Dashboard for the VISIR remote lab

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Abstract— **The VISIR dashboard (VISIR-DB) is a learning analytics tool connected with the VISIR remote lab. In VISIR, every action performed by a student from the interface over the remote laboratory and back is logged and recorded. VISIR-DB helps visualizing, in a fast and deep way, the recorded logs from this communication. Using this tool, a teacher can analyze and understand better how the students are using the remote lab during their learning process on analog electronics. With this information, the VISIR platform can be improved and the use of remote labs can be better understood.**

Keywords— remote laboratory, learning analytics, dashboard

I. INTRODUCTION

VISIR [1]is the most popular and well-known remote lab (Fig. 1). It is being used by more than fifteen universities and schools in the world and it is oriented to teach analog electronics.

Previous work [2-3] reported that the use of VISIR with DC circuits has a positive learning effect on the students, according to survey-based studies.
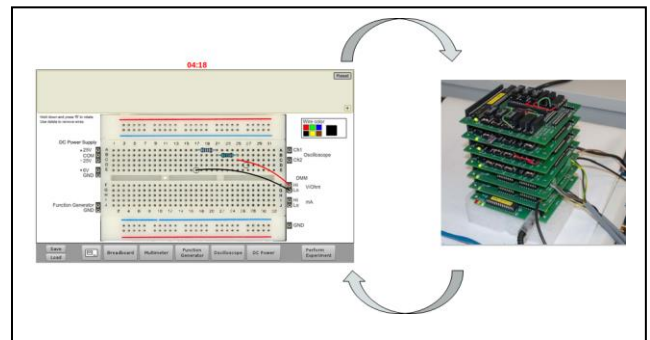
Fig. 1. VISIR remote lab: (left) interface, (right) hardware. Arrows represent information going back and forth.

Noticeably, when the students are using the VISIR remote lab under the WebLab-Deusto platform, every action performed by them is recorded, i.e. what circuit was created and what measurements were requested (if any). This is a huge amount of information that can give us a deep knowledge about how the students are using the VISIR remote lab.

Currently we work on using this information to get deeper insights of what happens on an academic task performed with the VISIR remote lab. This is the goal behind the VISIR-DB, a learning analytics tool currently in development [4].

Now we present, using this approach, some details on the students' use of VISIR in a DC circuits experimental activity. The objectives of this contribution are then two-fold: (1) to

present the use of the VISIR-DB tool in real academic task, and (2) to discuss what insights are gained from its use.

The paper is focused on the use of the VISIR remote lab in a Physics course during the second semester of the first academic year of the double degree in Informatics + Business Administration at the campus of San Sebastián of the University of Deusto (Spain). In the 2017-2018 academic year there were 19 students enrolled.

Physics course is divided in three parts: fundamentals of electromagnetism, AC and DC circuits and CMOS digital circuits. VISIR is used when teaching AC and DC circuits. In DC circuits, the students learn what a simple DC circuit (a combination of resistors plus one DC power source) is, how to solve it analytically and how to build and perform measurements on it.

In a common academic assigment, after solving a given DC circuit using Ohm's and Kirchhoff's Laws, each student must implement and measure the given circuit to compare whether the obtained measurements match the analytical results. Instead of using a hands-on lab, we use the VISIR remote lab. So, the students build and measure different circuits using only the VISIR remote lab. The DC circuits had a maximum of four resistors combined in parallel and/or series. This topic was covered during 2 weeks at the beginning of the semester, in February 2018.

In the paper, first the VISIR-DB tool is introduced (Section II), and then, the results obtained for the single presented activity are shown and discussed (Section III). At last, conclusions and future work are stated in Section IV.

II. VISIR-DB DESCRIPTION

VISIR-DB has been designed and developed as a Shiny application [5]. The Shiny app we are presenting is arranged in four sections: Data Input, Global Results, Circuit-based Analysis, and User-specific Results. Each section is organized into several subsections and panels, in which meaningful visualizations are displayed.

The Data Input section allows selecting the file to be analyzed. A CSV corresponding to the recording of the interactions in the WebLab-Deusto platform is expected. Summary data as number of users or date range are provided for double-checking purposes.

The Global Results section provides different summaries and visualization intended to provide a summarized view of the group of students, both in terms of time and amount of work (number of actions and experiments performed). Attending to the circuits, and not to the students, the Circuits-based Analysis section offers the list of circuits implemented by the users and shows when and who built each of the circuits. The User-specific Results Section facilitates information for a specific user and for the circuits created by him.

Next, we will show and analyze the results given by VISIR-DB for the 19 students described above.

III. ANALYSIS OF A TASK WITH THE VISIR-DB

The VISIR activity took place in two classroom sessions of two hours, so four hours in total in the classroom were with VISIR. Two other sessions of two hours were devoted

to the analytical solving of the electronics circuits using Ohm's and Kirchhoff's Laws.

During the first session the students had the first contact with VISIR and after some examples presented by the teacher to the students they learnt how to create an electronic circuit with only resistors, without power source. Then the students learnt how to measure the total resistance of a circuit. After some examples made by the teacher with the students, they had to create and measure 20 new electronic circuits with two resistors of 1 kΩ and two resistors of 10 kΩ. A google excel was shared by the teacher, and the students had to write there the obtained measurements. Using the google excel the concept of measurement error was introduced. After the session, the students were asked to measure only the total resistance of all the given circuits, as homework.

During the second session the students started to power the circuits and to measure the voltage and current. In a first step the teacher showed the students how to measure the voltage in a powered circuit. Then, the current measurement was introduced to the students. In this case more time was devoted to this because current measuring is harder than voltage measuring. After some examples made all together, students and teacher, the students started to work alone measuring voltages and currents of a set of given circuits. After the session, the students were asked to measure all the given circuits as a home work.

During the two sessions the teacher showed the students the most common errors made when creating, powering and measuring a circuit. Some errors can be defined as instrumental or manual errors, but other errors must be considered conceptual errors.

All the actions made by the students when they were mounting and measuring circuits either at home or in the classroom were recorded by WebLab-Deusto in a trace file.

To analyze the trace file, such as pulled from the system database, the first step, see Fig. 2, consists on loading the data to VISIR-DB. Once the file is loaded, the number of users, 19 in this case, and the date range, from February, 7th to February, 24th, are shown.

We move then to analyzing the global results for the class. Looking at Fig. 3 we can see that the average use time on task of VISIR was 4.25 hours per student, with a clearly right-tailed distribution. The minimum was less than two hours, the maximum was 9.64 hours and the total was 80.81 hours.
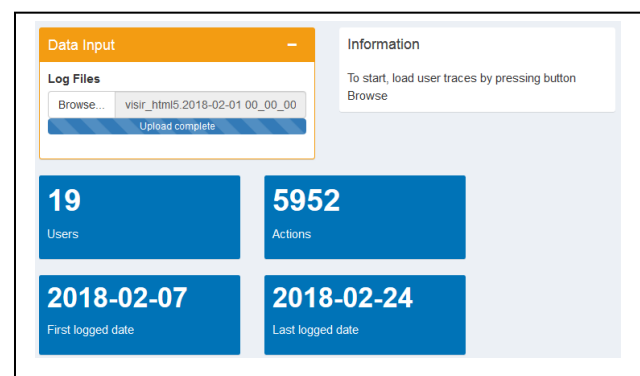
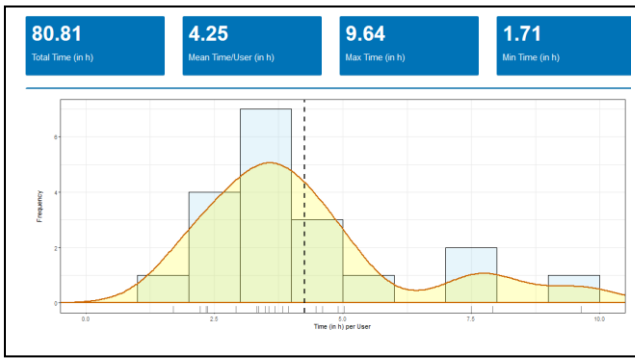Fig. 2. Data loading from Weblab-Deusto RLMS

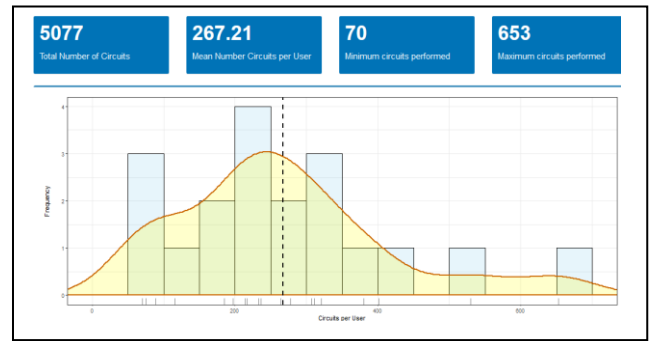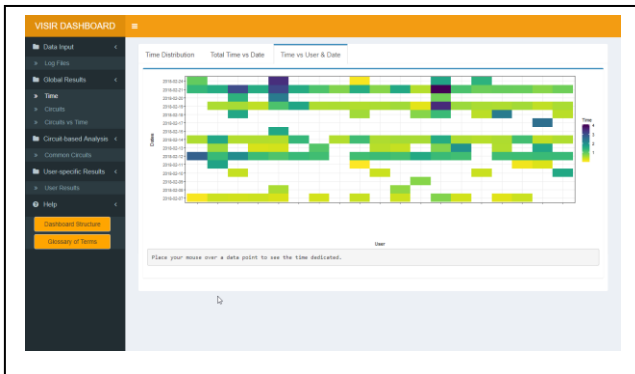Fig. 3.   Histogram of time on task, using VISIR, per student

Fig. 4.   Temporary distribution of the students work; rows are dates and columns are users, the color scale indicates time on task.

Fig. 4 shows hours of work of each student day by day. Yellow indicates that the activity was low, and blue remarks that the activity was high. Attending to this graphic the teachers can see the activity of each student. The instructor can also get insights on the time spend using the remote lab off-class by each user. In this case, students 3, 5 and 13 are the ones that seem to have put more effort into this task.

Looking at Fig. 5 we can analyze the VISIR platform attending to the number of performed circuits. 5077 circuits were created by the students, the mean was 267 circuits per student, the minimum number of circuits created by one student was 70, and the maximum was 653. We can see that there is a huge difference among the students. Like the time distribution, the number of circuits is a right-tailed distribution, with some users performing a quite large number of experiments.

Fig. 5.   Histogram of the number of circuits per user
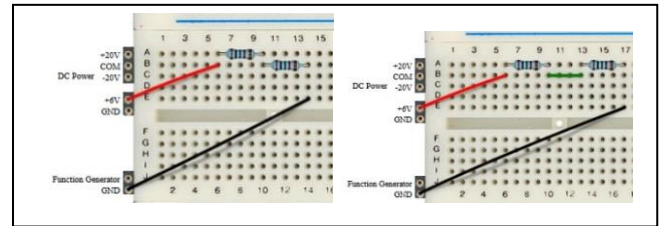

Fig. 6.   Two equivalent DC circuits

It is important to remark that in this first analysis in the VISIR-DB the two circuits of Fig. 6 are taken as different, when they are equivalent. To account for this, the VISIR-DB translates any circuit into an equivalent, normalized, one. If two circuits have the same components and connections (including the multimeter), then their normalized circuits are equal. The normalized circuits represent then different measurement made in a circuit.

Attending to the previous statement, VISIR-DB refines the initial analysis with the Fig. 7. Now we can see that the number of different circuits is 1004, the mean of circuits is 95 per student, one student created only 47 different circuits, and another created 181, almost four times more. We can also read than 3 students implemented a larger number of different experiments than the rest of the class.
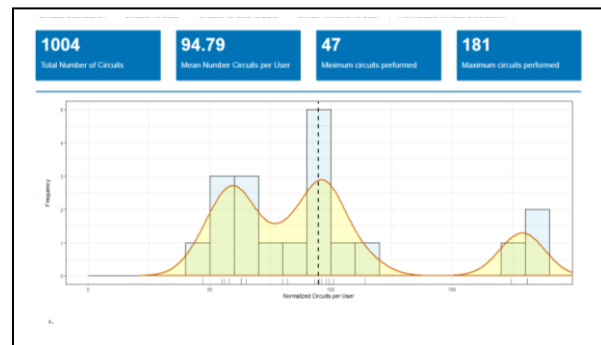

Fig. 7.   Histogram of the number of circuits per user

Fig. 8. Students activity; number of normalized circuits in front of time on task.

VISIR-DB also allows us to analyze the activity of the students. Fig. 8 shows students work (number of normalized circuits) in front of time on task (time spent using VISIR). This chart makes easy to spot students that may have difficulties with task or the class. Why are some students spending so little time to the task and building such a small number of different circuits? Are they getting confused? In our case study, three hard-working students are easily observed and a handful of students in the bottom part of the graph that may benefit of some tutorial action.

In each circuit, the student can measure resistance, voltage or current, or it can be an erroneous circuit. At this moment, a circuit is taken as erroneous if the multimeter setup and the circuit connections are not coherent or if there is no multimeter. Attending to this classification, we can visualize the activity of the students by plotting each of the measured circuits in a timeline (Fig. 9, each column is a different student). We can see that each student creates a significant proportion of wrong circuits during the entire lab time.
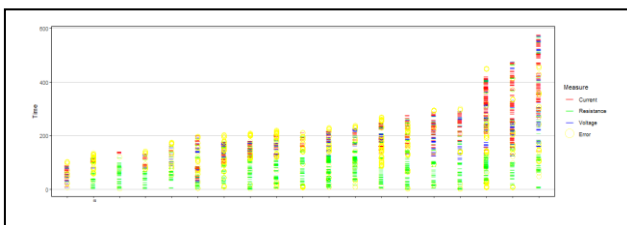

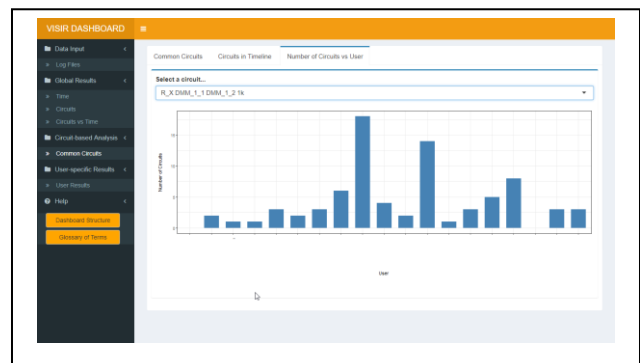Fig. 9. Summary of the actions of each student (columns)

Fig. 10. Creation of one circuit by the students.

It is also interesting to analyze the use of the VISIR attending to the specific circuits, i.e. for the circuits that are especially relevant to the academic task.

In the Circuits-based Analysis section of VISIR-DB, we can select a circuit and see how many times this normalized circuit was made by each student (Fig. 10). In our study case, the circuit corresponding to measuring the resistance of a 1-kΩ resistor was built by all the students but students 1 and 17. Student 9 implemented it 18 times.

Although not shown here, VISIR-DB also lists the normalized circuits by number of implementations. This allows the instructor to explore whether the expected circuits have been built. Unexpected and common erroneous circuits will also show up in this visualization.

As explained above, in the User-specific Results section of VISIR-DB, we can also select specific users to examine their work and to provide them more detailed feedback on their performance and their mistakes.

IV. CONCLUSIONS AND FUTURE WORK

As presented in the previous section, using the VISIR-DB, a teacher can have a better knowledge of what the students are doing during the learning process. Gained insights go from time spent in doing an academic task, to identify students that could benefit from some individual support, or to identify which specific tasks (expected circuits) where easily solved and which could need an extra explanation in class.

In our case study, time on tasks distribution was what we expected, and some highly-motivated students were found. Also, a large amount of wrong circuits appeared in the analysis and this suggests some research may be needed to deepen into them.

From now on, different teachers that are using the VISIR remote lab should start to process their own data and then share these results within the VISIR community [6]. This process will suggest new functions that can be included into the VISIR-DB to analyze other aspects of the use of VISIR.

A deeper exploration into the errors and a classification of the kinds of errors the students are making can also be warranted by our results. This analysis is likely to modify how we use VISIR to improve the learning outcomes attained by students.

ETHICS

Data processing follows the recommendations of the Ethical Committee of the University of Deusto.

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