Enriched scenarios for teaching and learning electronics

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Abstract—This paper aims to discuss and analyze the application of remote laboratories in teaching electronics to undergraduate students at the Federal Institute of Santa Catarina, Brazil. The application of remote labs is motivated by the fact that in Brazil, a Federal Law (LDB – Lei de Diretrizes Básicas da Educação, No. 9394, from December 20th 1995) establishes in Article 80 that the Higher Education Institutions can offer courses 100 % in distance education methodology. Complementary regulation was issued in December 10th 2004 by the Ordinance No. 4.059, that allows the Higher Education Institutions to use up to 20 % distance education methodology for all established (recognized) classroom courses. Thus, this paper will present the remote labs as an important and efficient distance education resource to implement practical experiments in electronics. To accomplish this objective, an exploratory activity was performed by using a remote laboratory with undergraduate students, and then, via an interview, the perception of them was obtained to discuss the results and gains of the methodology.

Keywords—Distance education; remote labs; undergraduate courses; teaching & learning strategies.

I. INTRODUCTION

If a schematic diagram of a transistorized section of an amplifier is shown to you, and you are asked to declare the value of the static voltage gain, how could you manage to obtain the number? Consider that resources as paper and pencil for notes, computer with adequate simulation software, as well as components, lab equipments and prototyping board are all available. What method will you choose and what will you take in account to make your choice?

Issues as the complexity of the proposed circuit, the amount of personal knowledge on that type of circuit, the available time to perform the task and even personal preferences will all be in balance. Add now the condition that you have just been presented to a new amplifying topology and might find it’s static voltage gain, for instance. One can only go through that problematic proposition by the construction of new knowledge, since there is no familiar rule or heuristic that can be applied [1].

Usually knowledge is classified in two great categories procedural knowledge and declarative knowledge [2]. Procedural knowledge refers to the one’s memory contents that allow him to perform tasks like to drive a car in a winding road. Declarative knowledge is relative to one’s memory contents that deals with concepts, facts or episodes and allow him to communicate about those concepts, facts or episodes. Knowledge in declarative form can be used for knowledge acquisition by one that wants to start learning how to drive a car reading or hearing about it or by someone that wants to tell another how to do that. So, in some conditions people may choose what type of knowledge is the preferred one to start learning something, and it depends on what way may him feel comfortable and confident. In its turn, the fact someone feel or not feel comfortable and confident using one or another approach, lays on his skills to process information contained in distinct modalities, to say, semantic or symbolic.

Technical expertise lays on some skills as the capacity to predict a result or a behavior of a given system as a response to a given input stimulus – a mental model of the system, and the capacity to describe and communicate system’s characteristics and behavior – a system of symbolic codification. To deal with those tasks one might use both semantic as well as symbolic information. To deal with those tasks one might use both semantic as well as symbolic information. To deal with those tasks one might use both semantic as well as symbolic information. To deal with those tasks one might use both semantic as well as symbolic information. To deal with those tasks one might use both semantic as well as symbolic information. To deal with those tasks one might use both semantic as well as symbolic information.

A. Knowledge

So, through the formative path, students may be presented to both situations. A practical experiment is a semantic approach as the student might deal with so called real world its appearance and its manifestations without the intermediation of any kind of symbol system. By opposite, an analytic exercise takes place in a space of complete abstraction where only symbols are in charge and there is no resemblance with the natural appearance or behavior of stuffs. In this case, the student might be introduced to the symbolic system and how to go from real world to abstraction space and vice versa.
Computer simulation and computer mediated emulation

On that background, to use computer simulation as a tool for electronic circuits learning is to use the computer processing capacity to run a symbolic model of the circuit in the abstraction space. As the computer system evolved, extra processing capacity may be used to create a mediation layer that performs some degree of semantically enriched interface for the student. That semantic enrichment appears as input modes that try to show real appearance of the electronic components and lab equipment and its graphical readings. While that approach gives some degree of realism – some semantic qualities and great security, it implies in some limitations as the lack of variability in components spec, environment generated interferences, crosstalk effects in the circuit itself. Computer emulation overlaps those problems not as a mathematical model but a physical arrangement of real parts and equipments. The role of computer is, first, to control a matrix of relays that interconnects electronic components and equipments in a desired topology, and, second, performs an user interface layer that affords to edit the circuit connections and read the results. If the computer as the host has a web connection, results that students may conduct their experiments remotely at any time he want. Picture 1 shows the proposed methodology in a form of a diagram, highlighting the learning alternatives available for the electronic students.

However, despite the incentives, distance education more rapidly increased in private educational institutions than in the public ones. Considering this, with Decree No. 5.800, from June 8th 2006, the Brazilian Ministry of Education (MEC) created the Brazilian Open University, with the aim of the expansion of higher education in Brazil with the implantation of distance education courses at public institutions. As a consequence, with this new program of distance education in public institutions, the country experimented a new impetus in the creation of higher distance education courses [4].

Although, in both cases (courses 100 % distance education or classroom courses that use up to 20 % distance education), the proliferation occurred more effectively in courses from areas that did not require conducting experiments in laboratories. The need for laboratory experiments, and especially the lack of a strategy to accomplish experiments at distance has been a barrier for the courses in some areas, electronics, for instance. It is important to highlight that this barrier initiates with the teacher/lecturer who teaches the disciplines in the technical areas, mainly with some resistance to the paradigm changes in space/time for the teaching and learning process.

With regard to the Federal Institute of Santa Catarina (IFSC) currently there is only one course (Technology in Public Management) using 100% distance education methodology and the possibility to apply up to 20% distance education methodology in all classroom undergraduate courses is not been used at the moment. This occurs because IFSC historically follows a strand of education in the field of technology and engineering.

This way, the barriers are amplified for the courses eminently based on laboratories. In this context, it is imperative to create conditions to implement practical experiments in a distance education basis.

A. Remote Laboratories

Remote laboratories stand for laboratories located distant from users accessing them and that may either be students, teachers, or researchers. Using a computer connected to the Internet, users may access the remote lab via a simple Web browser and perform real physical experiments on it. This way, a remote lab implies real test & measurement equipment and a web-accessible interface for interacting with those equipments.

Not having a remote lab installed at its premises, IFSC has used the OpenLabs Electronics Laboratory developed and maintained by the Blekinge Institute of Technology (BTH), in Sweden, to conduct this experience. Ingvar Gustavsson, from BTH, started developing this remote lab, under the Virtual Instrument Systems in Reality (VISIR) project, in 1999, and since then several institutions adhered to it, forming now one of the most worldwide active communities in remote labs [5].

B. Virtual Instrument Systems in Reality (VISIR)
A VISIR system allows remote users to physically wire electrical and electronic components into a virtual breadboard made out of printed circuit boards equipped with relays, forming a programmable matrix of interconnections. This matrix is controlled by a measurement server, via USB, which also controls the test & measurement devices located in a PXI system. The measurement server is also responsible for checking the circuits under experimentation to avoid electrical hazards [6, 7]. The VISIR system used in the experience done at IFSC is available in the following URL, in guest mode: https://openlabs.bth.se/electronics/index.php/en?sel=guestlogin.

Presently, there is a Special Interest Group (SIG) around VISIR that includes BTH, in Sweden, the University of Deusto and the National University of Distance Education, both in Spain, the Carinthia University of Applied Sciences and the Technical University of Wien, both in Austria, the Polytechnic of Porto, in Portugal, and also the Madras Institute of Technology, in India. All these institutions have a VISIR system installed at its premises, serving all of its teachers and students [8, 9].

VISIR has already been tested with over 1000 students accessing it, in simultaneous, during an entire semester. The learning gains obtained through its use were also measured and later reported in [10, 11].

III. ACTIVITY DESCRIPTION

The experimental activity was performed by 15 students as a school task associated with the curriculum subject on Operational Amplifiers, by the second semester of 2013. The emulation of two electronic circuits was proposed to be performed using the resources of VISIR project. The proposed circuits was: a one level voltage comparator with $V_{\text{ref}}=0\text{V}$, shown in the picture 2; and a two level comparator, $V_{\text{high}}=2\text{V}$, $V_{\text{low}}=-2\text{V}$ and $V_{\text{cen}}=0\text{V}$ illustrated in picture 3. On both cases an input voltage $V_{\text{e}} = 5\sin(wt)$ with a frequency of 400Hz was applied. The supply voltage was $V_{+} = 15\text{V}$ and $V_{-} = -15\text{V}$.

The proposed circuits was already been present to the students by the teacher in a form of project activities starting from circuits requirements. Once the projecting activity was done, a report might be presented by the students containing 4 basic topics:

- Theoretical conceptual analysis on which the students might present a bibliographic revision focused circuits and the steps of circuit project aiming the suggested requirements.
- Analysis of the computer simulation results against the expected theoretical results.
- The results of real implementation of the circuits in the lab bench.
- A comparative analysis taking in account the founded results and justifying the possible incongruences.

Those strategies had as their major aims to consolidate the students knowledge on voltage comparators using OpAmp and use the differences of the theoretical, computer and practical results to stimulate students in the construction of knowledge by themselves.

Observing the teaching / learning process as proposed we can realize that the activities could be faced by the pupils in any sequence and in any place, given the necessary resources, so the experimental tasks were restricted to school’s lab schedule – late night and weekends excluded.

Due the fact that the students had yet went through “real world” and computer simulation of the proposed circuits, they was simply asked to Access VISIR remote lab and implement the circuits. A text explaining what is a remote lab and a little tutorial on how to access VISIR resources was students given too. Teachers do not told the students about the objective of comparing the distinct approaches of circuit experimentation, how to work in the remote lab environment or who were its emulating restrictions. Students were in knowing that they could interchange information among them on how to deal with VISIR resources and that the task was not evaluative, so the 15 students adhered to the task freely.

Results
Students had a week along time to complete the task. Once the task was complete students were interviewed forming small groups in a open no structured way and stimulated to discuss the experience of had using VISIR. Among various issues pointed by the students, sometimes in a repeated way, the more important was:

- They had no problem in accessing web site and app/environment of VISIR.
- Spent a lot of time for them to realize how to flip the electronic components in the screen workspace.
- They dislike the impossibility of get the components from the upper area of the screen.
- They spend some time to realize how instruments work. Manuals were found too huge and many buttons/functions were not actives. They told had been quite boring to look for activated functions on the manual.
- Students dislike the fact the DC supply shown the voltage value ±25 V. The displayed information gave the false impression that the voltage value was a fixed one.
- They would like that in saving the circuits configurations automatically the instrument’s set up was saved too.
- Some students reported they had the impression as they were working in a simulation environment, while some others reported they felt as they had been working in real world experimentation.
- They had an overall opinion that remote emulation does not replace local experimentation.
- Students very appreciated the possibility of working at any time they want.
- They told they perceived the breadboard as been pretty realistic.
- They would like to use a “undo” function in the same way “control Z” shortcut.
- They took by strange the fact that electronic components may be placed point of the screen, even off of the breadboard.
- Students would appreciate if a major quantity of electronic components to be used there exists.
- They report it was difficult to distinguish resistors color code and that the place where the selected resistors were displayed was not at first sight view.
- The first task – one level comparator – was done without any trouble. By the other side, the two levels comparator task presented a problem who students could not realize what it is. When the circuit was submitted, the system returned the message “insecure circuit”, not telling what the cause was.

- They would like to select the format or shape the placed wires.
- They would appreciate if a version for mobile devices was available, so they will use the remote lab in more occasions.
- Students would like if it was possible to act on the DC supply current limit.
- They do not appreciate the precision level associated with the action of placing the wires in the breadboard, because it was the cause of many mistakes in the assembly task.
- They found might be not mandatory to set the wire color every time a wire was placed, even if they are in same color.
- They thought was not clear that the colors in the palette refer to the wires colors.
- They dislike that to acquire the curves displayed in the scope it is necessary to make a print of the computer screen.
- As the instruments had manuals, same way components data sheets could exist.
- Students related that different GND connections were the cause of mistakes.

Iç. ANALYSIS OF STUDENTS INTERVIEWS

The observation reported by the students during the interviews may be analyzed from two points of view: a) the perceptions of the emulation task in the remote lab; and b) the perception of the LabView.

A. Perceptions on the Emulation Task

In reference of the students perceptions may be reported:

- Some students had felt as they working in a real world situation, some others, as they working in a simulation environment. The simulation sensation came firstly from the graphical interface that appears as a virtual reality display. The presence sensation was felt firstly during the reading of obtained results in the scope screen.
- All the students interviewed keep the position that remote emulation do not replace local experimentation but consists in an excellent alternative to be used as a complementary parallel way of knowledge acquirement.
- That position came mostly by the fact that remote emulation does not present some aspects as, for instance, the handling of real components, tools and instruments.
Every students reported that is a positive aspect to allow to perform electronic experiments at any time they want. Some students reported they work in part time jobs by the morning, afternoon, night and even late night.

The fact that some functions were in the disabled state contributed to the sensation they was not real ones.

Interviews do not put it clear if the students had some kind of collaboration with their colleagues during the task execution.

B. Analysis of LabView Environment Impressions

Referring to the environment reports came from two points of view, analytical ones and suggestions of changes / new functionalities. Reports in the analytical sense were:

- There were no report telling about troubles in accessing the environment or in understand how it works. In general they reported that the environment is user friendly and nice to use it.
- The working fashion of the instruments was considered pretty realistic and manuals clear enough to starting using them. Students think that the background of had been using real equipment before the remote emulation experience help to turn the task easier. The time they spent reading manuals was caused in a great amount by the existence of disabled functions.

As suggestions in adding or changing some functionalities students reported:

- System must indicate what the reported error is and where is the problem. Sometimes even rebuilding all the circuit the system still returned the message “insecure circuit”. They suggest that a helping system could be used to clarify the situation.
- Students also suggested some changes in the environment layout. By their opinion those changes could improve system usability. Examples: better indication that the color palette refers to the wires color; include a shortcut to the “delete” function (it could be the right button of the mouse), among others.
- They asked for the inclusion of operative functionalities as “undo” function by the shortcut “control Z”; make possible to delete component without returning it to the upper area of the screen, and keep the last color section valid for next wires placement.
- System must save the set ups of the instruments all the times the circuit was saved even they recognize this does not match the reality.
- Make possible to extract and display a part of the manual containing only the active functions of the instruments.
- Make possible to save the graphs displayed in the scope in an computer file, not only by printing the computer screen.

Considering Final

Make possible to save the graphs displayed in the scope in an computer file, not only by printing the computer screen. Through the remote emulation approach the typical space / time paradigm was broken in the teaching / learning process of electronic circuits. Students reported they had executed the tasks in various places and occasions, sometimes along with other activity. In this sense remote labs made possible knowledge construction process completely centered in the pupils. The student’s talking reporting the use of remote lab made clear that it is an adequate resource to turn possible technical/technological education via DE (Distance Education), as well as a great tool in classroom courses.

Different students had diverse perceptions about the remote emulation task, so this is a task that needs to be well planned to lead to designed goals. If used in a non judiciously form remote emulation may not deal adequately with the paradoxical trade off of creating a filling of real world situation maintaining the conscientiousness about the restrictions imposed by the system, including that implemented for security issues.

It seems to be a relevant issue to take in sense the students suggestions of use remote labs as an alternative complementary resource along local resources using moments. Until the approach was completely understood by the teachers to be used in an wide way, it could be used to fulfill the 20% of academic activities to be done at distance, according brazilian education law (LDB).

By the other side, some students claims cannot be implemented. For instance functions for to delete electronics components have not a parallel in the real world where components cannot simply disappear from the bench top.

VI FURTHER STUDIES PROPOSAL

In alignment with students perception its desirable to implement a resource as VISIR system the IFSC campus. It is equally desirable to develop studies aiming to enhance the reality perception induced by the interface. In a simple example, a wire stripping function could be a desirable resource to teach pretty operative skills for beginners.

It is relevant to manage at BTH aiming to obtain access to VISIR not only as guests but contributing as partners with the project. That extended access could allow the use of remote lab turn greater and continuous in the academic subjects of Electronics undergraduate courses in IFSC.

At last, in the internal institutional level, to propose at Pro Rectory of IFSC and department of EaD the creation of a work group to seek the implantation of remote labs in other knowledge areas (chemistry, physics) due to enlarge the EaD methodology in the undergraduate courses of IFSC.
REFERENCES


