

# **From Traditional to Blended Learning: A Signals and Systems Course – First Results**

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# *From Traditional to Blended Learning*

## *A Signals and Systems Course – First Results*

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**Abstract**—This work presents the preliminary results of a switch from the traditional face-to-face teaching to the blended learning mode of the Signals and Systems course at PUC-Rio. This change in the way faculty teach to a mode where students learn with their professors was motivated by high rates of underachievements – classes have been showing high percentages of dropouts and of students who fail the tests/exams. Since this course is basic to many curricula, the performance of students is important. Blended learning was an extension of the technology enhanced learning that the university has been using for many years. Though the results presented in this work are from one term only, the authors believe this mode of learning-teaching will be accepted by the students and yield better results – students will get used to a new way of learning. When the results of more terms with blended learning are available, a statistical comparison of the grades in terms using the traditional face-to-face Signals and Systems course will be performed.

**Keywords**—signals and systems; blended learning; ICT supported learning; courseware;

### I. INTRODUCTION

Signals and Systems (S&S) is a mandatory course in five undergraduate curricula of Pontifícia Universidade Católica do Rio de Janeiro (PUC-Rio). In three of them, it is a pre-requisite to a sequence of three other courses. This means that being unsuccessful (failing or dropping out) in Signals and Systems may delay graduation and frustrate students and their families.

A time series was created to observe the performances of classes in the 10 terms from 2009 to 2013. They are presented and commented in section II. A term is one semester at PUC-Rio.

The analysis of the time series indicated that it was necessary to address the problem of how the course was taught. Some actions were taken in the direction of adding new courseware to the set in use and including other activities for students to develop. These two topics and the LMS – Learning Management System in use are addressed in section III.

Since the results of the actions did not indicate a change in trend of the time series, a decision to migrate from the traditional face-to-face to the blended learning mode was made in 2013 to be deployed in the first semester of 2014. This decision and the implemented solution are presented in section IV. Partial results are discussed too.

As the previous paragraphs indicate, the use of ICT – Information and Communication Technology tools was the basis for the switch in the learning-teaching style. This was a decision consistent with the international trends in education. It is interesting to cite the first two sentences of the first paragraph of the Executive Summary of Report of the NSF Task Force on Cyberlearning [1]:

“Imagine a high school student in the year 2015. She has grown up in a world where learning is as accessible through technologies at home as it is in the classroom, and digital content is as real to her as paper, lab equipment, or textbooks. At school, she and her classmates engage in creative problem-solving activities by manipulating simulations in a virtual laboratory or by downloading and analyzing visualizations of real-time data from remote sensors.”

The use of ICT was also consistent with other activities that had been under development at PUC-Rio for well over a decade. Section III briefly describes them.

The specific use of blended learning to help difficult situations in higher education was not new. One example was presented by Alonso, Manrique, Matínez and Viñes [2] in the use of blended learning applied to a module of the 5 year Computer Engineering curriculum at the Universidad Politécnica de Madrid, Spain. This work described a situation analogous to the one existing at PUC-Rio: (1) it was in similar context – course of an engineering curriculum; and (2) it had a similar motivation – high failing rates among students in a mandatory and important curriculum course. Another example is the one implemented at the University of Rijeka, Croatia, for the course of Teaching Methods in Information Science. Hoic-Bozic, Mornar and Boticki [3] mentioned that the dropout rate was “greatly diminished”.

### II. PERFORMANCES OF CLASSES 2009 - 2013

#### A. The School Year at PUC-Rio

The school year starts sometime between the last week of February and the first week of March. There are two semesters per year. In the time frame of the current analysis from 2009.1 to 2013.2, the total is 10 semesters.

#### B. Data That Were Gathered

In 2011, faculty who teach the course observed that the results had been deteriorating since 2009. In order to assess the

performance of different classes of S&S, data were gathered from 2009.1 on. The pieces of data were: (1) number of students who enrolled in the course; (2) number of students who dropped out; and (3) number of students who failed the course.

It is important to remark that if a student formally withdraws from a course, there are no grades associated with it and there is no impact in the GPA – Grade Point Average. This type of withdrawal is referred as a dropout in this paper. When a student fails the course, the grade ( $<5.0$ ) is used to compute the GPA. Unsuccesses are defined as the sum of dropouts and failings.

Figures 1–3 show the performances of the classes along the 10 semesters 2009 – 2013. Though the lines in the three graphs are similar in shape, it is important to observe that in figure 1, the numbers are of enrolled students (absolute values) while in figures 2 and 3, they are percentages of dropouts, failings and dropouts + failings. Growing percentages of growing numbers of students means that the numbers of unsuccesses has significantly increased.

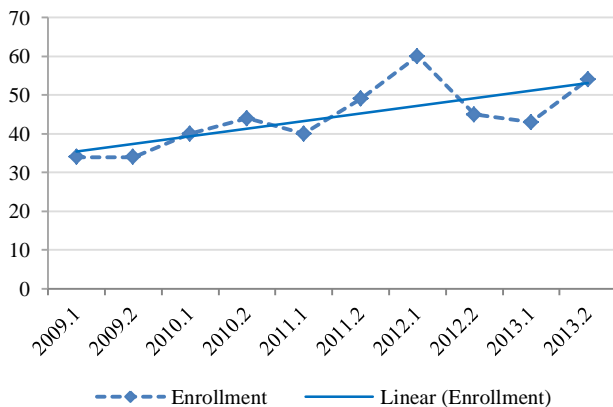


Fig. 1. Numbers of enrolled students in 10 semesters 2009 - 2013

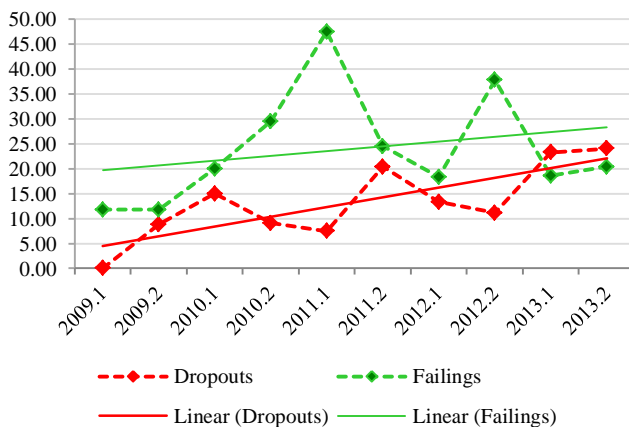


Fig. 2. Percentages of students who dropped out or failed in 10 semesters 2009 - 2013

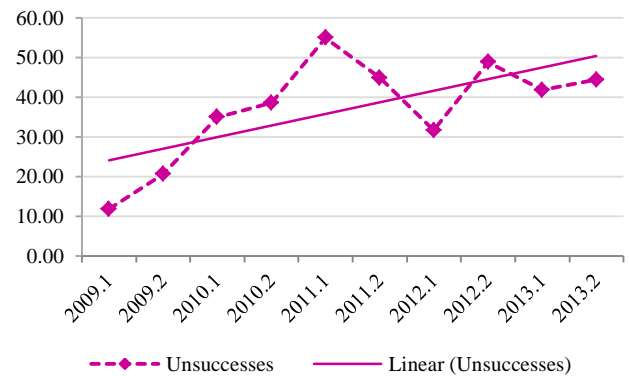


Fig. 3. Percentages of students who were unsuccessful in 10 semesters 2009 - 2013

The averages of the numbers in ten semesters were:

- Enrolled Students – 44.30
- % dropouts – 13.26
- % failings – 24.02
- % unsuccesses (dropouts + failings) – 37.27

In 2011, faculty who teach S&S detected the trend of increasing numbers of unsuccesses. It was decided that some actions had to be taken in order to revert the trend.

The first semester of 2014 made available the blended learning mode for the first time. Partial results are addressed in section IV.

In order to understand the actions and the choice of blended learning, it is necessary to understand how credit units are computed in Brazil.

### C. Credits and How They are Computed

To understand the first move, it is necessary to address the process of university teaching in Brazil – it is mostly based on lectures and tests/exams. In the Engineering curricula many courses have laboratory activities; some examples are Electric and Electronic Circuits, Digital Electronics and Electromechanical Energy Conversion. But courses that are theoretical rely on lectures and tests/exams.

One good example of how lecture-centered higher education is can be found in the definition of credit for theoretical courses: 1 credit unit = 1 classroom hour per week. This definition is quite different from the ones used in Europe, after the Bologna Declaration, and in the United States.

In the United States, 1 credit hour is equivalent to a minimum of three hours of work per week – “one hour of faculty or direct instruction and a minimum of two hours of out-of-class student work each week” (<http://www.nwccu.org/Standards%20and%20Policies/Policy%20on%20Credit%20Hour%20November%202012.pdf>). In Europe, the Bologna Declaration established a way to standardize the measure of work necessary to define a credit unit, the ECTS – European Credit Transfer System ([http://ec.europa.eu/education/tools/docs/ects-guide\\_en.pdf](http://ec.europa.eu/education/tools/docs/ects-guide_en.pdf)).

The document states: “ECTS credits are based on the workload students need in order to achieve expected learning outcomes.”; this is not the number of lecture or contact hours. Although implementation may vary from country to country, one credit can be thought as a workload of 25–30 hours during one semester; the workload contains lectures, seminars, laboratory activities, projects, self-study, etc. This total number of hours in one semester corresponds to an average of 1.7-2.0 hours per week. A typical semester has 30 credits.

Regardless of the different numbers used in the United States and in Europe, the importance of both definitions is that they are not based on lecture or contact hours only; they include all different activities students need to achieve the learning outcomes.

At PUC-Rio, students are allowed to take a maximum of 30 credits per semester. This is not a characteristic of PUC-Rio only. USP – Universidade of São Paulo is the most important and most prestigious university in Brazil. An exam of the curriculum of Computer Engineering (<https://uspdigital.usp.br/jupiterweb/listarGradeCurricular?codigo=97&codcur=97001&codhab=0&tipo=N>) shows that 1 classroom hour is equivalent to 1 credit and that the average number of credits recommend per semester in classroom hours is 24.3. There are semesters in this course that have recommendations of 28, 29 and 30 hours in classroom.

Comparing the Brazilian situation to the ones in Europe and the United States, 30 credits would mean, respectively, 51-60 and (at least) 90 hours of study per week.

The result is that Brazilian students strongly rely on listening to their faculty to learn. They are used to the idea of having someone explaining the contents during lectures.

### III. THE USE OF ICT FOR LEARNING AND TEACHING OF ELECTRICAL ENGINEERING AT PUC-RIO

Electrical Engineering at PUC-Rio has been using ICT tools for learning and teaching since 1995. Then the tools were rather primitive if compared to the ones available today. Different generations of courseware have been developed and, later on, discarded. Currently there is a large collection of courseware items of different purposes and formats, though all digital. The LMS is the same system of the IR – Institutional Repository [4] and this characteristic allows sharing and reuse of learning materials. Sharable and reusable digital contents are a necessary feature [5] of courseware; IRs support the management of such digital objects in a way that enhances these characteristics.

This section highlights the current characteristics of the use of ICT tools and mentions a little historical background.

#### A. The Maxwell System

The Maxwell System (<http://www.maxwell.lambda.ele.puc-rio.br/>) started in 1995 in the Electrical Engineering Department of PUC-Rio. At that time, it had two objectives that yielded two lines of work. The first was the development of courseware in Electrical Engineering and the second was the development of a platform to manage and deploy the courseware.

The platform was based on a DBMS – Data Base Management System and used web browsers as the sole interface. When the platform was ready and operative, the development team decided not to restrict its use to courseware – other types of digital contents created at PUC-Rio started being hosted by the system. For this reason, it is compliant with many metadata standards and practices; it is compliant with DCMES – Dublin Core Metadata Element Set (ISO 15836/2003) and other specialized sets.

Besides adding other types of digital contents the system grew wider in functionality. Other functions could and indeed were added, as well as other departments started using this infrastructure.

One of the important sets of functions added to the system are those of LMSs. It implements the relations that exist in a university – learning & teaching, accessing (digital) library contents, administrating agendas, grades, etc and communicating with one another. Among the communication tools there are discussion forums, chats, bulletin boards and mailing lists. Discussion forums have been used by students to discuss group work in distance learning situations (extension courses).

There are two very important functions related to the use of the system by students and faculty. The first is called *Sala de Aula* (Classroom) and its objective is to support traditional face-to-face courses; this has been done for many years. The second is called *Sala Virtual* (Virtual Classroom) and it is devoted to distance learning and, now, to blended learning. The latter has more functions than the former. One example is an environment for students to post their photos, mini-CV and other personal information.

Faculty have an additional set of functions devoted to the management of the courses. They can keep track of which and when contents are used by students, the grades and statistical data on assessment, students who are missing activities and aggregated data on forums. They can write messages to the bulletin board, send emails to all or some students, create forums with different profiles, record grades, etc.

PUC-Rio is a research university and for this reason is a source of scholarly publications as well as of works that are required to obtain degrees. Since the Maxwell is an IR, it manages and makes available preprints, articles, journals, books, technical reports, manuals, theses, dissertations, senior projects, etc.

Currently, there are a little over 7,100 ETD – Electronic Theses and Dissertations, over 3,500 senior projects, 10 online journals and 4 books. There is a collection of interactive books, a collection of learning objects and a collection of videos that will be addressed later since the contents are in Electrical Engineering, that is a specific focus of this work. A collection of 26 learning objects in Physics (Electricity and Magnetism) has been published in the last months.

PUC-Rio registered the system with INPI – Instituto Nacional de Propriedade Industrial (<http://www.inpi.gov/>) that is the Brazilian Patent Office. In March 2009, v. 4 was deployed; it offered new interfaces that are accessible to the blind and the visually impaired; this is the current version. The



systems has interfaces in pt-BR and en-US. Most contents have metadata sets in both languages too.

Since the system belongs to the university, new functions can be added to fulfill the needs of its community.

### B. Actions and Courseware

When the problem was identified the two faculty members decided to add individual work for students to do – exercises to be solved and turned in for grades, and discussion forums.

At the same time, new courseware was developed. The following items were added to the collection:

- New problems were created for the *Livro Interativo de Sinais e Sistemas* (Interactive Book on Signals and Systems). The current number of problems is 167. This book is part of the collection *Livros Interativos de Engenharia Elétrica* (Interactive Books in Electrical Engineering). The other two are on Electric Circuits and Control Systems. The books can be found at <http://www.maxwell.lambda.ele.puc-rio.br/livros.php#>. The first books (Electric Circuits and Signals and Systems) started being published in 2008. Since they are made of independent problems, they can grow as large as necessary. Currently the three books offer almost 700 problems, each with at least three sets of parameters/functions that are randomly chosen when the problem is selected.
- *Notas de Aula em Sinais e Sistemas* (Class Notes in Signals and Systems) were reviewed, enhanced and published in three volumes. They can be found at [http://www.maxwell.lambda.ele.puc-rio.br/Busca\\_etds.php?strSecao=resultado&nrSeq=19195@1](http://www.maxwell.lambda.ele.puc-rio.br/Busca_etds.php?strSecao=resultado&nrSeq=19195@1), [http://www.maxwell.lambda.ele.puc-rio.br/Busca\\_etds.php?strSecao=resultado&nrSeq=19395@1](http://www.maxwell.lambda.ele.puc-rio.br/Busca_etds.php?strSecao=resultado&nrSeq=19395@1) and [http://www.maxwell.lambda.ele.puc-rio.br/Busca\\_etds.php?strSecao=resultado&nrSeq=19593@1](http://www.maxwell.lambda.ele.puc-rio.br/Busca_etds.php?strSecao=resultado&nrSeq=19593@1).
- *Objetos Educacionais em Engenharia Elétrica* (Learning Objects in Electrical Engineering) is a series that was created to make available contents that are delivered as Learning Objects (LO) [6]. The first LO was published August 2012. Currently the series has 26 LOs and three more are under development.
- *Elétrica On-line* [7] is an interface that offers a unified access to all contents related to Electrical Engineering available from the system – theses and dissertations, senior projects, articles, courseware, books, etc. It also has a set of links to other IRs that hold contents in the same area. *Elétrica On-line* is an aggregator of contents to the interface, for this reason it is dynamic and grows with the growth of the collection on the system.

The results of these actions and contents were not significant – this can be seen from the last four semesters in the time-series. This led to the search for another solution.

## IV. SIGNALS AND SYSTEMS AS A BLENDED LEARNING COURSE

**Blended Learning** is defined in [8] as: “courses that combine face-to-face classroom instruction with online learning and reduced classroom contact hours (reduced seat time)”. This definition implies in reduced seat time and but the traditional face-to-face is not completely abandoned. Blended learning is also called hybrid learning, for having both types in one solution, and b-learning.

Besides the works of Alonso, Manrique, Matínez and Viñes [2], and Hoic-Bozic, Mornar and Boticki [3] mentioning good results in the technical area, other works were published indicating good results. Torre et al [9] had a very positive experience is using b-learning in Telecommunications Engineering Course in Valladolid, Spain.

Once the results of the first actions were not as expected, the authors decided to seek an alternate solution. In the second semester of 2013, the decision to switch from traditional to blended learning was already made [10].

### A. Motivation

The main motivation to change the way S&S was taught was to decrease the percentages of unsucceses in this course.

International experiences held and published prior to the decision indicated that b-learning used in higher education in technical areas yielded good results; some are references to this work. No doubt this was one of the motivations to use b-learning in S&S.

Other reasons were based on having the students as the center of the process. Students:

- who take this course are in the area of Science & Technology – the course is mandatory in the curricula of Computer Science, Computer Engineering, Control & Automation Engineering, Electrical Engineering and Nanotechnology Engineering. At the same time students in other Engineering curricula take it as an elective/optional course. Students in these areas are familiar with and enjoy technology, so there was an expectation that they would enjoy b-learning. This will be commented later when the results of a questionnaire are presented.
- would be encouraged to study the topics before coming to the traditional class every week. Classes would be devoted to discussing the topics and solving problems.
- would be guided to participate in different activities that could be pursued with their classmates thus stimulating interaction.
- would be allowed to study in other times that were not classroom hours. PUC-Rio does not have dorms, so students live off campus and sometimes have to commute for many hours.
- would be given more freedom to study but at the same time would relate to colleagues and to faculty.

Some of the goals were achieved by most of the students as the (partial) results indicate. This will be discussed later on in this section.

### B. Structure of Course

This subsection addresses three different views of the structure. The first logical structure – the way the units of the course were defined to fulfill the syllabus. The second is the learning-teaching structure – the way different topics were presented and activities were proposed; assessment belongs to this structure. The third is the physical structure – the way the course was implemented on the system.

#### 1) Logical Structure

The course was divided in six modules, each one addressing one of the main topics of the syllabus. The modules are: (1) Introduction – Basic Concepts of Signals and Systems; (2) Finite Difference Equations; (3) Z Transforms; (4) Laplace Transforms; (5) Fourier Series; and (6) Fourier Transforms.

The modules are the classic topics of an undergraduate S&S course.

#### 2) Learning-teaching Structure

The learning-teaching structure was based on four stages.

a) *Pre-class learning*: Students used the system to be guided through the topics and all referenced materials. Three text books were suggested [11, 12, 13]; the last is available in Open Access. Class Notes, LOs, Assigned Problems, Problems to Practice, Activities, Study Guides, Practice of MATLAB®, other systems with related Open Access contents, etc were also suggested in the *Roteiro* (Course Guide – to be addressed when the Physical Structure is presented). A discussion forum was available for students to submit their questions, doubts and contributions. It was interesting that students interacted among themselves in the forum, besides interacting with the tutor and one of the authors. Three TAs were available, 2 h/week each, for students to discuss about doubts – attendance to TAs office hours will be addressed with the questionnaire results. Figure 4 shows a partial view of the *Sala Virtual* (Virtual Classroom) – different tabs link to different functions, the calendar is visible, *Cursar* (Take the Course) links to different courseware items, there are *Avisos* (Notices) on the bulletin board, the *Últimas Mensagens no Fórum* (Last Messages Posted in the Forums) and *Atividades* (Activities) are shown too.



Fig. 4. *Sala Virtual* (Virtual Classroom) – partial view.

b) *In-class learning*: The course had one 2 h traditional class per week. The classes were used to introduce each module, discuss doubts of the pre-class learning and to solve exercises. A specific set of exercises was created to cover the main topics of each module.

c) *Post-class learning*: After pre and in-class learning, students return to activities that are available from the system and can start solving the problems that are to be graded. There is one set of problems for each module. They can use the discussion forums too.

d) *Assessment*: Each course must have three grades that can be given according to different types of activities. In the b-learning S&S course the following activities were graded: (1) problems to be solved – 6 sets; (2) tests – 3 tests; and (3) discussion forums. There was one set of problems for each module. Each test was about two modules, but previous topics were included. The discussion forums were on related subjects – Applications of Signals and Systems, and Scientists who Contributed to the area. Each student could contribute to one of the forums. Grade 1 was 95% of the grade of test 1 and 5% of the average of grades of problems 1 and 2. Grade 2 was 95% of the grade of test 2 and 5% of the average of grades of problems 3 and 4. Grade 3 was 90% of the grade of test 3, 5% of the average of grades of problems 5 and 6, and 5% of the grade of the discussion forum (subjective assessment). Students who did not get a passing average were entitled to an exam on all the topics of the syllabus. All tests and the exam were traditional face-to-face tests.

#### 3) Physical Structure

In order to clearly understand the physical structure of the course, it is important to address one important characteristic of the Maxwell System.

Since it is an IR, all contents are described and included in the system regardless of their future use. So all courseware undergoes the same procedure and can be searched and retrieved through digital library functions. This allows contents to be easily shared or to have different levels of access; learning contents do not belong to courses, they are used by courses; the data base contains information on contents per course, the order, when to be available or not, etc. Some contents are in Open Access – two examples are the Interactive Books and the Learning Objects.

Even contents that are not in Open Access can be used by students if their access level is “system user”. This is an important characteristic of the system because students use courseware from previous courses as references. S&S is “very popular” as a reference, since it is used by students who are taking Electric & Electronic Circuits, Controls & Servomechanisms, Communication Systems and Electromagnetism, for example.

This flexibility has a price – it requires that all contents to be used in a course be identified and organized for students to be guided in a suitable and comprehensive way. The solution used for S&S was the *Roteiro* (Course Guide).

The Course Guide is an html file that was specially planned, designed and programmed to organize the steps of the



students when not in In-class learning. Figures 5-7 show screen shots of the *Roteiro*.



Fig. 5. Opening page of the *Roteiro*.

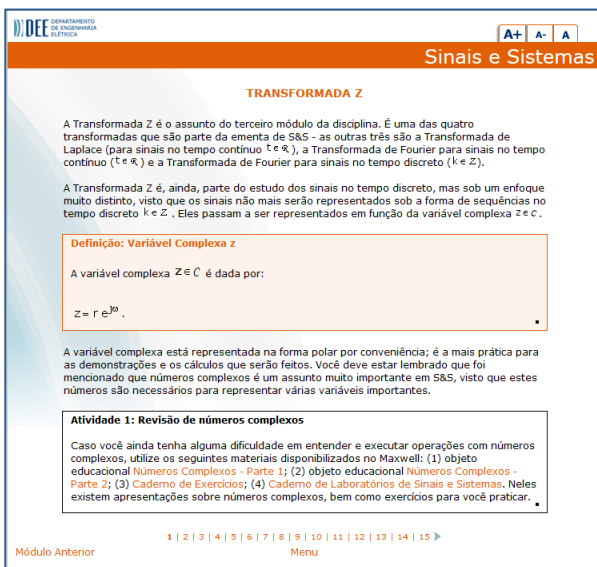


Fig. 6. Internal page of the *Roteiro*, Z Transform module, showing a definitions and an activity .

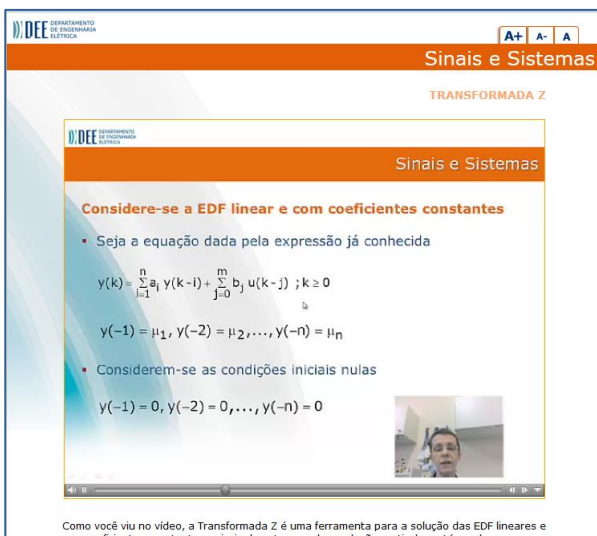


Fig. 7. Internal page of the *Roteiro*, Z Transform module, showing a video.

The *Roteiro* has the following characteristics:

- It contains all modules of the course; each one can be accessed from the opening page (figure 5) or from the previous one.
- It addresses the main topics of each module.
- It has 110 pages.
- It suggests 39 activities.
- It contains 12 videos – they are not classes but cover specific topics of the syllabus and are embedded in the *Roteiro*.
- It links to internal contents Class Notes, LOs, Assigned Problems, Problems to Practice, Activities, Study Guides, Practice of MATLAB® .
- It links to external Open Access Contents.

The *Roteiro* is important because it presents the logical order for the topics to be studied, it links to courseware that is available on the system, it suggests activities and it shows courseware in other institutions.

### C. First Run – First Term of 2014 (2014.1)

The first run of the Blended Learning S&S course happened in the first term of 2014 (2014.1). Unfortunately, the school term is not finished – all activities will be over on July 02. For this reason, some results are partial and can be modified in a week.

### a) Data Concerning Students Who Enrolled for the Course:

- Enrolled students – 54
  - Chemical Engineering – 1
  - Civil Engineering – 1
  - Computer Engineering – 20
  - Control & Automation Engineering – 11
  - Electrical Engineering – 10
  - Mathematics – 1
  - Mechanical Engineering – 3
  - Nanotechnology Engineering – 4
  - Physics – 1
  - International Exchange Students – 2

The course was mandatory for 45 students (83.33%).

- Enrolled students taking the course for the:
  - First time – 36
  - Second time – 11
  - Third time – 5
  - Fourth time – 2

For 18 (33.33%) students there had been previous unsuccessfuls; for 7 (12.96%) more than one.

*b) Data Concerning Students Performances in the Course:*

- Dropouts – 8 (14.81%)
  - Taking the course for the first time – 5
  - Second time – 1
  - Taking the course for the third time – 2

The percentage of dropouts (14.81%) is almost equal to the average number in the 10 terms (2009-2013) that is 13.26%. But it is lower than in the last two terms (23.26% and 24.07%). There is no evidence that this result will hold in the next terms.

- Passed the course – 23 (42.59%)
  - Taking the course for the first time – 18
  - Second time – 5

It is easily seen that the number of dropouts added to the ones who passed the course is 31. This means that there are 22 students who must take the final exam. Among them, there are 11 who have a high probability of passing the exam and 8 who cannot pass since they need more points than it is possible to get. For 5 there are not bets.

Thus, this is a partial result; final numbers will be available on July 02.

*c) Data Extracted from the Questionnaires:*

In the second half of the term, a questionnaire was made available from the system for students to express their opinions on the blended mode of S&S course. It did not address topics that are asked in the questionnaire that PUC-Rio gives all students to evaluate all the courses they take.

Additional information on the course will be gathered when the results of the usual questionnaire are made available. This will happen only in August, when the second term begins. These results will allow the same type of comparison presented in [9] – compare the overall course evaluation in the two situations (traditional and b-learning) using the same questionnaire.

The questionnaire was divided in four sections: (1) student profile; (2) use of courseware; (3) study habits – this section contained a special set of questions for students who were not taking the course for the first time; (4) overall evaluation of the blended learning mode – this section included a grade, suggestions and the willingness to take another b-learning course in case there was an option of the two mode. The total number of questions was 31; there were four more for students who had taken the course before.

It is important to remark that the number of students eligible to answer the questionnaire was 46, since 8 had dropped out. Some results of the most important questions are presented below.

- Number of replies – 21 (45.65%)

- Taking the course for the first time – 12 (33.33%)
- Second, third and fourth times – 9 (50.00%)

It is interesting that the percentage of students taking the course for the first time who replied is considerably lower than the one of the other group.

- Overall grade (average) – 7.95
  - Taking the course for the first time – 7.33
  - Second, third and fourth times – 8.78

It is interesting to observe that students who were taking the course for the first time seemed to like a b-learning mode less than their classmates who had taken the course in the traditional face-to-face mode. In one of the comments a student said she preferred the traditional mode to take a course for the first time and the b-learning mode for the second. Figure 8 shows the histogram of grades.

The student who graded the b-learning with a zero said he did not like courses without lectures and that sessions should not be used for discussions or problem solving, but for lectures.

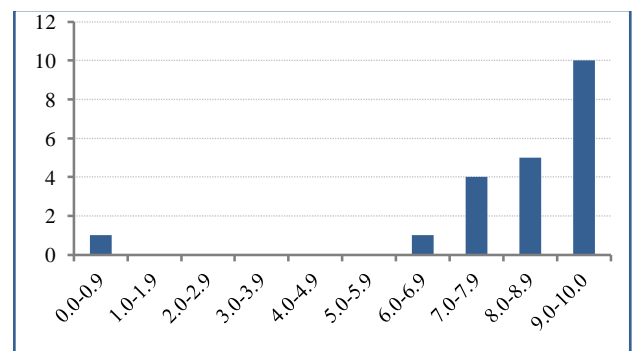


Fig. 8. Histogram of grades.

- Traditional (T) vs b-learning (b) in case the two modes were offered for other courses
  - Taking the course for the first time – T = 3 (25.00%) and b = 9 (75.00%)
  - Second, third and fourth times – T = 3 (33.33%) and b = 6 (66.67%)

There seems to be a contradiction with the overall grades – the first timers gave lower grades but the percentage of them that preferred b-learning was higher.

- Students who were taking the course for the second, third or fourth times in case the two modes were offered for S&S
  - Would choose b-learning – 8 (88.89%)
  - Would choose traditional – 1 (11.11%)
- Traditional (T) vs b-learning (b) in terms of learning more and more deeply (5 = strongly agree, 4 = agree, 3 = neither one, 2 = disagree, 1 = strongly disagree)
  - Average – 4.38

- Traditional (T) vs b-learning (b) in terms of changing study habits (5 = strongly agree, 4 = agree, 3 = neither one, 2 = disagree, 1 = strongly disagree)
  - Average – 3.71
- Rate of course materials developed for the course (1 is most used and 4 least used)
  - Class Notes – average 1.48
  - Learning Objects – average 2.43
  - Problems to Practice – 2.81
  - Practice of MATLAB® – average 3.10

Class Notes that are very similar to books were the favorite type of courseware, followed by LOs that have videos, animations, simulations, etc. The two most disliked were the ones that presented problems to solve.

- Videos embedded in the *Roteiro* (5 = strongly agree, 4 = agree, 3 = neither one, 2 = disagree, 1 = strongly disagree)
  - Watch them – average 4.57
  - They are useful – average 4.62

Chatting with students the authors received the information that “there should be more videos”, “videos are nice because you can hear the explanations”, “there should be videos showing the solution of problems”. The authors believe this perception comes from the fact that students are used to traditional lectures and videos are the closest to them in digital format.

- Interesting comments from the free text questions – the text questions were focused on commenting the materials and on suggestions to enhance the b-learning course
  - There should be more examples. (many comments)
  - The suggested activities and the problems in the traditional classes are good, but they require studying before classes.
  - The face-to-face classes should not be for problem solving but for lectures.
  - Course contents were very good and the choice for another b-learning course would rely on having similar quality contents for the other course.
  - Answers and/or solutions for the Problems to Practice are important. (almost unanimous)
  - The *Roteiro* with its links helps organize the studying. But there should be a huge pdf file with all textual materials.
  - The instructor should teach problem solving.

- The activities are very good but students are not used to study before classes, so some problem solving is missed.
- The course offers abundant and rich contents, but some videos showing the solutions of problems would be nice to have.

The comments seem to indicate that students are facing a change in the way they learn. Instead of having explanatory lectures they are offered many types of courseware so they can study by themselves. Classes are for problem solving (they solve proposed problems and the instructor replies their questions) and for discussions. This is quite a change of paradigm.

In the chatting, another important point mentioned by some students was that when more b-learning courses are made available students will get used to studying before face-to-face sessions and enjoy discussions and problem solving.

For all students S&S was the first experience with b-learning. Another b-learning course was offered in 2014.1, but students who took it had already passed S&S (pre-requisite).

One of the questions in the questionnaire addressed the availability of TAs – all students who replied the questionnaire said that having TAs is very important and replied that this was to be maintained in the next semesters. The TAs took notes on the numbers of students who attended the sessions – the average number was 1.18.

## V. COMMENTS AND NEXT STEPS

This was the first time that S&S was taught in the b-learning mode. The overall reaction of students was quite good. The use of the system function that shows who is accessing what and at what time revealed a lot of activity.

All comments and suggestions were positive – they were meant to help enhance the course. Many of them are under implementation. A student suggested a FAQ on the main topics of the course and he will create it. Some students suggested new functions to be added to the Maxwell System – one has already been implemented. A group of students is reviewing the *Livro Interativo de Sinais e Sistemas* (Interactive Book on Signals and Systems) to correct some mistakes and also to assign a level of difficulty to the problems. This is a functionality the Maxwell System yields but the levels had never been assigned; there are three possible levels. Having students involved with courseware is a nice by product of this mode of offering the course.

The authors expect that the use of b-learning will start changing the way students study.

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## REFERENCES

- [1] C. L. Borgman et al., “Fostering Learning in the Networked World: The Cyberlearning Opportunity and Challenge”, Report of the NSF Task Force on Cyberlearning, USA, June 2008. Available <http://www.nsf.gov/pubs/2008/nsf08204/nsf08204.pdf>.

- [2] F. Alonso, D. Manrique, L. Martínez and J. M. Viñes, "How Blended Learning Reduces Underachievement in Higher Education: an Experience in Teaching Computer Science", *IEEE Transactions in Education*, vol. 54, no. 3, 2011, pp. 471-478. Available <http://dx.doi.org/10.1109/TE.2010.2083665>.
- [3] N. Hoic-Bozic, V. Mornar and I. Boticki, "A Blended Learning Approach to Course Design and Implementation", *IEEE Transactions in Education*, vol. 52, issue 1, February 2009, <http://dx.doi.org/10.1109/TE.2007.914945>.
- [4] C. Lynch, "Institutional Repositories: essential infrastructure for scholarship in the digital age", *ARL Bimonthly Report*, 226, 2003, available from <http://www.arl.org/resources/pubs/br/br226/>.
- [5] M. Alsubaie, "Reusable Objects: Learning Object Creation Lifecycle", *Proceedings of the Second International Conference on Development of eSystems Engineering*, <http://dx.doi.org/10.1109/DeSE.2009.63>.
- [6] IEEE LTSC – IEEE Standard for Learning Object Metadata. 1484.12.1-2002. Available <http://ltsc.ieee.org/wg12/index.html>.
- [7] A. M. B. Pavani and G. P. Temporão, "Elétrica On-line", *Proceedings of the exp.at'13 – Experiment@ International Conference*, Portugal, September 2013, pp 168-169. Available <http://dx.doi.org/10.1109/ExpAt.2013.6703057>.
- [8] C. D. Dziuban, J. L. Hartman and P. D. Moskal, "Blended Learning". *EDUCAUSE Center for Applied Research. Research Bulletin*, vol. 2004, issue 7, United States, 2004. Available <http://net.educause.edu/ir/library/pdf/erb0407.pdf>.
- [9] I. Torre et al., "Blended Learning (b-learning) in Telecommunications Engineering – a Study Case". *Proceedings of FINDTI 2011 – Promotion and Innovation with New Technologies in Engineering Education*, Spain, May 2011, pp 1-3. Available <http://dx.doi.org/10.1109/FINTDI.2011.5936415>.
- [10] A. M. B. Pavani, "CMaps, Learning Objects and a Blended Learning Signals & Systems Course", *International Journal of Engineering Pedagogy*, Vol. 4, Num. 5, 2014, pp 5-11. Available <http://online-journals.org/index.php/i-jep/article/view/3533> and <http://dx.doi.org/10.3991/ijep.v4i5.3533>.
- [11] A. V. Oppenheim and A. S. Willsky, with H. Nawab, *Signals and Systems*, 2<sup>nd</sup> ed., Prentice-Hall, 1997.
- [12] S. Haykin and B. Van Veen, *Signals and Systems*, Wiley, 1999.
- [13] R. Baraniuk (editor), *Signals and Systems, Connexions*, Rice University, 2013. Available <http://cnx.org/content/col10064/1.14/pdf>.