Collaborative research and eLearning platform for a distributed microelectronics project

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Abstract: - The CoMSON project is a distributed European research project that combines research efforts from both academia and industry. This project is distributed among eight institutions across Europe. The aim of this project is to implement an experimental simulation platform (in software code) for devices in micro and nano-electronics with an integrated eLearning system. This project has two main goals. First, to train graduate students and post-docs in mathematical modeling, through the creation of this simulation platform, and second the delivery of this simulation platform to be used as a training tool for new recruits. In this paper we describe the information system architecture created to provide the partners with a strong collaborative and development research environment. This architecture provides a framework with three main goals: information sharing, collaboration in research and, training. This scheme easily allows users to access, update and interact with information and with other researchers within all the stages of the project.

Key-Words: - Microelectronics, Nano-electronics, eLearning system, Constructivism, Information system architecture, Higher education.

1 Introduction

The European project CoMSON (Coupled Multiscale Simulation and Optimization in Nanoelectronics) is a Marie Curie RTN (Research Training Network) project. It involves five partners from academia (Bergische Universität of Wuppertal, Politehnica University of Bucharest, Technical University of Eindhoven, University of Calabria, University of Catania) and three partners from industry (NXP, Qimonda AG, STMicroelectronics). The main goal of CoMSON is to implement a simulation software platform Demostrator Platform (DP) and with an integrated eLearning platform, that will connect each individual achievement, and will offer an adequate simulation tool for optimization in a compound design space [1].

The simulation software platform comprises coupled simulation of devices, interconnects, circuits, EM fields and thermal effects in one single framework. To create this platform implies the development and validation of appropriate mathematical models to describe the coupling of different physical effects, their analysis (well-posedness) and related numerical schemes [2, 3].

This DP does not aim at replacing existing industrial or commercial codes, but will be used for training young researchers in microelectronics in academia and industry. Using this framework, the students learn to develop software, through developing the DP environment, and get familiar with concepts and problems of testing and diagnostics in the microelectronics field. When the DP is finished it will be used with the integrated eLearning system to train new personnel.

Another benefit of DP is to collect the knowledge about models and methods, which is widespread distributed over the different nodes of this network, thus giving excellent opportunities for transfer of knowledge and mutual stimulation of new research. To coordinate all efforts the CoMSON project operates a collaboration and information-sharing system. This system comprises the DP the eLearning platform and an information-sharing system.

In the next section, we review the scientific context. In section 3 we describe the method that leaded to the adoption of this scheme and section 4 describes the architecture of the collaboration and Information-Sharing Element within CoMSON. Section 5 offers a review of the innovative aspects of our platform approach and highlights the successes in use of the main capabilities. The last section provides conclusions and an overview of future work.

2 Scientific context

During the last years other European projects have been approved to develop learning environments oriented to the microelectronics field. One of these projects is "LIMA – Learning Platform in Microelectronic Applications" [4].

The aim of the LIMA project [4] was the usage of the overall web technologies in order to prepare high-quality eLearning course. The web-based training platform uses all different document typologies and organization, such as navigation and linking between eLearning modules. In addition, the platform allows to include external links and other materials in order to improve the learning concepts.

The platform allows very different means of user interaction. Finally, to stimulate the student motivation, the platform includes an integration of tools that support the scientific visualizations and simulations. For the demonstration of the mostly complex physical interrelations a hierarchy has been developed in the project, which allows for interaction levels that require different time exposures.

Another European project is E-LIMM [5], which aims are to improve and to accelerate the development specific skills in microelectronics using new training and learning course, material and schemes. This project supports the learning process by appropriate training methodology that stimulates the acquisition of different and new knowledge. The The lifelong learning process is also supported.

Exploiting the recent achievements of the ICT, a new eLearning initiation denominated Yoto project was launched in 2004 [6]. The main objective of the Yoto project was to promote and divulgate the electrical engineering science, especially the fields of power electronics and drives. The multimedia rich curriculums are usually very popular, especially in the case of the young engineers and students.

The concept of the Yoto project was settled around the following key ideas [6]:

- "To popularize the electrical engineering sciences.
- To promote the high quality academic education of the electrical engineering field.
- To support the regular vocational trainings of the companies for the qualified engineers.
- To increase the flexibility of the education regarding the time and the location.
- To mitigate the geographical and regional inequalities by making accessible up-to-date research and development results.
- To support the education of handicapped students".

A more detailed description of the framework can be found in [7].

WebLab is an on-line microelectronics laboratory based on web technologies [8, 9, 10]. The main aspect of this laboratory is the development of a new graphical user interface that characterizes the on-line learning in microelectronics. In particular, WebLab allows to characterize the transistors and other microelectronic devices in real time through the Internet [8, 9, 10]. The graphical interface for WebLab consists of a Java applet which duplicates the essential functionality of the analyzer's console, allowing the user to configure a measurement the devices that is connected with the system.

When the user is ready to execute a measurement, the applet sends the measurement specifications to the server. Through WebLab, students can take current-voltage measurements on transistors and other microelectronics devices in real time from anywhere and at any time. The basic architecture of the system and its use in a variety of educational settings was reported in [11]. A prototype collaboration system for WebLab was described in [10].

Based on WebLab experience and in particular with the Microelectronics applications, the next generation of remote laboratory is iLab project [12]. "iLab Shared Architecture (ISA) is a Web service infrastructure that has been developed at the Massachusetts Institute of Technology (MIT) to provide a unifying software framework that can support access to a wide variety of online laboratories" [12].

3 Scientific and technological objective of the CoMSON project

The microelectronics industry is a highly innovative sector of research and development in which knowledge is in continuous development. Students, researchers engineers and mathematicians that work in these fields have the need to improve, transfer and distribute the necessary know-how to contribute to the development of new and improved systems.

The CoMSON project brings researcher from academia and industry together for the development of a common goal the transfer of knowledge (Fig 1).

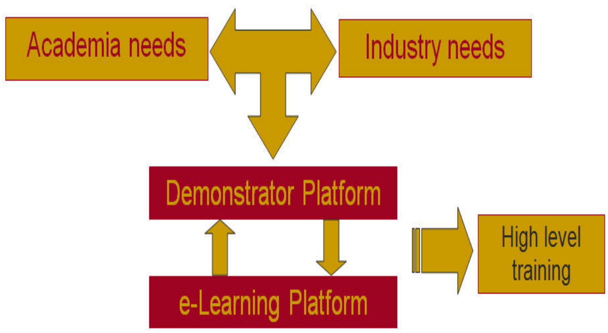

Fig. 1. The CoMSON project [3].

On one side through the diffusion of the research results, and on the other side through the creation of foundations of knowledge for students and future researchers. "The knowledge flow from researchers and universities to industry and vice-versa needs to be strengthened to achieve and ensure a leading-edge position for companies and educational institutes" [3].

The need for this work derives also from the fact that the knowledge in the electronics technology industry is in constant development. It is then necessary to update the course of study with new contents and methods in order to provide student with the appropriate courses and tools for study. This process of update is immediate if the organization of didactical contents is supported by the ICT [3, 6, 7, 13, 14, 15] and by the possibility of using advanced instruments used in real life in the sector.

De facto, the design of complex integrated circuits requires adequate optimization and simulation methods. The current design approach involves optimizations and simulations in different physical domains (electric, electromagnetic, thermal, circuit, and device). To limit the complexity of the design task, these domains are currently treated in isolation (divide and conquer approach), and dedicated simulation and optimization tools have been developed for the individual domains.

However, this design approach is nearing the limits of its validity. The design and realization of modern integrated circuits requires that the different domains are treated with their mutual dependencies as well. Performing the step from micro - to nano-electronics, high levels of integration of the different physical effects are needed.

Based on these theoretical and practical aspects, the main scientific and technological objectives of the CoMSON project are:

- To develop new descriptive models that takes these mutual dependencies into account.
- To combine these models with existing circuit descriptions in new simulation strategies.
- To develop new optimization techniques that will allow for new designs.

The interdisciplinary content of the CoMSON network can easily be explained by use of different approaches: the task of coupled multiscale simulation in nano-electronics has to combine the expertise of applied mathematics/numerical analysis and computer science (multiscale simulation) with physical modeling experts (coupled) and electrical engineers (nano-electronics).

The CoMSON network implies strengthening existing cooperation between industry and specialized university groups, as well as strengthening the cooperation of university groups working on the different aspects [13]. A new aspect is the tight cooperation between the semiconductor companies within Europe, as each of them has its own special expertise rather than the complete range.

The inter-sectorial dimension of this project is stressed by the participation of the three main European semiconductor companies working closely with specialized university groups to develop a DP.

4 Information system architecture

In order to design the CoMSON platform we analyzed the project needs placing a strong emphasis in the user during the project and after the completion of the project. The design of the platform is based on the analysis carried out using a questionnaire. The aim of this questionnaire was to gather information about the general architecture of the platform (DP, eLearning platform and information system). According to Human-Computer Interaction methodology [16, 17], we collected this information in order to design a system able to satisfy the request both researchers that will work within of project and students that will use this platform for training.

The questionnaire was composed of two sections. The first section analyzed the needs for the learning and training system. The second section analyzes the general architecture of the information system. The questionnaire was sent to the group leaders in the different nodes of the consortium. The reason for this choice was that the group leader was the best candidate to make an informed decision about the needs of the final users. After the analysis of the questionnaire results, the results were presented to the project management board with a proposal for the design and implementation of the CoMSON information and collaboration platform.

According to the users' opinions, the proposed system should conform to the following set of requirements:

- To be easy to use.
- To offer user-friendly help.
- To easily integrate existing digital materials.
- To support audio communication.
- To give the lecturer the capability to administer her/his own courses and to monitor the learners' progress and participation.
- To support multi-modal interaction between the users through visual communication, and real-time display of users' activities.

- To support application to share documents.
- To offer an interactive and shared whiteboard.
- To integrate eLearning environment with other system e.g. DP, Virtual Campus and Virtual Working Place.

In short, users want an eLearning system that can support three types of training: synchronous training (on-line lectures from a trainer on a specific theme), asynchronous training (autonomous training using educational material and notes from previous lectures or minutes from collaboration), and collaborative training (on- line communication and collaboration between the members of a user group on a specific theme).

The system is based on HP IA32 dual processor Xeon 32bit 2 Ghz frequency. The server has 15 GB of memory and two hard disk SATA architecture. The Operative System installed is Linux Slackware and after we install VMWare server and Openssh software. The Host Operative System manages, monitors the guest system, and allows to create new users. The Host Operative System contains the following guest system:

a) CoMSON Guest OS is a primary server. On this server run web service, eLearning system and mailing list system.
b) Kepler Guest OS is used to manage the CVS (Current Version System) service.
c) Copernicus Guest OS is used to compile source file stored inside Kepler server.

In order to synchronize the time between guest servers we install the Internet Systems Consortium - ISC- NTP Network Time Protocol server.

A schematic representation of the system architecture is shown in Fig. 2.

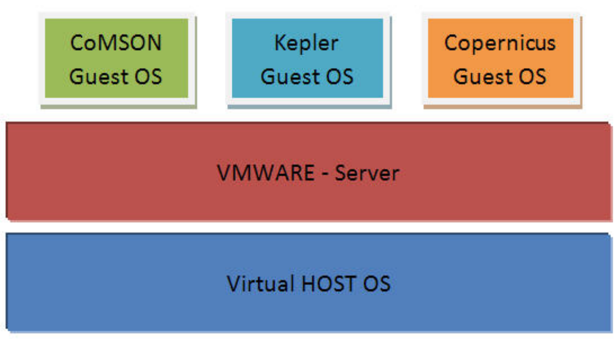

Fig. 2. CoMSON system architecture.

Finally, we divide the platform in three main elements that are interconnected. The elements are the information sharing element, the DP and the eLearning.

4.1 Information-Sharing Element (ISE)

The Information-Sharing Element (ISE) of the CoMSON platform provides three main macro functionalities: web-supported documentation authoring and distribution, exchange of knowledge and communication environment. This set of functions is intended to enable interaction and knowledge exchange during the duration of the project and after its completion. This set of tools provides a channel for communication between students and instructors as well as among researchers. Eventually this group will be enlarged including different academic and corporate institutions, cooperating on research or developing new methodologies. Furthermore, the ISE of the platform is the place where seamless knowledge exchange processes operate between academia and industry.

Its architecture, based on web technologies, enhances accessibility, ease of use and ease of integration with the other elements of the system [18]. The ISE has been developed as an enabler for the above functions, comprising a set of interconnected tools. These tools are: web services including streaming server for content distribution; a forum and a mailing list system, for communication; and a documentation environment, which is used as a central information and document repository [18, 19, 20, 21].

We used Plone [22] Content Management System (CMS) to implement the ISE of the CoMSON project. Plone is an open source CMS built on Zope [23] application server. “Zope includes an Internet server, a transactional object database, a search engine, a web page templating system, a through the web development and management tool, and comprehensive extension support”. Plone already has a large user base and multitude of developers, usability experts, translators, technical writers, and graphic designers who are able to work on Plone [22].

An important aspect of Plone is the workflow component (Fig. 3). Workflow is collaborative and cooperative systems that allow the management of the documents. Each object can be assume different states. The objects state define whether an object can be accessible by others users. The Plone workflow includes four states: visible, pending, public, and private (Fig. 3).

Another important aspect is that Plone [22] is easy for end users. The Plone team includes usability experts who have made Plone easy and attractive for content managers to add, and maintain content. Plone interface is easy and intuitive. Several mailing lists provide a channel to exchange information between participants.

The mailing lists, facilitates the communication among the researchers of the project that work to develop both of the DP and eLearning platform [2].

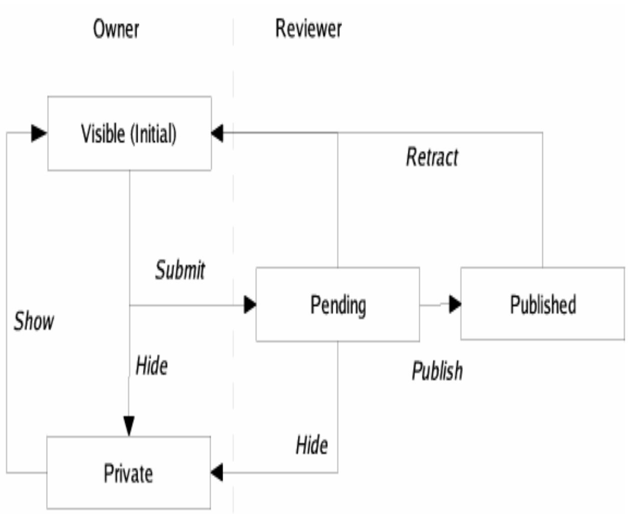

Fig. 3. The default workflow for content that comes with Plone.

Another objective of the mailing lists is to share information about the general and more administrative aspects of the project.

4.2 Experimental Server DP

The experimental platform is the core of the CoMSON project. This platform hosts the collaborative work for the main objective of the CoMSON project the implementation of the experimental DP. This software code platform is used to develop and validate mathematical models to describe the coupling of different physical effects, their analysis (well-posedness) and related numerical schemes [1]. The main components of the DP (Fig. 4) [1] 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 (Octave, is a high-level language, primarily intended for numerical computations), which enables to connect the aforementioned functions and form simulation algorithms.

The DP is organized as a repository of code. The history of changes in files is synchronized to allow changes made by different users that work on the same project. This synchronization has been implemented using the Concurrent Versions System (CVS), which allows users to work on the same DP files simultaneously. Each user can edit the DP files within his copy of a repository, and later report the change to the central database server.

The principal function of this server is to store the DP applications files, in order to collaborate at the realization of the experimental platform, and the documentation about the platform.

The DP is available as a collection of CVS modules, each containing one or more DP modules. To operate with the DP users should get an account for the CVS server.

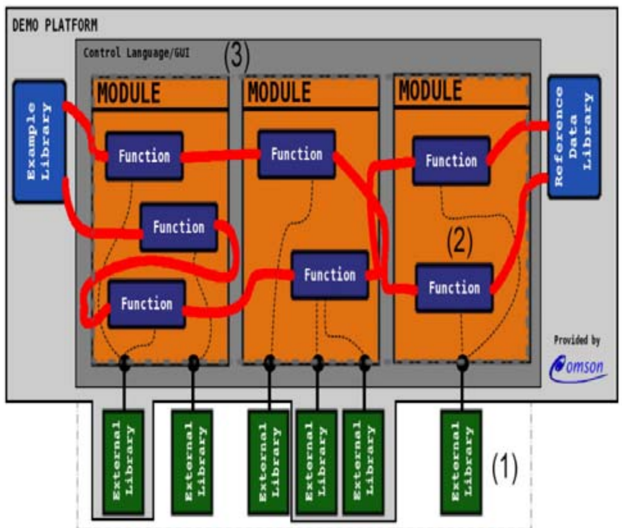

Fig. 4.The Demonstrator Platform architecture [1].

Once they have an account, the user can checkout the complete DP. After building the DP in his/her own environment, the DP can be used. All the contributions to the DP should have their corresponding description and test procedures to ensure quality and usability.

In order to avoid developing code already available outside of COMSON, the DP offers the possibility to use *external libraries*. These libraries are not part of DP but are connected to it by interfacing routines. Therefore, these external libraries are not included in the CVS repository, and they have to be downloaded and installed separately. These libraries are available in the reference machine, including instructions how to build them.

In order to distribute the DP outside of CoMSON, snapshots are created which can be downloaded from the web server. These snapshots contain all publicly available DP Modules.

4.3 eLearning platform

The third element of the collaboration system is the eLearning platform. This platform provides three kinds or learning resources [24, 25, 26, 27].

First, it is a repository for course notes, slide presentations, articles, book chapters, etc. Second, it hosts interactive courses that can be used as a stand alone learning solution or blended with face-to-face lectures or seminars. Third, a simulation platform that interfaces with the DP to create educational simulations. In order to develop this simulation platform in microelectronics field, our goal is to implement a Graphical User Interface (GUI) able to interface the knowledge in the eLearning platform with DP [29]. This interface will be implemented in Java language and will allow the users to perform tests and simulations of electronic circuits. In particular, these simulations will allow to train young researchers in mathematics applied to modern technologies both form a theoretical and a practical point of view. The aim of the eLearning platform is to create a flexible and innovative educational environment, which would actively engage students with the content in a meaningful and relevant way.

The eLearning platform includes constructivist methodologies based on a learning-by-doing approach [13]. Constructivism is a set of assumptions about learning that guide many learning theories and associated teaching methods. The active dimension of the constructivism learning is implemented by means of simulations. The simulations are presented as virtual laboratories, which allow to visualize (with animation) and to manipulate interactively, step by step, metaphoric representations of the functions, modules and coupling paradigms of DP. These characteristics give a deeper understanding of them. In our eLearning platform, learners and instructors can interact with different technologies, which support the students in the acquisition of skill on specific topics [27, 28].

The integration of different tools allows applying innovative eLearning methods and technologies. In particular, the eLearning environment foresees the development of a new generation of educational tools (e.g. 3D visualization, intelligent agents, etc.) [29]. This approach is supported by a full integration between virtual tools and remote simulation by the DP technology.

The integration into web of the learning and training materials for microelectronics skills is an new approach for professional training which requires the use of adequate contents, and appropriate eLearning environment and tools.

According to the educational and industrial needs, these environments need to be designed in order to integrate different systems and tools which improve the student skills in the microelectronics field. In recent years new applications have been developed in order to improve the training curriculum in this specific field.

ELearning contents are produced in various units of scale and scope. It is important to understand these units, because they influence the design techniques and tools used to create them. Fig. 5 show the principal components of a typical eLearning environment.

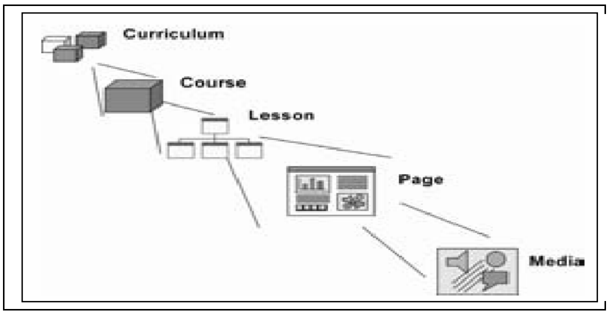

Fig. 5. Level of granularity of an eLearning system [31].

Units of learning span a range from complete curricula down to individual media components. In eLearning, the size of each of these units of learning is referred to as its level of granularity (Fig. 5). At the top, is the curriculum, which is a collection of learning products. The eLearning environment of the project CoMSON includes advanced courses on specific topics, for example mathematical model, numerical simulation, and so on.

According to Horton and Horton [30], a curriculum is composed of individual courses, books, and other learning objects. Courses are typically composed of clusters of smaller lessons; each organized to accomplish one of the major objectives of the course as a whole. At a lower level are the individual pages, each designed to accomplish a single low-level objective that answers a single question. Such units may also be called screens in multimedia presentations or topics in online Help. At the bottom level are media components. These are the pictures, texts, animations, and videos that contribute to design the page content. The learning contents and didactic modules will be provided both by CoMSON partners and by external collaborators, and are being implemented.

A complete eLearning solution requires a specific software platform to supply each of the above capabilities. The current version of the eLearning system is based on a Moodle system. Moodle is a free learning management system 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. The social constructionist approach is based on the assumption that people learn best when they interact with the learning material, construct new material for others, and interact with other students about the constructed material.

As said, the CoMSON eLearning system 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 a DP remote simulator in order to provide enhanced learning experience. The eLearning platform integrates different standards and technologies (HTML, SCORM standard, FLASH, PDF, media streaming, etc.) to allow flexibility in the definition, design, building and interconnection of learning contents. Some of these technologies will enable multiple interaction modalities to better suit the need of a heterogeneous audience, ranging from students to researchers, from institutional partners to third parties.

The eLearning platform provides contents based upon the Sharable Content Object Reference Model (SCORM) standard, which allows the creation of standard contents that are exportable and executable on every SCORM compliant system [15]. Moreover, the SCORM support is integrated with distributed technologies in order to develop a complete learning system. The distributed approach (e.g. DP architecture and Virtual Working Place - VWP) provides the capability for applications to run remotely. Intense research activity is ongoing on eLearning technologies especially focusing on accessibility, interoperability, durability, and reusability of components. Applying Web Service Technologies to a SCORM compatible LMS simplifies the implementation and maintenance of the LMS and it gives to web service consumers more choice in finding the services they require [31].

The Moodle LMS allows the management of courses, didactical modules, real-time and differed learning. Among the tools available to teachers, we find authoring tools for creating lessons and assessment tests. In addition to these standard tools, we would like to spend some words on a possible learning scenario, which might be consistent with the implemented Moodle platform.

This environment, as well as similar environments, is designed to include the principal aspects of the constructivist learning theory [32], in particular the possibilities to visualize (with animation), and to manipulate interactively, educational contents or metaphors of learning objects. The constructivist approach is based on learning-by-doing theory, which emphasizes the active role of the student in building his/her knowledge. The active dimension of learning is realized by means of virtual laboratories, which allow to visualizing (with animation) and manipulating interactively, step by step, metaphoric representations of the functions, modules and coupling paradigms for a deeper understanding of them. The learning environment foresees the development of a new generation of educational tools, for example: 3D architecture of circuits, immersive virtual environment, intelligent agents, virtual avatar, etc.).

These new educational tools, offer a computer-based approach for scientific instruction that provides a number of advantages over traditional learning methodologies. Students are stimulated by manipulating objects into simulated and real worlds that offer interactivity, authentic experiences, and a new adventure in learning [33].

The students are immersed in an authentic science learning context which is peopled by other users and virtual agents' avatars acting as tutor and guides. Constructivist approach emphasizes the role of manipulation activity, virtual agent, learn-by-doing, exploration, interactivity, and virtual tools. In this scenario, our eLearning system would be based on the hypothesis that a manipulation activity improves learning acquisition [13]. Therefore, our goal is to design and to develop an eLearning system based on experimentation activity (e.g. virtual laboratory) and the scientific method (e.g. simulation program write in Java and Java 3D language).

As each didactical context, students encounter different problem that are completed by using the tools of the environment and the scientific method to solve problems. In this way, the eLearning platform assures the maximum flexibility to the learner, whose results are assessed in terms of performance on specific tasks. Different studies have demonstrated a positive correlation between student motivation to learn and classroom integration of technology. In addition, recent researches indicate that the use of technology in the classroom no only increased student motivation, but also improved achievement [34].

The eLearning system of CoMSON, is related to other parts of the platform as is shown in Fig. 6.

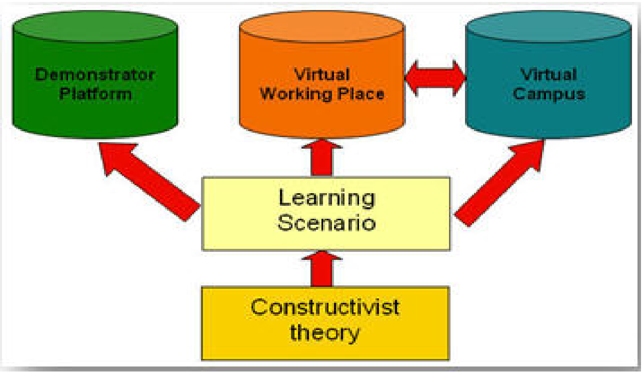

Fig. 6. Components of the CoMSON eLearning system.

5 Innovative aspects

The main idea of the CoMSON project is to develop an integrated platform that contains simulation tools in order to link industrial and academic knowledge and necessity. To achieve this objective information has to flow and interaction among members and with materials should be rich. These interactions have to observe two aspects, first the accomplishment of the objectives of the project and second the use of the final product for learning and training. This environment will help students to acquire basic and advanced knowledge and skills in the microelectronics field through production and later training [6, 7, 8]. The link between academic and industry helps students acquire creative and practical skills to apply during problem solving activities. The eLearning platform interfaced with an interactive environment composed of simulations, virtual repository, and so on, will allow to students to experiment and learn doing hands-on projects [13, 14, 15]. Learning through experimentation and practice is important for motivating students and to improve students' problem-solving abilities.

In particular, our system is based on five ways in which new technologies can be used:

1. To work on real-world problem into the virtual environment.
2. The virtual environment provides the students scaffolds and tools to enhance learning.
3. Students and instructors have more opportunities to share ideas and to collaborate using technological tools in order to work on common projects.
4. To build virtual educational communities in order to expand learning opportunities in the microelectronics field.
5. Integration between collaboration, sharing tools and simulation environments embedded into the eLearning platform.

Each of these poses an opportunity for technology integration, and successful integration increasing both technology skills and content knowledge.

From a methodological point of view, the informative system integrates a multidisciplinary approach in order to share both educational contents and tools. Academic partners and industrial companies participate to implement contents and tools to integrate within system.

The main goal of the information system architecture is to improve the integration between documents and tools for a better usage and collaboration by the consortium members and it's future as a learning tool. This integration will ease collaboration and improve learning.

6 Conclusion

On-line learning has seen explosive growth in higher education over the past decade [2, 3, 35]. CoMSON project is an important opportunity booth students and researchers that work in microelectronic field, because aims to integrate academic and industrial need, using the information and communication technology.

In this paper, we have given an overview of the informative system architecture that we have designed. We have showed the different tools of the informative system. In particular, to eLearning platform we have proposed the use constructivism approach, considering the nature of the learning processes using new technology.

Constructivist framework and technology can be used to promote relationship among theory, practice, and technological skill. However, this system needs a thorough analysis in order to evaluate if informative system support the eLearning platform. In order to verify it, we have design some experimentation with university students [36].

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