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A Pedagogical Canvas for On-line Simulation-based Lessons

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Abstract: This paper focuses on the use of real interactive simulations in order to improve student's knowledge, and to increase their autonomy for know-how acquisitions in engineering curricula. Simulations favor active manipulation but are not sufficient per se. Our simulations are integrated together with exercises and contextual information in a pedagogical canvas to constitute on-line accessible lessons. Those short lessons facilitate the implication of teachers for design and integration in their classrooms, and will allow future integration into more complete curricula, including distant project-based learning.

Introduction

The Internet is now a huge repository of knowledge and information for self-learning. Although there are numerous good tutorials available on the Worldwide Web (e.g., HTML pages, slides, online-books, Flash-shows), teachers developing such kind of educational materials should keep in mind that a mere on-line access to their lessons is not sufficient to be of pedagogical interest to the learners. The Web medium contents permit learners to self-consolidate, often freely, their own knowledge, but rarely allow learners to acquire in-depth skills (e.g., like know-how and know-how-to-do) with respect to a discipline. In light of the increasing number of competing sources of information accessible through the Internet, and considering that distant traditional products do not foster an active participation of their users, teachers must find ways to attract the students' attention and retain it for a pedagogical objective. Therefore, lessons need to provide various styles of inputs, as proposed in Felder and Silverman (1988).

During their learning process, students need motivations and a contextualisation of the theoretical information associated with the discipline concerned. In order to achieve this, interactivity or non-passive documents, including animations, may be used. However, in most cases, interactivity merely consists in distractions mixing up the various pedagogical objectives and taking away the students from what is essential (cf. the "Wahoo" effect discussed in Lelouche 2002). Without discarding animations as a mean to attract students' attention, the learning process is clearly improved by the use of real dynamic simulations (e.g., as in Masters al. 2002) 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 this article, we will focus on the use of interactive simulations in connection with the ICT disciplines, in order to improve our students' knowledge and expertise, and increase their autonomy (in particular, through self-validation of their knowledge and know-how acquisition).

This paper is divided into three sections. In the first section, we will describe the context within which we carry out our educational project. In the second section, we will present the basic pedagogical features of our on-line learning strategies. In the last section, we will describe how we consolidated some simulations and developed new ones into a common template, examine our design approach in order to increase teachers' implication, and describe progress issues. Our conclusion will focus on the practical applications of our final simulation products and will address internal issues relating to future works.

Context

Our institution is a French "Grande Ecole" (i.e. graduate Engineering School equivalent to MSc engineering level) which trains numerous engineers in the field of science, information technologies and communication technologies. It is a member of a leading institution, the GET (i.e. "Groupe des Ecoles des

Telecommunications”), which is the largest French center for training engineers in telecommunications, with over 1000 graduates per year. Our institution has a clear focus on the industrial and professional world and possesses incubator units as well as start-up companies. It is already converted to the Socrates/Erasmus ECTS credit systems that very much resembles that of the North American universities.

A long time ago, our institution started producing simulation applications to be used by students during class practices. As a participant in the INVOCOM European Project (see acknowledgements section for precisions), it is now extending some complex simulations previously developed (more than 40) as a basis for a distant learning program in the field of ICT (i.e., Information and Communication Technologies). Our simulation-based lessons are thus the starting point of a concrete autonomous learning focusing on interactive exercises which are integrated into a pedagogical canvas. More generally, at the end of the INVOCOM Project, our various products will be used to meet the expectations of different target learners: vocational training (whether initial or work-linked), open or distance training, continuing education, and self training. For our purposes, the simulation products are tailored for the Telecommunication topics, but the canvas could be applicable to other scientific disciplines subject to minor adjustments. In connection with the INVOCOM Project, we have designed a coherent set of interactive on-line simulation products covering several areas of ICT such as: networks and protocols, electronics, antenna, computer science, cellular networks, electromagnetism, microwave, optics, signal processing, or telephony. These products are progressively included into regular student courses, and ultimately, comprehensive educational materials based on such simulations will be put on the Web.

Learning Strategies Adopted

Constructivist perspective

Considering that students involved in a self-learning program need more interactivity, we have followed a constructivist approach (cf. Brooks & Brooks 2002) for the use of on-line contents. Simulations favor active manipulation but are not sufficient per se. We have integrated them as a part of the learning and teaching process. Accordingly, our lessons associate real interactive simulations with exercises and classical theoretical courses for the great benefit of the curriculum. In doing so, we have increased the autonomy of our students in their learning process (and thus created a new educational opportunity for them) while complying with the educational standards of the institution (e.g., project-based and active pedagogy, classical *ex-cathedra* courses). Our simulation-based materials are clearly related to the pedagogical objectives of traditional training (e.g., capacity and competence of our future engineers). The use and analysis of the simulations experiments integrated into lessons enable students to acquire additional knowledge and skills quickly, efficiently, and autonomously.

Pedagogical issues (canvas)

Our pedagogical outline is very simply structured as a set of standard Web pages giving all the entries to the learner. A lesson, the basic self-composed element, represents approximately $\frac{3}{4}$ hours of the learning time (the theoretical part being learned separately), and generally includes an interactive simulation with one or several related exercises. Simulations are associated with contextual information concerning their pedagogical objectives, the theoretical background necessary to understand the relevant simulation, related exercises and self evaluations. The sum of all this constitutes a lesson. The learning process of an ICT discipline includes courses. Courses are composed of such lessons. The value-added of an educational institution depends on the way it organizes the composition of lessons (scenarios for curriculum permitting dynamic selection of a learning route, e.g., in Atif, & al. 2003), which are possibly to be integrated in an interdisciplinary curriculum. Simulation-based lessons are mostly organized as follows (see the left column on Fig. 1):

1. description: provides topic, keywords, pre-requisites lessons, hardware and software requirements, expert teachers contact, etc.
2. introduction: gives an overview of the lesson thematic,
3. objectives: clarify statement of lesson objectives (e.g., as in Bloom’s taxonomy),
4. summary: is composed of theoretical reminders and links to other resources, it should be light to ensure a good time balance between theory and subsequent simulations/exercises,
5. self-evaluation activity: provides rapid intermediate control tests to self-ensure the ability to understand the simulation concept; control questions are attached to the lesson and links are attached to each question in case of failure so as to give access to related documents or on-line resources,
6. simulation: is most often a dynamic interactive application available on-line,

7. exercises: are based on several cognitive styles (e.g., descriptive, analytical, reflexive) such as problem resolution or verification, quizzes, basic games; priority is given to adjustment of simulation parameters rather than to choice from predefined scenarios; exercises greatly benefit from the applets technology used,
8. assessment: proposes final tests; the test part appears necessary when a given experiment is used in self-training or if it supports a course offered by an educational institution, in order for students to identify the forces and weaknesses of their knowledge or skills after the exercises,
9. glossary, index, Web-sites links, bibliography are also used to possibly clarify or increase knowledge.

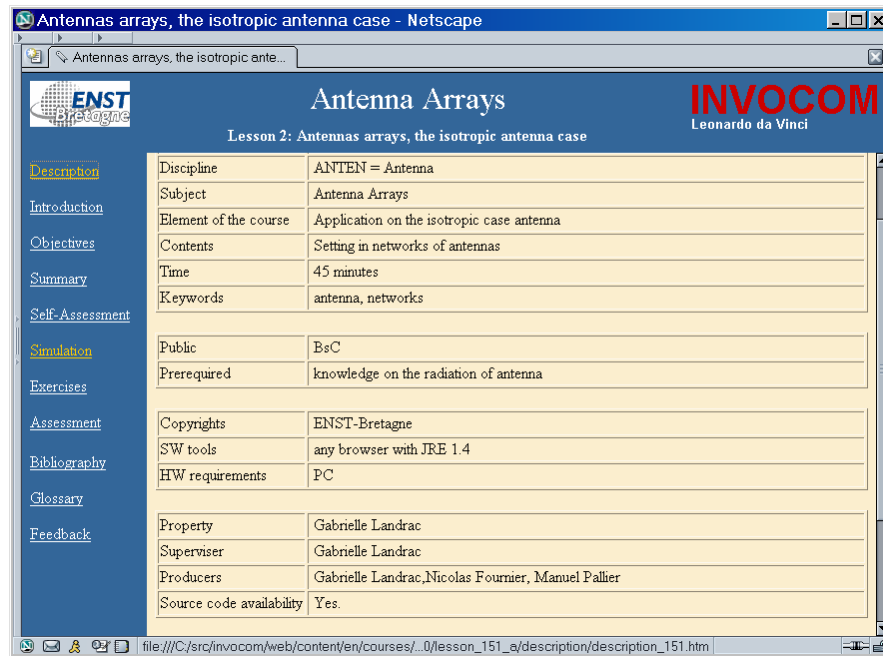


Figure 1: Template page of a lesson, description part selection.

Production of Content and Teachers Experience

We have drawn a roadmap for the introduction of on-line simulations in our curriculum. We will discuss below our experience relating to the production of content and the involvement of teachers in the design process and practical use. We will also give information on specificities due to the INVOCOM context.

Course materials and simulation template

As we focus on developing basic lessons for further integration in curricula, we have adopted a lightweight approach for content encapsulation and have centered our proposal on simulations. Accordingly, for the time being, the information presentation associated with our simulations and exercises is quite simple as regards multimedia and hypermedia actual technologies. We nevertheless concentrate on what is to be learned, thus anticipating the integration of our lessons in a more sophisticated ongoing technology (e.g., SCORM model).

From a technical standpoint (cf. Wright, & al. 1998), simulations are based on a standard template and implemented mostly as Java applets. The template ensures a standard look and feel for purposes of interface homogeneity between several simulations (see Fig. 2). 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. In addition, as INVOCOM is a European Project, we have to ensure an easy translation of all contents included in our materials. The structure of the canvas files and the systematic application of the internationalization in the Java applets source code guarantee this feature. Internally, we use an open-source development platform (i.e., <http://www.picolibre.org>) to centralize the different productions and maintain them, hence facilitating improvements.

From an operational standpoint, this project also involves the validation of educational materials (cf. Carrick-Simpson, & Armatas 2003). To this effect, e-forms are provided at the end of lessons or courses for learners' feedback, and external evaluators (i.e., industrial partners) carry out a more in depth evaluation in order to enhance presentation standards of our materials. Feedbacks are automatically processed to obtain statistics on usage and quality. The courses and simulation-based lessons are used and tested by our students, by ICT students from partner institutions, and by participants from the industry.

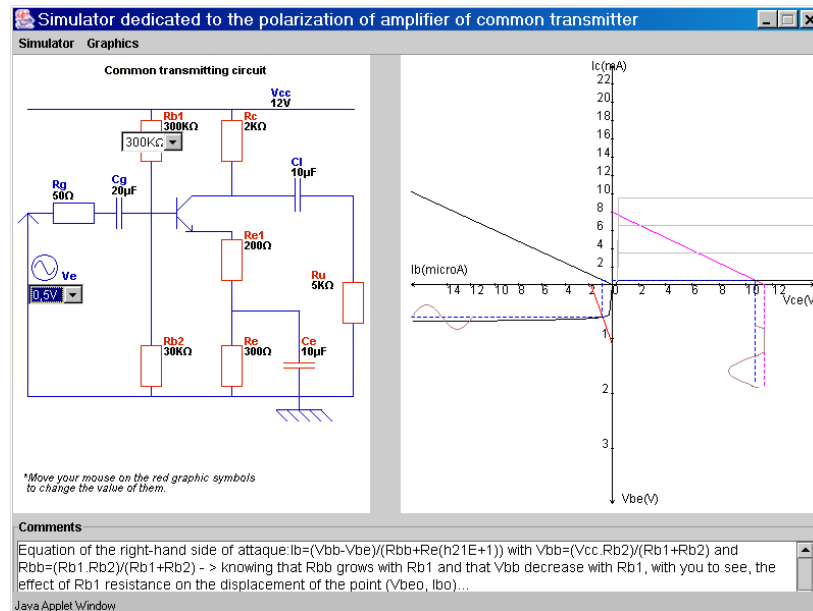


Figure 2 : Java applet example of a polarization amplifier for a lesson

Teachers' point of view

Our point concerning production issues also deals with the implication of institution teachers. For applicability purposes, the teaching members of our institution should agree on a common pedagogical canvas. We provide them with technical support and advices concerning the implementation aspects of the products, in order to help them start with online course design. In this respect, the fact that each simulation is a specific applet facilitates the involvement of teachers. The adaptation to specific needs in order to make simulations more relevant to particular pedagogical objectives is easily obtained through the programming framework. Additionally, our approach offers an easy adaptation of numerous applications existing in laboratories, as teachers in our institution have already participated in the development of many applet codes during previous students projects. Today, we can conclude that such modularity is an advantage as regards the participation of teachers.

Progress issues

Simulation-based lessons are already used as self-support to standard courses in classrooms of our institution. Hence, the student is not completely alone with all the on-line lessons. Still, this use of simulations already gives us useful information which we use with a view to further improvements of the 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 increase the involvement of the teachers in new pedagogical paradigms. The next step will be the systematic use of those simulation-based lessons for purposes of distant learning programs and continuing education curricula, as an integrated part of pedagogical materials.

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. In order to optimize the time spent learning, students should not only be attentive or passive in front of a screen, waiting for the virtual teacher to take the responsibility for providing the information as in regular courses. They should participate actively in their studies through a genuine engagement in their learning process (cf. Jonassen, & al. 2000). 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 contextualization and concretization of learning. We also hope that the presented canvas based on simulations can help teachers to build more significant active courses.

Simulations are the milestones of our on-line materials. For the moment, our interactive simulations-based lessons are only used within the institution, but they will be available on the Web at the end of the INVOCOM Project. Soon, they will be integrated in a fully constructivist pedagogical sequence based on group projects (cf. Jacques 2000 and Rouvrais, & al. 2004), as support for personal work, in order to gain the necessary skills to answer theoretical or technical questions (sometimes interdisciplinary) raised during project-based learning.

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