

# Interactive Digital Resources for a Blended Learning Controls Course

Ana M. B. Pavani\*, Member IEEE. William S. Barbosa\*\*

*Pontifícia Universidade Católica do Rio de Janeiro, Rio de Janeiro, RJ, 22451-900  
Brazil*

*\*(e-mail: [apavani@puc-rio.br](mailto:apavani@puc-rio.br)). \*\*\*(e-mail: [wbarbosa@ele.puc-rio.br](mailto:wbarbosa@ele.puc-rio.br))*

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**Abstract:** This paper presents the digital resources used in an undergraduate blended learning Controls course that is mandatory in the curricula of both Controls and Automation Engineering and Electrical Engineering. It briefly describes available items – texts, videos, online exercises, simulators and other assorted types of contents that substitute for class hours. The objective of blended learning and of the use of online resources is to stimulate self learning so that the sessions are used for discussion and problem solving.

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## 1. INTRODUCTION

The faculty of Electrical Engineering of Pontifícia Universidade Católica do Rio de Janeiro (PUC-Rio) has been very active in using ICT – Information and Communication Technology tools to support traditional face-to-face courses. This has been going on for two decades. In the first semester of 2014, two courses started being taught in the blended learning mode (b-learning) – Signals & Systems and Electric & Electronic Circuits. In the second semester, the Controls & Servomechanisms course was switched to this mode. Even before adopting b-learning, abundant online courseware was available from the Maxwell System (<http://www.maxwell.vrac.puc-rio.br/>), the integration an Institutional Repository (IR) with a Learning Management System (LMS); part of the courseware was interactive. The introduction of b-learning was a motivation to keep developing contents of the same types and to add new interactive resources. The new resources for the b-learning courses were introduced in the first semester of 2015.

Controls & Servomechanisms is a mandatory course in the curricula of Controls and Automation, and Electrical Engineering. It is taught every term with an average of 15 students per term. Before switching to b-learning, it had 8 hour per week of traditional face-to-face classes – 6 lecture and 2 laboratory hours. The b-learning option substituted computer mediated activities and home assignments for 2 lecture hours.

This work presents the courseware that has been developed for b-learning. It also mentions other resources that have been in use since ICT supported learning was introduced to enhance the traditional face-to-face mode.

Section 2 addresses the initial digital resources while section 3 deals with the new interactive courseware. Section 4 presents the b-learning mode and the use of the new resources for the first time (second semester of 2015).

Section 5 comments the results, current activities and actions to be taken in the near future. Finally, section 6 outlines the demo and access numbers.

## 2. COURSEWARE DEVELOPED AND USED BEFORE 2015

At the very beginning, due to the technological limitations in the second half of the 1990s, courseware was made up of two sets of resources – hypertext files with some images and the corresponding text files for linear navigation.

In the early 2000s, small videos, animations and simulators were introduced. The simulators allowed some interactivity. At the same time, online exercises started being developed – each had, at least, three parameters and/or functions sets and one was randomly selected every time the exercise was used; online check and suggested solutions were available too. Exercises were in Electric & Electronic Circuits, Control Systems and Signals & Systems.

In 2008, the numbers of exercises in the three topics had grown a lot and some organization was necessary. The exercises were organized in three interactive books, one for each subject; they are offered as a collection entitled *Exercícios Interativos em Engenharia Elétrica* (Interactive Exercises in Electrical Engineering).

The books do not contain texts, only interactive exercises. They maintain the characteristic of having at least three options of parameters and/or functions that are randomly selected each time the exercise is used. They also offer online checking and suggested solutions. The exercises are grouped in chapters that are the usual in text books in each area. The total numbers of exercises are: Electric & Electronic Circuits – 281; Controls & Servomechanisms – 237; and Signals & Systems – 167. They are in open access and can be found at <http://www.maxwell.vrac.puc-rio.br/livros/index.html>. Figure 1 shows screen shots of the interactive books.

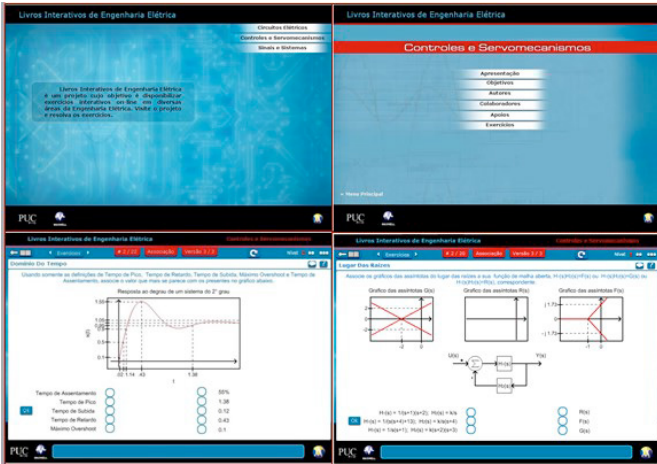


Fig. 1. Interactive books in Electrical Engineering cover, interactive book in Controls & Servomechanisms cover and two exercises.

In parallel, a set of class notes (5 volumes), a study guide and lists of assignments have been created. These are text files.

In 2012, a series of resources was started – *Objetos Educacionais em Engenharia Elétrica* (Learning Objects in Electrical Engineering). Each one is a stand alone content; they are in different areas of EE. They are of varied nature – simulators, animations, small videos and other hypermedia. Currently, there are 44 such objects. Among them, 28 are related to Controls, though they can be used in other courses too. The Learning Objects in EE can be found at <http://www.maxwell.vrac.puc-rio.br/series.php?tipBusca=dados&nrsqser=5>. Figure 2 shows screen shots of some Learning Objects in EE.

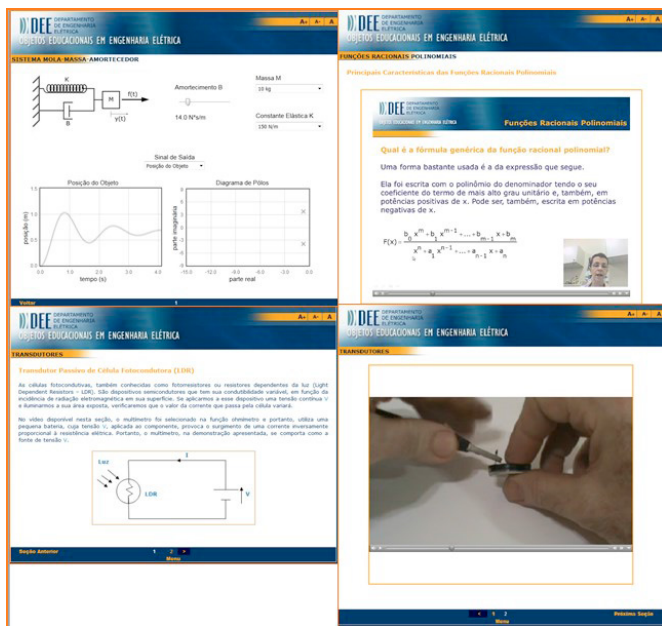


Fig. 2. Learning Objects with a a small simulator, videos and hypermedia.

When the course was switched to b-learning it was necessary to have a resource to guide the student from one topic to the other, to suggest activities, to link to other contents (internal and external links) and to present the main topics. This resource is called *Roteiro* (Course Guide) and also offers 23 short videos that address specific topics. The presentation materials used in the videos are available for students too. Figures 3 shows screen shots of the *Roteiro*. The *Roteiro* allows students a preliminary study of the topic before class so that it is used for discussions and questions on the subject, and also freeing time to solve problems.



Fig. 3. *Roteiro* – table of contents, a definition, a video and an activity.

These resources started being developed before 2015 but they were not discontinued; new items are added every semester.

### 3. A NEW TYPE OF COURSEWARE DEVELOPED IN AND AFTER 2015

In 2013, Costa-Castello, Guzman, Berenguel and Dormido wrote: “Many concepts have complex visual representations which can not sufficiently be explored through the normal classroom experience. For these reasons, a need arises for a set of applications which provide students the opportunity to visually and interactively explore the classroom concepts without use of pen and paper.” (Costa-Castello, 2013). Options of interactive tools have been presented by many authors, as for example the use of Augmented Reality (Restivo, 2014). Ariza (2015) introduced an interactive platform that integrates hardware and software to teach control systems. An interesting use of low cost technology is the implementation of an artifact that each student may have and take to home to experiment with control systems (Taylor et al., 2013). These works are based on the knowledge that experimentation, even if virtual or numerical, leads to a better understanding of concepts.

Engineering courses have been users of MATLAB® for many years. The Electrical Engineering Department of PUC-Rio has this software installed in its labs. Students are proficient

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