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Open remote VISIR electrical and electronics practices

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Platform Integration of Laboratories based on the Architecture of visiR – PILAR

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Table of contents

Figures:

Tables:

1. VISIR System

1.1. Overview

This document describes the access to a defined set of open remote VISIR practices developed during the PILAR project. These practices are available at EU level through a federation of remote labs openly available on Internet, via a Moodle accessible set of lessons and experiments, i.e. practices [1]. The federation policies were developed during the project and allow any EU interested institution (universities, schools, content providers) to provide and access its services [2]. Presently the available content is intended for learning basic (and complex) electrical and electronics circuits, for different subjects at school/high school and at grade and master university levels, but can be expanded in the future, as seen fit by the federation.

As a remote lab, VISIR presents several advantages to students with educational difficulties and geographical obstacles: it allows such students to carry out experiments the number of times they need, without having to be in the lab. These are two of the main advantages presented by remote labs over hand-on labs. In addition, and because remote labs imply real experiments with real components, they also present an additional advantage over virtual labs (simulations). The only problem, addressed by the PILAR project, is supporting all the experiments that are done, in a single semester, in all the courses that involve electrical and electronics circuits (implementable in VISIR), in a single institution. Although quite powerful, one VISIR platform has limitations regarding the total number of different components it can have, while also allowing for all possible interconnections. The VISIR federation and the developed PILAR Moodle repository allows for a structured and combined service benefiting from the individual offer of each VISIR node, making all of them available through the federation of those same nodes.

1.2. VISIR System

VISIR is an open remote laboratory dedicated to experiments with electrical and electronic circuits [3]. It allows teachers and students to practice real-world experiments, remotely and in real-time mode, with test and measurement equipment relying on a user interface that replicates hands-on equipment and components.

In the VISIR lab, users can wire the desired circuit with the available components and use several instruments to analyze its behavior. Figure 1 represents a VISIR system installed in ISEP/IPP, Porto and Figures 2 and 3 represent two parts of the VISIR interface, namely the virtual breadboard used for the experiment design and the interface panel of an instrument.

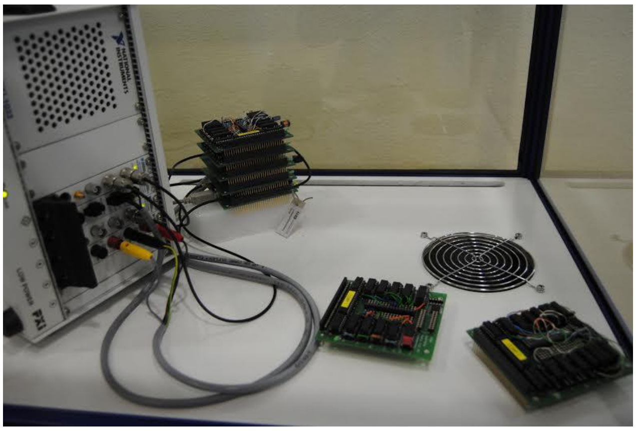

Figure 1 - VISIR at ISEP.

Presently the interface provides five different components, namely:

The virtual breadboard, with connectors for DC power, function generator, digital multimeter and oscilloscope.

- A function generator, with HP33120A front panel
- An oscilloscope, with an Agilent 54622A front panel
- A digital multimeter, with a Fluke 23 front panel
- A triple output power supply, with a E3631A front panel

The real instruments used on the remote lab consists of plug-in PXI boards installed on a National Instruments PXI chassis. The basis of the experimental apparatus is the switching matrix, presented on Figure 2.

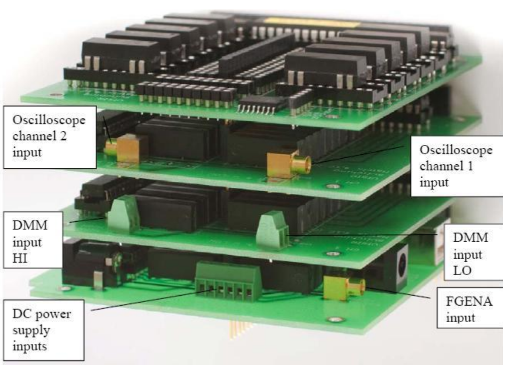

Figure 2 - Switching Matrix

The matrix displayed is the basic version, as it is possible to add boards and components. The circuit components are placed on the top boards, either on the boards themselves or mounted externally (but linked to the boards). The bottom three boards are used to connect the instruments and I/O signals, with a board used for the oscilloscope, another for the digital multimeter and the bottom one being used for the function generator and DC power. The matrix doesn't house any instruments, only the connections to external devices, but the component board (or boards) can house a reasonable number of components.

VISIR includes also a Learning Management System (LMS) designed to control access to the remote laboratory resources, although several universities opted to integrate it into their own LMS systems.

VISIR may be considered as a remote workbench, equipped with the same instruments that exist in a hands-on laboratory for conducting experiments with electric and electronic circuits; these workbenches are similar to each other, every place in the world: usually in each, there is a breadboard and components, provided by the instructor, and the student uses them to mount the circuits and to connect the test probes, as determined in the lab instruction procedure. Using VISIR, an identical simulation of the real equipment and instruments appears (a virtual breadboard and photographs of the components) on the student PC screen. Students use the mouse, instead of their fingers, to adjust the instruments, to position components on the breadboard and to do the wiring to assemble the circuits. The corresponding real components are mounted in sockets in a switching matrix and the measurement results, through the instruments virtual front panels, are displayed in students´ PC screen. So, as long as the student as a PC or more recently a handheld device, such as a smartphone or tablet, he has the ability to access to this real electronic lab (which mimics a traditional workbench), at any location, by using the internet and a web-based user-interface using any web browser.

2. Access System

Access to the PILAR federation is open and described in the federation policies [2]. Any institution that is part of the federation can access and publish content on the access system. Presently, all content is stored on the PILAR Moodle system, responsible for managing access, content and experimentation. All the teachers and students in subjects related with electronics and part of the federation institutions can access all different practices and include them in their subjects' activities. All the participants in the different workshops in the multiplier events of the project that used PILAR have access to the available resources that were used on that workshops.

The PILAR federation allows for the possibility to integrate all different experiments made available by each partner as a complementary educational tool for fostering the acquisition of lab skills in courses involving experiments with electrical and electronic circuits.

Users of the PILAR Moodle system can be divided into (1) Administrators, (2) Editors and (3) Clients. Administrators can create courses and manage other users' access and interface configuration. Editors can add, edit and revise course contents. Clients have no editing privileges and can only access the contents.

Access to the PILAR Moodle system can be made in two different ways, namely:

1 – Direct access by obtaining a username and password from any federation institution.

2 – Indirect access through each federation institution own LMS system.

The latter option should be used as the default procedure, and the system was tested and is currently operating with the partner institutions own Moodle systems but can be extended to any compatible LMS system. The technical solution adopted is the inclusion of the PILAR Moodle (or an individual lesson or experience) and an external LTI (*Learning Tools Interoperability*) on the host Moodle system. For the Editors and Clients (teacher, student, technician) on each institution the PILAR tools can be made available as a whole or in part, as an internal resource of its own institution. The course designer can provide a link to an individual experiment, lesson or the entire course tree as he sees fit, provided access was granted by and Administrator. Login procedure is managed in each LMS and the access to PILAR federation is transparent to the user.

Alternatively, users can be created in the PILAR Moodle system itself, but this will require an extra login/password to be executed and stored by each one. Access to the PILAR Moodle base system will provide the user with the interface displayed in Figure 3.

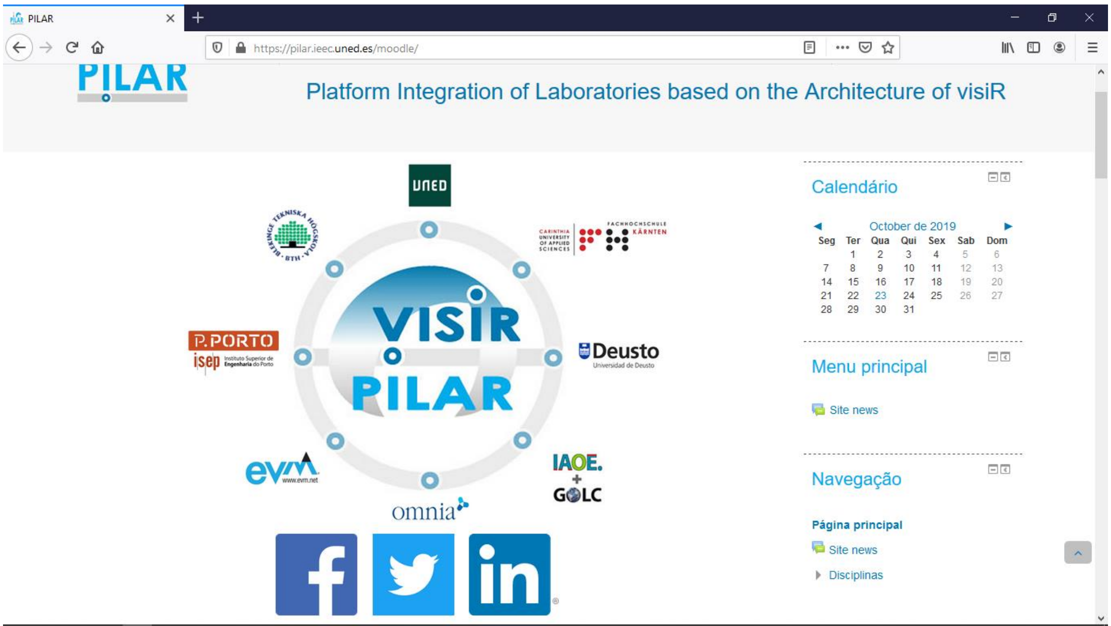

Figure 3 – Main Access Screen

Administrators can configure access to the PILAR Moodle so that a user (or set of users) will get access through the above interface or reduce the number of options available or direct the user directly to only one course or experiment. The procedure is completely dynamic, and link based, so a link on the user original LMS can provide access to one simple experiment, and another link can provide access to a broader area of the system. Figure 4 presents a set of courses made available to a user. It should be noted that these experiments are provided and managed by different institutions within the federation.

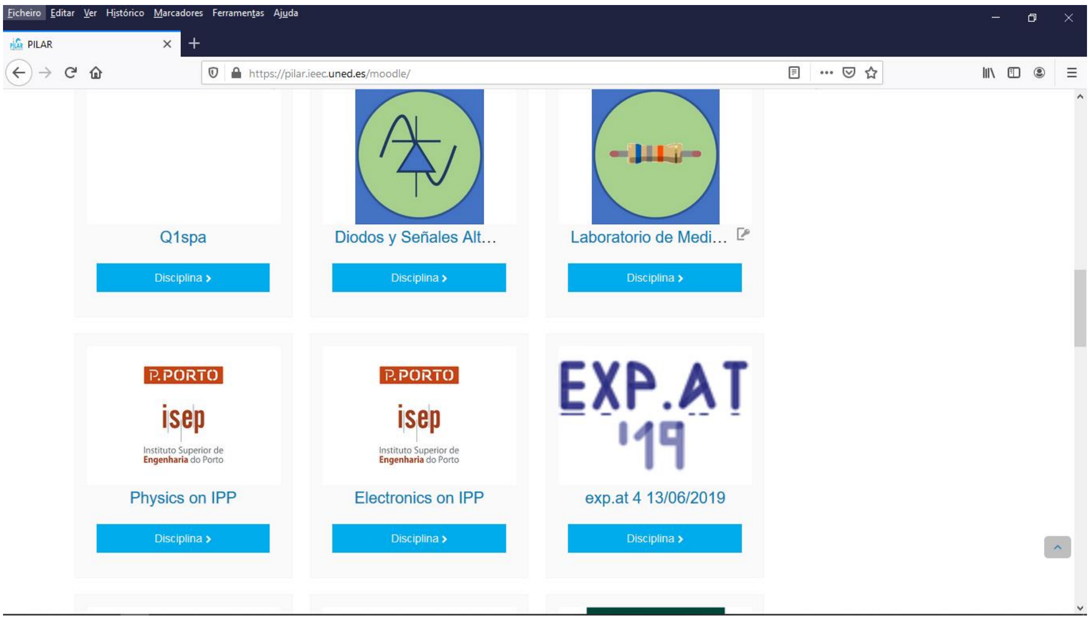

Figure 4 – Example Set of Courses

3. Structure

Table 1 presents the initial set of courses available at PILAR project ending phase (July 2019). The list is updated frequently, namely on each semester start in order to accommodate the different subjects being taught at federation institutions and the ongoing development of new courses and experiments.

Table 1 – List of Available Courses

Designation	Responsible Institution
Diodos y Señales Alternas	UNED
Laboratorio de Medidas Eléctricas Básicas	UNED
ELAPL Course on PILAR	IPP
Physics on IPP	IPP
Electronics on IPP	IPP
Plaza Robótica	UNED
UNED - Curso Básico de Electrónica FIE	UNED
UNED 2 - Fundamentos de Ingeniería Electrónica	UNED
DEUSTO Industrial Electronics	UDeusto
DEUSTO Physics	PILAR pilot course
DEUSTO Analog Electronics	PILAR pilot course
BTH Basic Electronics	BTH
BTH Operational Amplifiers	BTH
BTH Electric measures	BTH
IESRM Semiconductors I	UNED
IESRM Basic Electricity	UNED
CUAS Equivalent Circuits	CUAS
CUAS First-Order Circuits	CUAS
CUAS Transmission Line Measurements	CUAS
PILAR pilot course	ALL

Most courses are delivered in English by default or as an option, with some courses being still under migration with the English support materials under development. The VISIR federation provides and incentivizes the use of a common template [4] for experiment guides in order to uniformize the user experiment and make clear the adherence to the federation policies and common methodologies. Although not presently mandatory, ongoing and new experiments will progressively migrate to the standardized format.

Within the flexibility made available by the PILAR Moodle and Federation policies, BTH opted for making available a link to its own internal VISIR system where users can perform the available experiments with an institutional "open access" policy. In this case the PILAR Moodle acts as an access broker, providing access and login data only.

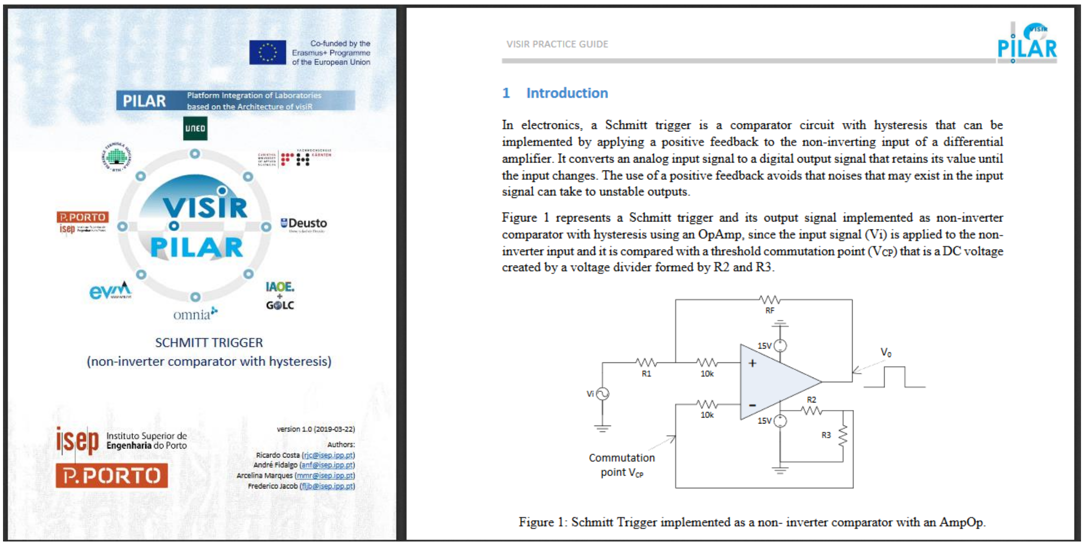

Figure 5 – Experiment Template Examples

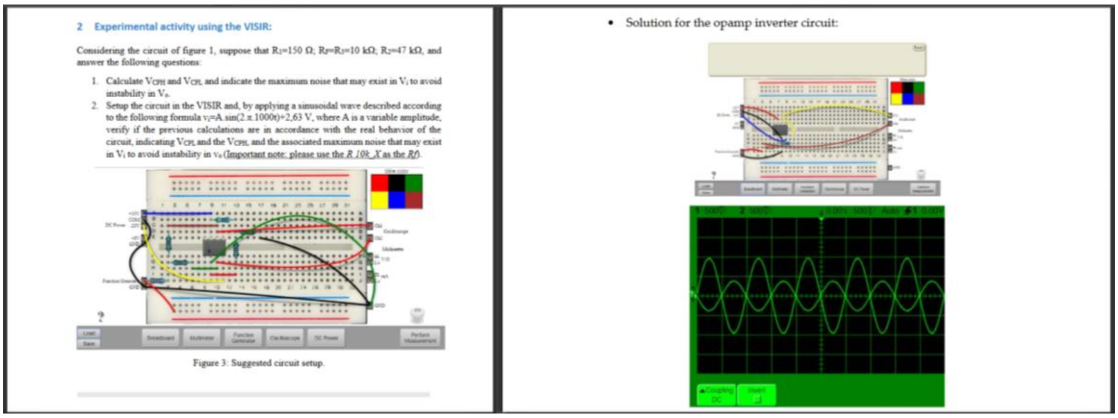

Figure 6 – Experiment Template Examples

Figure 5 and Figure 6 present an example of an experiment guide on the PILAR template, including the front page, experiment description and the expected solution. It should be noted that each content provider can tailor the template to its preferences adding or removing content, providing the base information and style is maintained.

Each course is structured into lessons and experiments as designed by the course provider. Each institution is free to determine its own policies for course management, grading, content, etc.

The usual approach is the definition o a responsible teacher for each course and a support technician to handle technical issues. The PILAR project guaranteed technical support and pedagogical counselling during the project execution, and this will be maintained after the project is terminated within the VISIR federation sphere of operation, as defined in its policies.

Figure 7 presents the initial page of one of the courses (Rectifier Diodes), including the course structure, navigation panel and an experiment (including the link to the guide in PDF format).

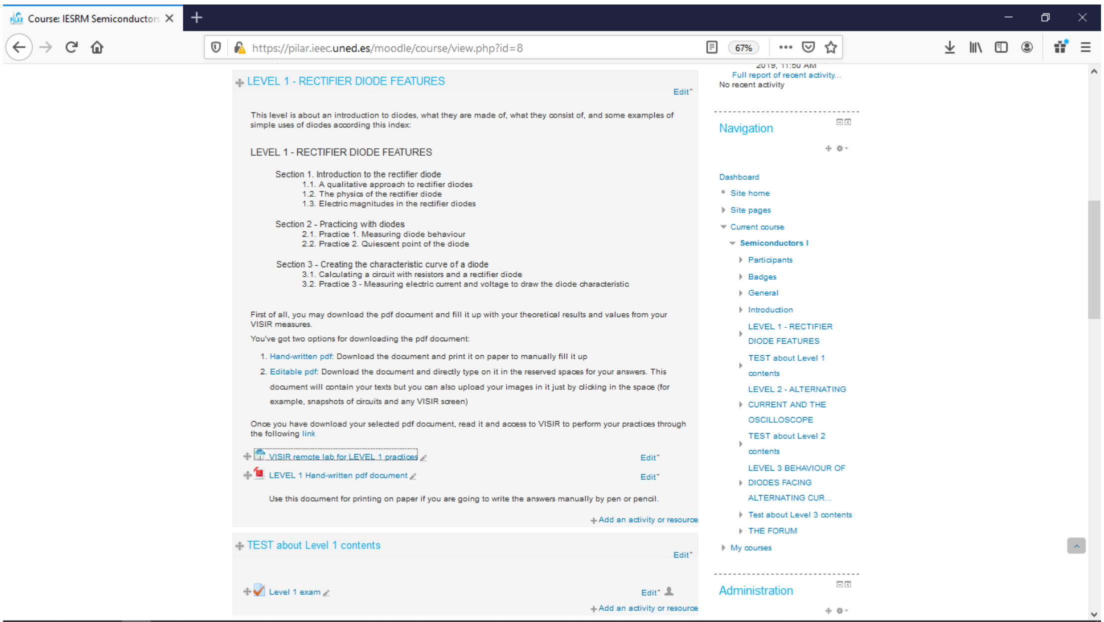

Figure 7 – Course Example

Figure 8 presents the initial screen of an experiment as accessed by a student. In this case the experiment is initially bare, with the student having to plan and perform the entire procedure, but the system allows for an initial setup to be made available.

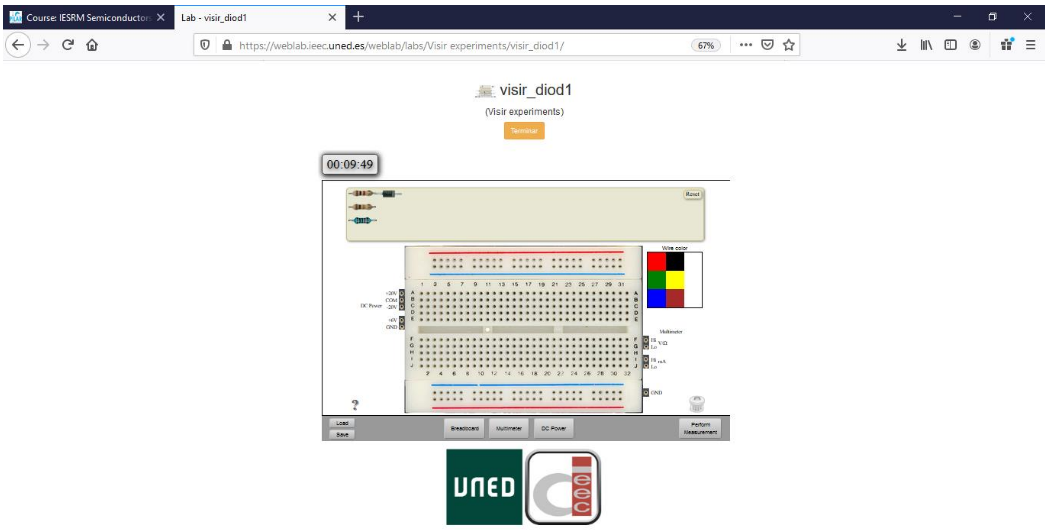

Figure 8 – Experiment Example

During the execution of the PILAR project, several combinations of experiments were made available by all partners and tested in detail by the consortium. Within the course ser each partner provides the following set of experiments:

- Function Generator / Oscilloscope
- Resistors Association
- Ohms Low / Voltage Divider

Additionally, each partner made available a specific experiment that should be permanently available as a base of the common Electrical and Electronics course, namely:

- UNED - Filters and/or RCL
- UDeusto - Wave Rectifier
- ISEP/IPP - Operational Amplifier
- CUAS - Transmission Line
- BTH - BJT Transistor and Transient

These experiments were fully tested and are available for use in any partner course. The VISIR dynamic structure on each partner dictates that at any specific moment it may be necessary to change the available set of courses in order to manage the available resources as the Matrix is finite in its capabilities. Consequently, at each semester the actual set of available experiments may change and is managed within the federation policies.

PILAR project also required students to fill satisfaction questionnaires, which are present on most developed courses. Although optional, these provide an important source of information for course developers and VISIR federation managers and are recommend to all course creators, and therefore present on most developed courses. Additionally, the VISIR federation system can provide considerable background information, available to administrators by default, but sharable with all users as desired by each institution. Figures 9 to 12 present the different data analysis reports that are available.

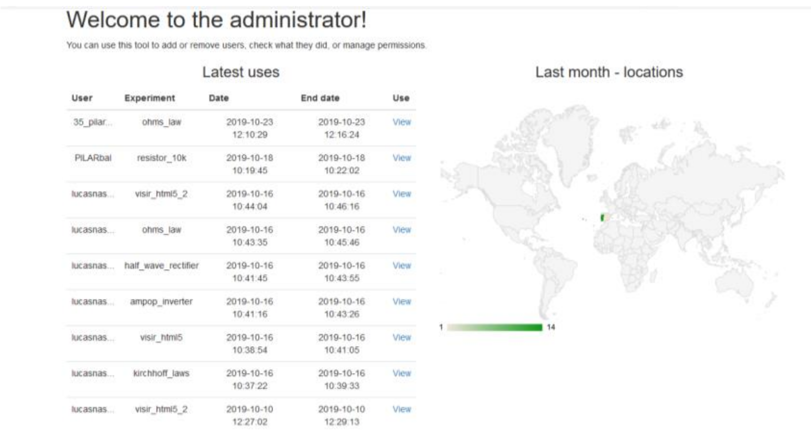

Figure 9 – Administrator Access with access map

Administrators can access individual login information and establish the geographical origin of each access, providing this information is made available by the user network (it usually is).

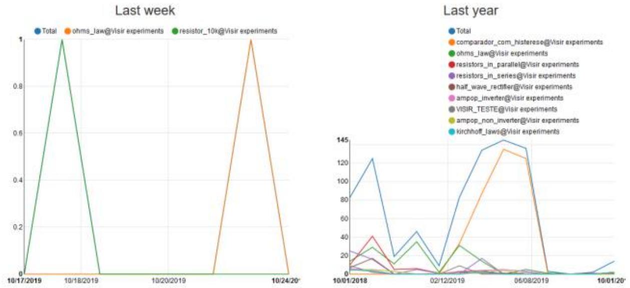

Figure 10 – Usage graphs

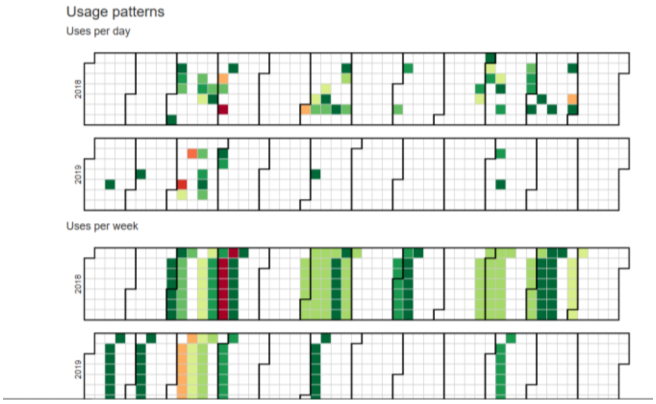

Figure 11 – Daily Usage patterns

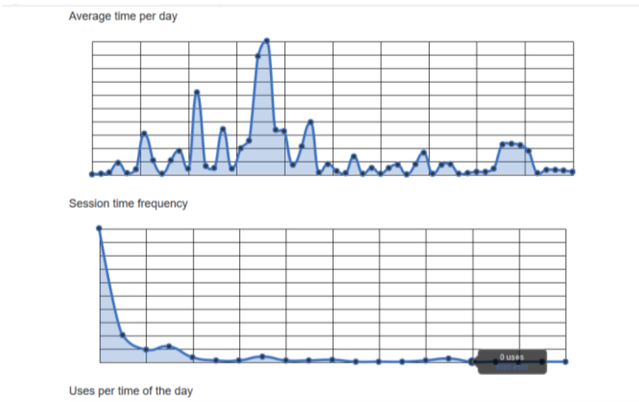

Figure 12 – Hourly Usage Patterns

Several types of usage graphs can be accessed in order to determine the access patterns and loads. Data can be further datamined in order to obtain all necessary information for pedagogical, grading and data balancing purposes. Presently this information is only available to Administrators, but as the system gets more usage it may be gradually provided to course creators in order to improve the content quality and the user experience.

4. Conclusions

The PILAR project allowed the creation of a large set of open remote VISIR electrical and electronics practices, which will be now maintained and expanded by the VISIR federation. The developed technical, methodological and pedagogical solutions represent a step forward in the online teaching and experimenting, applicable to teaching in Electronics and parent fields.

The main advantages to the user community would be the increase in competences in electronics due to the versatility and experiments offered in the portfolio of services included in PILAR project, the strategic and integrated use of ICTs and open educational resources (OER) and reinforced interaction between practice, research and policy in each system.

One of the main results of PILAR is the ability to use of its outcomes into the curriculum of subjects related to electronics in institutions that do not have yet deployed VISIR or increase the presence of VISIR with more experiments shared through PILAR and VISIR federation.

As a result, the VISIR federation has the necessary tools to progress into the development and installation of a large VISIR based remote labs set, which will be available to current and prospective users as, for example, high schools. This system will include experiments from all partners, a unified access to the experiments, and a common set of documentation and support material. This will enhance the interest and usability of the system and motivate its use in additional courses and institutions.

The federation will allow any of its members (present or future) to add and use content and experiments to the shared resources, making it a very useful and interesting way to include laboratorial experimentation into electric or electronic based courses at several levels of education. It is expected that several universities and secondary schools will gain interest in the federation, not only as passive users but, eventually, as content providers

The end objective of the federation that originated from the PILAR project is the increased quality of education and training and youth work in Europe and beyond: using the words of Ingvar Gustavsson, the “father" of the VISIR at BTH: “The only way to learn the language of nature is performing many experiments in laboratories that can be hands-on or remote.” In that way, VISIR, thanks to the outcomes of PILAR , will increase the number of experiments, experiences, learning materials and hours that a student can spend in a lab in a remote way. This issue will have a great positive effect on the quality of the student’s training due to the increase of learning tools and its availability 24/7.

References

[1] Pilar Moodle Website, available at pilar.ieec.uned.es/moodle/

[2] VISIR Federation Policy v 2.4, Platform Integration of Laboratories based on the Architecture of visiR – PILAR, C.Kreiter, A.Pester, T.Klinger, CUAS, 2018

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