the other learners drop out.
- Can be found video segments that learners watched more than once.
- Can be discovered what learners decide not to watch.

This information can be used to guide research on the video files and assess where to might make changes.

Video Views for Sections and Subsections

To access data about a video, select the section and subsection that contain the video. When made each of these selections, edX Insights provides data about complete and incomplete video views.

In this chart of video views for the sections in a completed course, Fig. 27, each bar represents the number of views of all videos in a section. Each of the bars is divided into the number of completed views in green and the number of incomplete views in gray.

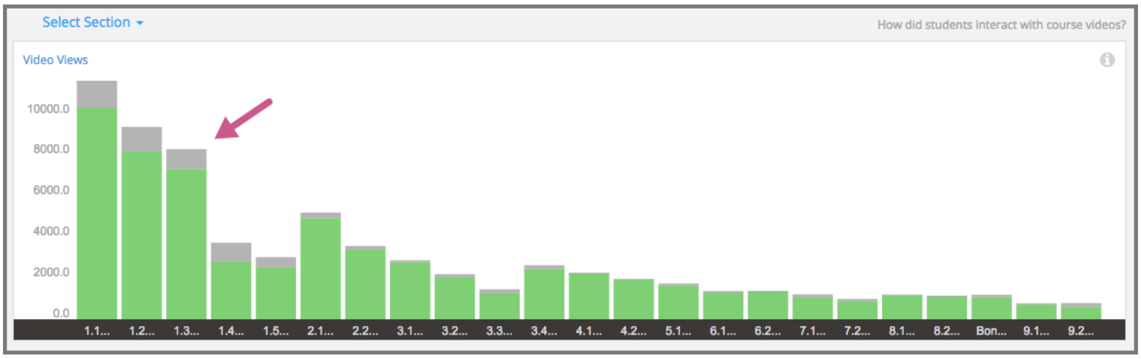

Figure 27. Video Views, first example

Reviewing the data in this chart might lead to investigate several questions. Understand why there are so much more incomplete views in some of the sections than in others. If the course has short videos in some sections, and comparatively longer videos in other sections, does that make a difference in the completion rates? Are there differences in quality? Could have, accidentally or deliberately, included the same video file in your course more than once?

In Fig. 28, when selected a section with a relatively low average of complete views, another stacked bar chart appears for the subsections in that section.

Figure 28. Video Views, second example

This chart, Fig. 29, helps to focus the investigation on the third subsection, in which the completion percentage dropped to 68%. After selecting that subsection, the chart for the actual counts of complete and incomplete views for the videos in the unit appears.

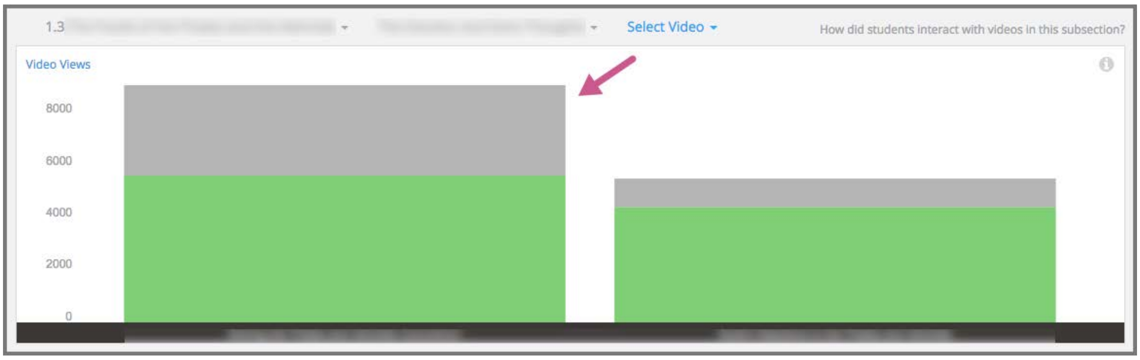

Figure 29. Video Views, third example

Once again, the data can help guide the investigation into possible causes for the disproportionate number of incomplete video views.

Researching Replayed Segments

When reviewed the chart for a video, in Fig. 30, it can be seen which five-second segments learners played more than once. The stacked area graph shows replays in darker blue above plays by unique users.

Once seen the graph for this video, it is decided to investigate what exactly happens at the 40-second mark.

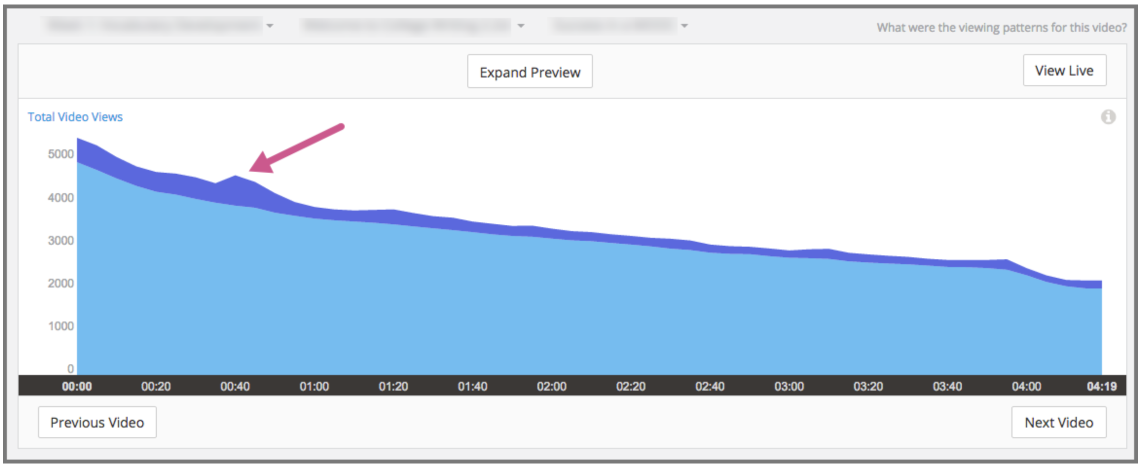

Figure 30. Total Video Views, first example

In this video, the stacked area graph shows that learners replayed certain segments of the video, particularly near the end, more often than others (Fig. 31):

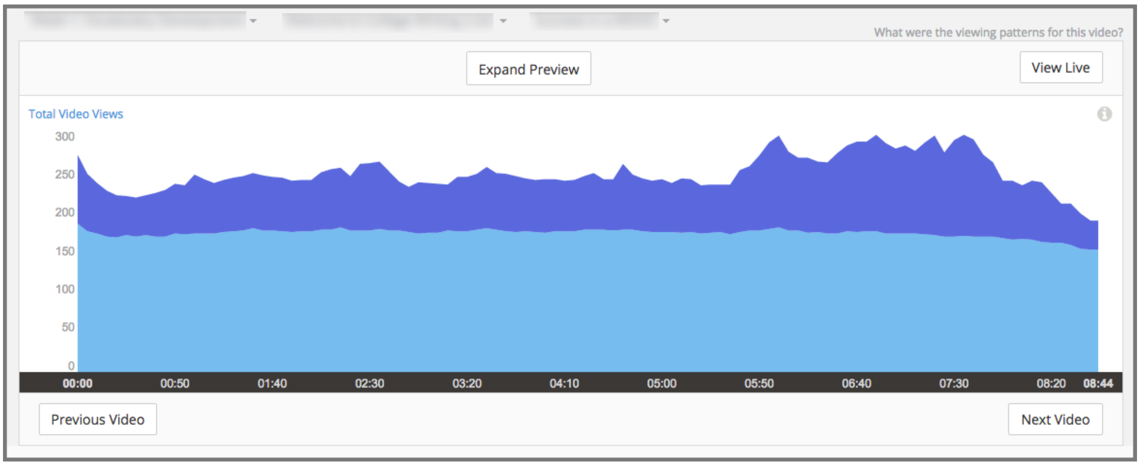

Figure 31. Total Video Views, second example

After previewing that video, the increased number of replays was an indicator of the complexity of the material being covered. It is might decide to spend some extra time answering questions in the discussion topic for that unit, or provide a course handout with additional references to the material covered for learners who want them.

Establishing an Engagement Baseline

Week 1 of the course begins with a video lecture that is about an hour long. About two weeks after the course start date are used the video metrics available in edX Insights to find that over 35,000 learners started playing the video and that almost 18,000 learners completed it.

This count of 18,000 will be a more meaningful baseline of committed learners than the overall course enrollment count. As the course progresses, the number of learners who completed the first video is used as the basis for evaluating how many learners continue to engage with course content.

What Are They Not Watching?

In addition to giving information about how many learners are watching the course videos, edX Insights can also help to investigate what, and when, they choose not to watch.

When seen the graph in edX Insights for this video (Fig. 32) notice that there is a temporary drop in the number of completed segment views near the beginning of the video. This goes on for about a minute, and then the number recovers to the previous level.

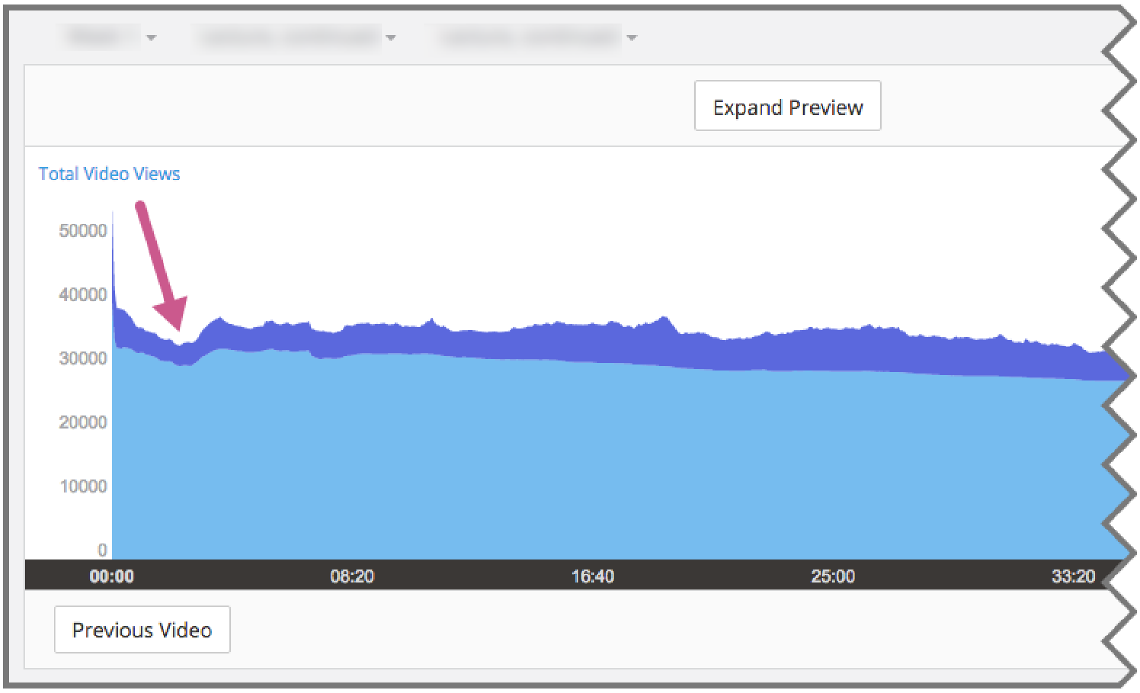

Figure 32. Total Video Views, third example

This pattern indicates that learners chose to skip whatever was included in that part of the video, but then they began playing the video again about a minute further on.

In another video, Fig. 33, the stacked area graph shows a steady decline in views and very little replay activity.

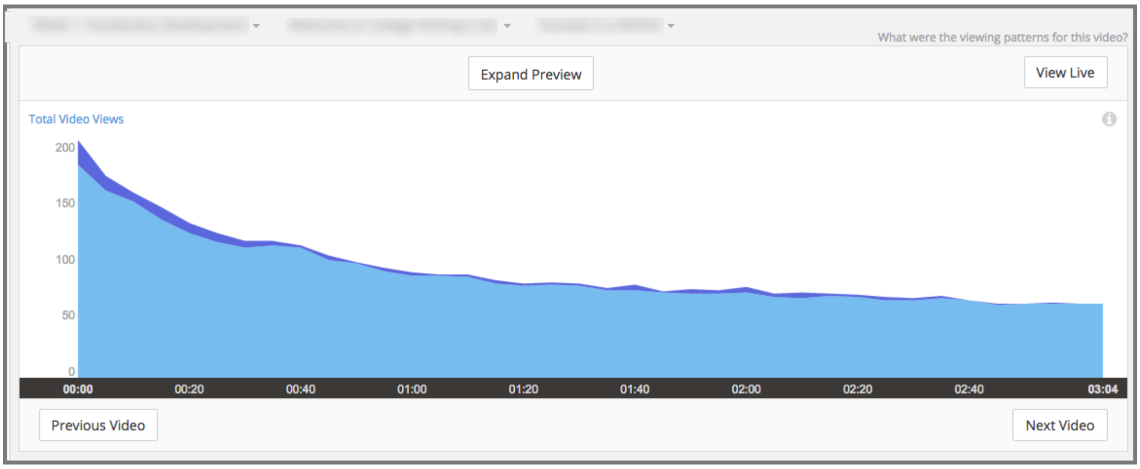

Figure 33. Total Video Views, fourth example

This pattern indicates that learners who began to play the video did not continue to the end and that they rarely chose to replay any of its segments.

The course teams might be curious to learn why learners chose to skip over part of a video or to stop watching it completely. Analyzing the content of a video with the objectivity gained from edX Insights can help to find content that is not well matched to the audience.

Course teams that try to deduce the cause of viewing patterns like these might not take any action for a currently running course. However, they might share their deductions in an organizational "video best practices guide" for future reference.

Understanding the Results of Component Design

Insights can also help to understand how the choices made when add video components to the course can affect learners. The chart for this video, in Fig. 34, shows an unusual viewing pattern, with most learners watching for only a minute or so, beginning at 8:20.

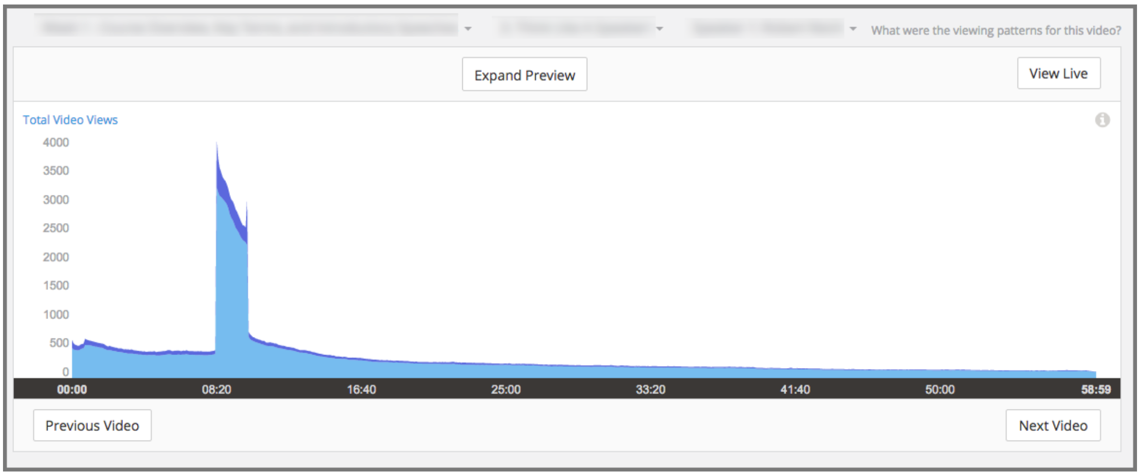

Figure 34. Total Video Views, fifth example

When reviewed the video component settings, it can be realized that start and stop times were defined to artificially reduce the length of the video from almost an hour to less than two minutes (Fig. 35).

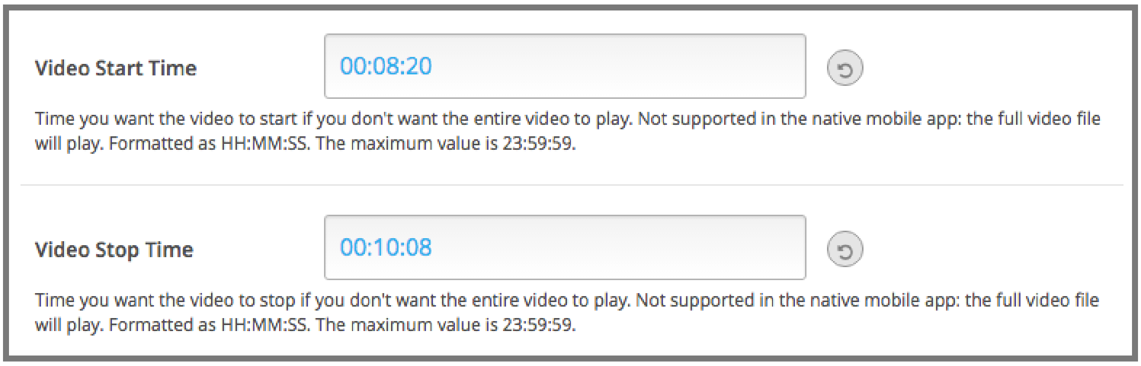

Figure 35. Reducing the length of the video

The edX video player applies the start and stop times defined in Studio only when learners watch videos in a browser. As a result, it might be concluded that viewers who watched the video before and after the defined start and stop times are using the edX mobile applications. It might then be decided to make the entire video available to all of your learners by removing the start and stop times. Alternatively, it might be edited the file and then upload a new version that includes only the relevant section of the video.

4.2.3 Graded Content Submissions

How are students answering questions? In edX Insights, graded content submissions show you the responses that students submit for graded problems, and help to evaluate what they find difficult. Student performance data is available in edX Insights for problem components of these types:

- Checkboxes
- Dropdown
- Multiple choice
- Numerical input
- Text input
- Math expression input

Interpreting Graded Submissions

A review of the distribution of student answer submissions for a graded problem can lead to discoveries about the students and about the course.

- Assess how difficult the problem is for students to answer correctly.
- Detect common mistakes.
- Understand student misconceptions.
- Find errors in problem components.

In addition, can be used the stacked bar chart presented for each course assignment type and assignment to identify where students are submitting relatively more incorrect answers.

<u>Researching Unexpected Difficulties</u>

For problem types that provide both the question and a set of possible answers (checkboxes, dropdown, and multiple choices) submission data helps to assess how difficult it is for students to identify and submit the correct answer. The submissions chart provides a visual contrast to the number of students who select incorrect answers with the number who answer correctly.

If the proportion of students who answer the problem incorrectly surprises, research can reveal a variety of causes. The investigation might begin with some of these questions.

- Is the text of the question and of its possible answers clear? Has it been translated accurately?
- Does the course outline include relevant course content before the problem, or after it?
- Are all of the course prerequisites presented to potential students?

- Does the problem rely on student access to a video or textbook?
- Are there transcripts for the videos, and can the textbook files be read by a screen reader?
- Are students relying on conventional wisdom to answer the question instead of newly acquired knowledge?

The results of the investigation can guide changes to future course runs.

<u>Investigating Similar Responses</u>

For open-ended problem types that provide only the question (numerical, text, and math expression input) submission data can help to identify similar responses. In the Submission Counts report, it has access to every answer submitted by a student. The chart, however, presents only the 12 most frequently submitted responses. The initial investigation into how students answer a question can begin with this set of 12.

For example, in Fig. 36, the edX Demo course includes a text input problem that has a correct answer of "Antarctica". The problem is set up to recognize variations in capitalization for this English spelling as correct.

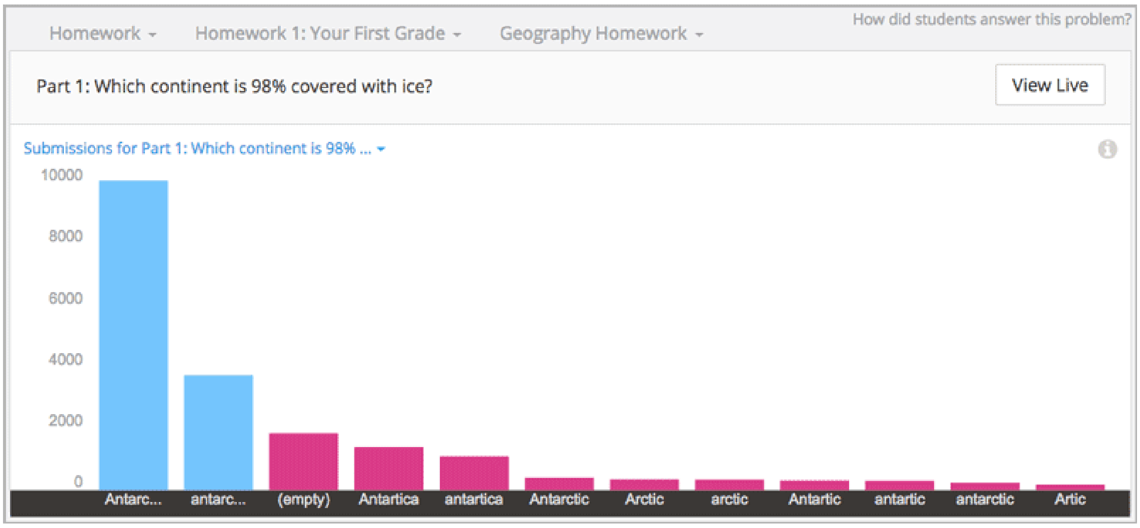

Figure 36. Variations in submissions

When reviewed the submissions chart for the problem, is seen that the two most frequently submitted answers are both marked correct: Antarctica and antarctica. Also several misspelled variations, including "Antarctic" and "Antartica", are marked incorrect.

A review of the Submissions Count report reveals several more variations, including "antartika", "Antartide", and "el continente Antártico". These answers also indicate the continent of Antarctica, but in languages other than English. Seeing answers such as these in the report might reassure that more students understand the question and the relevant course material than is indicated by the correct answer count. Is decided to reconfigure the problem so that correct answers in other languages also are evaluated as correct. Alternatively, is decided to revise the question to specify that answers be given in English only.

<u>Reviewing Answers to Complete Course Setup</u>

Before the release date of each section, encourage beta testers to answer every question and to submit both correct and incorrect answers. Then use edX Insights to review the answers that testers submit for each problem. Verify that each problem is set up as intend, and correct any oversights before students can encounter them.

In this way, can be used edX Insights to validate the grading configuration, and to proofread the display names, accessible labels, and text that you have provided for the graded assignment types, assignments, problems, questions, and answers.

Selecting the Assignment Type, Assignment, and Problem

EdX Insights displays the assignment types that make up the grading configuration of the course (Fig. 37):

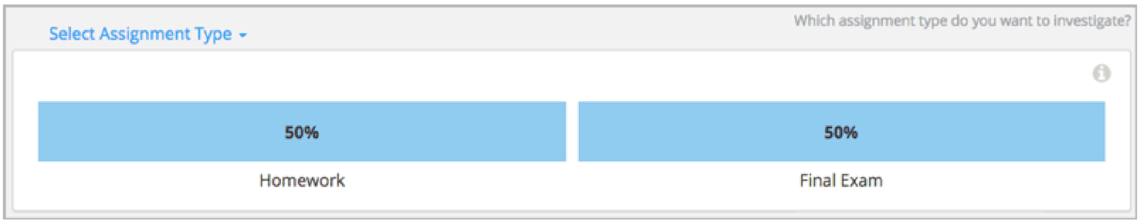

Figure 37. Assignment Type

After selecting one of the course assignment types, edX Insights displays a stacked bar chart that summarizes student performance on each assignment of that type (Fig. 38):

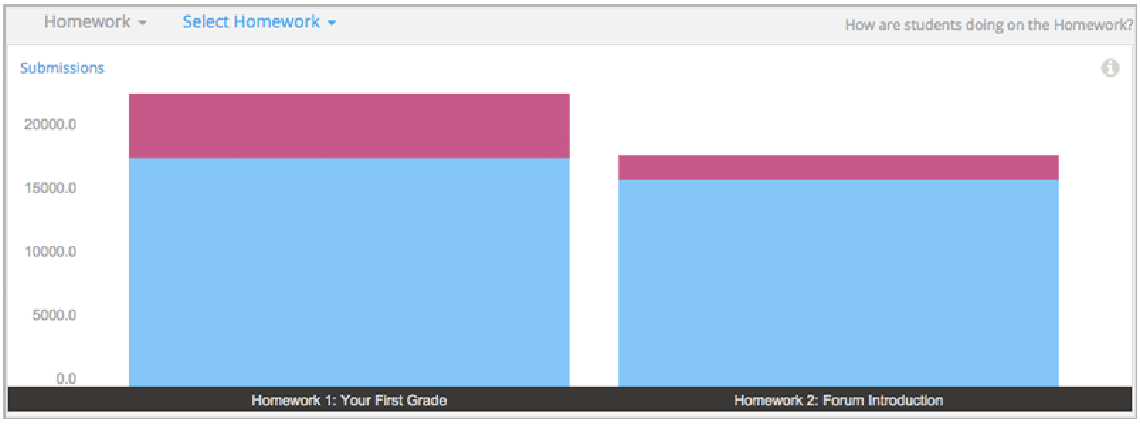

Figure 38. Submissions

The Assignment Submissions report on this page provides the number of problems in each assignment. The report also includes the correct and incorrect submissions received. These values are averaged by the number of problems in each assignment.

EdX Insights displays a stacked bar chart that summarizes student performance on each problem in that assignment. In this example from the edX Demo course, the selected homework assignment includes just one problem (Fig. 39):

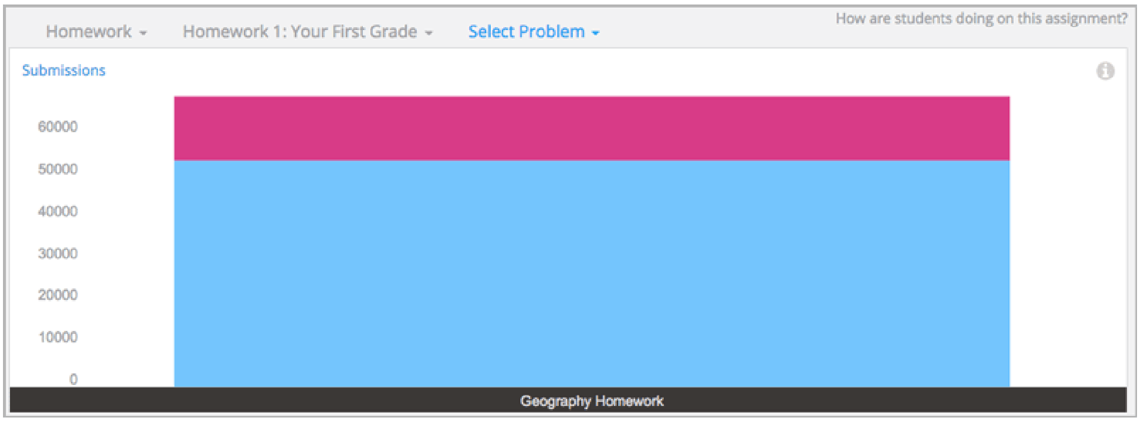

Figure 39. Student Performance of one problem

The Problem Submissions report on this page includes a row for each problem and provides the number of correct and incorrect submissions received for each one.

Review Answers to Graded Problems

After selecting a problem or problem part, edX Insights displays submission data in a bar chart and a report that can be viewed or downloaded. Descriptions of the chart and report follow.

Submissions Chart

The bars on this chart represent the number of enrolled students who submitted a particular answer to a question in a problem component. The x-axis includes the most frequently submitted answers, up to a maximum of 12. Due to space limitations, the answer text that is used to label the x-axis might be truncated. Moving the cursor over each bar shows a longer version of the answer.

All submitted answers and complete answer values are available for review in tabular format at the bottom of the page and can also be downloaded.

Examples of the graded content submissions chart follow. In the first example (Fig 40) most students selected the correct answer for a multiple choice problem:

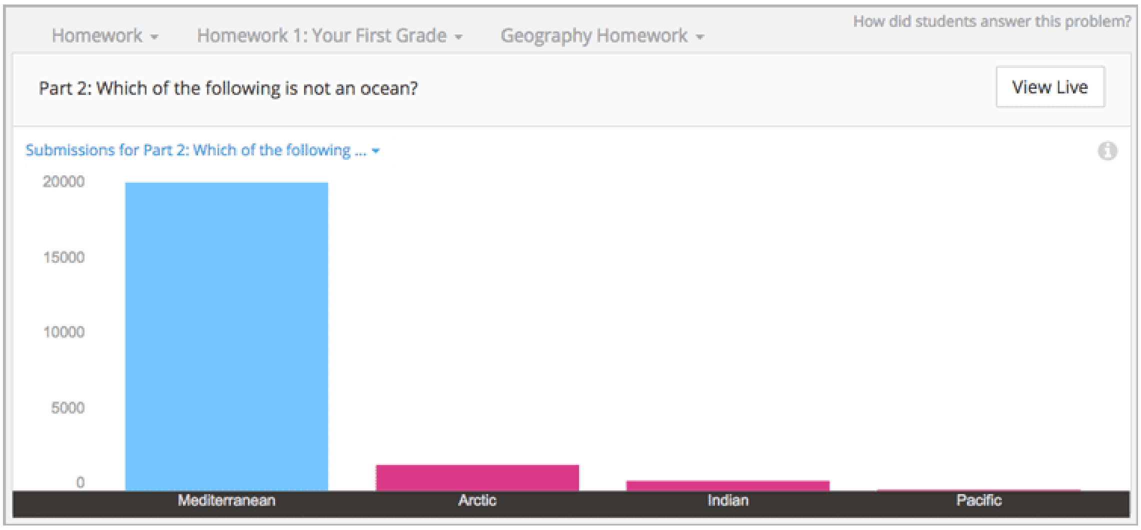

Figure 40. Most frequently submitted answers

The second example (Fig. 41) shows the graph of the top 12 answers submitted for a numerical input problem. Most students left the answer for this question blank, or "(empty)", which was marked incorrect. Other answers that students submitted, both correct and incorrect, are also graphed. The Submission Counts report includes a row for every submitted answer:

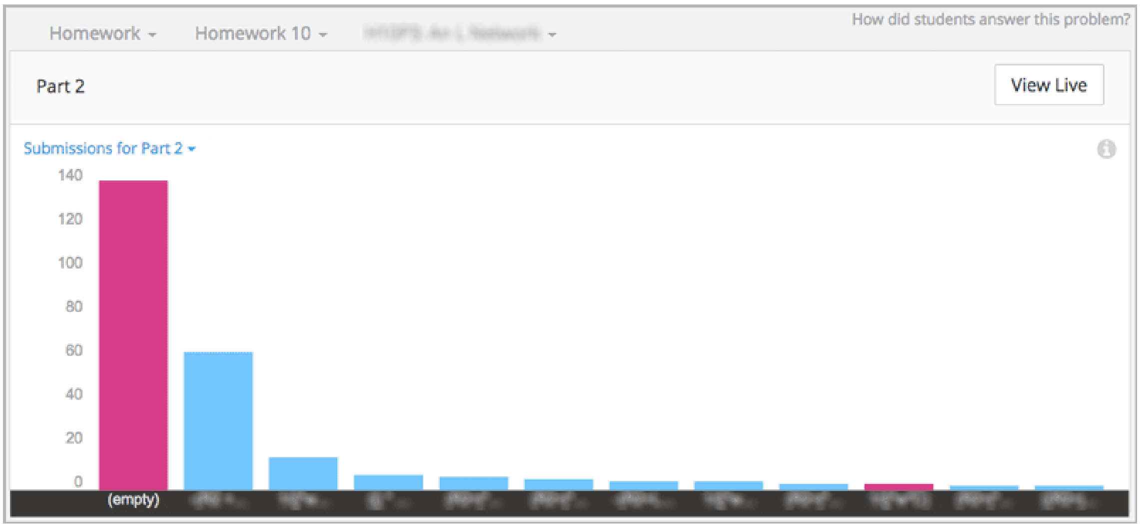

Figure 41. Most frequently submitted answers for a numerical input problem

<u>Submission Counts Report</u>

A report with a row for each problem-answer combination submitted by students is available for review or download. The report columns shows each submitted answer, identify the correct answer or answers, and provide the number of students who submitted that answer.

The report includes one row for each problem-answer combination submitted by a learner. Only the most recent attempt submitted by each learner is included in the count. For example, consider a dropdown problem that has five possible answers.

The report or file contains up to five rows, one for each answer submitted by at least one learner in their last attempt to answer the problem.

If the problem selected includes more than one part, the chart and report for the first part appears.

For problems that use the Randomization feature in Studio, the report has one row for each problem-variant-answer combination selected by at least one student.

4.2.4 Ungraded Problem Submissions

How do learners answer problems that do not count toward their course grades? Do they answer these questions at all? Using edX Insights, data for the ungraded problems in a course and its sections can be reviewed. This data shows how many learners are submitting answers, and the average number of answers that are correct.

Then, can be reviewed the actual responses learners make to questions that are not part of the grading configuration for your course. Also, can be compared data about ungraded and graded course content. Information about learner performance on ungraded problems can help to understand where learners are making errors, and also find ways to improve the problems.

Interpreting Ungraded Submissions

A review of the distribution of answer submissions for an ungraded problem can lead to discoveries about your learners and about your course.

Initial Assessments

Ungraded problems that are included early in the courseware can provide valuable information about how well prepared enrolled learners are to complete your course successfully. You can use edX Insights to answer questions like these.

- What percentage of enrolled learners completed the initial set of exercises?
- Do the submissions demonstrate the core competencies that you expect?
- Do the submissions reflect common misconceptions?

The illustration that follows in Fig. 42 is a course that includes a preliminary assessment during "Week 0". The chart includes one bar for each of the problems in the subsection that contains the assessment. The average number of incorrect answers, in pink, is stacked on top of the average number of correct answers, in blue, in each bar. The chart indicates that for most of the questions in the preliminary assessment, a significant percentage of learners submitted an incorrect answer:

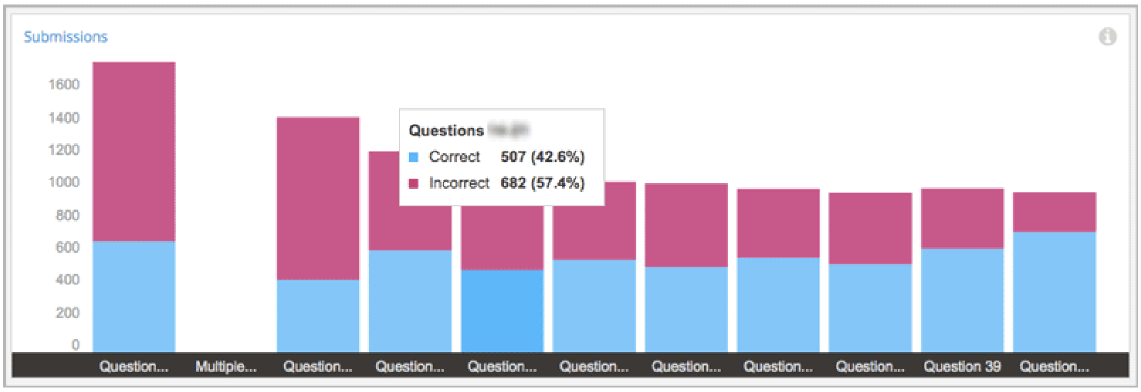

Figure 42. Correct and incorrect answers, first example

Reviewing this information early in the course run can help to decide whether to take any action and what that action might be. For example, if relatively few of the enrolled learners are answering the question, might be decided to add a link to the edX DemoX course on the Course Info page. To help learners understand course prerequisites better can be uploaded references to the additional preparatory material. Or decide to post more frequently, and with more detail, in the content-specific course discussions.

<u>Practice Problems</u>

To give learners opportunities to practice, gain confidence, and learn from their mistakes, many courses include ungraded problems throughout. The data available for practice problems in edX Insights can help you answer questions like these.

What percentage of learners submit answers to the practice problems? Does that percentage change over time?

- Do more learners answer the practice problems or the graded problems?
- Do more learners answer the practice problems correctly or the graded problems?

The illustration that follows in Fig. 43 is a course that includes ungraded practice problems in most sections. The chart includes one bar for each section in the course. Each bar shows the average number of incorrect answers for the entire section, in pink, stacked on top of the average number of correct answers, in blue. These values are averaged by the number of problems in each section.

In this course, the number of learners submitting answers in each section went down over time. However, the number of learners who submitted the correct answer went up.

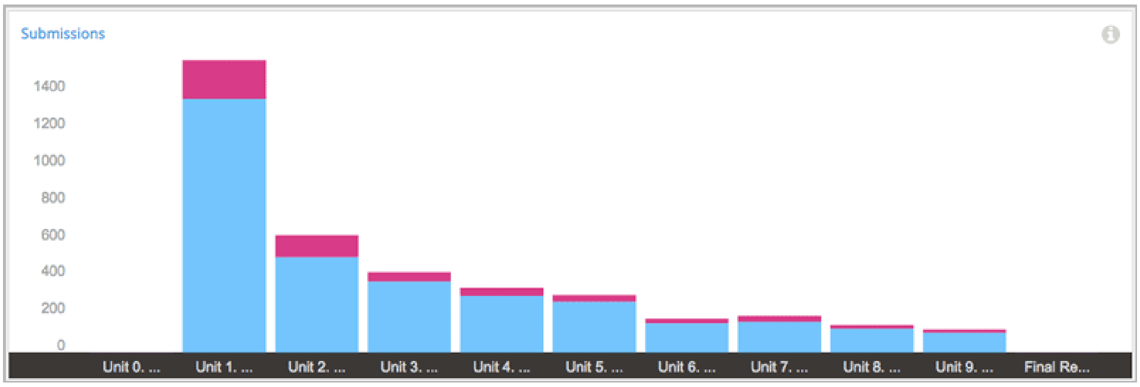

Figure 43. Correct and incorrect answers, second example

This data can be used for course sections and subsections to track changes in how many learners are working through the practice problems. Also, can be compared the answers submitted for similar ungraded and graded problems. Depending on what found, can be considered changes to future versions of the course. For example, add or revise the explanations for the practice problems, add hints or feedback, or increase the number of attempts that learners have to submit the correct answer. It might also be able to find and address differences in problem difficulty.

<u>Surveys</u>

If to survey learners have used problem components, can be used edX Insights to review their responses. The data available for survey-type problems in edX Insights can help you answer questions like these.

- How many learners responded?
- For questions with a limited number of possible answers, such as multiple choices, what percentage of learners selected each answer?
- For open-ended questions, such as text input, what did learners submit?

The illustration that follows in Fig. 44 shows the number of students who selected each of the choices offered for a multiple choice question. The chart includes one bar for each answer:

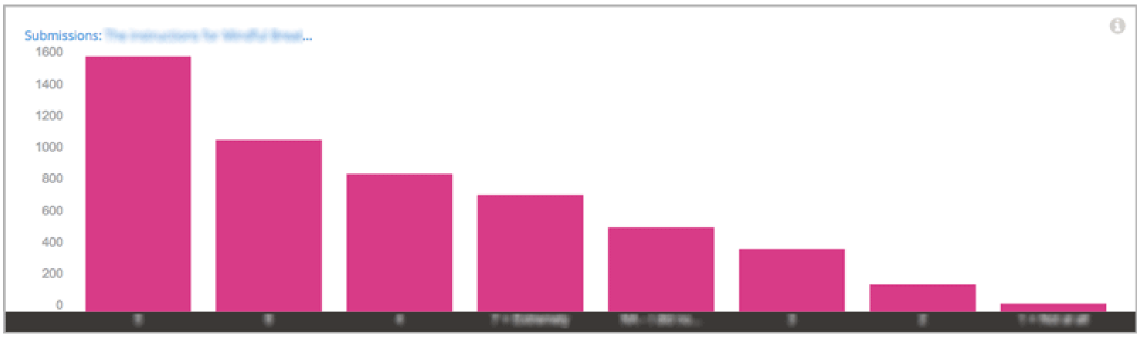

Figure 44. Number of students who selected each of the choices offered for a multiple choice question

The downloadable reports of answer data that are available from Insights can aid further analysis of survey answers.

Selecting the Section, Subsection and Problem

To access data about the answers that learners submit for an ungraded problem component, edX Insights provides data for each selection:

- the section in the course
- subsection
- problem

EdX Insights displays a stacked bar chart that summarizes learner performance on ungraded problems in every section in the course (Fig. 45):

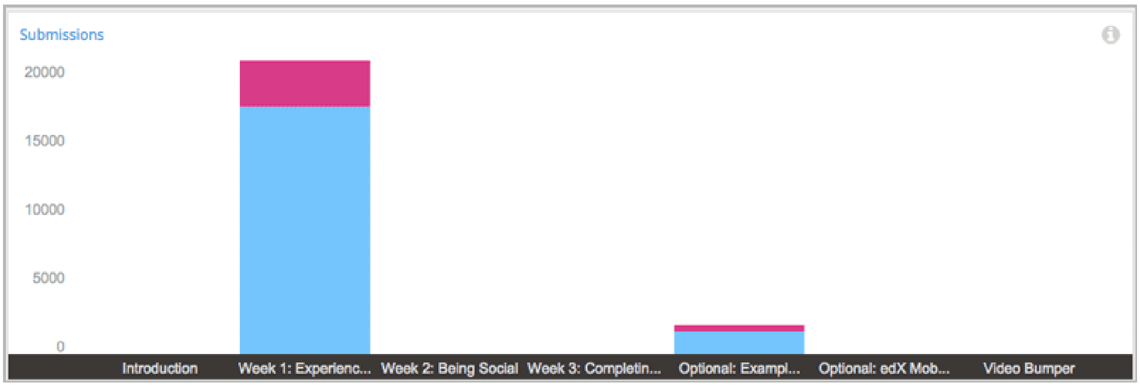

Figure 45. Learner performance on ungraded problems, first example

The graph includes a bar for a section only if that section both contains an ungraded problem and at least one learner has submitted an answer.

The Section Submissions report on this page provides the number of ungraded problems in each course section, and the average number of correct and incorrect submissions received based on the number of problems in each section.

EdX Insights displays a stacked bar chart that summarizes learner performance on the ungraded problems in each subsection. In this example from the edX DemoX course, there is only one subsection in the selected section (Fig. 46).

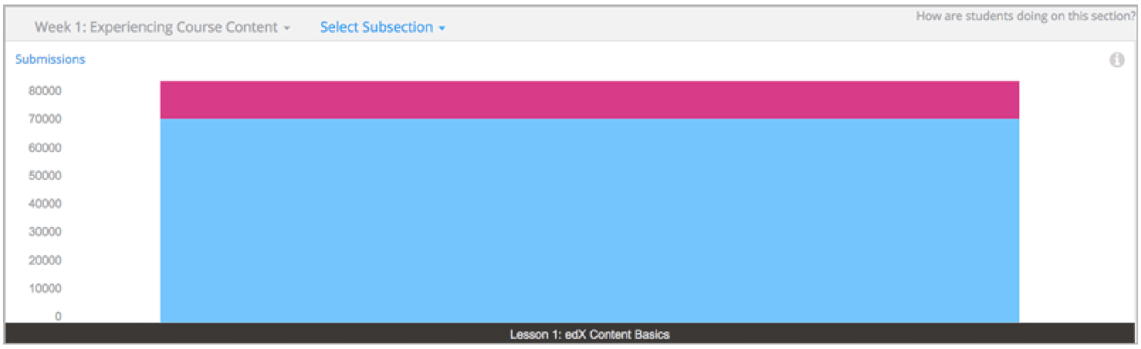

Figure 46. Learner performance on ungraded problems, second example

The Subsection Submissions report on this page provides the number of ungraded problems in each subsection and the number of correct and incorrect submissions received, averaged by the number of problems in each section.

EdX Insights displays a stacked bar chart that summarizes learner performance on each problem in that assignment. In this example from the edX Demo course, the selected subsection includes four problems (Fig. 47).

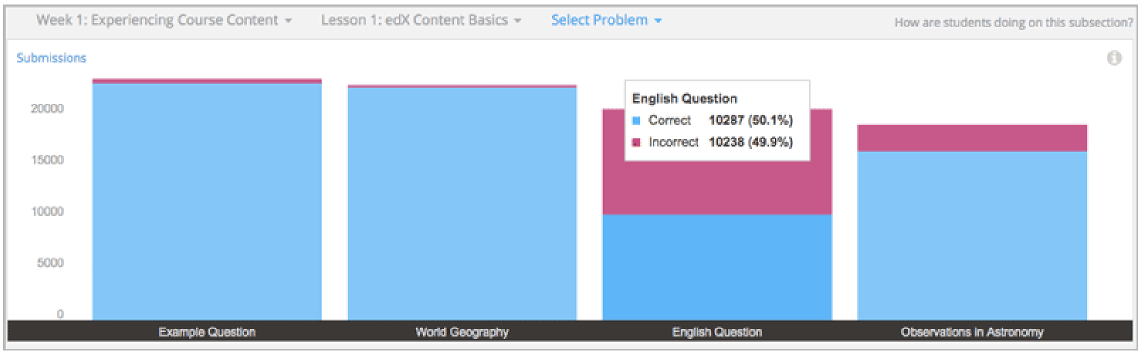

Figure 47. Learner performance on each problem, third example

The Problem Submissions report on this page includes a line for each of the problems in the selected subsection, and the number of correct and incorrect submissions received for each one.

Review Answers to Ungraded Problems

After you select a problem or problem part, edX Insights displays submission data in a bar chart and a report that you can view or download. Descriptions of the chart and report follow.

Problems that use the Randomization setting in Studio result in many possible submission variants, both correct and incorrect. As a result, edX Insights does not attempt to present a chart of the responses submitted for these problems. Can be downloaded the Submissions Counts report to analyze the answers that are of interest.

Submissions Chart

The bars on this chart represent the number of enrolled learners who submitted a particular answer to a question in a problem component. The x-axis includes the most frequently submitted answers, up to a maximum of 12. Due to space limitations, the answer text that is used to label the x-axis might be truncated. Moving your cursor over each bar shows a longer version of the answer (Fig. 48):

Figure 48. Number of enrolled learners who submitted a particular answer to a question

All submitted answers and complete answer values are available for review in tabular format at the bottom of the page and can also be downloaded.

Submission Counts Report

A report with a row for each problem-answer combination submitted by your learners is available for review or download. The report columns show each submitted answer, identify the correct answer or answers, and provide the number of learners who submitted that answer.

The report includes one row for each problem-answer combination submitted by a learner. Only the most recent attempt submitted by each learner is included in the count. For example, consider a dropdown problem that has five possible answers.

The report or file contains up to five rows, one for each answer submitted by at least one learner in their last attempt to answer the problem.

If the problem that selected includes more than one part, the chart and report for the first part appears.

For problems that use the Randomization feature in Studio, the report has one row for each problem-variant-answer combination selected by at least one learner.

4.2.5 Individual Learners Activity[1]

Can be accessed to information about what individual learners are doing in the course, and how frequently: from the edX Insights menu select **Learners**. A report of the key activity metrics for all enrolled learners appears, including problems tried and videos played. Then can be review a chart of individual learner activity over time by selecting a learner by username.

[1] This feature is not yet supported. EdX is currently testing the individual learner activity feature.

Which learners, specifically, are engaging with the course? Who is struggling, and who is doing well? Investigating and comparing the activities of individual learners helps to focus on those who are most likely to benefit from additional attention.

Learner Roster and Key Activity Report

Insights delivers data about the engagement of individual learners by providing counts for the following key activities.

- Problems Tried
- Problems Correct
- Attempts per Problem Correct
- Videos played
- Discussion contributions added

The report includes one row for every learner who ever enrolled in the course. The reported metrics represent each learner's activity in the course during the last seven days, through the end of the day (UTC) yesterday.

<u>Reviewing the Report</u>

To review the learner roster and key activity report, select **Learners** at the top of any Insights page. By default, the report shows data for all learners. To find data that is of interest, the report includes the following options.

- Sort by username or by an activity metric, in ascending or descending order.
- Search for a learner by name or username.
- Select an enrollment track to report only learners who are enrolled in that track.
- Select one cohort (in a course that includes learner cohorts).

To help to compare an individual learner's level of engagement to that of the class as a whole, the numbers on the report are color coded.

- Red: The learner's activity is in the 15th percentile or below. These learners might be falling behind or struggling.
- Green: The learner's activity is in the 85th percentile or above. These learners might be doing particularly well.
- Black: All other values.

An example roster follows in Table 6. In this example, the report is sorted in descending order by the number of problems tried.

Learners					
Name (Username)	Problems Tried	Problems Correct	Attempts per Problem Correct	Videos	Discussions
Mary W	38	38	1.6	37	0
Margaret M	35	35	2.6	44	0
Richard m	19	19	2.0	6	0
Susan S	1	1	2.0	0	0
Linda A	1	1	1.0	70	0
Robert L	1	0	N/A	5	0

Table 6. Learner roster and key activity

Learner Activity Chart

To review the learner activity chart, you select the learner's username in the learner roster and key activity report.

The learner activity chart is a timeline that shows when a selected learner was active in the course. The markers on this chart represent the number of times the learner interacted with the course each day. The graph plots the following types of activity.

- Discussion Contributions
- Problems Correct
- Videos Viewed

The chart shows when a learner was active in the course, beginning with the first day that one of these activities took place, and ending with the last day that one these activities took place. Unlike the roster, this timeline is not limited to activity in the last seven days.

Examples of learner activity charts follow. The first example, in Fig. 49, shows the activity chart for a learner who is playing 10 or more course videos every day. However, the learner is not answering any problems correctly, and has not yet contributed to the discussions:

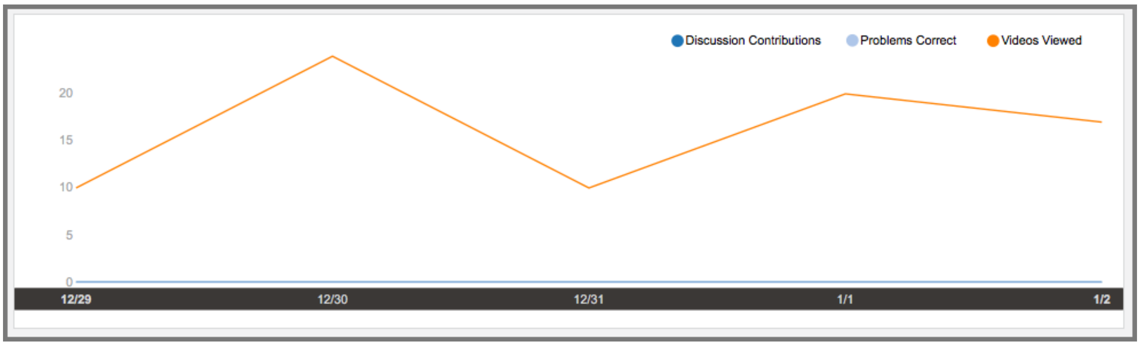

Figure 49. Learner activity, first example

This learner might be getting exactly what they want out of the course, the opportunity to learn from the videos. However, to get a complete understanding of this learner's experience, you could go back to the learner roster and key activity report to see if this learner is attempting to answer problems, but not managing to answer any correctly.

The next example, in Fig. 50, shows the activity chart for a learner who watches one or more videos almost every day, and who has occasionally contributed to the discussions. However, there was only a single day on which this learner answered any problems correctly. The tooltip shows the counts for each type of activity on that day.

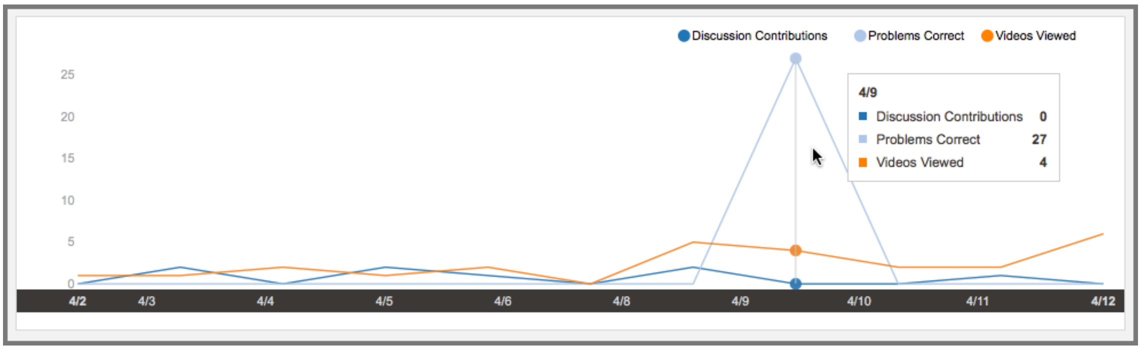

Figure 50. Learner activity, second example

Knowing the context of how your course is set up, this pattern might indicate when the learner reached the first homework assignment. Or, it might indicate that the learner completed all of the ungraded practice questions and the midterm on one day.

<u>Sending Email Messages to Learners</u>

To make taking action to help a struggling learner, re-engage an inactive learner, or recognize the achievement of a successful learner easier, the learner activity chart includes the learner's email address. You can select the email address to send a message directly to that learner.

Before you use Insights to send email messages to learners, note that this feature is different from the bulk email feature that is available on the instructor dashboard of an edx.org course.

- Selecting a learner email address in Insights opens the default email client of the computer that you are currently using. As a result, if you use your personal computer to access Insights, your personal email address might be the default for sending the message. Be sure to use only your official institution email address when you communicate with learners by email.
- Insights does not log when messages are sent, or record the email address of the sender or the recipient.

When you use Insights, be sure to follow your organization's guidelines for communicating with learners.

Activity Over Time Report

A report of specific course activities that the learner completed each day is available for review. Columns show the counts of Discussion Contributions, Problems Correct, and Videos Viewed.

4.2.6 Interpreting Individual Activity Patterns

A review of how many times each of the learners in the course completed key activities, and when, can help to identify learners who are most likely to need some form of intervention.

Identifying Learners Who Are At Risk

To identify learners who are falling behind, and who might be at risk of failing, course teams can use the 15th percentile and below color coding that is automatically indicated for values on the learner roster and key activity report.

For example, a course team member can sort the report using any of the metrics, and then scan the report to locate any learners with a value that appears in red.

In the example that follows in Table 7, reported values in the 15th percentile and below appear in red and are circled.

Name (Username)	Problems Tried	Problems Correct	Attempts per Problem Correct	Videos	Discussions
Dorothy U	20	19	2.2	23	2
Richard m	6	6	1.8	6	1
Mary m	5	4	2.0	4	2
William n	5	5	1.4	0	1
James J	2	2	1.0	2	2
Robert	2	2	1.0	7	1

Table 7. Learners who are at risk

When the report is reviewed, the knowledge of the context can help to decide whether, and how, to intervene. Some possible scenarios follow.

- The course is a small private online course and it began three days ago. The report shows that many learners are engaging with the course, though some more than others. You decide to send an email message to all enrolled learners at the end of the first week to congratulate them on their efforts so far, and to point out that they can track their own achievements on the Progress page.
- The course is an on-campus course, and the third week just started. You use the report to identify the learners who are not on pace to complete the course successfully, but who might be able to catch up. You make sure that all of your teaching assistants know how to use the report to identify such learners in their sections.

The learner activity report can be used throughout the course run to guide the decisions about when, and how, to contact learners who are struggling.

Promoting Learner Interaction

A course has several small cohorts with a teaching assistant (TA) assigned to each one. The members of these cohorts are expected to contribute to the discussions at least once a week throughout the course run. In turn, the TAs are responsible for making sure that any questions that cohort members post in the course discussions get prompt and thorough answers.

The learner roster and key activity report can make monitoring discussion activity easier for these TAs. The cohort filter and column sorting features can help them identify the cohort members who are contributing to the discussions. They can also search by username to find the activity reported for individual cohort members. The learner activity charts can show, at a glance, whether discussion activity is a regular part of a learner's weekly involvement in the course, or if it takes place more sporadically.

Identifying Questionable Activity

Certain activity patterns can alert you to behavior that might be either exemplary or counterproductive. You can use learner data to identify unusual combinations of activity and decide whether to investigate further. Examples follow.

- A learner has a high number of correct problems and a very low ratio of attempts per problem correct: a top performer. When you look at that learner's activity chart, however, you see that all of the problems were answered correctly on the very first day the course opened. Did this learner enroll in the audit track for a previous course run, and is now taking the course for the second time in the verified track? Or, could this learner have violated the honor code?
- A learner is in the 85th percentile (or above) for discussion contributions: a highly engaged community member. However, the same learner has zero problems attempted and zero videos played, so the discussions are the only type of key course activity in which the learner engages. Is this learner answering questions thoughtfully and with accurate information?

4.3 Learning Analytics of Remote Operation & Measurement with VISIR

There is another group of indicators: those derived from remote operations and measurements with VISIR (VISIR Analytics). The analysis of students' navigation around the web interface, his actions (election, connection, configuration and measurement) with the components, power supply, function generator, multimeter and oscilloscope are a source of indicators of the degree of the content understanding and the skills and abilities deployed in the practices. A good number of indicators can be extracted using the raw data from both the students' tracking as the XML-based communication protocol. Such data exploitation requires a particularized own development and offers the following additional benefits to the classic LA:

- Precise knowledge of students' behavior in the practices
- Detection of attempts of gaming the system by students, by repetition of actions, until hitting the solution
- Automatic evaluation of students, with rubrics, according to [35] as shown in the proposed assessment model in the Fig. 51

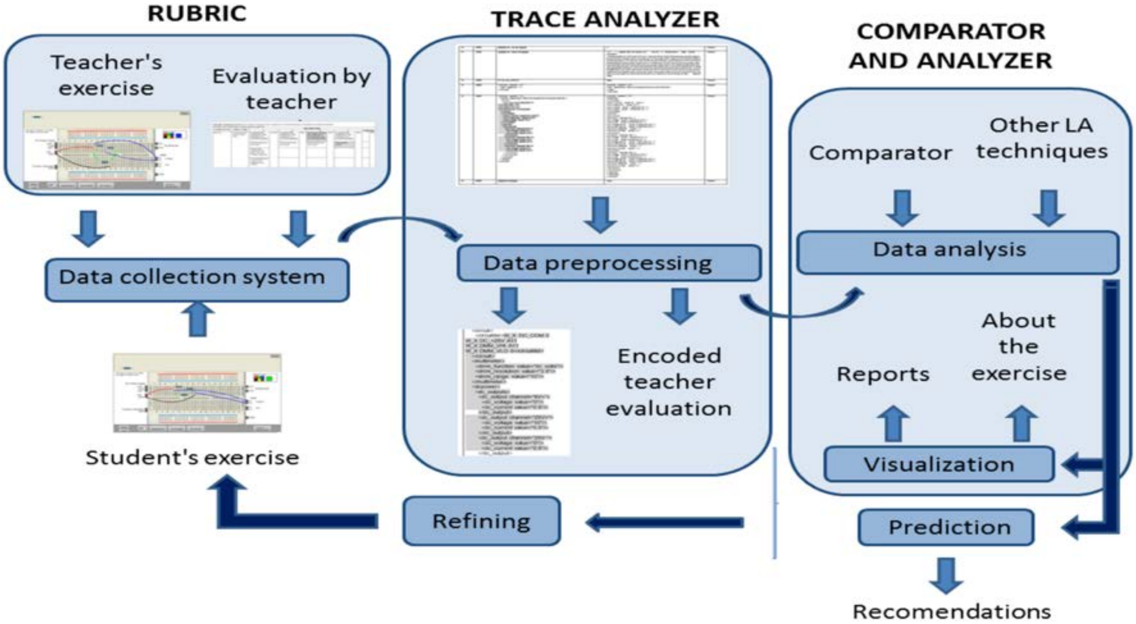

Figure 51. Proposed assessment model in [35]

The statistical analysis of these data can be a great aid to obtain conclusions and improve the course: where and how to act upon the breadth and depth of the contents or what specific aspects must be modified or reinforced in function of the difficulties encountered by students in the practical activities.

4.3.1 General indicators of practices

From the XML-based protocol can be obtained a set of general parameters that can indicate how students face and manage the practices:

- Temporal distribution of practices
- Transitions between practices
- Number of reserves of the booking system used in each practice
- Total time of practices
- Time for each practice
- Number of performances
- Time between performances
- Transitions between breadboard and instruments
- Performances inside max list
- Performances outside max list

4.3.2 Indicators based on the components, the power supply and the function generator

Likewise from the XML-based protocol also can be obtained a new set of parameters that indicate how the students connect the circuit, handle and configure power supply and signal generator before starting measurements:

- Components selection
- Connections of components, instruments and GND

- Number of access to each instrument (transitions to)
- Time using each instrument
- Configuration parameters of power supply and function generator

4.3.3 Indicators based on the multimeter and the oscilloscope

Finally from the XML-based protocol can be obtained a set of parameters that indicates the configuration and handling of the oscilloscope and the multimeter, its settings and the results of visualizations and measurements:

- Number of access to each instrument (transitions to)
- Time using each instrument
- Setting and configuration values of the oscilloscope and multimeter
- Connection points of each instrument
- Signals values obtained from each instrument

4.3.4 Example of DC current measurement with multimeter

The Fig. 52 shows a breadboard with two serial resistors (1kΩ and 10kΩ) connected between the power supply (+20V DC configured at 10V) and GND, with the multimeter terminals measuring the current. The Fig. 53 shows the measurement result after performing the practice:

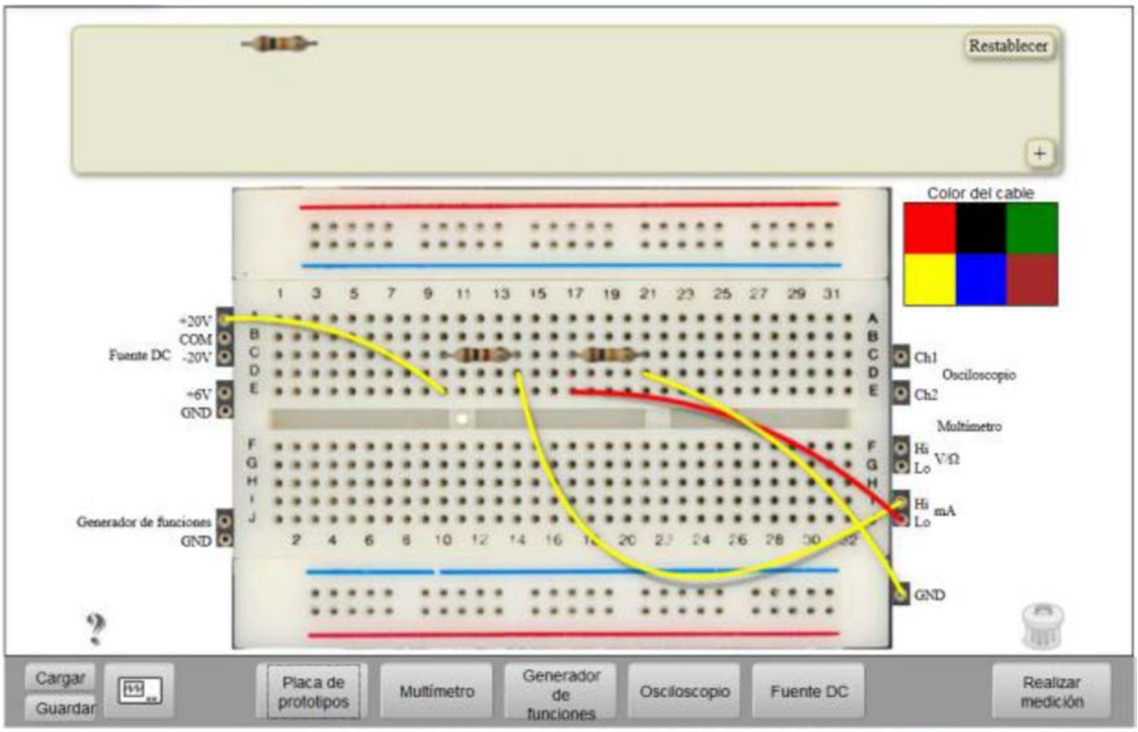

Figure 52. DC current measurement with multimeter

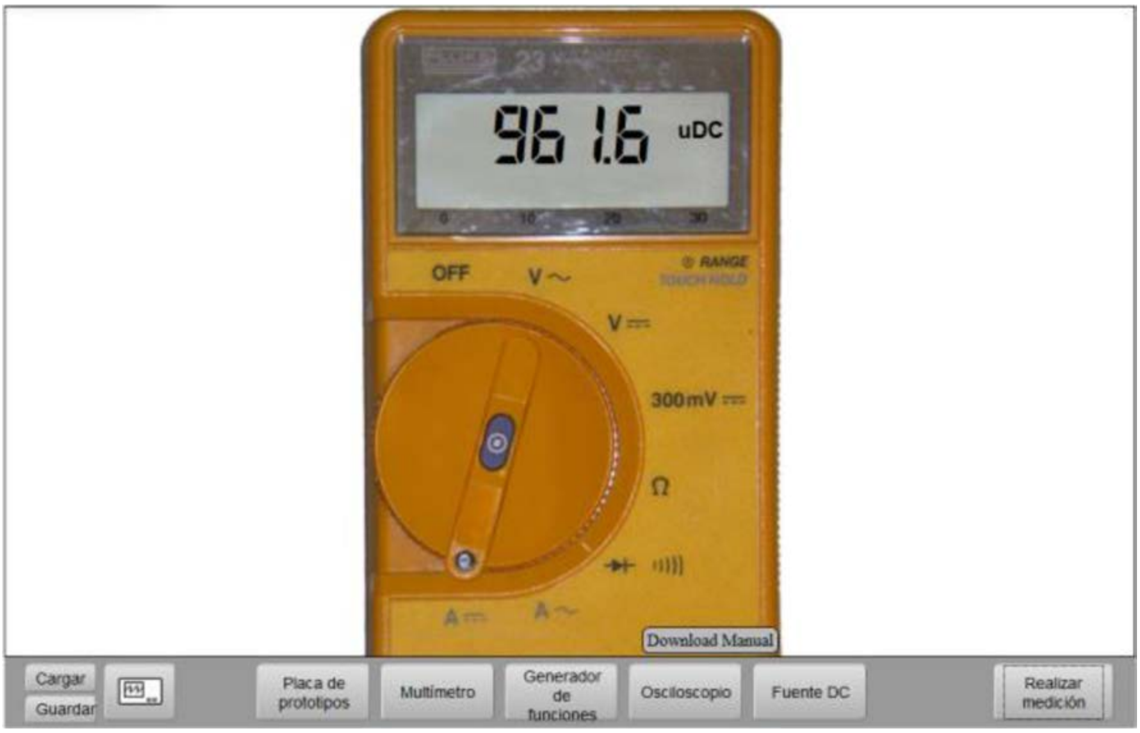

Figure 53. Displayed value on the multimeter

After mounting the circuit, setting the instruments and clicking the *perform button*, is generated an XML-based description of the circuit, which includes the circuit connections and the instruments configuration. The request is shown in Table 8:

```
<protocol version="1.3">
<request sessionkey="97e1cba2f578872dc12f8a20a81778e1">
<circuit>
        <circuitlist>
                W_X IPROBE_1_1 A14
                W_X IPROBE_1_2 A17                              <!--circuit connections-->
                W_X A21 0
                W_X A10 VDC+25V_1_1
                R_X A17 A21 10K
                R_X A10 A14 1K
                IPROBE_1 IPROBE_1_1 IPROBE_1_2
                VDC+25V_1 VDC+25V_1_1
        </circuitlist>
</circuit>
<multimeter id="1">
        <dmm_function value="dc current"></dmm_function>        <!--multimeter configuration-->
        <dmm_resolution value="3.5"></dmm_resolution>
        <dmm_range value="-1"></dmm_range>
        <dmm_autozero value="1"></dmm_autozero>
</multimeter>
<functiongenerator id="1">
        <fg_waveform value="sine"></fg_waveform>                <!--function generator config.-->
        <fg_frequency value="1000"></fg_frequency>
        <fg_amplitude value="0.5"></fg_amplitude>
        <fg_offset value="0"></fg_offset>
</functiongenerator>
<oscilloscope id="1">
        <horizontal>                                            <!--oscilloscope configuration-->
                <horz_samplerate value="500"></horz_samplerate>
```

```
        <horz_refpos value="50"></horz_refpos>
        <horz_recordlength value="500"></horz_recordlength>
    </horizontal>
    <channels>
        <channel number="1">
            <chan_enabled value="1"></chan_enabled>
            <chan_coupling value="dc"></chan_coupling>
            <chan_range value="1"></chan_range>
            <chan_offset value="0"></chan_offset>
            <chan_attenuation value="1"></chan_attenuation>
        </channel>
        <channel number="2">
            <chan_enabled value="1"></chan_enabled>
            <chan_coupling value="dc"></chan_coupling>
            <chan_range value="1"></chan_range>
            <chan_offset value="0"></chan_offset>
            <chan_attenuation value="1"></chan_attenuation>
        </channel>
    </channels>
    <trigger>
        <trig_source value="channel 1"></trig_source>
        <trig_slope value="positive"></trig_slope>
        <trig_coupling value="dc"></trig_coupling>
        <trig_level value="0"></trig_level>
        <trig_mode value="autolevel"></trig_mode>
        <trig_timeout value="1"></trig_timeout>
        <trig_delay value="0"></trig_delay>
    </trigger>
    <measurements>
        <measurement number="1">
            <meas_channel value="channel 1"></meas_channel>
            <meas_selection value="none"></meas_selection>
        </measurement>
        <measurement number="2">
            <meas_channel value="channel 1"></meas_channel>
            <meas_selection value="none"></meas_selection>
        </measurement>
        <measurement number="3">
            <meas_channel value="channel 1"></meas_channel>
            <meas_selection value="none"></meas_selection>
        </measurement>
    </measurements>
    <osc_autoscale value="0"></osc_autoscale>
</oscilloscope>
<dcpower id="1">
    <dc_outputs>                                        <!—dc power configuration-->
        <dc_output channel="6V+">
            <dc_voltage value="0"></dc_voltage>
            <dc_current value="0.5"></dc_current>
        </dc_output>
        <dc_output channel="25V+">
            <dc_voltage value="10"></dc_voltage>
            <dc_current value="0.5"></dc_current>
        </dc_output>
        <dc_output channel="25V-">
            <dc_voltage value="0"></dc_voltage>
            <dc_current value="0.5"></dc_current>
        </dc_output>
    </dc_outputs>
</dcpower>
</request>
</protocol>
```


Table 8. XML request for a DC current measurement with multimeter

Then the XML response is sent to the client with the obtained values for all instruments, in this case for the multimeter, as shown in Table 9. Then is displayed the multimeter with the value (Fig. 53):


```
<protocol version="1.3">
<response>
<multimeter id="1">
        <dmm_function value="dc current"/>
        <dmm_resolution value="3.5"/>
        <dmm_range value="-1.000000e+000"/>
        <dmm_result value="9.616348e-004"/>              <!--obtained value on the multimeter-->
</multimeter>
<functiongenerator>
        <fg_waveform value="sine"/>
        <fg_amplitude value="5.000000e-001"/>
        <fg_frequency value="1.000000e+003"/>
        <fg_offset value="0.000000e+000"/>
        <fg_startphase value="0.000000e+000"/>
        <fg_triggermode value="continous"/>
        <fg_triggersource value="immediate"/>
        <fg_burstcount value="0"/>
        <fg_dutycycle value="5.000000e-001"/>
</functiongenerator>
<oscilloscope>
        <osc_autoscale value="0"/>
        <horizontal>
                <horz_samplerate value="2.500000e+004"/>
                <horz_refpos value="5.000000e+001"/>
                <horz_recordlength value="500"/>
        </horizontal>
        <channels>
                <channel number="1">
                        <chan_enabled value="1"/>
                        <chan_coupling value="dc"/>
                        <chan_range value="8.000000e+000"/>
                        <chan_offset value="0.000000e+000"/>
                        <chan_attenuation value="1.000000e+000"/>
                        <chan_gain value="0.000000e+000"/>
                        <chan_samples encoding="base64">
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA=
                        </chan_samples>
                </channel>
                <channel number="2">
                        <chan_enabled value="1"/>
                        <chan_coupling value="dc"/>
                        <chan_range value="8.000000e+000"/>
                        <chan_offset value="0.000000e+000"/>
                        <chan_attenuation value="1.000000e+000"/>
                        <chan_gain value="0.000000e+000"/>
                        <chan_samples encoding="base64">
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
```

```
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA=
                        </chan_samples>
                </channel>
        </channels>
        <trigger>
                <trig_source value="channel 1"/>
                <trig_slope value="positive"/>
                <trig_coupling value="dc"/>
                <trig_level value="0.000000e+000"/>
                <trig_mode value="autolevel"/>
                <trig_delay value="0.000000e+000"/>
                <trig_received value="110"/>
        </trigger>
        <measurements>
                <measurement number="1">
                        <meas_channel value="channel 1"/>
                        <meas_selection value="none"/>
                        <meas_result value="0.000000e+000"/>
                </measurement>
                <measurement number="2">
                        <meas_channel value="channel 1"/>
                        <meas_selection value="none"/>
                        <meas_result value="0.000000e+000"/>
                </measurement>
                <measurement number="3">
                        <meas_channel value="channel 1"/>
                        <meas_selection value="none"/>
                        <meas_result value="0.000000e+000"/>
                </measurement>
        </measurements>
</oscilloscope>
<dcpower>
        <dc_outputs>
                <dc_output channel="6V+">
                        <dc_voltage value="0.000000e+000"/>
                        <dc_current value="5.000000e-001"/>
                        <dc_voltage_actual value="-2.650000e-004"/>
                        <dc_current_actual value="8.100000e-005"/>
                        <dc_output_enabled value="1"/>
                        <dc_output_limited value="0"/>
                </dc_output>
                <dc_output channel="25V+">
                        <dc_voltage value="1.000000e+001"/>
                        <dc_current value="5.000000e-001"/>
                        <dc_voltage_actual value="1.000156e+001"/>
                        <dc_current_actual value="3.880000e-004"/>
                        <dc_output_enabled value="1"/>
                        <dc_output_limited value="0"/>
                </dc_output>
                <dc_output channel="25V-">
                        <dc_voltage value="0.000000e+000"/>
                        <dc_current value="5.000000e-001"/>
                        <dc_voltage_actual value="1.940000e-004"/>
                        <dc_current_actual value="2.000000e-006"/>
                        <dc_output_enabled value="1"/>
                        <dc_output_limited value="0"/>
                </dc_output>
        </dc_outputs>
</dcpower>
</response>
</protocol>
```


Table 9. XML response for a DC current measurement with multimeter

4.3.5 Example of AC voltage measurement with oscilloscope

The Fig. 54 shows a breadboard with two serial resistors (10kΩ and 10kΩ) connected between the function generator (in Table 10 it can be seen configured a sine wave of 1kHz, 3V of amplitude and 0V offset) and GND, with the oscilloscope measuring. The Fig. 55 shows the measurement after performing the practice:

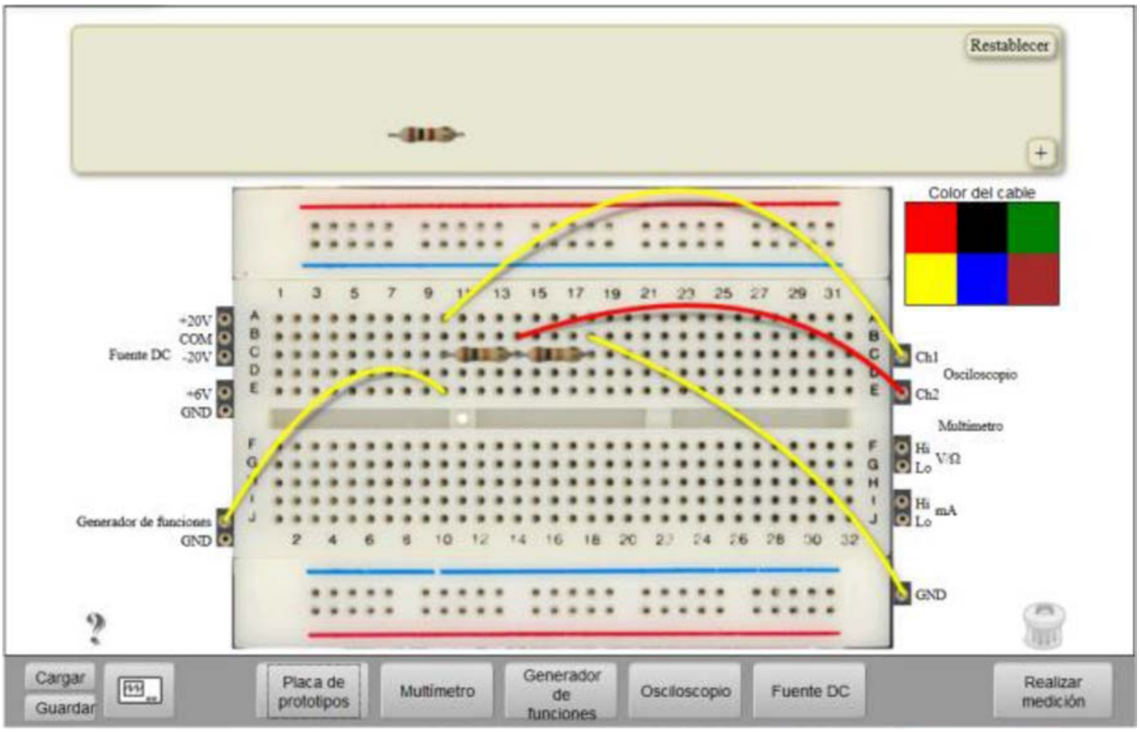

Figure 54. AC voltage measurement with oscilloscope

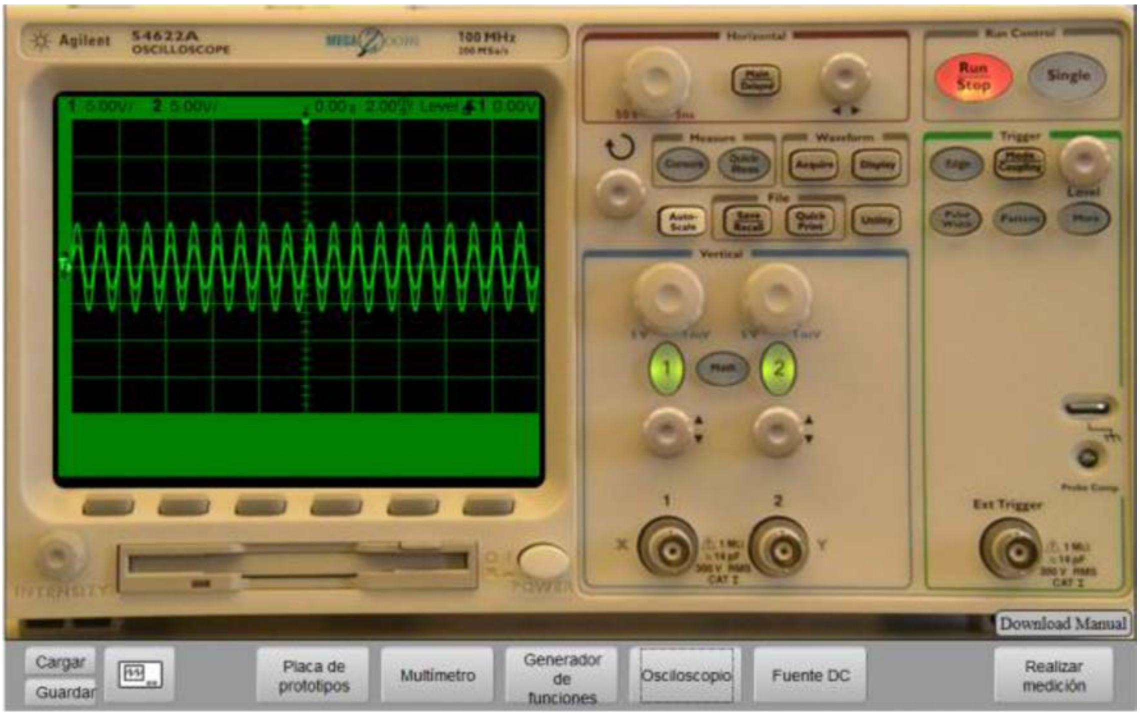

Figure 55. Obtained values on the oscilloscope

After mounting the circuit, setting the instruments and clicking the *perform button* is generated a XML-based description of the circuit which includes the circuit connections and instruments configurations. The request is shown in Table 10:


```
<protocol version="1.3">
<request sessionkey="97e1cba2f578872dc12f8a20a81778e1">
<circuit>
        <circuitlist>
                W_X PROBE1_1_1 A10                        <!--circuit connections-->
                W_X PROBE2_1_1 A14
                W_X A18 0
                W_X A10 VFGENA_1_1
                R_X A14 A18 10K
                R_X A10 A14 10K
                PROBE1_1 PROBE1_1_1
                PROBE2_1 PROBE2_1_1
                VFGENA_1 VFGENA_1_1 0
        </circuitlist>
</circuit>
<multimeter id="1">
        <dmm_function value="dc current"></dmm_function>
        <dmm_resolution value="3.5"></dmm_resolution>
        <dmm_range value="-1"></dmm_range>
        <dmm_autozero value="1"></dmm_autozero>
</multimeter>
<functiongenerator id="1">
        <fg_waveform value="sine"></fg_waveform>          <!--function generator config.-->
        <fg_frequency value="1000"></fg_frequency>
        <fg_amplitude value="3"></fg_amplitude>
        <fg_offset value="0"></fg_offset>
</functiongenerator>
<oscilloscope id="1">
<horizontal>
        <horz_samplerate value="500"></horz_samplerate>   <!--oscilloscope configuration-->
        <horz_refpos value="50"></horz_refpos>
        <horz_recordlength value="500"></horz_recordlength>
</horizontal>
<channels>
        <channel number="1">
                <chan_enabled value="1"></chan_enabled>
                <chan_coupling value="dc"></chan_coupling>
                <chan_range value="5"></chan_range>
                <chan_offset value="0"></chan_offset>
                <chan_attenuation value="1"></chan_attenuation>
        </channel>
        <channel number="2">
                <chan_enabled value="1"></chan_enabled>
                <chan_coupling value="dc"></chan_coupling>
                <chan_range value="5"></chan_range>
                <chan_offset value="0"></chan_offset>
                <chan_attenuation value="1"></chan_attenuation>
        </channel>
</channels>
<trigger>
        <trig_source value="channel 1"></trig_source>
        <trig_slope value="positive"></trig_slope>
        <trig_coupling value="dc"></trig_coupling>
        <trig_level value="0"></trig_level>
        <trig_mode value="autolevel"></trig_mode>
        <trig_timeout value="1"></trig_timeout>
        <trig_delay value="0"></trig_delay>
</trigger>
<measurements>
        <measurement number="1">
                <meas_channel value="channel 1"></meas_channel>
```

```xml
        <meas_selection value="none"></meas_selection>
    </measurement>
    <measurement number="2">
        <meas_channel value="channel 1"></meas_channel>
        <meas_selection value="none"></meas_selection>
        </measurement>
    <measurement number="3">
        <meas_channel value="channel 1"></meas_channel>
        <meas_selection value="none"></meas_selection>
    </measurement>
</measurements>
    <osc_autoscale value="0"></osc_autoscale>
</oscilloscope>
<dcpower id="1">
    <dc_outputs>
        <dc_output channel="6V+">
            <dc_voltage value="0"></dc_voltage>
            <dc_current value="0.5"></dc_current>
        </dc_output>
        <dc_output channel="25V+">
            <dc_voltage value="10"></dc_voltage>
            <dc_current value="0.5"></dc_current>
        </dc_output>
        <dc_output channel="25V-">
            <dc_voltage value="0"></dc_voltage>
            <dc_current value="0.5"></dc_current>
            </dc_output>
        </dc_outputs>
</dcpower>
</request>
</protocol>
```


Table 10. XML request for an AC voltage measurement with oscilloscope

Then the XML response is sent to the client with the obtained values from all instruments, in this case from the oscilloscope, as shown in Table 11. Then the oscilloscope image with the values can be displayed (Fig. 55).


```xml
<protocol version="1.3"> <response>
<multimeter id="1">
    <dmm_function value="dc current"/>
    <dmm_resolution value="3.5"/>
    <dmm_range value="-1.000000e+000"/>
    <dmm_result value="0.000000e+000"/>
</multimeter>
<functiongenerator>
    <fg_waveform value="sine"/>
    <fg_amplitude value="3.000000e+000"/>
    <fg_frequency value="1.000000e+003"/>
    <fg_offset value="0.000000e+000"/>
    <fg_startphase value="0.000000e+000"/>
    <fg_triggermode value="continous"/>
    <fg_triggersource value="immediate"/>
    <fg_burstcount value="0"/>
    <fg_dutycycle value="5.000000e-001"/>
</functiongenerator>
<oscilloscope>                                        <!--obtained values on oscilloscope-->
    <osc_autoscale value="0"/>
    <horizontal>
        <horz_samplerate value="2.500000e+004"/>
        <horz_refpos value="5.000000e+001"/>
        <horz_recordlength value="500"/>
    </horizontal>
    <channels>
        <channel number="1">
```

<chan_enabled value="1"/>
<chan_coupling value="dc"/>
<chan_range value="4.000000e+001"/>
<chan_offset value="0.000000e+000"/>
<chan_attenuation value="1.000000e+000"/>
<chan_gain value="1.638400e-001"/>
<chan_samples encoding="base64">
Bw8XHiIkJCIeFxAH/vXt5uDd3N3g5u31/gcQFx4iJSUiHhcQB//17ebg3dzd4Obt9f4HEBgeIiUkIh4YEAf+9e3m4N
3b3ODm7fX+Bw8XHSIlJSMdFxAI/vbt5uDd3Nzg5uz1/gcQFx4iJSUiHRgQB/717ebg3dzd4Obt9f0HEBgeIiUkIx0
YEAj+9ezm4N3b3eDm7fT+BxAYHSIlJCIeGBAI/vXt5uDd3N3g5u31/gcQGB0iJCUiHhgQB/717ebg3dzc4Obt9f4H
EBgeIyUkIx4XEAf+9e3m4d3c3ODm7fX+BxAXHSIkJCIeFxAH/vXt5uDc3Nzg5uz1/gYQGB0iJCQiHhgQB/717eXg
3Nzd4Obt9P4HEBceIiQlIx4YEAf+9ezm4N3c3eDm7PX+BxAYHiIlJCMeFxAH/vXt5uDc29zg5u31/gcPFx0iJSUiHh
cQB/717Obg3Nzd4Obt9f0IEBcdIiQkIh4YEAf+9e3m4d3c3ODm7PX+BxAXHSIkJCMeFxAH/fXt5uDd3N3g5uz1/
QcQGB4iJCQjHhgQB/717ebg3Nzc4OXt9f4HEBceIyUkIx4YEAj+9e3m4N3c3eDm7Pb+BxAXHiIlJSIeFxAH/vXt5u
Dd3N3g5u31/gcQGB0iJSUiHhgPB/717ebg3dvc4Obt9f4=
</chan_samples>
</channel>
<channel number="2">
<chan_enabled value="1"/>
<chan_coupling value="dc"/>
<chan_range value="4.000000e+001"/>
<chan_offset value="0.000000e+000"/>
<chan_attenuation value="1.000000e+000"/>
<chan_gain value="1.644010e-001"/>
<chan_samples encoding="base64">
BAgLDxESEhEPDAgEAPv38/Hv7+/w8/f6/wMIDA8REhIRDwwJBP/79/Tx8O7v8fP3+v8DCAwPERISEQ8MCQQ
A+/f08e/u7/Dz9/r/AwcMDxESEhEPDAgEAPv38/Hv7+/x8/b6/wQHDA8REhIRDw0JBf/79/Pw7+7v8fP3+v8E
CAwPERISEQ8MCAMA+/fz8e/u7/Hz9/r/BAgMDxESEhEPDAgE//v38/Dw7+/x8/b6/wQICw8REhIRDwwIBAD
79/Py7+7v8fP2+v8DBwsPERISEQ4NCAQA+/jz8O/v7/Hz9vv+AwgMDxETEhEPDAgEAPz39PHv7u/w8/b6/w
QHCw4REhMRDwwIBAD79/Tx7+7v8fP3+/8DCAsPERISEQ8MCAQA/Pf08e/u7/H09vr/BAcMDhESEhEQDAgE
//z39PHv7u/x8/b6/wMIDA8QEhIRDwwIBAD79/Tx7+/v8PP3+v8ECAsOERISEQ8MCAT/+/f08e/u7/H09/v/B
AcLDxESEhEPDAgE//v28/Hv7u/w8/f7/wQICw8REhIRDw0IBAD79/Px7+/v8fP2+/8ECAsPERISEQ4MCQT/+/
fz8e/v7/Hz9vv/BAgMDhESEhEPDAgE//v38/Hv7+/w8/b7/wQIDA4RExISDwwIA//79/Px7+7v8fP3+/8=
</chan_samples>
</channel>
</channels>
<trigger>
<trig_source value="channel 1"/>
<trig_slope value="positive"/>
<trig_coupling value="dc"/>
<trig_level value="-1.406000e-003"/>
<trig_mode value="autolevel"/>
<trig_delay value="0.000000e+000"/>
<trig_received value="1"/>
</trigger>
<measurements>
<measurement number="1">
<meas_channel value="channel 1"/>
<meas_selection value="none"/>
<meas_result value="0.000000e+000"/>
</measurement>
<measurement number="2">
<meas_channel value="channel 1"/>
<meas_selection value="none"/>
<meas_result value="0.000000e+000"/>
</measurement>
<measurement number="3">
<meas_channel value="channel 1"/>
<meas_selection value="none"/>
<meas_result value="0.000000e+000"/>
</measurement>
</measurements>
</oscilloscope>
<dcpower>
<dc_outputs>
<dc_output channel="6V+">

```
                <dc_voltage value="0.000000e+000"/>
                <dc_current value="5.000000e-001"/>
                <dc_voltage_actual value="-2.030000e-004"/>
                <dc_current_actual value="5.200000e-005"/>
                <dc_output_enabled value="1"/>
                <dc_output_limited value="0"/>
            </dc_output>
            <dc_output channel="25V+">
                <dc_voltage value="1.000000e+001"/>
                <dc_current value="5.000000e-001"/>
                <dc_voltage_actual value="1.000180e+001"/>
                <dc_current_actual value="3.770000e-004"/>
                <dc_output_enabled value="1"/>
                <dc_output_limited value="0"/>
            </dc_output>
            <dc_output channel="25V-">
                <dc_voltage value="0.000000e+000"/>
                <dc_current value="5.000000e-001"/>
                <dc_voltage_actual value="3.970000e-004"/>
                <dc_current_actual value="1.000000e-006"/>
                <dc_output_enabled value="1"/>
                <dc_output_limited value="0"/>
            </dc_output>
        </dc_outputs>
</dcpower>
</response>
</protocol>
```


Table 11. XML response for an AC voltage measurement with oscilloscope

4.4 Using the indicators

Course instructors and MOOC video providers want to know if the lecture videos are engaging and which parts of each video excite viewers and which parts are skipped. Course instructors may also want to monitor the performance and sentiments of students and identify the challenges facing different student groups. Education researchers, on the other hand, want to understand the reasons behind the high drop-out rates in MOOCs and evaluate the effectiveness of different assessment schemes (such as peer grading). MOOC platforms want to know whether the forum provides an effective way for students to communicate with instructors, Teaching Assistants and other students. Students may want to review their use of course materials and monitor their performances compared with other students taking the same course. Lastly, university administrators want to know whether the data from MOOCs can provide a new way to evaluate instructors.

To address these challenges, it is needed to develop both advanced data mining methods to reveal patterns from MOOC data and visualization techniques to convey the analytical results to end users and allow them to freely explore the data by themselves [36].

The number of questions and groups interested in Learning Analytics is enormous.

The ultimate purpose of the indicators is to answer some questions. For the case at hand, the quality of indicators depends on its usefulness for improving the course, its capacity to respond to some key questions about the CFBE MOOC as:

- *Providing freedom for completing the course (disorderly advance) helps or favors abandonment?*
- *The videos have parts that are not understood?*
- *Are students at risk?*
- *The contents achieve their goal or some part requires more support materials?*
- *Do students acquire skills labs?*

4.4.1 Providing freedom

For example regarding the question about the orderly or disorderly advance, Fig. 56 provides a legend to understand the state transition diagram tool presented in [37] which can help to respond the question. The legend shows two possible states, A and B. The figure shows that students enter the State A from the top, make transitions between the states, and then exit the State A from the bottom. The arcs above the states indicate transitions from left to right (i.e. from A to B) while the arcs below the states indicate transitions from right to left (i.e. from B to A). Additionally, line thickness represents the relative number of transition made, while the size of the circle for any given state indicates the number of unique students that entered the state. Each state's name and size is presented as text inside the circle to aid in the explanation of the visualization in this paper, but this information is not strictly necessary in practice.

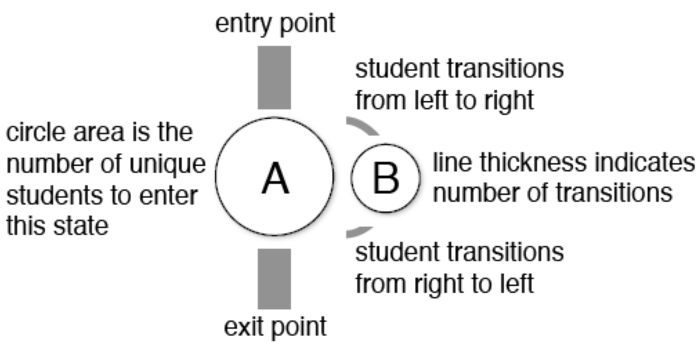

Figure 56. State Transition Diagram Legend [37]

Originating as finite state automata in the computer science discipline, the purpose of state transition diagrams is to represent how a system moves from one state to another state over a sequence of events. Previous educational researchers have used state transition diagrams with learning analytics. In the context of MOOCs [38] used a form of state transition diagram to show student movement between categories of engagement over assignment periods.

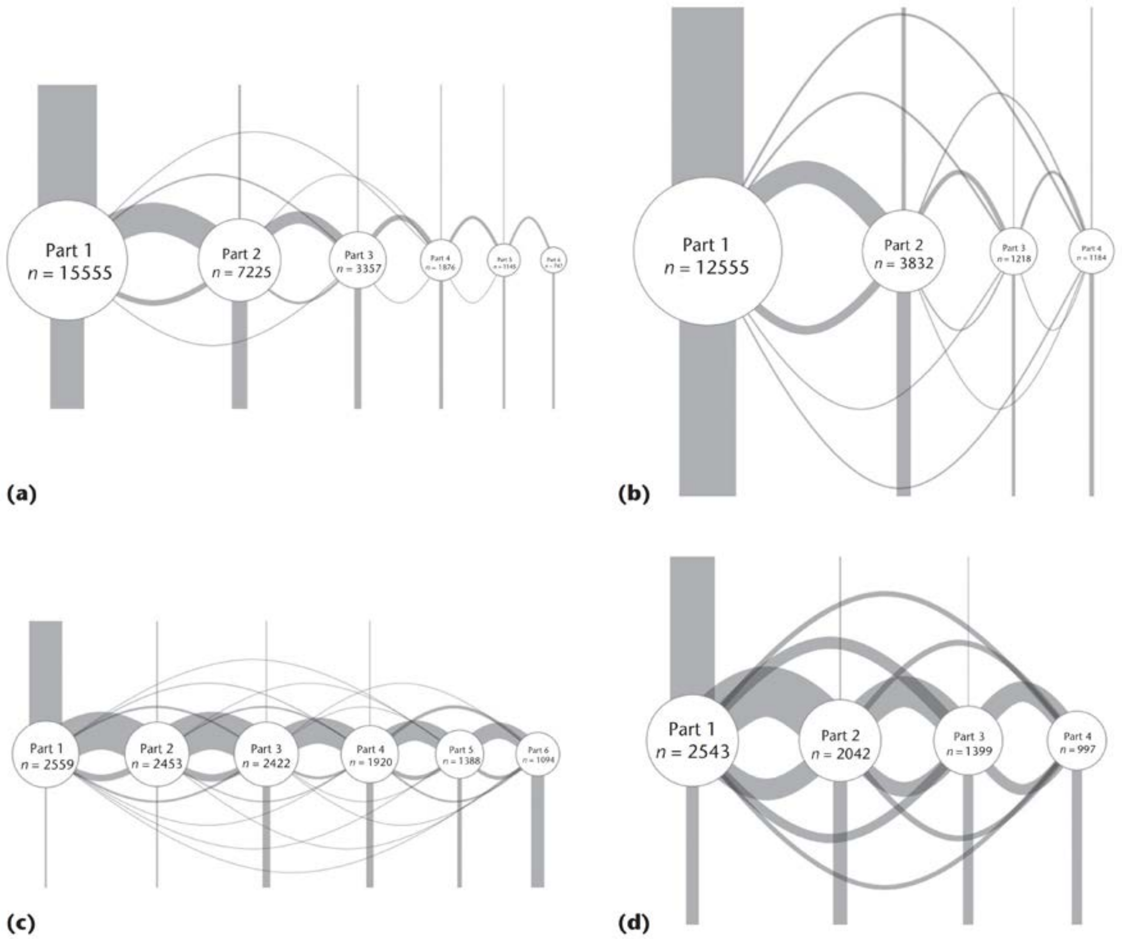

Figure 57. Student video viewing transitions by two subgroups: nonqualified and qualified students [37]

The four state transition diagrams show data from two different courses developed at the University of Melbourne: (a) Principles of Macroeconomics course (nonqualified), (b) Discrete Optimization course (nonqualified), (c) Principles of Macroeconomics (qualified), and (d) Discrete Optimization course (qualified) [37].

From this form of visualization can ascertain whether students following the course orderly get more successful than those who do disorderly. It can be correlated the students' transitions on the CFAE MOOC with the successful completion of the course (or not successful).

4.4.2 Understanding the videos

EdX Insight responses to this question with its video engagement indicators, as discussed in section 4.2.2. In this sense, edX Insight offers better indicators than YouTube Analytics:

- how many learners watch each video
- how many learners watch the entire video, and where the other learners drop out
- video segments that learners watched more than once
- videos that learners decide not to watch

4.4.3 Are the students at risk?

The paper [39] discusses how the results of predictive learning analytics are being used today to improve students' success, shares key predictive learning data sources, highlights factors to consider when working with these data and identifies strategic implementation considerations. A risk-quadrant is provided in [40] that visualizes the students' positions based on the success index (the overall predicted outcome, based primarily on engagement) and the student's current grade in the course (Fig. 58). The quadrant identifies each student in the class with a dot, with the current student highlighted. The quadrants are as follows:

- Withdrawal/Dropout Risk: Identifies students who seem to be struggling in terms of both engagement and performance. In this case, the students may be at risk of dropping out.
- Academic Performance Risk: Identifies students who seem to be engaged but are struggling in terms of performance.
- Under-Engagement Risk: Includes students who appear to not be engaged yet are achieving high grades. In this case, the students may be under-challenged.
- On Track, Not At Risk: Identifies students who are engaged and achieving high grades.

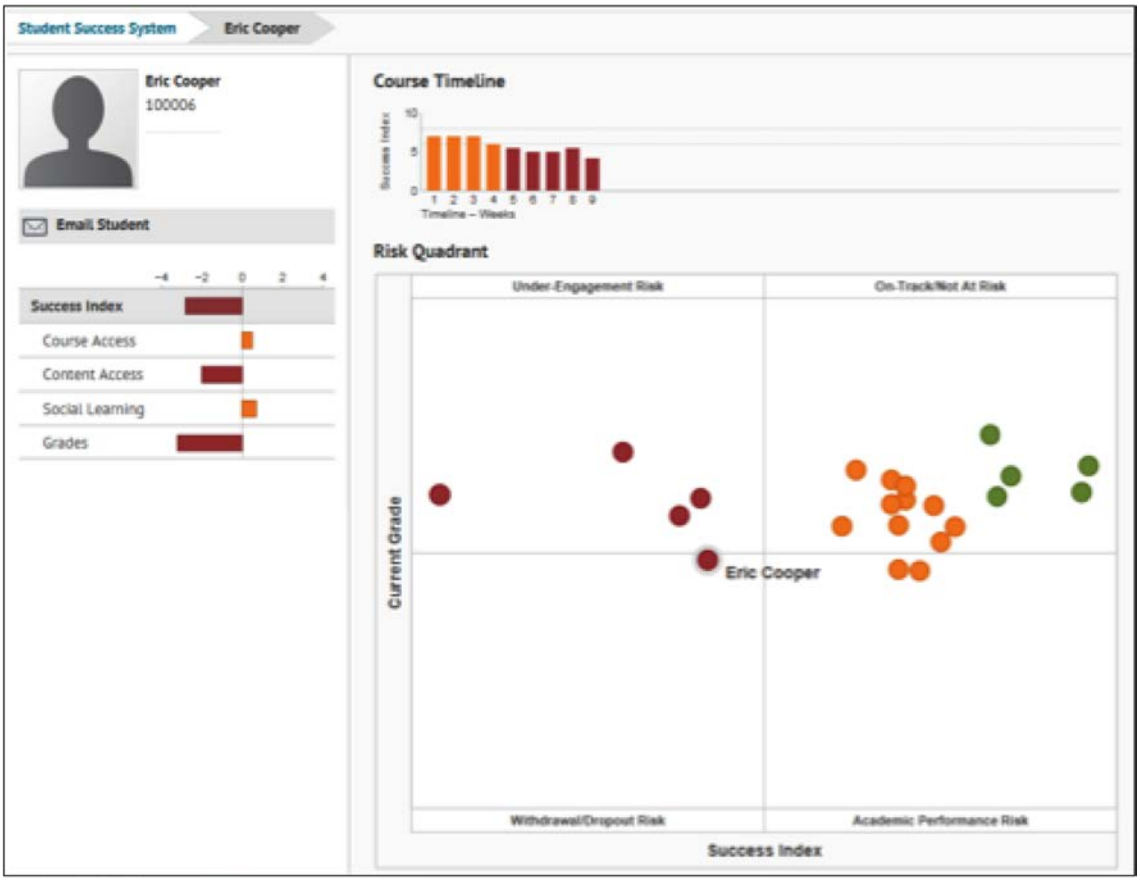

Figure 58. D2L Brightspace Student Success System [40]

Students are often direct consumers of learning analytics, particularly through dashboards that support the development of self-regulated learning and insight into one's own learning.

It would be useful to develop this quadrant using general parameters of the course and make it available to teachers and students.

4.4.4 The contents achieve their goal?

Graded and ungraded content submissions indicators viewed in sections 4.2.3, 4.2.4, 4.2.5 and 4.2.6 may represent the suitability of content or problems in the same. In these sections was discussed its utility.

Also, the information about content achievement can be obtained directly from the databases. The study [41] uses the data published by MITx and HarvardX. These are extracted from actual classes and are, therefore, reliable for testing. With the given set of data, the study implements different graphs to present the correlation between these data, especially regarding the performance of the students and their engagement in the system.

This study represents the following graphs: Grade and No. of Event Interactions, Grade and No. of Days Active, Grade and No. of Video Plays, Grade and No. of Chapter Views, Grade of Certified and Non-Certified, No. of Event Interactions of Certified and Non-Certified, No. of Days Active of Certified and Non-Certified, No. of Video Plays of Certified and Non-Certified, No. of Chapter Views of Certified and Non-Certified, No. of Forum Posts of Certified and Non-Certified, No. of Views per Type (Certified vs. Non-Certified), No. of Event Interactions of Students (Grades > 0.5 vs. Grades <= 0.5), No. of Days Active of Students (Grades > 0.5 vs. Grades <= 0.5), No. of Video Plays of Students (Grades > 0.5 vs. Grades <= 0.5), No. of Chapter Views of Students (Grades > 0.5 vs. Grades <= 0.5), No. of Forum Posts of Students (Grades > 0.5 vs. Grades <= 0.5), No. of Views per Type of Students (Grades > 0.5 vs. Grades <= 0.5), Grades per Course (Explored = 1 vs. Explored = 0), Location Distribution of a Course and of All Students, Level of Education Distribution of a Course and of All Students, Gender Distribution of a Course and of All Students, Grades per Location of a Course and of All Students, Grades per Level of Education per Course and of All Students, Grades per Gender of a Course and of All Students, Grades and Student Behavior per Level of Education of a Course and of All Courses.

Similarly, the corresponding graphs for the CFBE course can be established using the databases of Open edX.

4.4.5 Do students acquire skills labs?

Acquire practical skills in the analysis of electrical and electronic basic circuits in a laboratory with real components, in handling the equipment making up an electronics laboratory and employment and the behavior of real components are objectives of the course.

As said in section 4.3, the XML-based communication protocol allows extracting the concrete configuration settings of instruments, measurement results and correct circuit assembly. For each practice and student, these dates can be obtained and visualized.

In any case, [42] and [43] show how indicators for success can be derived from discussion forums, because communication in forums provides a lot of information about the level of knowledge and about learning behavior of students in a course. There is a higher probability that students participating in a forum discussion will complete (parts of) a course.

5 Conclusions and future work

This work has shown indicators of the students' behavior, based on the contents of the MOOC course *Circuits Fundamentals and Applied Electronics*, in the ambits of the edX platform, the video provider YouTube and the own electronic remote laboratory VISIR, as a part of the Learning Analytics processes of selection, capture and processing of data that will be helpful for improve the course.

The analysis of both the edX platform as the video provider YouTube, added to the analysis of the VISIR architecture and its communications allowed to find indicator sources related to the video viewing, the engagement with contents, the submission of exercises, the students' activity and progress along the course and even related to the students' handling of VISIR. EdX Insights and YouTube Analytics are existing analytic platforms and both allow explode video based indicators. Additionally, edx Insight allows a wider range of indicators type (students' progress, submissions...). The third set of indicators, related with the analyzing of the students' remote operation and measurement with VISIR (we can name it *VISIR Analytics*) should be extracted with a specific application yet to be developed from the XML communications and therefore constitutes a line of future research. Such indicators would allow a very deep understanding of student handling: how they handle components and instruments and definitely how students perform the practices.

In all cases is common the graphic presentations of results, because allows the visually comparison and evolution of indicators, like a control panel. In this sense, it would be useful that the students access to their results in order to show them its locations in relation to other students and make them aware of their progress or delays. This constitutes another line of future work.

Finally, it should be remembered the existence of social learning analytics. In this regard is possible, for example, the developing of indicators based on the forums of the courses, related to the students' speaking and listening. So that is another challenge to face…

iv References

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