Interactive Books in Electrical Engineering: a Long-Term Experiment

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Abstract

For over 10 years, ICT – Information and Communication Technology tools have been used at the Electrical Engineering Department of PUC-Rio as a support to traditional face-to-face acitivities. In 2007, the same team that has developed and used ICT tools decided to start a new experiment – the development of online interactive books. This article addresses the following subjects related to the experiment: (1) background in terms of courseware; (2) the decision to 'pack' some courseware into an online interactive book; (3) the development of the book – technological and contents aspects; (4) intellectual property and Internet publishing; (5) the current experiment on the use of the books; (6) the next steps on the development and the assessment of the products as learning aids.

Introduction

In March 2009, a search on Google (http://www.google.com/) using as argument 'definition of book' yielded 81,000,000 hits.

The first hit among the 81 million is a definition on WordNet – a lexical database for the English language, of the Cognitive Science Laboratory (http://wordnet.princeton.edu/), of Princeton University (http://www.princeton.edu/). It says:

> **Book** (n) – a written work or composition that has been published (printed on pages bound together)
> (http://wordnetweb.princeton.edu/perl/webwn?s=book)
> March 14, 2009

The third comes from the online version of the well known Merriam-Webster Dictionary (http://www.merriam-webster.com/). It says:

> **Book** (noum)
> 1 **a**: a set of written sheets of skin or paper or tablets of wood or ivory **b**: a set of written, printed, or blank sheets bound together into a volume **c**: a long written or printed literary composition **d**: a major division of a treatise or literary work **e**: a record of a business's financial transactions or financial condition —often used in plural <the books show a profit> **f**: MAGAZINE 4a **g**: E-BOOK
> http://www.merriam-webster.com/dictionary/book
> March 14, 2009

Both definitions are closely related to the idea that persons born in the 20th century have of a book – written pages of paper bound together. Books, and in general written records, have been in constant evolution since the first clay tablets were written in Mesopotamia approximately 6,000 years ago (Manguel, 1997).
Evolution has happened due to the changes in technology of supporting and recording information – parchment, palm leaves, paper, inks, pens, printing press, off-set machines, etc. Readers have also had a great influence – increased number of readers requiring larger production of books as well as wider availability of titles, necessity to make books portable due to the increased mobility of readers, etc.

Electrical Engineering is young when compared to books; its history goes back to the first half of the 19th century, but "Electrical Engineering became a true profession in the 1880s" (IEEE Center for the History of Electrical Engineering, 1984). Electric motors and generators had been invented about 50 years earlier as well as the telegraph (Computer Networking and Telecommunications Research – University of Salford, 2009). As books, it has gone through many changes; the difference is that they have been very drastic and at a much faster pace.

The evolution of Electrical Engineering has lead to a set of technological tools that allows books to be viewed from a different point of view. The use of ICT in the development of books can add a new relationship with 'readers' – interaction. ICT also allows portability to any place where there is an Internet connection, as well as offers a fast and simple way of updating, enhancing and incremeting contents. This means that the development of Electrical Engineering can be used to enhance books to teach Electrical Engineering. It is important to remark that PUC-Rio has a peculiar organization – the Department of Electrical has LAMBDA – Laboratório de Automação de Museus, Bibliotecas Digitais e Arquivos. This laboratory is also involved in publishing and developing courseware. This makes the project easier since contents and technology are 'together'.

This article addresses the development of a series of books in Electrical Engineering – Livros Interativos de Engenharia Elétrica (Interactive Books on Electrical Engineering). It is divided in 5 sections, besides this introduction, the aknowledgement and the references. Each section devoted to a specific aspect of the project.

Background and Decision to 'Pack' Contents into a Book

ICT tools have been used in education in general and in Engineering Education in particular – from simulators to discussion forums, there is room for enhancing the learning process. Current students are comfortable and enjoy technology.

Contents available before the book

For over 10 years, there has been activity in this area at the Electrical Engineering Deparment of PUC-Rio. The products of this activity have been presented at previous ICEE Conferences (2002, 2003, 2005 & 2008). These works addressed the use of different tools and the development of courseware.

Electric Circuits has been the discipline with most attention due to its importance in the curricula of 3 engineering courses: Controls & Automation, Computer and Electrical. Electric Circuits courseware has been developed in 3 different types of products: (1) online hypermedia documents suitable fo nonlinear use and the corresponding linear printer friendly versions; (2) small simulators; and (3) online interactive exercises.

At the end of 2007, there were 90 online interactive exercises with the following characteristics:

- They were of 3 types – T/F, multiple choice and fill in the blanks;
- They had online checking of results;
- They presented one step-by-step solution (some exercises may have different solutions);
- Each numerical exercises had 3 sets of parameters and functions and each theoretical exercise had 3 possible questions – there was a random selection each time the exercise was to be solved;
- They had been implemented using Macromedia Director, an obsolete product.

At the same time, there were 60 exercises ready to go online. But the sets for selection had to be created; exercises had to be programmed, tested and validated.

The 90 exercises had been used by many classes and students had presented various suggestions for enhancement, many of them implemented right away. The most important were the classification by level of difficulty and the development of new exercises to increase the coverage of the syllabus. Although there were no specific requests on this, users of the exercises had an unnecessary work during navigation. To go to different exercises could require going

from one set to other by choosing the topic of the syllabus and the type of exercise, since this was the way they were grouped. These exercises also required a careful review in terms of making the interfaces more uniform. Inspite of the attention given to the development, there were problems.

This situation lead the laboratory team to decided for the development of a tool to automatically generate the technological part of the implementation of exercises; it would secure the necessary uniformity. The tool is PRESTO (Siqueira et al, 2008). This was good time investment because there were 90 exercises to standardize and change technology; there were 60 new exercises to implement. The new technology was decided to be Adobe Flash,.

Choice of a book

To solve the navigation problem the team chose to organize the exercises into a online interactive book. Four questions may be asked and answered at this point:

What is the concept of an interactive book in this project?
In the context of this project, it is a book of online exercises that the user can solve and check; a right solution (there may be different ways to solve a problem!) for each exercise is shown step-by-step in case the user wants to learn it.

Why is it called a book?
It is called a book because it is organized like one – it has chapters on different topics – the same topics of the traditional text books, and the exercises are classified by levels of difficulty, as in many text books. It differes from a traditional book though because it has no texts on the theory; it is expected that students keep using the traditional text books.

Is it to substitute for a text book?
No, its objective is to complement the corresponding text book.

Why use online interactive books?
IThe idea is to have an additional attractive contents to motivate students. When surveys were taken of the use of the online interactive exercises, students always reported they like ICT tools as complements to traditional texts.

The characteristics of an online interactive book in this project are:

- It is divided in chapters, according to the topics of traditional texts books in the corresponding area;
- Each chapter contains a set of exercises on the topic – exercises as group by type and are assigned a difficulty level;
- Each exercise is cataloged on the digital library of the Maxwell System (http://www.maxwell.lambda.ele.puc-rio.br/); discipline, type, level of difficulty, interface colors and order in the set are stored on the database (the database management system is IBM DB2,);
- Books are created dynamically from the information on the database of the system.

Development of the Books

Once the decision was made, the next step was to plan and implement the project. This section addresses the development of the series of online interactive books.

Plan & Implementation

The first step was to plan the project, as expected. At this stage, it became obvious that other disciplines could benefit from the use of online interactive books. So, it was decided that a series of books on Electrical Engineering would be the objective.

At this point, 2 paths had to be followed. The first concerened the development of the exercises and the second the subsystem of the Maxwell System that would manage the series of books. For this reason, 2 groups started work-

ing simultaneously and had permanent interaction since the characteristics of the series, the books and the exercises would be controlled by the system.

The implementation, as the plan, had 2 paths – exercises and subsystem.

The workflow of the implementation of the exercises had the following steps: (1) intellectual creation of a new exercise (or creation of new sets of parameters/functions/questions for the 60 partially developed or review of the 90 old exercises); (2) technological implementation using PRESTO; (3) review of contents and test of implementation; (4) final corrections; and (5) descritption and upload to the Maxwell System. This workflow still exists because additional exercises are under development.

In order to give creators of exercises more flexibility, a 4th type of exercise was created – match objects (diagrams with transfer functions, for example). PRESTO was enhanced to generate the code for this new type. PRESTO was also enhanced to draw diagrams and graphs of discrete-time signals (sequences) since the second book was chosen to be Sinais e Sistemas (Signals and Systems).

The subsystem of the Maxwell System to manage the online interactive books was designed and implemented to operate in a higher level – series. Then there is a 3-level hierarchy: (1) a series holds books; (2) a book is divided into chapters; and (3) the chapters contain exercises. All this 'organizational' information is stored on the database and automatically 'mounted' online by a set of applications. The applications also manage colors, types and levels of difficulty, as well as randomly select the sets for each solution.

Results

The series started with 2 books: Circuitos Elétricos (Electric Circuits) and Sinais e Sistemas (Signals and Systems). Tables 1 and 2 show, respectively the numbers of exercises when the series was published in December 2008.

Table 1 – Exercíses: Electric Circuits Book

Topic	Type 1	Type 2	Type 3	Type 4	Total
Rsistive Circuits	42	25			**67**
First Order Circuits		26	1	5	**32**
Second Order Circuits	4	30		6	**40**
Sinusoidal Permanent Regime		8	1	15	**24**
Filters	3	15	1	27	**46**
Bode Diagram	10	26		5	**41**
Operational Amplifiers	5				**5**
Diodes	3	2			**5**
Bipolar Transistors		2			**2**
Field Effect Transistors	1	1			**2**
Mixed Topics		1		14	**15**
Total	**68**	**136**	**3**	**72**	**279**

Table 2 – Exercises: Signals and Systems Book

Topic	Type 1	Type 2	Type 3	Type 4	Total
Basic Concepts	2	6		4	12
Finite Difference Equations	3	6			9
Periodic Signals		1			1
Z Transforms		2			2
Fourier Series	2				2
Fourier Transforms	2	2		1	5
Total	9	17		5	31

The types are: (1) Fill in the blanks; (2) Multiple choice; (3) Match objects; and (4) T/F.

Currently, more exercises are under development in the area of Signals and Systems. The total number is higher than 60, but since the new exercises have not been reviewed, they have not been pubished. The figures tha follow show some pages of the series.

Figure 1 – Series cover

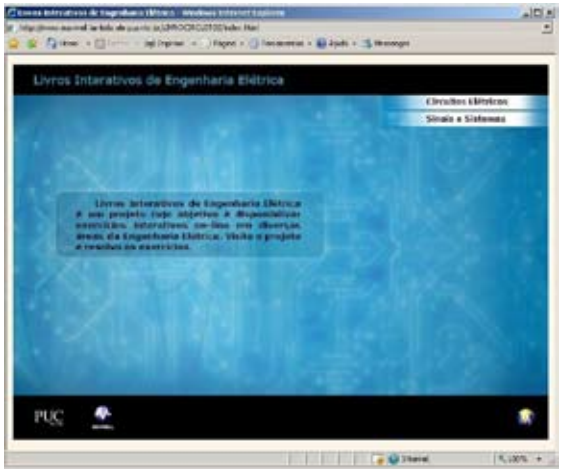


Figure 2 – Electric Circuits book cover

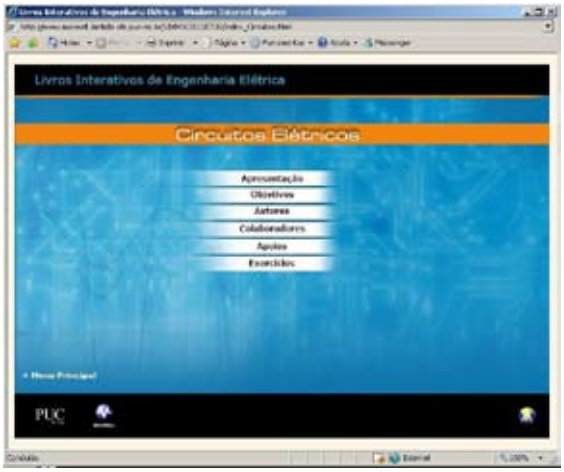


Figure 3 – Signals and Systems book cover

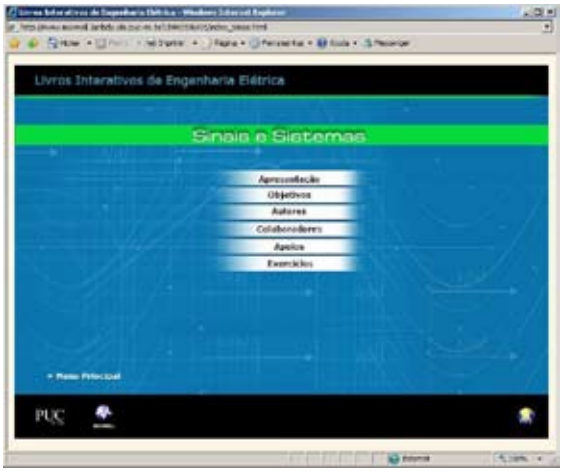
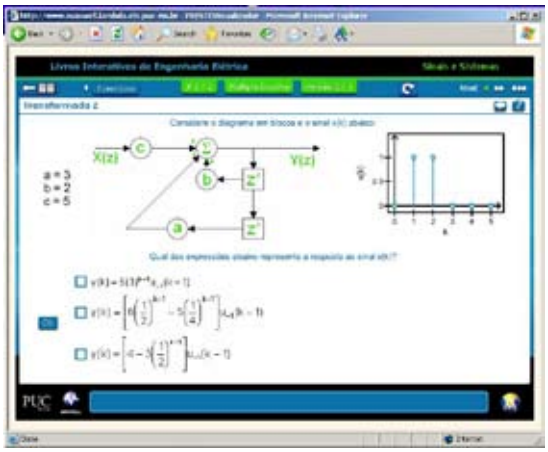


Figure 4 – Electric Circuits book presentation

Figure 5 – Electrics Circuits exercise

Figure 6 – Signals and Systems exercise



Figures 1 – 3 show, respectively, the covers of the series Livros Interativos de Engenharia Elétrica, the book Circuitos Elétricos and the book Sinais e Sistemas. The color of the first book is orange and of the second is green – the colors are used in the interfaces of the exercises too. Figure 4 shows the Presentation page of the Electric Circuits book, where it is stated that the series and the books are published under license 3.0 of the Creative Commons (http://www.creativecommons.org/); this subject will be addressed in a later section. Figure 5 shows an Electric Circutis exercise – it is a match objects type on sinusoidal permanent regime. Figure 6 shows a Signals and Systems exercise – it is a multiple choice type on Z Transforms.

A remark is important at this point. The developers did not feel comfortable to classify the exercises in 1 of 3 levels of difficulty. All exercises were uploaded on the system under the classification 1 (simple). The team will ask users to help classify the exercises as they use them. This subject will be discussed in the section that presents the current experiment on the use of the books.

Intellectual Property and Internet Publishing

Currently, there is a worldwide effort towards OA – Open Access to scientific information. Institutions all over the world are establishing policies to make the contents on their institutional repositories OA. One example of such an institution is Humboldt University in Berlin – the Open Access Declaration of Humboldt University Berlin can be found at (http://edoc.hu-berlin.de/e_info_en/oa-declaration.php, captured on March 14, 2009). Schrimbacher (2007), a Professor at Humboldt University, shows a new trend on OA publishing that is changing cultures and allowing contents to be accessed 24/7 from all over the world.

Another interesting aspect of OA is the increase of the impact factor of works that are published under OA or under a conventional license and an OA license. Harnad published 2 very important articles on OA in 2004. The first (Harnad and Brody, 200) shows that OA articles have more citations and they start earlier than for their printed counterparts; the authors present numbers to prove their points. The second paper (Harnad et al. 2004) analyzes the evolution of the numbers of publishers that allow OA publication simultaneous to the printed version; they also discuss the different types they permissions – preprints, postprints or both. In this same article, they present numbers of the increased impact factor for OA articles in some areas of Physics; the data they worked with is from the period 1992-2001.

Creative Commons is an organization that advocates that publishing can be accomplished with “some rights reserved” instead of “all rights reserved”. They suggest some types of licenses – these licenses keep some rights and waive others.

Considering the OA effort and the suggestions of Creative Commons, the authors decided to publish the series

completely OA and under Creative Commons license 3.0 (http://creativecommons.org/licenses/by-nc-sa/3.0/). This license allows users To Share (to copy, distribute and transmit the work) and To Remix (to adapt the work), under the conditions of Attribution (refer the work in the manner the authors or distributors specified), Noncommercial (the work cannot be used for commercial purposes) and Share Alike (all followons of the work must be shared under the same or similar license).

Current Experiment on the Use of the Books

The series was published in December 2008, just at the moment that the summer vacation started in Brazil. Schools reconvened in the beginning of March and 2 new classes have just started at PUC-Rio – Electric Circuits and Signals and Systems.

Students in these 2 classes will use the books. At the end of the school semester, they will be asked to fill a survey on their experience. Students will also be asked to fill a form to classify the exercises in the 3 levels of difficulty. The LAMBDA team will examine results to assign a level to the exercises on the database. The assigned level can be changed by updating the description on the database.

Next Steps and Assessment of the Books as Learning Aids

A new book is planned for the series in 2009. A faculty member of the Department of Electrical Engineering has already contacted the laboratory; at the moment a proposal for funding is being drafted to support the students working in the project. At the same time, other activities are either already under way or being planned.

One student is developing additional exercises in Signals and Systems. They will be published as soon as they are reviewed. A faculty member will create new axercises in Electric Circuits – it can be seen from table 1 that there are very few exercises on the last topics of the syllabus (analog electronic circuits). This situation is the result of a change in the syllabus that will be effective in the second semester of 2009 – when these topics will be added to the discipline. This means that students taking the discipline in the current semester will not be impacted by these low numbers.

The development of the online interactive exercises and of the books has had the collaboration of many persons. Concerning the contents, the contributors have been faculty of the Electrical Engineering Course and students at the 3 levels – undergaduate, master and doctoral. As far as the technological aspects, collaborators have been designers, systems analysts, librarians and programmers. It is then necessary to submit the project to an assessment from the point of view of educational practices. During the second semester of 2009, after the surveys of the first semester have been compiled, the team expects to work with faculty in the Department of Education to plan and implement the assessment in terms of educational results.

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∂ FAPERJ – Fundação Carlos Chagas Filho de Amparo à Pesquisa do Estado do Rio de Janeiro (http://www.faperj.br)

The software products used to develop and operate the Maxwell System digital library were made available by IBM Brasil (http://www.ibm.com.br/) through the Academic Initiative Program.

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