An Automatic Assessment Model for Remote Laboratories

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***Abstract*— In this paper we present an automatic assessment model for competences developed in a physics course using VISIR remote experiment, based on a rubric and using learning analytics techniques to process data automatically collected from students' activity using Weblab-Deusto platform.**

Keywords— Learning Analytics; Remote Laboratories; Automatic Assessment Model

I. INTRODUCTION AND BACKGROUND

The University of Deusto (UD) introduced in 2001 a competence-based Learning Model (UD-LM), with the student as the center of the learning process and the teacher as a facilitator [1]. In this context we define competence as "the integration of a series of elements (knowledge, techniques, attitudes, procedures, values) people brings into play in a specific problematic situation, demonstrating they are able to solve it" [2].

The UD-LM includes five steps to achieve the objective of an autonomous and meaningful learning (Fig. 1). The main innovation of the proposed model, compared to traditional teaching and learning, focuses in the last two phases: active experimentation and assessment and evaluation. This learning model relies on active experimentation to consolidate knowledge and skills, even more in engineering studies [3]. In this sense, one of the most innovative technologies is Remote Laboratories, which are real experiments accessed through a web interface [4]. Robots, microcontrollers and other resources are available anytime and anywhere if the user has an Internet connection. For example, in figure 2 you can see an experiment where the user can manipulate a robot from his/her computer, and see the behavior of the robot thanks to a webcam located in the laboratory. Remote laboratories enable multiple accesses of users to the same experiment, managing queues and booking resources properly. They provide a controlled environment for risky laboratories and promote sharing resources among teachers and schools. Weblab-Deusto [1] has developed a complete infrastructure to connect experiments and share them with other educational institutions. Undergraduate students of Computer Engineering in the second semester at the Faculty of Engineering use VISIR experiment at their physics class as an essential tool for their practice works. Visir is a remote experiment to practice digital and analog electronics, in figure 3 you can see its workbench. Authors have demonstrated the teaching effectiveness of using remote experiments in engineering grades [5-9].

Assessment is the other phase of the model we want to highlight due to its importance. If competences are not only based on the acquisition of content, assessment cannot be the result of a unique theoretical exam. Formative and summative assessment is necessary. The result and the process have to be assessed during the whole course, giving continuous feedback to the student, and using evaluation techniques similar to the ones used during the learning process.

Nowadays, an exercise done with WebLab-Deusto VISIR is corrected manually. Teachers access students' exercise and evaluate it according to the competences students are supposed to have acquired when completing the activity. This type of assessment is very time consuming, it is complex and it is possible to make mistakes. In addition, only the result of the activity is assessed, the final deliverable, and teachers do not know the process carried out to obtain it.

Technology provides a great amount of data about users interacting with tools and content. Learning Analytics techniques enable their exploitation for prediction and assessment. Since remote laboratories are an innovative learning resource, no tools are available for automatic evaluation. There are some statistics of usage, but not enough valuable for teachers and students.

In this paper we propose a model to assess students' competences that relies in two elements: 1) data provided automatically by the VISIR experiment [10] running over WebLab-Deusto platform, and 2) a rubric designed by the teacher with information about expected results of the activity. These data, processed using Learning Analytics techniques [11-13], allow teachers to obtain valuable information about students' behavior and their progress; it permits to personalize learning and predict results. WebLab-Deusto has been developed to register a great amount of data from students' interaction with experiments. Available data are rich and very useful because we can analyze not only the final result - the circuit students have to design with VISIR - but we have the trace, and thus the whole process to get it.

II. REQUIREMENTS AND DESIGN GOALS

The proposed model follows all stages of Learning Analytics process [14] (Fig. 4): it starts with automatic data

[1] WebLab-Deusto Remote Lab: https://www.weblab.deusto.es/web/ (2014-07-03)

collection from teachers' and students' interaction with WebLab-Deusto. Following, integrated datasets are pre-processed to remove useless data and separate circuit design from additional information. Further process contrasts teacher's rubric with students' activity, resulting in the comparison of circuits and additional reports about student's progress.

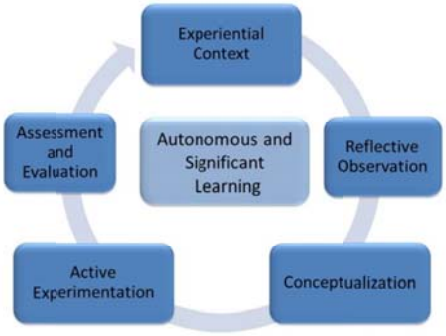

Fig. 1. Representation of UD-LM.

Fig. 2. A Weblab-Deusto remote experiment.

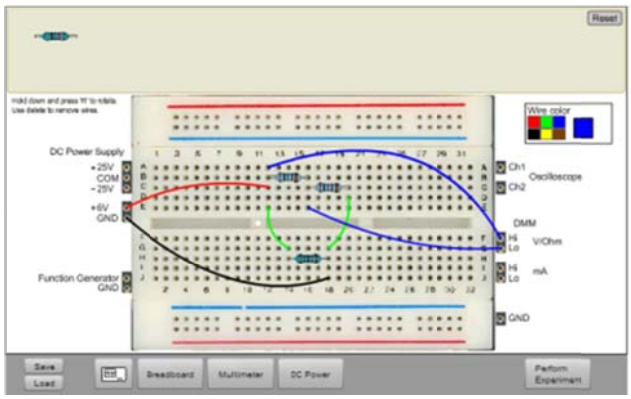

Fig. 3. Exercise solved with VISIR.

The outcome of the model feeds back the teaching and learning process for improvement.

The final goal of the proposed model is to provide teachers valuable information to assess students' knowledge and progress, as well as to redesign their teaching process. On the other hand, students benefit from a tool to self-assess their knowledge and skills.

The model has to fulfill the following requirements:

- Data collection from Weblab-Deusto is done transparently to the user.
- Students' assessment has to be done with the same tool they have been practicing.
- The interface of the rubric must be simple, so it eases teachers' work.
- The results of the automatic assessment have to be clear and understandable for the final user.

Different tools are implemented to match the requirements: Rubric, Trace analyzer, and Comparator and analyzer.

A. The rubric

In education a rubric is a set of criteria and standards used to carry out subjective assessment about the performance level or a learning activity, allowing more simple and clear score. We can see experiences where rubrics are used [15], as well as tools to generate them [16].

In our case the rubric includes two parts: 1) the exercise solved by the teacher using VISIR, and 2) additional data to interpret the result, because acquired competences should be different depending on the type of exercise (if it is test, analysis or evaluation activity).

In Figure 5 we show part of the rubric designed to assess students' knowledge using VISIR in a physics course. It specifies the competence to be developed (specific competence and level of mastery), indicators and their weight in the overall score. Each indicator has five descriptors. The teacher has to select the elements that define each descriptor and balance to reach the 100% of the indicator.

Descriptors within each indicator can be described in terms of things students have to do (correct answer) or in actions students should not have done (errors). When teachers create the rubric they have to select, among all possible options, those that assess they competence in the task or errors that are serious enough to invalidate the exercise.

When students complete an exercise using the VISIR remote experiment through Weblab-Deusto, it records data about the interaction with the system, such as the number and position of components in the circuit, connections, power supply, measurement tool, etc.

The rubric and the student's exercise's trace is the input for the evaluation process.

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B. *Trace Analyzer*

This module analyzes traces provided by Weblab-Deusto. It has to be able to distinguish the elements not involved in the circuit such as time, IP address, system failures, etc. The execution provides as an output a "clean" dataset (Table I) that is the input to the last part of the process. However, initially separated data are useful for analysis later in the process.

C. *Comparator and Analyzer*

Finally, the model compares the rubric designed by the teacher (circuit and additional data) with the dataset obtained from students' traces. It reports similarities and differences with respect to the rubric.

Teachers are not only interested in the final result, but in the whole process. With Weblab-Deusto traces they can see the final circuit assembled by the student and intermediate steps followed to complete it: number and type of components used in different trials, if the student has done several tests, if there have been errors, etc.

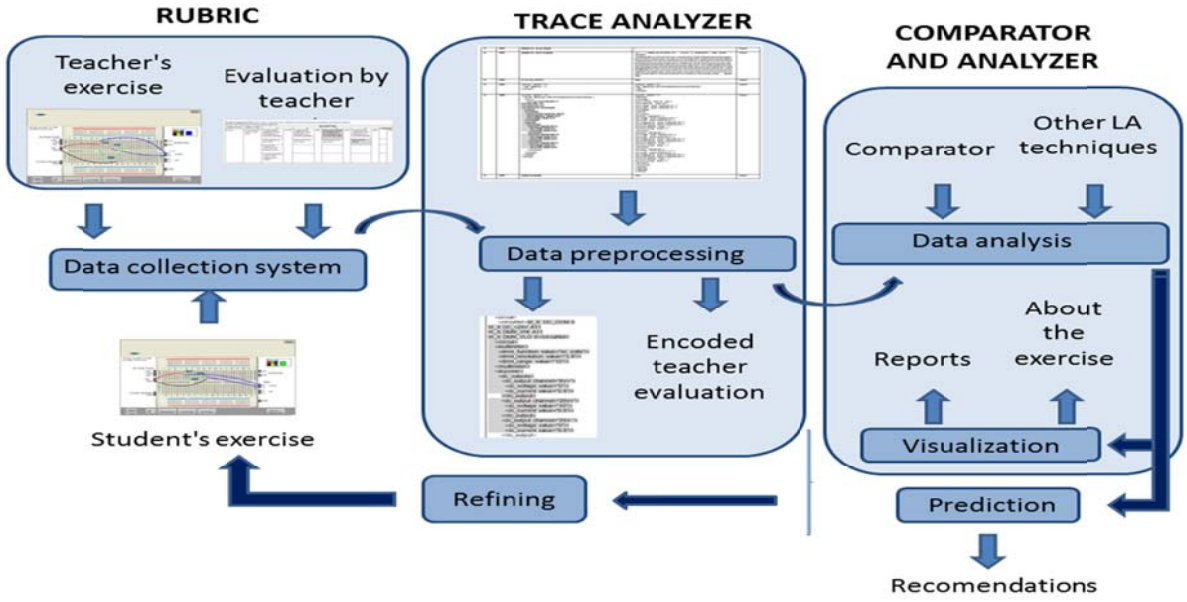

Fig. 4. Proposed assessment model.

Specific Competence 1 (SC1): Solve Direct Current circuits, using the associated terminology, formulation and analysis methods.
Level 1: Solve basic Direct Current circuits using Visir.

COMPETENCE	INDICATORS	DESCRIPTORS									
		1		2		3		4		5 (default)	
SC1-L1	It measures the resistor value 25%	It connects the multimeter to the terminals to be measured (parallel)	% 100	It connects the multimeter to the terminals to be measured (parallel)	50%	It does not connects the multimeter to the terminals to be measured (parallel)	30%	It connects the multimeter to the terminals to be measured (parallel)	20%		0 %
		It does not power the circuit		It does not power the circuit		It does not power the circuit		It Powers the circuit			
		It inserts the multimeter test probes into the V/Ohm connector									
		It sets the function switch of the multimeter for V/(DC)									

Fig. 5. Additional data provided by the teacher.

III. Model Status and Future Work

The model has been reviewed by several physics teachers that use VISIR at de UD.

At this moment we are working in the implementation of the model and creating ICT-based tools to put it into practice with data registered from 2012-2013 and 2013-2014 courses.

TABLE I. DATA PROVIDES BY WEBLAB-DEUSTO HAS TO BE PREPROCESSED.

```
<circuitlist>W_X DC_COM 0
W_X DC_+25V A11
W_X DMM_VHI A11
W_X DMM_VLO 0</circuitlist>
  </circuit>
  <multimeter>
   <dmm_function value="dc volts"/>
   <dmm_resolution value="3.5"/>
   <dmm_range value="10"/>
  </multimeter>
  <dcpower>
   <dc_outputs>
    <dc_output channel="6V+">
     <dc_voltage value="0"/>
     <dc_current value="0.5"/>
    </dc_output>
    <dc_output channel="25V+">
     <dc_voltage value="10"/>
     <dc_current value="0.5"/>
    </dc_output>
    <dc_output channel="25V-">
     <dc_voltage value="0"/>
  <dc_current value="0.5"/>
```

The initial implementation of the model focuses on direct current circuits, because they represent a more varied type of exercise and can take advantage of automatic evaluation. However, tools being developed take into account later usage for the assessment of alternating current circuits.

In the line with other authors [17-19], and based on the results of assessment, in the future we will provide recommendations both to students, about their learning, and to teachers, about the design of the course.

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