On the use of VISIR under different course implementations

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***Abstract*— This paper addresses different course integrations of VISIR. The didactic approaches are summarized and the analysis done provides explanations to some of the problems encountered, plus some guidelines for future implementations. A number of strengths and weaknesses are highlighted, leading to suggestions on how to enhance some strategic approaches to motivate teachers and students to the potential of using VISIR in teaching and learning processes. Proper references to previously published work also help to understand the research background and the lessons derived from a more intensive usage of VISIR.**

Keywords- Remote labs; motivation for learning; assessment

I. INTRODUCTION

The roles of higher education teachers and students are being rethought, as has been argued that computer technology and software can provide a significant help to identify problems and offer solutions for life-long learning. The educational computer-based technology has reached the point where many great improvements can be made, and significant cost reductions can be achieved, specifically in the area of engineering education. We are aware that "it is not possible to transform the ways of thinking and acting at the process level" training without the effective involvement of actors participating in them, especially teachers and students [1]. Numerous studies have shown that students can improve their learning when they are motivated and become part of the learning process [2, 3, 4]

Motivation is a broad construct related to the conditions and processes representing the trigger, the direction, effort magnitude and persistence [5]. Students' perception of their success and failure initiatives plays a central role in the development of their motivation for learning. Students who attribute success to effort, realizing that change is manageable are those who likely deal constructively with failure and continue their learning progress [6]. Motivation can be considered as intrinsic or extrinsic. Intrinsic motivation is related to involvement in activities carried out by performance based on personal interest to learn (the activity is an end, in itself). Opposed to this is extrinsic motivation, in which students enrolled in the activities as a mean of achieving a valued goal or purpose [7].

Teachers also have an important role in academic self-regulation of students [8]. However, in addition to an updated scientific preparation, this requires an appropriate pedagogy. Laurillard [9] reinforces this teachers' need to go beyond their area of knowledge, and emphasizes that: *"Teachers need to know more than just their subject. They need to know the ways it can come to be understood, the ways it can be misunderstood, what counts the correct understanding: they need to know how individuals experience the subject. "*

Students' assessment is known in literature as a major conditioning of students' efforts and commitment [10]. Therefore this is an important aspect of curricula design which may determine students' enrollment in learning. As Biggs [10] also states that formative assessment is inseparable from teaching and the effectiveness of different teaching methods is directly related to its ability in providing formative feedback that helps students monitor their own learning. According to Miller and others [11], formative assessment is the use of regular tests and assignments throughout a course, where the results for each work contribute to the final grade. The objective is to enrolled students in developing work throughout the course, so they more likely develop competences and knowledge. These tasks can serve as formative assessment, if regular feedback of students' work is given to stimulate learning and provide them with helpful information that will facilitate the effectiveness evaluation of their learning strategies. These authors also alerts teachers to the fact that themes or approaches to teaching in which students are having more difficulties focusing may require special attention.

This paper intends to compare different implementations of VISIR usage in engineering courses, which were implemented in order to facilitate students' learning.

In the next section, a brief description of the previous VISIR implementation at ISEP (in a large course) is made,

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stressing its major contributions. Section III describes the different didactic implementation, including VISIR usage of the system, courses methodologies and assessment. In section IV, preliminary results and discussion are presented, divided into five major categories: teachers' expectations, students' actual usage, students' interest, competences development and diagnosed problems. Finally, in section V, several conclusions are drawn in order to help future implementations to become more effective.

II. BACKGROUND

A. *The VISIR system: description and previous usage*

VISIR is an open remote lab dedicated to experiments with electrical and electronic circuits. It allows teachers and students to practice real-world experiments, remotely and in real-time mode, with test and measurement equipment (triple DC power supply, function generator, multimeter, and an oscilloscope) connected to electrical and electronic components mounted in a solderless breadboard. Its usage in a large undergraduate course during the fall term (1st semester) of 2010/11, at the School of Engineering – Polytechnic of Porto, has already been reported [12, 13], where the main aspects referred and illustrated were: i) references to documents and manuals describing in detail its architecture and technical characteristics [14, 15]; and ii) actions done by persons using it under three different roles (administrator, teacher, student). The study reported in [12, 13] addressed the utilization of VISIR in a single, large, undergraduate course, where the roles of all actors involved were well defined and, in particular, the head-teacher was able to motivate the lecturing team to the learning activities carried out with VISIR. All lecturing team elements had the opportunity to practice before using it in their own classes and everyone was informed about and aligned with the learning goals planned for this complementary lab resource.

That study also allowed us to define a students' profile according to the context of how they were enrolled in the course. Students from group-A used VISIR both as a practical and a training tool, in classroom, and then repeated the same type of experiments in a hands-on session with real equipment, in the following week. This was compulsory and lasted for 2+2 weeks. Students from group-B, who had already been enrolled in a previous course edition, had to use VISIR in the same weeks where it was compulsory for group-A students. One major conclusion from our initial findings [13] was that first-time students used the remote lab if compelled to do so. On the other hand, students previously enrolled in the course easily recognized the complementary role of VISIR in the course, to help them maintaining their learning goals (on track).

III. SIMULTANEOUS UTILIZATION BY SEVERAL COURSES

In the same line of reasoning as previous work referenced in previous section, a similar approach was adopted for this study. Several study cases were conducted in different courses. The collected data for this analysis included elements from the VISIR and didactic implementations, course plan of activities, teachers' interviews, students' results in pre- and post- competence and knowledge test, students' usage of VISIR, students' answers to a simple questionnaire and open-questions about their perception, and students' tasks results.

A. *Present scenario*

The previous experience, done with one course, contrasts with the spring term (2nd semester) of 2010/11, where VISIR was used in six different courses, of different sizes (47-to-574 students enrolled) and belonging to six different degrees, i.e. with quite different backgrounds. Therefore, electricity and basic electronics represent subjects addressing different competence areas, as described by Table I. In this group of courses, there is only one belonging to basic knowledge competence area (B1). In this case, electricity, taught during a period of 3 weeks, represents only one topic in the course program. All other courses have their entire program dedicated to electricity and basic electronics. The only difference between the complementary knowledge (C1-C2) and scientific knowledge courses (S1-S2-S3) is related to the corresponding degree program.

TABLE I. TARGET COURSES IDENTIFICATION, COURSE LEVELS, AREAS OF COMPETENCE, NUMBER OF STUDENTS ENROLLED AND TEACHERS ENROLLED IN VISIR ACTIVITIES (+ HEAD-TEACHER)

ID	Course level	Area of Competence		
B1	Introductory	Basic knowledge	188	1
C1	Introductory	Complementary knowledge	47	1
C2	Introductory	Complementary knowledge	574	6+1
S1	Introductory	Scientific knowledge	49	2+1
S2	Intermediate	Scientific knowledge	68	3+1
S3	Intermediate	Scientific knowledge	345	7+1

This scenario allowed to explore the remote laboratory to its maximum capacity and performance, and to test its operational limits. Our system has four component boards, each having 14 connecting pins (relays) to mount components, in a total of 56 connecting pins. From these, 52 were in use, representing 93% of the system physical capacity. These four boards hosted a total of 18 circuits with different topologies, using a broad range of electrical and electronic components (resistors, capacitor, inductors, diodes, transistors and op-amp's). In the selected courses, only 15 different circuits were used (Table II).

The remote system was online during the entire semester, from 1st March till 29th June, in a total of 120 consecutive days (2880 hours). During this period, several events, like weekend power maintenance shortcuts, internet instantaneous failure episodes due to intervention needs, system reconfiguration in order to solve some circuit design problems, accounted for a downtime of 146 hours and 55 minutes, representing 5% of the total time, which included 30 system startup events.

B. *Implementation methodology and description*

Due to the overall capacity of our system, in order to make an adequate choice and to be aware of all limitations, every potential head-teacher was invited to attend a workshop where they had the opportunity to use VISIR and to learn about the experience done in the previous semester and its preliminary conclusions, since it took place in 19th January, some time before gathering and analyzing the whole data from the study. Head-teachers understood better what VISIR could offer and were later able to develop an approach for their course. Furthermore, each head-teacher had the opportunity to define a number of remote experiments – and the associated learning goals. The range of experiments defined that responded favorably to the challenge of integrating VISIR in their courses implied some negotiation due to intrinsic technical limitations already referred and to the fact the time constant of all remote experiments is limited to tens-to-hundreds of milliseconds, depending on the source type – AC or DC, making impossible any sequential and multiple measurements of dynamic phenomena, like for instance, measuring a capacitors charge/discharge curve. These limitations led us to: (i) suggest the utilization of a complementary remote lab, developed in-house, for electrical and electronic experiments [16, 17]; and (ii) consider the exploitation of a VISIR implementation that includes a commercial LXI-based matrix [18], which enables a larger number of interconnections.

TABLE II. TYPE OF ELECTRIC CIRCUITS MOUNTED IN VISIR ACTIVITIES IN EACH COURSE

Course	VISIR experiments and number of circuits						
B1	Kirchhoff's	1					
C1	Resistors	--	Diesel motor equivalent circuit	1			
C2	Kirchhoff's	1(*)					
S1	Ohm´s + Kirchhoff's	2; 1(*)	Passive filters	2	Diode circuits	2		
S2	Diode circuits	2(*)	Transistor polarization	1	Op-amp's	3		
S3	Oscillosc.	--	RC circuit	1	RL circuit	1	RLC circuit	1

(*) indicate the circuits used are similar to others already accounted for.

From Table II, we can identify different levels of predetermined usage of VISIR, with a more intense use corresponding to scientific competence area courses, accounting for 12 out of the 15 circuits used. The less use corresponds to B1 (basic area of competence), and C2 courses, where the head-teacher used one VISIR experiment as a summary task to assess students in DC current, only. The circuit was the same in these two and also in the other complementary competence area course, C1, where a second circuit, present in diesel-powered cars, illustrated basic electrical voltage-current-resistance-power concepts. The students enrolled in these courses have few knowledge of electric circuits and laws, i.e. they have to learn from the scratch, while their motivation can be considered low, given the nature of their degree which deals more with other thematic, rather than electrical or electronic concepts. Using VISIR with such students can be tricky as some of its inherent technical constraints can be readily explained to persons knowledgeable of electric circuits or more aimed to test and measurement equipment (scientific area of competence) but can be difficult to understand by persons learning the basics. This was not the case in the other three scientific competence courses. In S1 and S2 courses, students had to implement a lab work and handing in a lab report for each major topic in the course program (3 in total). In S3 course, VISIR was proposed to students as a training tool to be used before every week lab class.

As for students, VISIR was introduced in different weeks during the semester, depending on the planned starting task, except for S1 and S2 courses, where it was introduced right in the beginning, so that students could use it as a training tool to measure voltages and currents in a sample-circuit. Table III summarizes these presentation dates and identifies the period each course started using VISIR as planned.

TABLE III. TIMELINE OF VISIR ACTIVITIES PLANNED FOR EACH COURSE

Event/Course	B1	C1	C2	S1	S2	S3
Introducing VISIR to students	1st April (W5)	16th March (W3)	28th March (W5)	1st March (W1)	1st March (W1)	21st March (W4)
Type of class	Theory	Theory	Theory	Lab	Tutorial	Theory
1st VISIR task start	6th June (W16)	---	14th April (W7)	26th April (W9)	26th April (W9)	Before each lab class
VISIR tasks deadline	2 weeks after	---	2 weeks after	2 weeks after start of each task	2 weeks after start of each task	---

Note: Wx means semester' week

C. Course ID and VISIR assessment

Since VISIR course implementations were so different, so were the assessments, by including issues like, if they were compulsory, individual, a complementary tool for students to develop competences, or simply an assessment tool to certify students' learning. These differences are expressed in Table IV where, e.g. formative task means that it allows students to evolve while doing it, which eventually will help them in the next phase of their work.

TABLE IV. VISIR ASSESSEMENT

VISIR tasks' assessment	Course					
	S1	S2	S3	C1	C2	B1
Individual?	Yes	Yes	No	Yes	Yes	Yes
Compulsory?	No	No	Yes	Yes	No	Yes
Formative task?	Yes	Yes	Yes	Yes	No	No
Identical?	Yes	Yes	Yes	Yes	Similar	yes
Number of VISIR tasks / total tasks	3 in 15	3 in 14	Part of 3 in 5	2 in 10	1 in 8	1 in 5
% VISIR in final grade	up to 4%	up to 4.2%	Contributes to 6%	0.4%	up to 1.3%	10%

This information was available to students from the beginning of each course, even though it was not perceived by everyone as clearly as it should, as later explained.

In S3 and C1 course, the planned number of VISIR tasks was initially 4 and 3, respectively, but due to problems (in the first task in S3 and in the last one in C1), its VISIR implementation contribution were confined.

IV. PRELIMINARY RESULTS

The analysis is based in five parts and organized in sequence, in order to better understand the influences each implementation suffered and to be able to identify more clearly the main reasons of the outcomes. Since different implementations had different styles, the presented results are not exhaustive, but try to identify the weaknesses and/or greater values as being an outline of possible learning outcomes.

A. Teachers' expectations

Since the primary goal of these implementations was testing ISEP's VISIR usage under stress conditions (in terms of number of users and number of experiments), some of these implementations happened mainly with this intention. The second purpose was to test different types of course implementations. Some teachers realized that it could be an opportunity for developing important competences in their students' learning and tried to use it more effectively.

The difference between distinct kinds of implementations was also related with teacher prior expectations of VISIR potentialities. This fact affected some curricular implementations design as well as teachers' ability to mobilize their peers and their students. Some teachers showed a good understanding of VISIR potentialities and had greater expectations which were well transmitted and deeply influenced both peers and students.

B. Students' actual usage

The system usage was in most cases directly related with their necessity in terms of the tasks schedules they were obliged to observe. This is notorious on the different implementations analyzed, as shown in Table V and Fig. 2.

TABLE V. VISIR USAGE

	Course					
	S1	**S2**	**S3**	**C1**	**C2**	**B1**
Students who access	79%	47%	41%	47%	29%	47%
Accesses/ user	5.4	4.9	3.3	2.8	3.2	4.0
Accesses/ user/ VISIR task	1.8	1.6	0.7	1.4	3.2	4.0
Usage	Residual; with 2 strong peaks	Low. but continuous usage. with a strong final peak	Higher at the beginning then fell to residual	Higher at the beginning then fell to residual	1 strong peak	1 strong peak

Students who made the effort of working with VISIR are clearly the ones who felt its impact in their learning. In C2 course, for instance, the majority of students saw these VISIR tasks as an obstacle and not as an added value, but those few who chose to accomplish it, did find it useful and thus accessed it several times. The same happened in B1 course, but since this task had a greater impact in their final grade, more students enrolled in this activity, when compared to C2 course. In scientific courses (S1-S2-S3), where VISIR usage was more continuous, the observed peaks (see Fig.1) are aligned with the tasks timetable. In C1, even though these tasks had little weight in students' final grade (Table IV), students' usage of the system was relatively high, denoting some motivation. In course S3, due to problems occurring in the initial task, which prevented its implementation, students' usage declined in the following tasks (although the 3 remaining tasks were successfully completed).

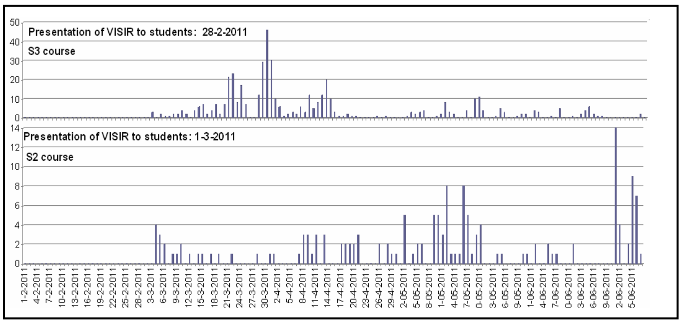

Figure 1. Students' acesses in S3 (top) and S2 (bottom) courses.

In S2 and S3 courses, students misunderstood the meaning of VISIR task being optional. The majority failed to understand that those tasks would also be accounted for the necessary ⅔ of compulsory reports they were obliged to do. When this was clarified, nearly at the end of the semester, several students engaged in its preparation, as it can be seen in Fig.1.

C. Students' interest

These results were obtained by crossing information from three data types: teachers' perception of students' interest, students' answers to a brief questionnaire and their open opinion about the VISIR. The results obtained with the questionnaire showed, in general, that these implementations were worst perceived by students than the previous implementation in the 1st semester (already characterized [12, 13]). The number of students who replied to this request was also much lower than the previous one (only 12% to 28% of students, depending on the course, have answered this questionnaire, contrasting with 33% in the former), already denoting their lower engagement with VISIR. Fig. 2 highlights students' responses in one of the questions: "Was VISIR helpful with circuit mounting?" The obtained levels indicate a better perception in C1 and B1 courses (closer to the level obtained in the former implementation, which appears in Fig.1 as a dashed line). Contrasting, in scientific courses is where students' perceptions of this development were lower.

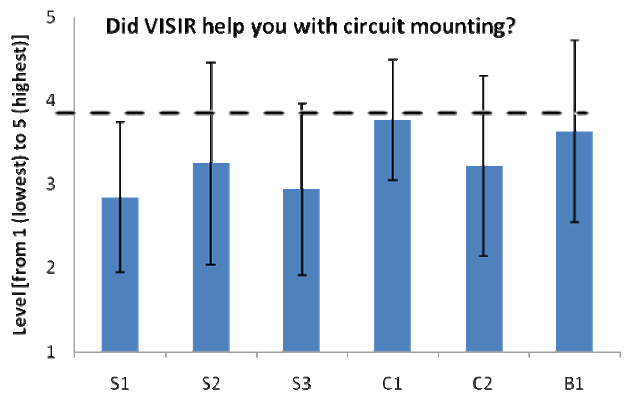

Figure 2. Example of the differences in a question at the open questionaire

In S3 course, the problems that occurred in the initial task, affected not only teachers motivation but also students interest, which was initially very high. The head-teacher referred that these initial problems prevented an effective usage of VISIR due to students discredit. This is corroborated by the students' usage (Fig.1) where this decline is visible.

Students' interest in using VISIR is related with their perception in terms of its utility. There are two perception levels, depending on students' motivation to learn. Some students develop an intrinsic motivation to learn, which will help them enrolling in activities they feel will facilitate their learning development. For these, the teacher' role in explaining VISIR's potential is crucial. This was more visible in S3 course (at the beginning). Other students (the majority) developed an extrinsic motivation, which means they only intend to complete the task because they know they will be assessed for it. In this group of students we find those with a strategic approach who only performed tasks when their effort is sufficiently accounted for in their final grade (see B1 and C2 courses in Table IV for contrast).

Several students answered an invitation to give their opinion about ways of enhancing future implementations of VISIR at ISEP. These opinions corroborate the need of VISIR being explained to students in a hands-on session; others refer the importance of a more relevant feedback of their mistakes.

Combining these results with each course information about the assessment and its usage, it is clear that some students did not realize the advantages VISIR could bring to their learning or simply view it as too much effort regarding the assessment benefits.

D. Competences development

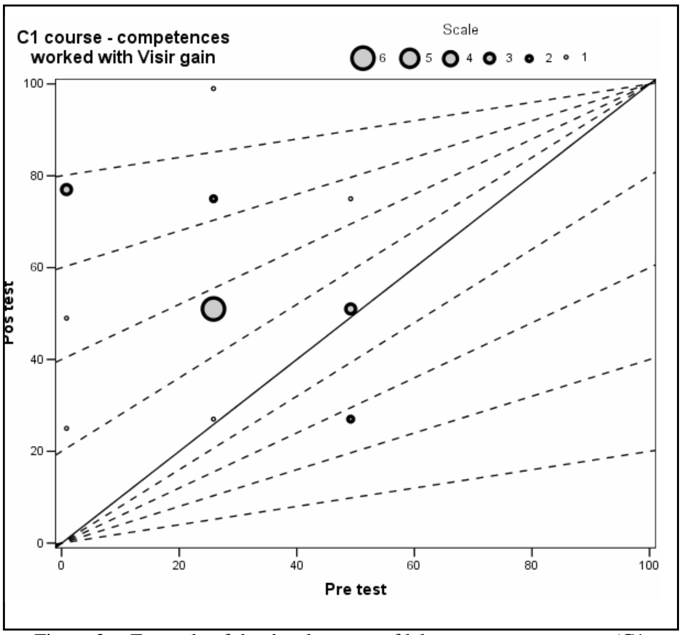

Figure 3. Example of the development of laboratory competences (C1 course)

In scientific courses (S1, S2 and S3) the head-teachers have no doubt that students have developed some laboratory competences while using VISIR, namely their ability to judge the validity of their results. But they also state that it would be more helpful in Introductory Courses, while working principles of measuring, interconnecting components and measurement equipments.

In the four courses where VISIR has been more systematically used (S1, S2, S3, C1), providing a longer accompaniment with the system, the analyzed gain in the competence test (competences worked with VISIR analysis) were greater than in the ones where this task was unique (C2 and B1). Even so, the gain was not very high, as it can be seen in Fig. 3 in C1 course.

E. Diagnosed problems in VISIR implementations

From teachers' interviews and the acknowledgment of some of the VISIR limitations, some problems were diagnosed, which paves the way for future improvements.

First, in S3 course, even though the formative tasks were well designed in order to accompany students' developments, the initial experience significantly reduced students' interest in using it.

Secondly, it was referred in several courses that VISIR presentation was done too early, relatively to students' usage of the system and therefore was not very efficient. As suggested, this should be a hands-on session where students have the ability to try for themselves and manage their progressive use of the system.

Third, it was referred a problem occurred with a resistance of 100 Ω reading, which gave several distinctive values in consequent readings. This fact was unknown, and led to students mistrust.

At last, it was referred in some courses a difference between the layouts (namely with the oscilloscope and the breadboard) between VISIR and the hands-on laboratory. This was differently foreseen by different teachers. Although this might be confusing to students in Introductory courses, as a head-teacher referred, it can even become of a greater value in more advance courses, since students will develop greater abilities while working in different manners.

V. CONCLUSION

VISIR's implementation efficacy in a course can be linked to several factors, some of which were empirically identified in this paper. Accordingly, in order to enhance future VISIR implementations several issues must be taken into account:

1) a careful planning must be made, involving both the head-teacher course and the teacher-manager of VISIR, in order to ensure that the desired implementations can actually be performed by VISIR, without restrictions;

2) it will be helpful to present a hands-on session (previously to students' first VISIR real task), where the system can be explained during students' contact with the real problems and where explanations will come after students have felt the difficulties;

3) students' errors should be commented by the system, in order to be more helpful to students progress in their learning;

4) use of higher values of resistances, in order to minimize the error due to VISIR measurements.

More than one teacher referred the fact that VISIR was more useful to students in their first contact with electric circuits, implying its usage in Scientific, Complementary or Basic courses, but in an early stage, i.e. in Introductory courses.

These results lead us to conclude that it is important to consider methods of teacher training to provide the questioning and understanding the problems of learning and teaching mediation, more focused on attitudes and motivations of learners, the alignment between objectives and assessment techniques learning, which leads us to the need to enhance the appreciation of the processes of analysis and understanding of own methods and techniques of teaching and students processes of learning.

This analytical study allows us also to consider that the proper use of techniques and methodologies is fundamental in any education system intensive technology development / learning. It should also be assured that the projected work persists after curriculum revision and updating, and that laboratory work should be relevant to the material taught in class, facilitating the learning process.

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