Electronic Simulations within a Polymorph Pedagogical Canvas for On-line Education

S. Rouvrais, J-M. Gilliot , G. Graton and D. Degrugillier,

Ecole Nationale Supérieure des Télécommunications de Bretagne,
Technopôle Brest-Iroise, CS 83828, BREST Cedex 3, FRANCE
e-mails: dominique.degrugillier@enst-bretagne.fr, siegfried.rouvrais@enst-bretagne.fr

Abstract— *Information and Communication Technologies (ICT) can be used in order to induce student-engineers to initiate an active and constructive learning process for the electronic discipline in distant learning. To achieve this, the ICT model must include a systematic usage of really interactive simulations. These simulations improve students' attention, develop their know-how, autonomy and competences. However, in order to have a real pedagogical impact, simulations must be integrated into a global pedagogical canvas. In this article are exposed two electronic lessons: analogue-digital conversion and polarization of amplifier.*

Index Terms— **simulations, electronic circuits, polarization amplifier, analogue/digital conversion, on-line education, know-how, distant training.**

I. Introduction

The engineer profession relies on disciplines which are in constant evolution. From now on, higher engineering education (e.g. B.Sc. or M.Sc. levels), whether in class or distant, shall be borne increasingly by the learner [3] (socio-constructivist approach more and more predominant). We believe that engineer schools should insist on transmitting to their students know-how and competences which are required in the engineer profession rather than only theoretical engineer-related knowledge (i.e. traditional instructivist paradigms). We also consider that an active participation of the students in their learning process is requested [8]. In this context, we wondered how we could use ICT (i.e., Information and Communication Technologies) in order to induce the student-learner to initiate an active and constructive learning process for the electronic discipline in distant learning.

To achieve this and especially to maintain, and even reinforce, the initial motivation of the distant learner, we determined that our ICT model had to include a systematic usage of really interactive simulations. We also concluded that our ICT model had to be build as a global pedagogical canvas, dedicating a large place to know-how and competences [5] (e.g., professional expertise, agility, know-how to do).

This article is structured as follows: in section II, we will discuss the advantages of using real interactive simulations for electronic learning. Section III will clarify our proposition for a polymorph pedagogical canvas for on-line engineering lessons, including such simulations. Section IV will give two examples of lessons we designed and developed in electronics. Finally, section V will address our ongoing investigations on the subject, followed by a conclusion in section VI.

II. Simulations: an added-value for the electronic discipline

Simulations are the founding stones of our on-line teaching model as regards the know-how necessary for engineer formations. As a general matter, the learning process is clearly improved by the use of real dynamic simulations (e.g., [7]) with the possibility for the users to change behaviors through parameters modification (e.g., variation of speed, pausing, data entries, zooming on results). In engineering curricula, such simulations include for example experimentation, demonstration of properties, validation of theoretical concepts, depiction of phenomena or examples. In connection with the ICT disciplines, we concluded that the use of interactive simulations could similarly enhance our students' knowledge and expertise, and increase their autonomy (in particular, through self-validation of their knowledge and know-how acquisition).

As of today, there are already numerous good tutorials available on the Worldwide Web (e.g., HTML pages, slides, online-books, Flash-shows). Unfortunately, as regards the learning paradigm, the purpose of these transcriptions on-line are rather to record the lesson on the Web than to build a genuine learning environment. This way, unfortunately, many projects and their related productions are too rapidly forgotten and unused. As a matter of fact, a mere on-line access to information is usually not sufficient to attract and maintain the

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attention of the learner. In order to be really profitable, the access to information must be combined with an active participation of the learner [8]. This may be achieved through the use of real interactive on-line simulations.

However, in designing our ICT model, we wanted to avoid the flaws attached to the existing simulation products which are quite exotic. In practice, we were facing the following problem: on the one hand, we can surely find some simulations available through the Web, if freely accessible (e.g. see [10] for a quite good one). However, most of those simulations are often disconnected from pedagogical frameworks and objectives. On the other hand, many lessons including simulations are accessible on-line, but they are mostly based on the “Wahoo” effect, using animations in Flash or PowerPoint instead of being real interactive simulations.

Considering this, we believe that our project brings a real new contribution in the ICT domain for on-line teaching as it combines an interactivity concern with a pedagogical objective. From a practical standpoint, we have drawn a roadmap for the introduction of on-line simulations in curricula. For the time being, we have favored standard templates in order to ensure interface homogeneity among simulations [4], enhance usability both by teachers and learners and facilitate usage. Technically, this simple format also allows us to adjust to an evolution of the ICT domain. This lightweight approach aims at preparing a future integration of our electronic-oriented model into more global pedagogical materials [9].

III. A POLYMORPH CANVAS FOR ON-LINE SIMULATIONS

We strongly believe that simulations favor the learning process, as they imply active manipulation and thus increase students’ attention [1]. However, from a pedagogical standpoint, they are not sufficient per se. We had to keep in mind that these simulations should have a pedagogical objective. ICT constitute a field where usage profits are still limited. Nevertheless, today, we believe that ICT may be used in order to conceive an outstanding distant teaching project, and this must necessarily be combined with a structured pedagogical study. The conclusion of our study [5] led us to integrate simulations, as a part of the learning process, into our global pedagogical canvas. Accordingly, our on-line lessons associate real interactive simulations with exercises and classical theoretical courses for the great benefit of the curriculum. This work resulted in the definition of a polymorph pedagogical model aimed at favoring both the attention of the students and the implication of professors in the definition or production of lessons.

More precisely, our lessons are self-contained objects, supporting composition with other lessons. Every simulations are integrated in lessons composed of reminders, self-assessment exercises, glossary and feedbacks. The glossary is sometimes plugged with our *DocTelecom* database previously developed in the institution [2]. The exercises and problems we use in our simulations include an assistance aiming at conducting, dynamically, the learner to answers.

Each pedagogical objective of our lessons (lesson reminders, really interactive simulations, FAQ, exercises, training and formative/sommative evaluations, etc.) may change, very simply, in accordance with the technologies we choose to use. Our approach simply favors a pedagogical polymorphism which may, by nature, satisfy the professors concerned in the specification of the lessons or courses.

IV. TWO EXAMPLES OF ELECTRONIC LESSONS FOR STUDENT DISTANT TRAINING

Our institution developed several software which may be used for on-line courses. We present in this section two examples of lessons (i.e. parts of a course) which were tailored for the electronic discipline. From a technical standpoint, simulations are based on standard templates and implemented mostly as Java applets. As mentioned above, the template ensures a standard look and feel for purposes of interface homogeneity between several simulations. The use of applet facilitates distant use and help teachers to make design choices when proposing simulations as support for examples and exercises within lessons.

A. Analogue-digital conversion on-line lesson

This simulation, integrated into an active learning project, is dedicated to improving the students’ understanding of a specific difficult key presented during a classical course. It clearly identifies the different steps involved in the analogue-digital conversion and the digital-analog conversion of a sine signal (cf. Figure 1).

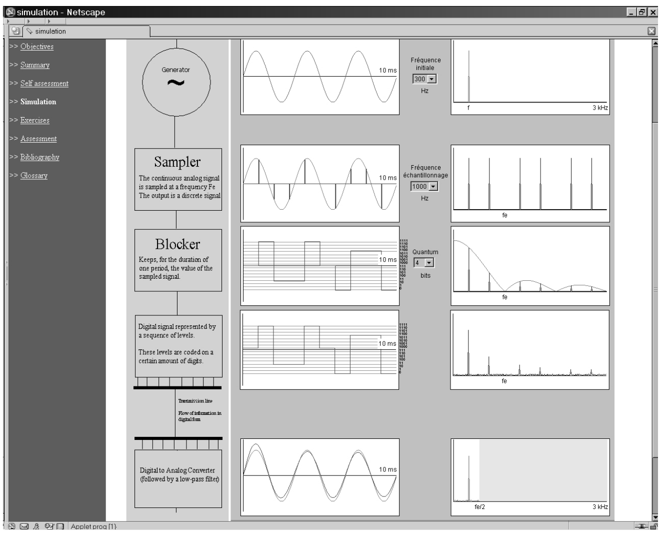

Fig. 1: Part of the analogue-digital converter on-line lesson.

In a digital signal processing system, the signal to be transmitted is usually an analog signal. On the receiving end, it must be reconstructed with almost identical characteristics. The analog to digital and digital to analog conversions must comply with certain rules. The simulator used in the lesson describes them graphically. The frequency of the signal, noted "*f*", as well as the sampling frequency, "*Fs*", and the number of quantifying bits can be determined by the user.

The simulator displays the signal at each step of the digital communication chain in the time domain and spectrum: the analog input signal, the sampled signal, the hold signal, the reconstructed signal and finally the output signal at the end of the smoothing filter. The simulation emphasizes the influence of two conversion parameters:

1. the ratio Fs/f: if the Shannon theorem is not respected, that is to say $Fs/f > 2$, we observe that it is not possible, on the receiving end, to obtain the frequency f, since the smoothing filter (low-pass) has a cutoff frequency of $Fs/2$. We also note that, in this case, it is possible to obtain a sine wave with a frequency of $Fs\text{-}f < f$.
2. the number n of quantifying bits: if n is too small, the signal is altered at the receiving end. This translates into an unacceptable increase of the noise level.

The simulator is currently limited to the conversion of sine waves. Further developments are being considered:

- simulations of periodic signals;
- simulations of random signals with a continuous spectrum such as the voice signal. This will show the need for a filter, called anti-aliasing filter, at the input of the digital signal processing system. Its cutoff frequency should be made variable. It is then worth showing the difference between the emitted and the reconstructed signals.

Some improvements for the amplifier simulator can also be examined. We can propose another type of transistor (MOSFET – JFET). We can also analyze this circuit in the microwave frequency domain with transmission lines and specific bias circuit. The result area will then be a Smith chart and/or the scattering parameters *S11* and *S12*.

Another circuit can be simulated such as an emitter or source coupled pair, an output stage, a transistor current sources or an active load. The command "*Simulate*" allows it.

From a pedagogical standpoint, this simulation allows the user to quickly grasp the principles of a signal digitalization and its reconstruction. If the user wishes to deepen his/her knowledge on the matter, a course as well as exercises are available.

B. Polarization of amplifier on-line lesson

This pedagogical simulation tool is also specific. It describes the behavior of a simple analog function (i.e. a common-emitter amplifier [6]). Although it is not an actual SPICE-like electrical simulator, it allows to visualize the effect on the circuit of a particular set of component values. So, it is more oriented toward pedagogy by shedding light on the modifiability aspects of electronic components and their implications on final behaviors of the common emitter amplifier.

Learners handle this tool, a Java applet integrated in a lesson, by means of a graphic interface (see Fig. 2) which is constituted of three main areas and two commands (Simulator and Graphics). The first area is used to specify the component values. In this area, the five resistors', the load's and the generator's values are selected by the user. The learner can choose for each resistor, except *Re1*, one value among three and for the generator one value among five. *Re1* takes two values (either *0* or *200*Ω). The capacitor *Ce* can also be chosen among three values). The second area is dedicated to the results of the simulator. These results depend on the command "*Graphics*" which displays DC or dynamic (transient and AC) simulation outputs. The third area consists in a textual help linking theory (relations and equations) and the graphic outputs. The text is modified by a roll over with the mouse of the learner's computer. It explains, dynamically, the role of the devices and their relation to the results.

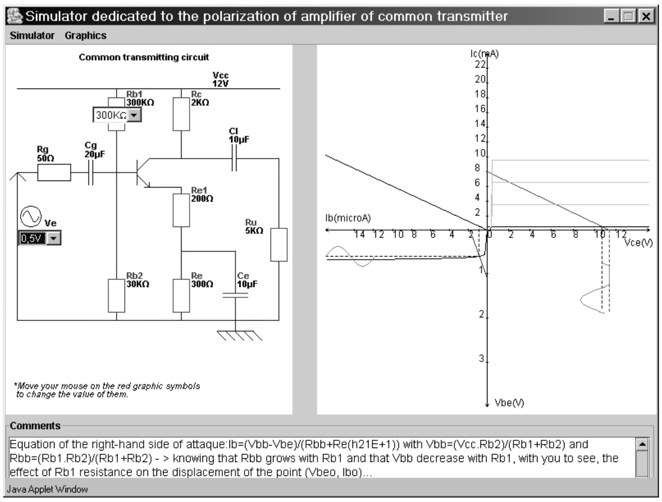

Fig. 2: Common emitter amplifier simulator.

This tool, within its lesson, is used as a complement for traditional courses. When the learner modifies a value (either of a resistance or of the amplitude of a signal), the pedagogical simulator displays in the graphic area, the DC and AC load lines, the bias point and the transient input and output signals. All these results are displayed in the bipolar transistor characteristics network. Therefore, the learner can better understand the effect on the circuit of his/her chosen set of component values. If any problem arises, the textual area assists the learner by confirming these results with equations and their relationships. The learning time of the lesson is close to 45 minutes, which is our standard time for the canvas. The simulator is at the base of exercises and self-assessments, usable in other lessons to construct by aggregation a whole course.

V. Perspectives

Our simulation-based lessons are already used as self-support to standard courses in classrooms of our institution. Hence, the student is not completely left alone. Still, this use of simulations already gives us useful information which we analyze with a view to further improvements of the fully-distant learning process. In addition, it is of great help in connection with more traditional teaching methods as it offers a different style of learning and increases the involvement of the teachers in new pedagogical paradigms. Within one year, our lessons (i.e. electronics and other disciplines from the ICT domain), prepared for composition, will be available for their integration in class courses, whether on site or distant. The next step will be the systematic use of those simulation-based lessons for purposes of distant learning programs and continuing education engineering curricula.

As regards the socio-constructivist pedagogical components of our lessons, e-learning platforms are under consideration for combined in class/distant pedagogical models. Within two years, we will be able to use such platforms for real on-line tutoring with co-learners. At that stage, our lessons will be used as a support for on-line active pedagogy [8] and on-line problem-based learning.

VI. Conclusion

Too often, despite the development of promising technologic tools, the integration of on-line resources in courses has minimum impact with respect to training and learning know-how. Particularly in engineering studies, constant interactions between theory and practical skills (i.e., know-how and know-how to do) are necessary. Thanks to the on-line simulation-based style, learners can assign some certitude degrees to their knowledge and competence, developing as such more control and autonomy around contextualisation and concretization of learning.

More globally, in addition to lessons which are given in accordance with an expandable pedagogical canvas, our approach aims at inducing changes in the pedagogical practices and, if possible, at creating new pedagogical practices. The impact of our proposals should translate into a progressive evolution toward more active, participative and cooperative pedagogical forms for scientific engineering curricula.

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