RESEARCH PLAN

EDUCATION IN THE KNOWLEDGE SOCIETY PhD PROGRAMME

UNIVERSITY OF SALAMANCA

Title: “Learning from complementay ways of developing experimental competences”

Author: Natércia Maria Pereira Machado Lima

Supervisors: Maria Clara Viegas and Francisco García Peñalvo

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INTRODUCCIÓN Y JUSTIFICACIÓN DEL TEMA OBJETO DE ESTUDIO (MÁXIMO 50 LÍNEAS):

INTRODUCTION AND JUSTIFICATION OF THE TOPIC OF STUDY (50 LINE MAXIMUM):

Engineering education, regardless the area, has solid needs of experimental competence developments (Jara, Candelas, Puentes, & Torres, 2011) (García-Peñalvo & Colomo-Palacios, 2015) (García-Peñalvo, Sarasa Cabezuelo & Sierra González, 2014). These competences, were traditionally developed in laboratories, along their education.
In the last decades, there was a general growth of the number of students attending higher education and has a consequence the physical resources available were no longer sufficient. Simultaneously, with Bologna Process, the laboratory time was reduced in most European Engineering Schools and the number of students per class increased, due to economic restrictions. Simultaneously scientists started developing computer simulations and remote laboratories, allowing students to practise some experimental skills in a different manner – giving them freedom to organize their own learning activities according to their perception of their learning needs and extended access to the learning resources (access many times and from different places), potentiating students' autonomy (Gustavsson, et al., 2011).

Nowadays and even though there is still some controversy about these new technologies efficacy (Corter, et al., 2007) (Corter, Esche, Chassapis, Ma, & Nickeson, 2011) (Marques, et al., 2014), teachers are often using these resources either instead or as a complement to the traditional hands-on lab. As a matter of fact, remote labs emerge as one of the main instructional technologies adopted and valued in engineering education, corresponding to one of the major shifts in engineering education in the last 100 years.

This poses new trends regarding pedagogical and didactical issues, as its' use, on their own, may even be prejudicial – some of these tools are quite complex and not immediately understandable to students, leading them to frustration and dropping out the task (Sticker, Lookabaugh, Santos, & Barnes, 2005) (García-Peñalvo, 2015) (González-Rogado et al., 2013; 2014). Students also need to understand the major differences in the type of measurements that can be obtained from these different resources: model results from simulations and real experimental results from hands-on and remote labs. This way, remote labs give the advantages of simulations and the advantages of working with real things. Sill remote labs are not the perfect solution – the underlying technology of the laboratory (as the interface of the equipment) may influence learning effectiveness (Corter, et al., 2007), with some authors regarding these methods as inhibitors of students' learning (Ma & Nickerson, 2006). Still some studies present evidence that the use of these technology-enabled lab formats can be effective in students' learning outcomes, as long as teachers realize that the educational objectives associated with each of them may be different (Ma & Nickerson, 2006) – each method allows the developing of different competences, so teachers should be aware of this fact, when deciding which method or combination of methods to use. Although there are already, in literature, some experiences describing the simultaneous use of these resources, these experiences are small-scaled, particularly for remote labs, and no significant and consistent difference between hand-on, simulation and remote labs stand out (Ma & Nickerson, 2006), (Viegas, Lima, Alves, & Gustavsson, 2014), (Lima, Alves, Viegas, & Gustavsson, 2015), (Alves, Viegas, Lima, & Gustavsson, 2016) Nevertheless, it is well studied in literature, that teachers can reach more students, if they diversify the methods and techniques used in classroom, due to student' different learning styles (Felder & Silverman, 1988), (Richardson, 2011).

The remote laboratory VISIR (Virtual Instrument Systems in Reality) initially started in 1999, at the Blekinge Institute of Technology (BTH) in Sweden. VISIR is a combination of open source software packages and commercial equipment from National Instruments (NI) for creating, wiring and measuring electronics circuits on line (Claesson & Hakansson, 2012). BTH research group is still responsible for maintaining and updating the VISIR distribution that is available as open source. Nowadays, VISIR is installed in six different European Institutions of Higher Education (HE), in four different countries (Austria, Portugal, Spain and Sweden) and it has served well several thousands of students (Tawfik, et al., 2011), (Alves, et al., 2011).

These European Countries VISIR users have, along the time, set cooperative and institutional ties and thought of creating a consortium/project to replicate in South America (Brazil and Argentina) the level of cooperation and novelty associated with VISIR in Europe. This lead to the recently started (November 2015) VISIR+ Project, - being Polytechnic of Porto, School of Engineering/CIETI-LABORIS the project coordinator. A VISIR system will be installed in each Latin American partner and it will be used not only by the owner institution (the one, in which, VISIR is installed) but also for other secondary/professional/higher education institutions.

It´s crucial to design the course curriculum based on the learning outcomes teachers want their students to develop (Biggs, 2007) and for this planning teachers must take in to account not only the teaching methods but also the resources they will be using, designing students' activities accordingly.

By now, thousands of students have already used VISIR, with effective learning gains (Alves, et al., 2011), but in most cases, this resource was not used simultaneously with others, such as, simulation and hands-on lab, together with calculus, except for some small scale didactical experiments (Alves, Viegas, Lima, & Gustavsson, 2016) (Lima, Alves, Viegas, & Gustavsson, 2015) (Viegas, Lima, Alves, & Gustavsson, 2014). VISIR + Project aims to define and develop a set of educational modules comprising hands-on, virtual and VISIR remote lab, together with calculus, following an Enquiry-based Teaching and Learning Methodology, which will allow to conduct a study to understand how and which students' learning outcomes are affected by the use of these simultaneous resources.

HIPÓTESIS DE TRABAJO Y PRINCIPALES OBJETIVOS A ALCANZAR (MÁXIMO 50 LÍNEAS):

WORKING HYPOTHESIS AND PRINCIPAL OBJECTIVES SOUGHT (50 LINE MAXIMUM):

The underlying problematic that can be tackled in this thesis project is to better understand how and which students' learning outcomes are affected by the use of different experimental resources (hands-on, simulated and remote labs) together with calculus, in class and assessment, applying an enquiry-based teaching and learning methodology.
Considering circuit analysis, we have to distinguish between CC (continuum current) and AC (alternate current) – AC circuit analysis and calculus imply using vector and complex numbers notations, being quite more challenging than DC analysis. So, several insights must be taken into consideration, including also external factors, such as socio-cultural and/or political factors.

Considering this problematic, the main goal of this work aims to study 3 Research Questions (RQ):

- **RQ1**: **In which way the use of simultaneous resources, applying an enquiry-based teaching and learning methodology, contributes to promote students' autonomous continuum work and engagement?**

- **RQ2**: **Is the level of competence under development affects students enrolment in using the different resources?**

- **RQ3**: **Are there teacher mediation traces (while using simultaneous resources) that can be linked to better student performances?**

METODOLOGÍA A UTILIZAR (APORTAR CONFORMIDAD/INFORMES/PROTOCOLOS GARANTIZANDO BIOÉTICA/BIOSEGURIDAD SI EL TIPO DE EXPERIMENTACIÓN LO REQUIERE) (MÁXIMO 50 LÍNEAS):

METHODOLOGY TO BE USED (PROVIDE CONSENT FORMS/REPORTS/PROTOCOLS GUARANTEEING BIOETHICS/BIOSECURITY IF REQUIERED BY THE TYPE OF EXPERIMENTATION) (50 LINE MAXIMUM):

Educational Research consists of applying the scientific method to the educational problems study, with the goal of explaining, predicting and/or controlling educational phenomena (Gay, Mills, & Airasian, 2011) Educational research originates with at least one question about one phenomenon of interest and can be regarded as an organized approach to asking, answering and effectively reporting a question, with steps parallel to the ones in scientific method.

To conduct this research work, we will be using a mixed methods approach, that is, it will be incorporated in a unique research study methods of colleting or analysing data from the quantitative and qualitative approaches (Creswell J. W., 2014).

It will be used a case study methodology, *a specific instance that is frequently used to illustrate a more general principle*, as Cohen defines it. (Cohen, Manion, & Morrison, 2007). They are descriptive and detailed with a narrow focus, combining objective and subjective data, establishing cause and effect – observing effects in real context, recognizing that contexts are a powerful determinant for both causes and effects (Cohen, Manion, & Morrison, 2007). Its purpose is to solve a particular problem and to produce guidelines for best practise, enabling readers to understand how ideas and abstract principles can fit together, opting for analytical rather than statistical generalization.

A key issue in this research method is the selection of information: it should be collected/recorded not only typical, representative occurrence but also unrepresentative or even critical incidents, as they can be crucial to the understanding of the case (Cohen, Manion, & Morrison, 2007). There is a diverse range of techniques employed in the collection and analysis of both quantitative and qualitative data, depending upon the question that the researcher wants to answer. Nevertheless, the researcher should spend time on-site interacting with the people studied and the data collection must be extensive and drawn from multiple sources such as direct or participant observations, interviews, archival records or documents, physical artefacts and audio-visual materials (Williams, 2007).

The samples that will be used are students/teachers from the target courses where the didactical implementations will take place. These courses deal with electric and electronic circuits and are from five Latin American (LA) Institutions:

- Federal Institute of Education, Science and Technology of Santa Catarina, Brazil (IFSC): public vocational and technological education institution, with approximately 24,000 students;
- Federal University of Santa Catarina, Brazil (UFSC): ´public University with 1,651 professors, 2,874 technical and administrative staff, more than 1,800 lines of research and 34,000 students.
- Pontifical Catholic University of Rio de Janeiro, Brazil (PUC): private University, with 15,000 students;
- School of Exact Sciences and Technologies – National University of Santiago del Estero, Argentina (UNSE): public university, with 7 engineering programs and 12,000 thousands
- National University of Rosario, Argentina (UNR): public institution offering 124 postgraduate courses, 63 college degrees, 15 technical degrees and 53 intermediate level colleges degrees.

The first didactical implementation – one course per institution - will occur, in the second semester, of the current academic year (August –January 2017). In the both semester of next academic year, it will be implemented in several courses per institution.

The data collection to tackle each RQ, is summarized in the table below (most of these data will be collected in VISIR+ Project, even though not to address the same purposes).

	Collected Data	RQ1	RQ2	RQ3
Quantitative Data	VISIR Labs access logs' (quantity and distribution over time)	x	x	
	Simulated Labs access logs' (quantity and distribution over time)	x	x	
	Presences to classes	x		
	LMS course page – number of accesses and distribution over time	x		
	Students final grades	x	x	x
	Students grades per component/task	x	x	x
	Students grades per AC/DC		x	
Qualitative Data	Participation and/or delivery of proposed tasks (in due time)	x		
	LMS course page – contents accessed, participation in forums	x		
	Course Curricula: contents, education materials, T&L strategies, assessment tools	x	x	x
	Students' PLEQ questionnaire	x	x	x
	Teachers interview and/or informal comments	x	x	x
	Types of assessment tools and its' distribution along the semester			x
	Time used in giving feedback and type of feedback given to each assessment task			x

Finally, for the data analysis it will be used the statistical tool SPSS (Statistical Package for Social Sciences). It will be done a qualitative and quantitative cross analysis, considering several items, namely: Brazilian students/Argentine students, Public Institutions/Private Institutions, Polytechnic /University; Large Institutions/Small Institutions.

MEDIOS Y RECURSOS MATERIALES DISPONIBLES (MÁXIMO 50 LÍNEAS):

MATERIAL MEANS AND RESOURCES AVAILABLE (50 LINE MAXIMUM):

For the literature review phase, it will be used all the databases provides both from Salamanca University and from Polytechnic of Porto – School of Engineering.

All resources available at CIETI-LABORIS (Centro de Investigação em Engenharia e Tecnologia Industrial – Núcleo de Investigação em Sistemas de Testes) Research Group, can be used for the different research phases.

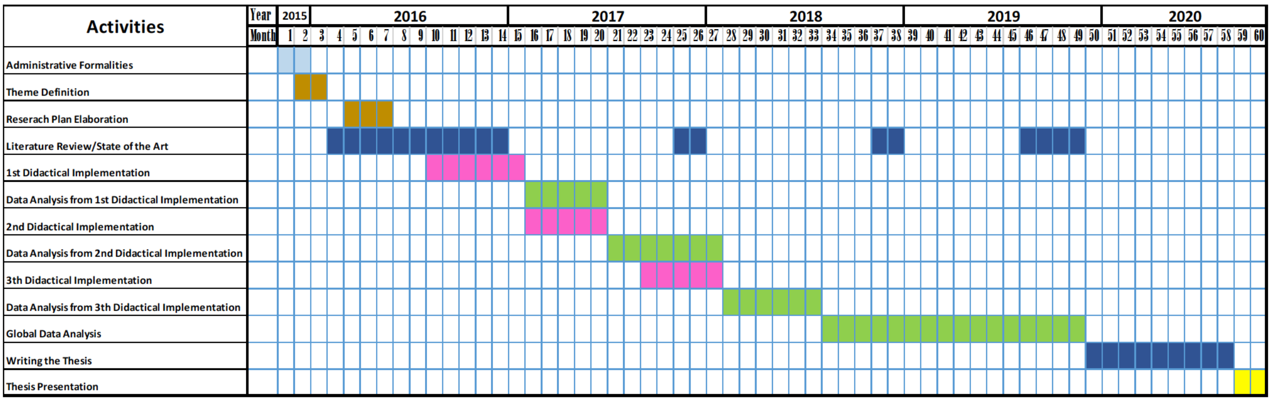
VISIR+ Project resources, including VISIR Systems, will be used. Most of the required data will be provided through the Project. VISIR+, from the LA HE Institutions involved: IFSC, UFSC, PUC, UNSE, UNR and eventually from other secondary/professional/higher education institutions (associate partners) that will be also using VISIR. Most of the data will be collected without the need to displacement.

VISIR+ Project funds will cover for the necessary LA trips and participations in project meetings.

PLANIFICACIÓN TEMPORAL AJUSTADA A TRES AÑOS / CINCO AÑOS (Tiempo parcial) (MÁXIMO 50 LÍNEAS):

TIMING SCHEDULE OVER THREE YEARS / FIVE YEARS (Part time)(50 LINE MAXIMUM):

It is expected that this research is concluded in five years, as the registration in this PhD Program is in part time. So the activities developed to fulfil the research goals are planned for a 5 year period, accordingly to the table below:



Along this five years period, it is intended to disseminate the results obtained in each research phase, namely:

- Participation, as far as possible, in the activities fostered by the PhD Education in the Knowledge Society Program as well as the ones promoted by the VISIR+ Project;
- Participation (with submission and paper presentation) in the future editions of Technological Ecosystems for Enhancing Multiculturality Conferences (TEEM). I´ve already participated (with paper submission and communication) in TEEM2014 and TEEM2015;
- Participation (with submission and paper presentation) to the future editions of Congresso National de Prácticas Pedagógicas no Ensino Superior (CNAPPES). I attended CNAPPES2014 and submitted a paper to CNAPPES. 2015;
- Participation in the future editions of other relevant Conferences, such as International Conference of the Portuguese Society for Engineering Education (CISPEE) and Experiment@International Conference (EXP@).

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