The VISIR Implementation Process at IFSC - problems, obstacles and solutions

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Abstract— **In recent years, the use of remote laboratories applied to teaching has become more frequent in several educational institutions around the world. The benefits to the learning process are easy to verify. In addition, remote laboratories bring with their application, operational advantages associated to component inventory, equipment maintenance, security, plus other practical issues. Considering this general scenario, it is intuitive that the implementation of a remote laboratory and its use is easily recognized and accepted by the users, namely, students and teachers. This paper aims to present the obstacles and advantages observed in the implementation of the VISIR (Virtual Instruments Systems in Reality) remote lab at the Federal Institute of Santa Catarina - IFSC, as well as the obtained results.**

Keywords— remote labs, teaching-learning process, usability of remote laboratories, VISIR+ Project.

I. INTRODUCTION

This work describes the implementation and use of the VISIR remote lab, in the Technical Courses in Electronics and in the undergraduate courses in Electronic Engineering and Higher Course of Technology in Industrial Electronics of the DAELN - Academic Department of Electronics of the Campus Florianópolis, and also in the technical course in electronics of the Campus Itajaí, both from IFSC - Federal Institute of Santa Catarina. The implementation of VISIR was carried out by a team composed by lecturers and laboratory technicians, with this team being responsible for assisting and guiding students and teachers, setting up experiments and systems and mainly acting as a facilitating and motivating team.

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To implement the VISIR remote lab, this team has worked from 2013 to 2017 and during this 4-year period it has faced several obstacles. To report this implementation process, this article will be divided as follows:

- Motivation and implementation feasibility;
- Technology definition;
- Initial steps;
- Usability of the VISIR platform at IFSC (VISIR@IFSC);
- The VISIR+ Project;
- Operation and implementation of the VISIR+ Project.

II. MOTIVATION AND IMPLEMENTATION FEASIBILITY

A. Motivation

The motivation to use a remote laboratory initiated when a group of teachers was seeking for a teaching strategy placing the students as active agents in their training, that is, the student as the center of the teaching-learning process. In that way, the initial steps were to build a teaching environment where the students could learn the theoretical concepts and apply them in computer simulations and practical implementation of experiments. The idea is to lead the students to acquire autonomy and decision-making ability on how they may build their knowledge, while the teacher must act as a facilitating agent in this process.

Thus, as shown in [1], if a schematic diagram of a transistorized amplifier is presented to a student and he/she is asked what must be the static voltage gain of the structure, what should he/she must do to get the value? Consider available resources like paper and pencil for notes, computers with appropriate simulation software, as well as components and electronic laboratory equipment. Which method would he/she choose to determine the value of the gain and what factors would he/she consider in his/her choice?

A practical experiment is regarded as a semantic approach where the student must deal with the "real world", its appearance and manifestations without the intermediation of symbolic systems. Otherwise, using a computer simulation as a learning tool is to use the processing capacity of the computer to run a symbolic model of a circuit in an abstract space. It is an analytical exercise that occurs in a space of complete abstraction where only symbols exist and there is no similarity to the real-world appearance or behavior.

The students can choose what kind of approach they prefer to start learning something, considering how they feel more comfortable and confident and depending on their ability to process the information contained in different modalities, i.e., semantic or symbolic. In this case, the student must be introduced to the symbolic system and how to go from the real world to the space of abstraction and vice-versa.

As computers evolved, extra processing power could be used to create a semantically enriched mediation layer that is used as an interface for the student. Such enrichment consists in input modes that simulate the real appearance of electronic components and equipment and how to connect them to the circuit. While this approach gives some degree of realism and promotes safety (because it is a simulation), it implies some limitations in reproducing the real-world behavior such as the lack of variation on the component specifications, interference of the environment and self-interference effects [1], [2].

On the other hand, the practical experiments are also limited, because the student can only make the experiments at IFSC facilities and during the class period.

Thus, although students could decide between computer simulations and practical experiments, the process of having the student as the central agent of the learning process has always problems related to real-world emulation and space/time limitations.

Computer mediated emulation, or remote experimentation, solves these problems by using physical arrangement consisting of real components and equipment, instead of analytical models. In this case, the role of the computer is initially to control a relay matrix that interconnects electronic components and equipment in a defined topology, and then offer an interface layer where the student can edit the circuit connections and obtain the results of the experiment. If the computer that controls the remote experiment is connected to the internet, the students can conduct their own experiments remotely from their personal computer at any time and from anywhere [3], [4].

B. Implementation Feasability

In Brazil, the Law of Basic Education Directives (LDB) - Law 9394 from December 20th 1995 establishes in its article 80 that Higher Education Institutions (HEI) can offer courses 100% in the distance education modality (EaD). This article is regulated by Decree 5.622, from December 19th 2005. Parallel to the regulation of the 100% EaD courses and seeking to further encourage the EaD modality and associated technologies, the Administrative Rule No. 4.059, from December 10th 2004, was published, which allows HEI to use EaD and its technologies in 20% of the total hours of a course.

In this context, considering the established Brazilian Law, it is possible to implement a strategy to execute practical experiments by using remote experimentation.

However, the feasibility of implementing remote experimentation also encounters two obstacles. The first refers to the technology to be used for remote experimentation and its costs, and the second refers to the cost/benefit ratio, understood here as the benefit related to the number of students and disciplines attended by remote experimentation.

III. Definition of the Teaching Tecnology – Remote Laboratories

It is known that the ideal situation should be to apply a technology that combines the advantage of the use of computers and the internet, as in the case of computer simulations, with the practice of the physical laboratories, where the students can assemble a circuit, make connections and measure values resulting from the “real word”. This kind of experimentation, in fact, already exists and it has been developed in different places of the world as remote laboratories. It consists in a physical unit composed of a server computer that communicates with the client through a web interface and with the experiment board, where all components and measuring instruments are installed. Thus, the laboratory can be assembled in a specific location and users from all over the world can access it and conduct real experiments through the internet [1]-[8].

Remote laboratories do not present physical risks to the student's health and equipment, and in addition, they provide the same experience of a real laboratory, because the circuits are assembled with real components and the results are made with real measurement equipment. The remote lab interface with the users is exactly the same as the front panel of all the used equipment, such as an oscilloscope, a signal generator, power sources, and a multimeter, among others. This whole experience is part of the student's imaginary about what is a laboratory and promotes an important emotional incentive in the learning process [1]-[5].

Another interesting feature is the fact that experiments can be carried out outside normal school hours, when staff usually needs to supervise the experiments in real laboratories. This promotes greater flexibility for teachers who can use class time for giving more explanations and theoretical orientations rather than spending part of the time with the organization of the laboratories, and also for students, who can practice at more adequate times and with more concentration. In addition, some remote laboratories provide virtual discussion rooms about practice results as well as tutoring where teachers can schedule a specific time to answer questions from their students who can be anywhere, such as in their respective homes, for instance [1]-[11].

The VISIR remote laboratory was chosen to initiate a new phase of the learning process at IFSC based on its characteristics and also because it was already in use at the Polytechnic of Porto (IPP), an important partner of IFSC since 2009. Thus, through IPP, IFSC was able to test and evaluate VISIR in its academic context [1], [9].

IV. First Steps

After selecting the VISIR remote laboratory as the teaching technology, in the second semester of 2013 a professor proposed two experiments to fifteen students in the subject of Operational Amplifiers. A tutorial was given to the students explaining how to access the VISIR platform and the schematic of the proposed circuit. Students were then asked to perform the experiment as a regular classroom activity. At this occasion, the students were not informed that the main objectives were to verify the applicability of a remote laboratory in the teaching of such subject and also if they would adapt in a natural way to the use of this new technology-enhanced education tool. This omission was intentional to not induce the students to think about such matters when performing the experiment. The idea was that the experiment should be done in a natural way [1].

In general, the activity was well accepted by the students, and they pointed several positive and negative opinions about the tool. There was a difference of opinions when they were asked if it felt like performing a practical experiment or a simulation. Some said that it was like a real experiment because of how components are positioned, instruments calibrated, and so on. Another group of students answered that it was like a simulation, because everything was performed in a computer environment. However, everyone converged to a common opinion: this method does not replace practice, but it is an excellent learning tool for electronics subjects [1].

V. Usability of the VISIR platform at IFSC

As presented, the obstacles to the use of remote laboratories are the cost of the VISIR platform and the number of students and subjects that can be served.

A. Number of subjects/students

Considering the students' acceptance of the experimental activities in the remote laboratory, the next step was to expand their use to other subjects taught at the Academic Department of Electronics (DAELN). To do this, it was necessary to verify with the teachers the possibility to implement VISIR in their subjects and how it could be used. Thus, a questionnaire was applied with two questions asking teachers about who would teach subjects in second semester of 2014 in the following courses [7]:

- Technical Course in Electronics;
- Superior Course of Technology in Industrial Electronics;
- Electronic Engineering Course;
- Post-Graduate Course in Electronic Product Development.

The questions were as follows:

1. How many experiments did you perform in the subject?

2. Other experiments can be implemented in the remote laboratory?

Three workshops were held in order to help the teachers to answer the questions. These workshops took place in the first semester of 2014 and they aimed at presenting the principles and to capacitate the teachers on the use of the VISIR platform. The presentation was done to 29 teachers. However, only 9 teachers were willing to cooperate with the project and they were trained on how to use VISIR. It is important to emphasize that the other teachers did not participate for different reasons, for instance:

- They taught a discipline in which they did not see how to apply VISIR;
- They did not intend to use a technology that would change their teaching-learning process;
- They understood that the simulation already fulfilled what VISIR was proposing.

The majority of the teachers actually taught subjects in which it is difficult to verify how to apply VISIR (e.g. microcomputers, antennas, digital electronics, etc.). However, some teachers showed resistance to use a technology that they did not have knowledge about, and which (mainly) requires a paradigm shift.

Considering the results presented in [9], it was possible to verify the approval and interest of the teachers related to the use of VISIR, as the teachers answered that they could do a significant number of their experiments using the remote laboratory. In some disciplines, it would be possible to increase the number of experiments usually performed. This is due to the necessary preparation of the real laboratory experiments, which demands time during the class. Considering the results of [9], there are 58 accomplished experiments and 70 applicable experiments.

With the perception of the approval by students and professors and with the possibility of the VISIR platform to attend nine professors from eleven disciplines for approximately one hundred students per semester, the application of VISIR in the second semester of 2014 was started.

To initiate this process, two hypotheses were raised: the first would be the purchase of a VISIR system by IFSC and the second would be continuing to use the VISIR@IPP platform, as in the second semester of 2013.

B. Cost of the VISIR platform

The VISIR remote lab is a system composed by hardware and software elements. The hardware is composed by a NI PXI instrumentation platform from National Instruments, which has a specific chassis for each PXI model and instrument modules such as power supply, digital multimeter, function generator and oscilloscope. These instrument modules are connected to the chassis and to a controller module. The controller module is a server computer that can be mounted onboard (docked into the chassis) or it can be an external computer. Using coaxial cables, the PXI is connected to a relay matrix, which also contains individual printed circuit boards that connect each module of the NI PXI [5], [8].

As a public and federal education institution, IFSC must attend specific legislation for equipment acquisitions. The purchases made by IFSC must be done through Public Bidding where the proposal that matches the technical requirements at the lowest price is usually the chosen one. This Call is usually a quite slow and time-consuming process. Considering this, in the first semester of 2014 an NI PXI system was included in a Public Bid [7]. The first trading session with this item occurred at the end of 2014 and, for the PXI module, the value presented by the winning bid was approximately € 36,000.00. The complete VISIR system would cost approximately € 47,000. This amount corresponds to approximately 60% of DAELN's annual equipment purchase budget. Thus, the purchase of the VISIR system by IFSC was not possible. One option would be to purchase VISIR in parts in more than a year. It was found that with this procedure it would take around 3 years to acquire the complete system.

C. *Using the VISIR@IPP platform*

Once the first hypothesis for using VISIR was set aside, the second one was to use the VISIR platform installed at IPP (i.e. the VISIR@IPP platform). For this purpose, a preparation meeting was held with the interested teachers in order to establish the methodology of the implementation of the experiments on several subjects in the first semester of 2014. The new IFSC-VISIR team encountered the following situations:

- IPP already had the matrixes almost fully occupied with components;
- The available components and connection possibilities did not meet the DAELN teachers' necessities;
- Some DAELN teachers did not want to change their circuits, that is, to adapt to existing connections and components. This is because this adaptation would again result in a major change in their experimental programming and consequently in their teaching strategy.

These remarks showed that the second hypothesis was also practically unfeasible.

It was noticed the difficulties to implement VISIR system, due to the cost, the purchase process and the hard work to convince teachers to change paradigms.

VI. The VISIR+ Project

At the end of 2014, the IFSC-VISIR team was asked to participate in a project involving twelve institutions from six countries. This project aimed to transfer educational technology from Europe to other countries, using funds from the European Community's Erasmus+ Program [10].

In 2015 the Erasmus+ Program approved the project entitled "Educational Modules for Electric and Electronic Circuits Theory and Practice following an Inquiry-based Teaching and Learning Methodology supported by VISIR".

The main objectives of the project are:

• Development and application of educational modules;

• Acquisition and installation of a VISIR platform in the Latin American partners;

• Dissemination of the obtained results;

• Dissemination of the VISIR platform to associated partner institutions.

On the proposal, the project started in October 2015 and finished in October 2017. The second major objective of the project (acquisition of a VISIR platform) was finally met.

VII. Operation and Implementation of the VISIR+ Project

The operational phase and the consequent implementation of the VISIR+ project began in October 2015. This phase can be summarized in the following steps:

- Project agreement signature;
- Transfer of resources from the European Community's Erasmus+ Program to IFSC;
- Acquisition of the VISIR platform;
- Implementation of the didactical modules at IFSC;
- Dissemination of the project to the associated partner institutions.

A. *Project agreement signature*

Initially, it was thought that this would be an easy step, however, the IFSC's administrative staff encountered many bureaucratic and management problems. It happens because this was the first time that a project brought international monetary resources to IFSC. Due to that, the administrative staff faced a procedure they had never performed before. The understanding of how the agreement should be implemented showed to be a barrier to the signature of the agreement. There was a risk of signing the agreement and not being able to use the resources from the Erasmus+ Program. This procedure took extra time from the project and could only be finished at the end of 2016, when the agreement was finally signed.

B. *Transfer of resources from European Community's Erasmus+ Program to IFSC*

This stage was less bureaucratic, but barriers were also found. The main problem encountered was that any resource received by IFSC should be foreseen in the annual budget of the previous financial year with its origin duly justified. As the resources of the VISIR+ Project had not been initially foreseen, it was necessary to make a change in the IFSC's budget. Budget revisions or changes are possible but can only be made in certain periods of the year, called budget review window. This budget review must be approved by the Brazilian Ministry of Planning, Development and Management. Thus, only after the change in the annual IFSC's budget it was possible to transfer monetary resources from the Erasmus+ Program to IFSC. The transfer was done at the end of 2016.

C. *Acquisition of the VISIR platform*

In parallel with the transfer of the monetary resources, administrative staff, together with the IFSC-VISIR team, began the acquisition process of the VISIR platform. However, as the purchase of the equipment by IFSC can only be made through a Public Bidding process, it would take approximately 12 months. This amount of time would only allow the acquisition of VISIR platform in August 2017. As the project was due to expire in October 2017, the process would make the VISIR+ Project probably unfeasible.

In addition to the slowness of the purchase process, the IFSC-VISIR team found one more problem for the acquisition of the equipment. The first quotes of these equipments presented values above the predicted in the project proposal.

To solve these problems, the solution found was to sign an extra agreement with the Engineering Teaching Foundation of Santa Catarina - FEESC. The agreement with FEESC was extremely useful in the acquisition of the VISIR system. In May 2017 the system was installed at IFSC, at a cost of 50% of the Public Bidding quotation.

D. *Implementation of the didactical modules at IFSC*

Although the VISIR system was only installed at IFSC in May 2017, the IFSC-VISIR team was able to implement the first didactic modules. Despite the teachers' resistance in using the VISIR@ IPP platform, in 2016 the VISIR system was used by one teacher in the subject of electrical circuits. In the two semesters, 40 students accessed the system more than two hundred times.

From May 2017 onward, the IFSC-VISIR team initiated a new approach to DAELN teachers in an attempt to convince them to use the VISIR platform, since the IFSC now had a system and could be configured according to their needs. The teacher who had used the IPP VISIR platform in 2016, again, in the first semester of 2017 used the IPP VISIR platform. In the second semester of 2017, he was able to use the VISIR@IFSC platform, this time with 25 students.

In the second semester of 2017, the VISIR@IFSC platform was used by six professors in six subjects at the IFSC - Campus Florianópolis and by one professor in one subject at the IFSC - Campus Itajaí. This semester, it was used by 150 students with more than 1000 accesses. The courses in which the VISIR@IFSC platform was used were:

- Operational amplifiers;
- Circuits III;
- Electricity I;
- Electricity II;
- Electronics II;
- Amplification Structures;
- Instrumentation (Campus Itajaí).

It should be noticed that other partner institutions of the VISIR+ project have used the VISIR remote lab in similar courses. These implementations, plus the training actions done under the scope of the project, are presented in [12]-[18].

E. *Dissemination of the project to the associated partner institutions*

As foreseen in the project, the VISIR platform should be disseminated to the associated partner institutions. Thus, the IFSC Campus Florianópolis disseminated the project to the Campus Itajaí and Campus São José of IFSC and to the Regional University Foundation of Blumenau - FURB. To this end, the IFSC-VISIR project team traveled to the cities of São José, Itajaí and Blumenau to present the project.

In Itajaí the project was presented in August 2017 for six teachers and in São Jose and Blumenau the project was presented in August 2017, for 30 and 9 teachers, respectively. These presentations resulted in one implementation in the first semester of 2018, by a professor in a course at IFSC - Campus Itajaí.

At FURB we found again a bureaucratic issue. FURB may only use a system or a service from another institution if there is a signed formal agreement. Thus, during the course of 2017 an agreement was drawn up and in the beginning of 2018, it is being consolidated.

VIII. Conclusions

The need to improve teaching practices and teaching strategies has brought up the theme of searching for a teaching strategy in which the student is the center of the teaching learning process. In this perspective, remote laboratories have emerged as a tool from which students are instigated to construct knowledge at any time, with the available resources. In order to meet this technology of remote laboratories, the Brazilian legislation built several ways with the regulations of the EaD courses, which reinforced the importance of this approach to the teaching and learning process.

In the Latin American context, specifically the countries that are part of the VISIR+ Project, remote experimentation is still incipient compared to other countries in Europe, the United States and Oceania, for instance. In the case of IFSC, the effective use of the VISIR platform in regular courses since 2013 has brought benefits to students and teachers, as demonstrated in [1]. However, there are still several paradigm barriers to overcome. In the student's vision, about the benefits of this practice and in the teacher's view, about the need to adapt to new realities and innovations in teaching.

As part of the history of cooperation between IFSC and IPP, the participation in the VISIR+ Project was carried out in 2015 in order to disseminate the use of remote laboratories in Latin American countries. This cooperation was fundamental to enable the acquisition of the VISIR platform by IFSC, mainly due to the high cost of the system. Although economic viability was important, bureaucratic barriers proved to be a difficult issue at the project start. After solving bureaucratic problems, the acquisition and installation of the VISIR system at IFSC and the implementation of the didactic modules has started. The dissemination of the VISIR usage was carried out by the IFSC-VISIR team in order to increase the number of accesses and the number of didactical modules. Despite of the efforts to spread VISIR platform to three different campuses of two distinct institutions (IFSC and FURB), only one campus uses the laboratory effectively. The resistance to innovations and adaptation to new realities is still present, although there has been a considerable increase in the number of accesses and subjects attended by the VISIR@IFSC remote laboratory. It is important to point out that the physical presence of the VISIR system at the IFSC facilities has led some teachers to demystify the remote use with something different from the traditional laboratory, which is verifiable by the increase on the courses served by VISIR platform.

In the process of implementing the VISIR remote laboratory at IFSC, several difficulties were pointed by the executing team. Some of them are the slowness in internal processes to accomplish partnership agreements and the approach that was used to enthrall new users. In this sense, it was concluded that bureaucratic processes are still a great barrier or at least a retarder in the implementation of partnerships. However, it is plausible to believe that, after the institution's first experience, future projects will not face the same difficulties. It is also concluded that teachers and students should be encouraged to use new technologies in teaching and learning, showing the importance of student participation in the learning process as an active agent in their course.

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