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# E-Learning Strategies in Academia-Industry Knowledge Exchange

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## Abstract:

*The information and communication technologies are transforming the way people learn. E-learning system not only provides new possibilities for personalized learning at home or workplace, but also reduces the requirements of the expensive classroom training and introduces new innovative forms of knowledge transferring. In this paper, we describe an e-learning platform developed during the first year of the CoMSON European project.*

## 1 Introduction

The knowledge flow from University to Industry and vice-versa needs to be strengthened to achieve and ensure a leading-edge position for companies and educational institutes. The integration into web of the learning and training materials for microelectronics skills is an ideal approach for professional training which requires the use of adequate learning contents, and appropriate e-learning environments. According to the educational and industrial needs, these environments are designed in order to integrate different systems which improve the student skills in this specific field.

In recent years, new applications and tools have been developed in order to improve the training curriculum in the microelectronics domain. The rapid technological progress of Internet tools has fostered the development of web-based interactive environments which include new didactic approaches [6,7,10,13]. In most cases, the goal of these systems is to create a problem-based learning which supports the student activities. These opportunities have sparked a proliferation of open-source course delivery systems, courseware delivery systems and on-line educational applications (for example ATutor, MOODLE, and so on). The courses are generally divided in several sections mixing individual distant learning and experimentations at home with remote interaction tools, which help the students to keep in contact with the teachers, and stimulate cooperation among students and team work.

In this paper we concentrate on the CoMSON case. The European project CoMSON (Coupled Multiscale Simulation and Optimization in Nanoelectronics) is a Marie Curie RTN (Research Training Networks) project, started on October 2005, which involves partners both from academia and industry, with the common task of realizing an experimental platform in software code which will be used for training young researcher in microelectronics and new employees in the microelectronics industry [1,2].

In the next section of the paper, we illustrate the learning scenario within CoMSON, based on the constructivist approach. In the third section we give a short description of the three main environments which are being developed within CoMSON, that is, the Demonstrator Platform, the Virtual Working Place, and the E-Learning Platform. In the subsequent section, we describe the interfaces between these environments. In the fifth section we present an overview of the e-learning architecture, which will be implemented by means of the above interfaced environments. Finally, we conclude by discussing some perspectives for future work and research.

## 2 The learning scenario within CoMSON

The European project CoMSON (Coupled Multiscale Simulation and Optimization in Nanoelectronics) is a Marie Curie RTN (Research Training Networks) project. It involves five partners from academia (Bergische Universität of Wuppertal, University of Calabria, University of Catania, Politehnica University of Bucharest, Technical University of Eindhoven) and three partners from industry (NXP, Qimonda, STMicroelectronics), with the common task of realizing a Demonstrator Platform (DP), that is, an experimental platform in software code which will be used for training young researcher in microelectronics and new employees in the microelectronics industry. Learning and training experiences will be amplified and enhanced by coupling this experimental platform with a Virtual Working Place (VWP) and an E-Learning Platform (E-LP).

In this framework, the students learn software, through the DP environment, and get familiar with concepts and problems of testing and diagnostics in the microelectronics field, interacting with teachers and other students through the VWP environment. All the activities are guided, organized and assessed within the E-Learning Platform.

Thus, the learning scenario within CoMSON consists of three different interrelated modules, as shown in Figure 1.

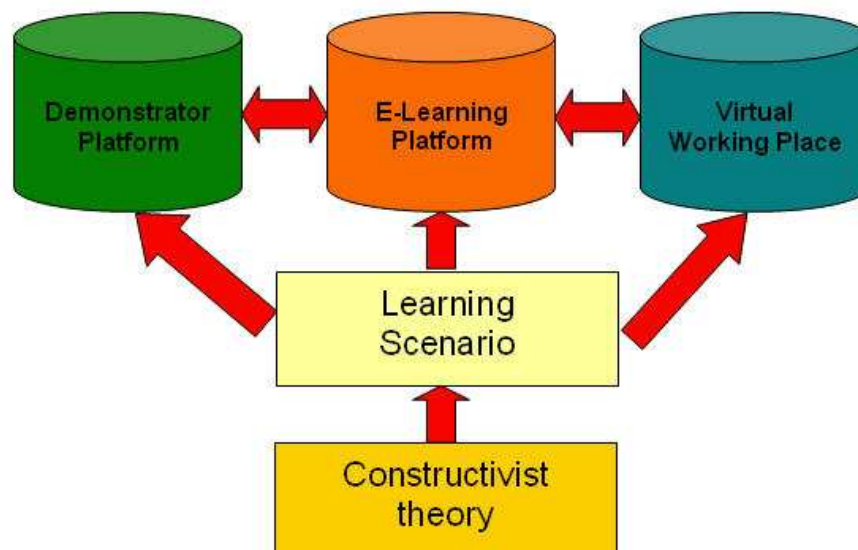


Figure 1. Overview of the e-learning system.

This learning scenario is based on the constructivist theory, which asserts that learning environments should support multiple perspectives or interpretations of reality, knowledge construction, context-rich, experience-based activities [5,12]. The constructivist paradigm guides learners to conduct and manage their personalized learning activities, and encourage collaborative and cooperative learning for critical thinking and problem solving [9]. The knowledge is constructed through interaction with the environment in which a process of

personal interpretation of the perceived world and the negotiation of meaning from multiple perspectives takes place [13].

In short, we may say that the constructivist approach asserts that people learn best when they interact with the learning material, construct new material for others, and interact with other students about the newly constructed material.

The environment through which learners can interact with the learning material is provided by the DP. The environment through which they can interact with other learners is provided by the VWP. The E-LP has the central role of unifying these experiences and guide the learners to an experience-based knowledge.

### 3 The components of CoMSON learning activities

In this section we describe briefly the three components shown in Figure 1, which are central for the learning and scientific activities within CoMSON.

#### 3.1 The Demonstrator Platform

The DP system is a remote simulator in software code, which comprises coupled simulation of devices, interconnects circuits, EM fields and thermal effects in one single framework. This system is dedicated to the development and validation of appropriate mathematical models for describing the coupling of different physical effects, their analysis (well-posedness) and related numerical schemes. The seminal idea of the DP is to provide an integrated system framework for researchers in order to study new strategies for coupling simulation tools from different physical domains. The main components of DP (see Figure 2; for more details, see [4]) are: (1) A library of test examples and experimental measurements to be used as benchmarks for any new method. (2) A set of modules consisting each of a collection of functions providing the basic functionality of the single domain simulators. (3) A control programming language which enables to connect the aforementioned functions and form simulation algorithms.

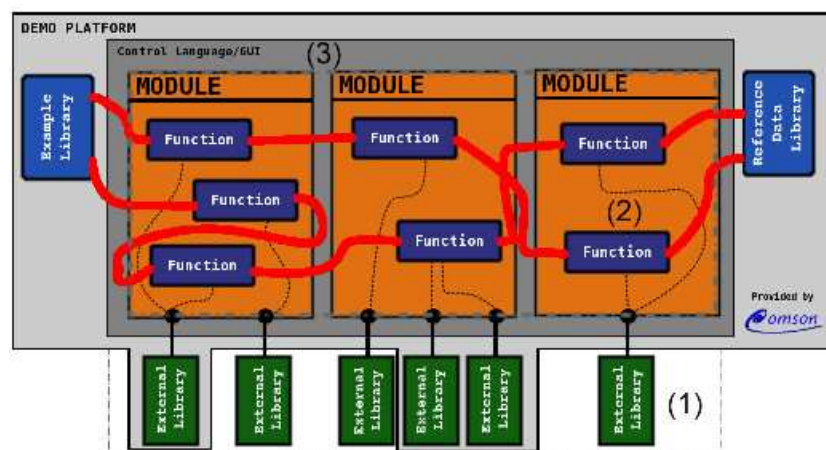


Figure 2. The Demonstrator Platform architecture [4].

From the CoMSON web server (<http://www.comson.org>), maintained at the University of Calabria, it is possible to access both to the source code of DP components which is developed in a CVS (Concurrent Versions System), and to the main development and testing system. DP provides a natural test bench with state-of-the art models and parameters from different domains rather than academic simplifications, which will prove very precious for educating and training young researchers by hands-on experience. DP architecture will be able researcher to implement, test and assess their application. “At the same time, researchers

interested in new mathematical models for the basic physical phenomena can assess their relevance for overall system behaviour taking advantage of the coupling with system level simulation tools” [4].

### **3.2 The Virtual Working Place**

The Virtual Working Place is an environment based on web technologies, which integrate different services: information and knowledge exchange, communication, collaborative and cooperative learning. Therefore, the VWP environment supports the following main functions: web-supported documentation authoring and distribution; interchange-of-knowledge; communication environment. This set of functions is intended to enable interaction and knowledge interchange between students and teachers as well as among researchers from different disciplines cooperating in developing new methodologies. Furthermore, the VWP is the place where seamless knowledge exchange processes operate between academia and industry. Its architecture, based on web technologies, has to enhance accessibility, ease of use and ease of integration with other possible platforms. In particular, the goal is to integrate different technologies within the environments of the CoMSON project, in order to improve the user interaction and the information retrieval.

Currently, the VWP has been developed as an enabler, comprising three interconnected tools: a web site and a streaming server, for Information/knowledge sharing; a forum and a mailing list system, for Communication; a CVS server, for Collaboration and Cooperation [1,2].

These tools are connected to and integrated by a Wiki environment, which is used as a central information and document repository. Collaboration and Cooperation tools assist students at a distance. They allow participants to share their ideas. They are essential for collaborative e-learning, virtual agents, and knowledge management initiatives. This category spans a wide range of tools, from simple text-based e-mail clients to complex online meeting tools.

### **3.3 The E-Learning Platform**

The CoMSON e-learning platform will be used for training new researchers in the microelectronics field. This environment will be interfaced with a standardized Learning Content Management System (LCMS) and DP remote simulator in order to provide enhanced learning experience. The core of the CoMSON e-learning platform is the E-Learning ENabler (ELEN) paradigm, that is, the set of technologies, instruments and operational processes that constitute the CoMSON e-learning platform. The current version of the e-learning system is based on a MOODLE platform. MOODLE is a free Learning Management System (LMS) that enables one to create powerful, flexible, and engaging online learning courses. MOODLE is designed to support a style of interactive learning called Social Constructionist Pedagogy, shortly discussed in the previous section.

The learning contents of the didactic modules will be provided both by CoMSON partners and by external collaborators, and are being implementing. More details will be given in Section 5. The authoring tool adheres to the Sharable Content Object Reference Model (SCORM) standard and allows the creation of standard contents that are exportable and executable on every SCORM compliant system.

## **4 Interfaces**

A lot of effort is currently being put in designing efficient interfaces between the three main CoMSON environments, with a special emphasis on visual and Graphical User Interfaces (GUI).

Most of the things that we will present in this section are concepts which are currently being studied and, is proved valuable, will be implemented in the near future. In fact, most of the CoMSON activities has so far concentrated on developing the single environments, before addressing the problem of connecting them by appropriate interfaces.

#### **4.1 Interface between E-Learning Platform and Virtual Working Place**

First, we discuss briefly the interface between the E-Learning system and the Virtual Working Place. So far, GUIs have been designed for some specific components of the VWP and E-LP, in order to:

- ease the use of such components;
- enhance user experiences and understanding within such components.

Recent researches on visual interfaces concentrate on “virtual worlds” technologies. Success metaphors are those based on everyday experience [10]. The evolution and availability of such enabling technologies suggest research and experimentation in this direction within CoMSON.

A possible unifying idea for a graphical interface between E-LP and VWP is the Virtual Campus metaphor. We are currently working on the definition and implementation of a Virtual Campus (VC), based on assistive 3D technologies. This environment provides a unified concept allowing seamless access to the VWP and e-Learning platform.

We are also investigating the possibility of creating, inside the VC, a Virtual Laboratory (VL) for supporting experimentation in micro and nanoelectronics through a 3D visual interface. The implication is that virtual interfaces should be perceived by a user as believable and natural, perhaps comrade-like, so as to have a meaningful interaction impact. Thus, the VL could provide an enhancement of the learning experience, playing an important role in the affective and cognitive characteristics of a user in a computer-based environment.

#### **4.2 Interface with the Demonstrator Platform**

Enhancing the users’ learning/training experience means also letting them contextualize their learning by practical applications that can be traced back to their everyday work experience, thus keeping the amount of abstraction brought to users as limited as possible [8,15]. For this reason, within CoMSON, and in general, we believe that interfacing the e-learning system with the application platform the users are going to deal with during their work activities, is a very effective way of bridging the common gap between experience gathered from e-learning sessions and the experience coming from hand-on activity on the job. This kind of approach implies that an application platform, such as CoMSON’s DP, should have a set of suitable interfaces to be integrated with an e-learning platform.

Designing an interface for the DP presents several problems, due to the different typologies of users. For expert users, it is more adequate a command line interface, similar to the one used by most simulation tools for industrial applications. This kind of interface may not be appropriate for non-expert user, students or young trainees, for whom a manipulatory and exploratory experimentation with the simulation platform would be more adequate. For this reason, we are studying a 3D interface, inside the VL, through which users can, in a tactile fashion, define mathematical systems that represent and model physical elements.

Furthermore, the 3D interface design allows users to create algorithms and solve such equations and, by a set of examination instruments, verify step by step how the algorithms are working and performing. Its concept design is totally based on a model using specific abstraction layers to interface heterogeneous simulation engines. This model supports both general-purpose user interfaces and application/mission specific interfaces.

An example of DP-GUI model used for the experimental simulation is shown in Figure 2 [3].

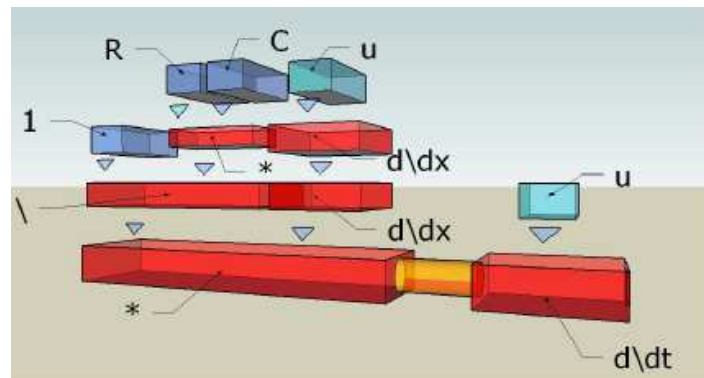


Figure 2. The partial differential equation modelling the integrated power device.

The yellow cylindrical element is used to define an equality relation between two terms. In this model, operators and functions are red, literals and constants are light blue while variables (to be calculated) are light green.

This environment would include virtual agents, interactive simulation (based on Java Applets) which allow to visualizing, with animation, and manipulating interactively, step by step, metaphoric representations of the functions, modules and coupling paradigms of DP, for a deeper understanding of them. All environments would be connected through user-friendly graphical interfaces in order to facilitate the interaction with the different levels of the system.

## 5 A general architecture of the e-learning system

In this section, we present the general architecture of the e-learning system, which results from the environments and interfaces described in the previous sections.

The general aims of the CoMSON e-learning system are:

- Fostering research in Mathematics dedicated to industrial needs
- Training to use the main simulation tools in Micro and Nanoelectronics
- Design Flow
- Planning and developing systems, processes and complex or innovative services
- Advanced modelling and simulation expert
- Designer

The architecture of the e-learning system has been designed in order to satisfy the following constraints:

- Multiplatform, independent of the host operative system.
- Graphical interface based on Java, for maximum portability.
- Standard format content management as used by microelectronics companies.
- No specific software is required to be known by the user in advance. The e-learning platform should provide for tutorials on simulation steps (process, device, circuit, EM, optimization), including related software packages as examples.

In general, no prerequisite topics are required to be known by the user, but each Learning Unit has its own prerequisites. The full list of prerequisite topics is:

- Modelling of semiconductor devices
- Introduction to electrical circuits
- Electromagnetism
- Interconnects
- Basic numerical analysis
- Numerical methods for DAEs

The contents have been split in two categories, Basic contents and Advanced contents. Each content will consist of a minimal number of Learning Units (modules). It is decided that specific nodes will provide modules on specific contents. In order to implement the Learning Units contents, the e-learning architecture is composed of four parts: (1) organization of the learning contents, (2) organization of the learning activities, (3) hands-on activities through VWP and VC environments, (4) learning assessment. In the next section, we describe the principal aspects of each of these parts.

### **5.1 Organization of the learning contents**

The content of the learning material is organized into two levels. In each level, different forms of the content are presented. The descriptions of the learning content in each level follows.

**First level:** The content is organized in Learning Units (or Module). Each module is organized in order to give appropriate, efficient learning activities, which are adequate for the learning style of each specific student. For the design of these activities, we use the constructivist learning theories. Each unit is implemented in multiple representation system, in order to stimulate the motivation of the student and satisfy different learning needs. Varieties of media elements and contents are used, such as animation, text, web page, multimedia, simulation, and so on.

**Second level:** Each module is based upon three components:

1. Organization of the course.
2. Conceptual model of the lesson. Description of the learning activities and laboratory experiences.
3. Additional resources.

Also, each CoMSON partner will receive a template, which contains a description of the lessons organization to publish through the e-learning system.

### **5.2 Organization of the learning activities**

Modern constructivist and social views of learning constitute a fruitful theoretical approach for the design an appropriate e-learning environment. These approaches emphasized the following aspects:

- a. **Create interest:** Design specific activities in order to motivate the student. Such activities reproduce practical problem.
- b. **Stimulate in the student high mental functions:** Problem-solving activities are a very important aspect, because they enable in the student analytical and synthetical thinking skills, as well as critical and reflexive thinking.
- c. **Cooperative and Collaborative environment:** These systems allow the learners to:
  - i. Construct their solution strategies and to set up a knowledge exchange flow between students.
  - j. Realize solution strategies by using different representation tools.
  - k. Have a control over their learning. The representation tools provide adequate feedback, in order to give them the opportunity to verify their solution strategies.

### **5.3 Hands-on activities through VWP and VC environments**

This part of the e-learning system is a collection of virtual environments where the learners can actively construct and experiment their knowledge by performing the specific learning



activities using a variety of tools. Also, these environments are strongly related to specific learning styles, which are different between students, for example age and cognitive abilities, or content and nature of the instructional material. Learning is a complex process that differs from subject to subject. Generally, people use a mixture of several styles and may indeed find different learning styles more appropriate to particular tasks. These environments are based on the learning-by-doing concept, which provides the student with an opportunity to do something, get a feedback, and learn from their mistakes. It places the learner at the centre, and in control of the learning experience. A successful design should focus on the construction of limited and specific tools that can successfully help the student perform the learning activities. The main objectives of these environments are to enable the learners to:

- a. Perform different solution strategies during the problem solving activities.
- b. Experiment new modalities of learning using virtual environment tools, which are based on the learning-by-doing approach.
- c. Stimulate the student to acquire hands-on ability. These tools can help learners to manipulate and explore more sophisticated data using different type of tools, such as 3D graphical object, equations, ad so forth. The integration of different tools can help learners to construct knowledge by exploring dynamic representation of the learning concepts in more depth way.

#### **5.4 Learning assessment**

From the constructivist point of view, assessment can become a valuable tool for learning. From this perspective, the emphasis of assessment is placed on each individual's learning processes and not only on her learning outcomes. In our e-learning environment we use a combination of methods, such as:

- a. Self-assessment.
- b. Self-assessment by answering multiple choice questions, automatically corrected by the system.
- c. Assessment by the teacher based on project work.
- d. Assessment of the student activity analyzes automatically by the system, for example use of tools, simulation, interaction with agent of the environment, and so on.

## **6 Conclusions**

Future activities will be mainly focused on research, design and implementation, with some space for ToK and dissemination. The research activities will focus on concepts elaboration and evaluation. The design activities will focus on detailing architectures, based on the concepts emerging from the research, involving from time to time the other partners in CoMSON, based on their interest and expected impacts. The implementation activities will be aimed at producing working prototypes and demonstrators.

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