Integrated Environment for Active and Collaborative e-Learning in Micro- and Bio- Electronics

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Abstract

The paper presents an implemented architecture of a software platform used in a master program from our university. The interactive teaching consists in online courses and virtual laboratories about electronics devices simulation, circuit optimisation and biocomponents analysis. The software is based on Core and Collaboration components from the Lotus LearningSpace package. Both a demonstrative course and virtual laboratory are included in the first step of the Core component installing. After the Collaboration component set-up, whiteboard and live session are used. Then some applications concerning microelectronics and bio-components simulation are presented, as a collaborative work from the e-Learning environment. The implemented platform gives the possibility to integrate the poor universities in the international framework and to make the national qualifications more readable.

Keywords: Collaborative method, Information Technology, Bioengineering

1. Introduction

The building process of a learning environment begins with the learner, ends with the learner and is constantly shaped and validated by the learner [1]. The main component of such educational environment can be the content, pedagogy, tools and technologies, community, setting, assessment and evaluation. Because the learning, as an education component, is addressing for people, not for users, learners must be firstly identified [2], besides their needs during each step of the learning, the prior knowledge level, skills and abilities, in conjunction with the teachers' motivations, [3-7].

Because the content in conjunction with the learner has the primary influence on all others elements of learning environment, a microelectronics course and laboratory [8, 9], with applications in bioelectronics and e-healthcare, is approached.

From the pedagogy point of view, an active learning and metacognition is promoted to make learning relevant and a priority activity for learner [10]. The on-line course and the virtual laboratory present the

newest research aspects of the instructors, like the modelling, simulation, remote control and design of semiconductor micro- and bio-devices, [11, 12].

In this paper is depicted a virtual laboratory for the simulation and design in the microelectronic devices and biocomponents. The tools and technologies that aid in teaching and learning are physical, remote or virtual [13,14]. The IT tools are used so that the students are never focused on making the tools work, but rather on using them in the information capturing.

A special attention is paid for assessment and testing in order to provide evidence of the learner's ability. In order to provide continual feedback [15] regarding the performance, the course is organized in chapters and the students have the possibility to go to the next chapter after a short test passing.
The method was applied for the students from post-secondary education in our university, which mean two master years after four-year of college.

2. E-Learning Aspects

The progress of computer technology and its increasing complexity change our live. A new vision was developed concerning the personalised lifelong education, as well as the form of augmented cognition that enables learners to supplement their own knowledge with readily accessible digital information. There is also growing evidence that e-learning provides increased opportunity for plagiarism, with obvious consequences for education effectiveness.

This paper reports the development of a prototype authentication system, checked for use with a graduate e-learning program. A new challenge in the biomedical engineering is the contextualized access and semantic interoperability of the electronic health records, especially in web assisted patients [16]. Remote bioengineering is one of the future directions for advanced teleworking, e-working environments especially in engineering and bioscience [14].

E-Learning includes content delivery in multiple formats, management of the learning experience and a networked community of learners, content developers and experts. E-Learning provides faster learning at reduced costs, increased access to learning and clear accountability for all participants in the educational process [17]. Intelligent e-Learning tools, able to optimally complement or replace traditional instruction in certain specific domains are currently being developed [18]. Such tools are endowed with intelligence, the capability of guiding the trainer and customising the knowledge to the learner preferences, interest and needs. Today, the microelectronics field strongly collaborates with nano-electronics [19], micro-mechanical systems [20] and biodevices [21].
This paper presents an integrated e-learning environment based on the Lotus LearningSpace 5.01 package, for micro- and bioelectronics courses and laboratories implementation.

3. Systems Organisation for Implemented E-Learning Environment

3.1. Hardware and software requirements

Theoretically, all the Core and Collaboration components of Lotus LearningSpace 5.01 package can run on the same machine. However, for performance and scalability, at least the Database server and the Collaboration server should be on separate machines. All servers should be connected into a network with a minimum speed of 10 Mbps. Database server requires 1MB of database table space for each LearningSpace user. The minimum configurations for LearningSpace Core and   Collaboration servers, when are installed on separate machines, are: (1) Pentium-based (Pentium III or higher) servers; (2) 500 MHz CPU speed; (3) 512 MB RAM; (4) 500 MB available disk space for data storage.

If LearningSpace Core and Collaboration are installed on the same machine, the server must be at least: (1) Dual Pentium-based (Pentium III or later) server; (2) 1 GHz CPU; (3) 1 GB RAM; (4) 1 GB available disk space for storing data.

Memory and disk space requirements are directly proportional with the number of courses and users registered in LearningSpace and with the number of students connected in the same time. Both LearningSpace Core and LearningSpace Collaboration run on the following operating systems:

1. Microsoft Windows NT 4.0 server with Service Pack 5 for international installations.
2. Microsoft Windows NT 4.0 server with Service Pack 6a (or later) for US installations.
3. Microsoft Windows 2000 Server with Service Pack 2 or later.
4. Microsoft Windows 2000 Advanced Server with Service Pack 2 or later.
5. Microsoft Windows 2007 Advanced Server or later.

Additional software is required to support the functions of the LearningSpace Core server:

1. Internet Information Services 4 for Windows NT 4.0 or 5.0 for Windows 2000.
2. Microsoft Management Console.
3. NT Option Pack Common Files (Windows NT 4.0 only).
4. Transaction Server Core Components (Windows NT 4.0 only).
5. Microsoft Data Access Components (MDAC) 2.5 for Windows NT 4.0 or 2.7 for Windows 2000.
6. Microsoft Java Virtual Machine MSJVMx86 Build 3177 or newer.

Minimum requirements for client's workstations are the following: (1) Pentium II (500 MHz) or higher; (2) 128 MB RAM; (3) 50 MB free disk space; (4) resolution 800x600 (256 colours); (5) 50 Kbps connection speed.

Operating systems for clients are the following: (1) Microsoft Windows 98; (2) Microsoft Windows NT 4 Workstation; (3) Microsoft Windows 2000 Professional; (4) Microsoft Windows XP; (5) Microsoft Windows 2007.

The client workstations require browsers and audio/video features for the Collaboration sessions. All machines are networked and communications between workstations and servers are performed via

Internet. A Linux Server is necessary to run the network services, like connection and firewall protection. The network configuration and administration are very important for the successful implementation of LearningSpace environment.

3.2 E-Learning Environment Components and Flow

The e-Learning Environment based on LearningSpace 5.01 requires Core server, Content server and Relational database management system (RDBMS) modules. In addition, this environment supports Collaboration server, Lotus Domino server and SMTP server, as optional modules. The Core server is the entry point for all users. A user accesses the e-Learning Environment (ELE) by using Hyper Text Transfer Protocol (HTTP) [22].
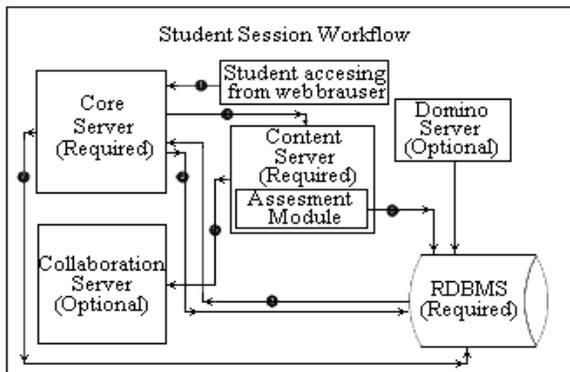

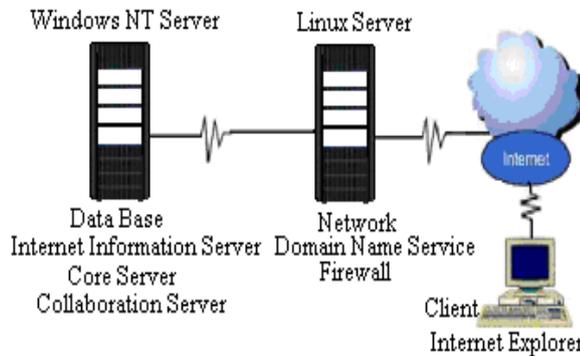Fig. 1.   Student session workflow.

Fig. 2. System Configuration.

As shown in Fig. 1, when the user accesses the system, entering the correct URL in browser, this responds by displaying a logon page. Once the user logs on, the Core server provides the client browser

with an interface, with access to the course materials and assessments, but users do not access the Core server itself. The Core server also provides a mechanism for accessing and tracking data stored in the Relational Database Management System (RDBMS), the Collaboration server, and all course content servers. Microsoft Internet Information Services (MIIS) and the Microsoft Data Access Components (MDAC) manage these connections.

3.3 General Organisation

The generic representation from fig. 2 is a proposed configuration for a system that fulfils all the requirements for the ELE package. The system consists in a Linux Server, which runs the network services (physical level connectivity), the DNS (BIND-named) and the Firewall.

Windows NT 4.0 Server which runs the Data Base server, the IIS (Internet Information Services) server, the Core server and optionally Collaboration server. The Linux server has two network interface cards both having the transfer rate of 10/100Mbps. It has a 2GHz processor, 512MB RAM memory and a 160 GB hard disk. The Linux software proved a good stability and liability along the experimental exploitation. The NT server has one network interface card having the transfer rate 10/100Mbps, 2.6GHz dual processor, 2GB RAM memory and RAID configured hard-disk matrices. The software running the server is Windows NT Server 4.0, Service Pack 6.a, Internet Information Server 4.0, necessary updates for ELE, Data Base Server IBM DB2 7.1 Workstation and Lotus LearningSpace Core and Collaboration.

3.4 Administrative Aspects

In LearningSpace Core, the users are divided into two major groups: student interface and administrator interface. The students are users, which can be enrolled in a course and receive scores. Students work only through the student interface accessed by browsers.

The administrator interface is only used by the system administrators, course administrators or instructors and is accessible via a specific URL, separated from the student interface. The system administrator uses the Administration interface for settings [23]. He must be aware of system and software requirements for different servers and machines. The course administrators are users who perform tasks related to creating, posting and tracking online courses and materials, as well as enrolling and tracking students. For documentation purposes, content developers and course designers they are included in this group, as they use administrative features. Course administrator may be responsible for adding users, enrolling students in courses, creating assessments and tracking student's progress.

4. Microelectronics course implementation

The course "Electronics Processes and Simulation in Integrated Micro-nano-structure" is implemented in this ELE system. The course content concerns the modelling, simulation and design of MOS devices, nanoscale effects in integrated circuits and microsystems [24, 25]. Sometimes the simulators can be replaced for emulators, when atypical microstructures are defined, [26]. Firstly, a user profiles is created to set permissions and the users registering. The user profiles help us to search data accordingly with a user's membership in a user profile, assign permissions for a member, enrol profile members into courses and create reports within a profile. At the beginning, one can use the Core server to provide the content to users. The content itself is data rather than a program, so the virtual directory should point to a data directory. To create the course structure, an instructor in the Enrolment module is defined, fig. 3.
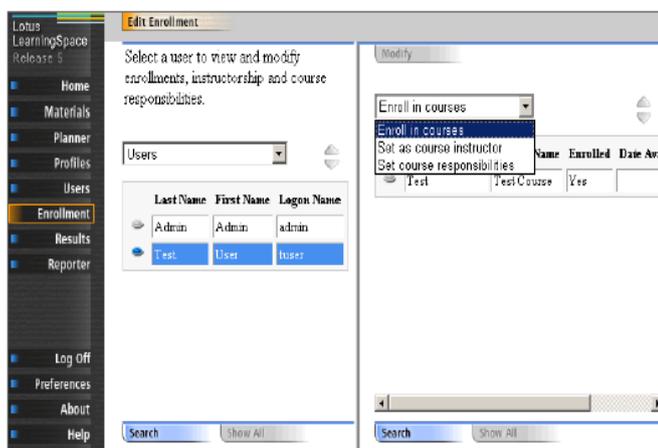

Fig. 3. Setting a course instructor.

Authors who design courses in the Planner module get responsibility for their own courses by default. New instructors can be assigned to a given course. This information is used in the course catalogue, the e-mail list, and lives sessions. The next step is the tests creating. The questions can be created, with proper permissions in the Materials module and can be evaluated on the server without human interaction. In order to improve the questions format, the web design Macromedia Dreamweaver tool is used, to edit mathematical equations, like equation (1):

$$\zeta = \frac{1}{\hbar} \Delta_K E_K. \qquad\qquad (1)$$

After the questions creating, the assessments from the Materials module can be defined. The tracking student progress is one of the major advantages of this e-Learning environment, due to the storage data capability. Some student activities, like time spent on browsing or the interactions made during an assessment, are stored. Finally, the organized course from the Planner administrative interface looks like in fig. 4.
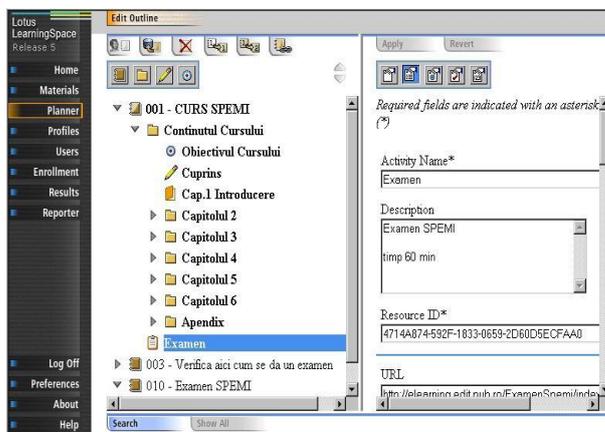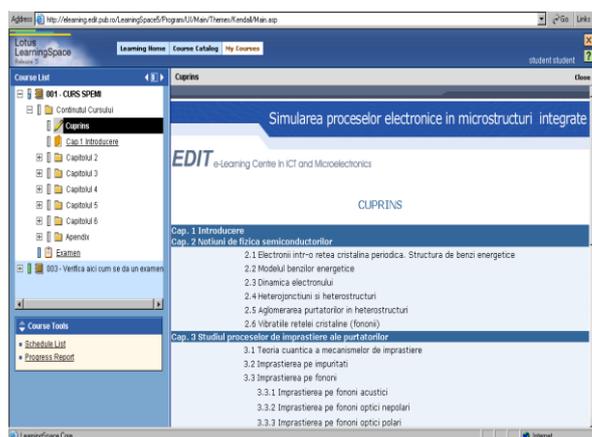
Fig. 4. Planner administrative interface.

Fig. 5. Student Interface Course.

After the student login by user-name and password, the student interface makes available the course content, fig. 5. The course is organised in chapters with tests at the end of each chapter.

5. Virtual Laboratory Implemented On Collaboration Server

Labs have always played an important role in education for practical skills. As the technology expansion, the demand for more efficient and expensive equipment has increased, besides to the specialist requirements. Essentially, only some large research centres and perhaps some top universities can afford such equipment and even these more fortunate institutions can only partially have the top endowments.
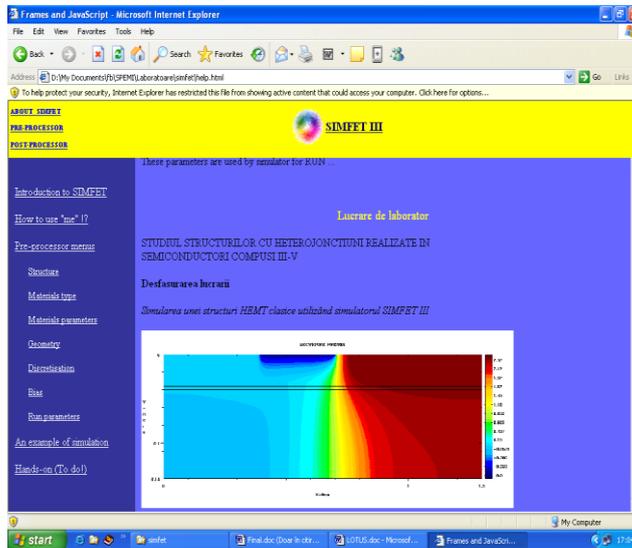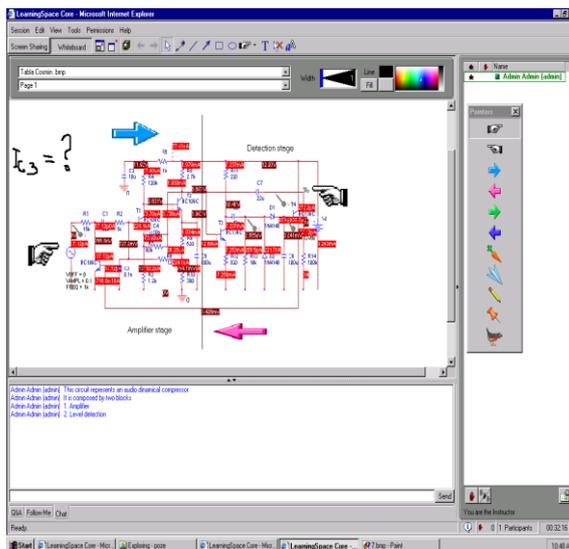
Fig. 6. Micro/Nanodevices Laboratory.

Fig. 7. Live session example.

Using the virtual laboratory, the basic data can be introduced for devices, like geometry and dimensions, type and material properties or the bias parameters in Athena or Atlas simulators. The results, as the flow currents through a FET device, are presented in fig. 6 and are available on-line.

Installed multiple Collaboration servers that will work together are known as a community. This process involves two types of installation: the first Collaboration server, and the additional Collaboration servers. The first Collaboration server owns the community's "master" copy of the Domino Directory, where user information is stored. The LearningSpace Collaboration component provides features that allow instructors and students to interact as part of course activities. It also manages discussion forums for courses. When is creating the Materials interface as a live session, other tools are available: Chat - allow to send messages to everyone; Follow Me - allows the Instructor to simultaneously direct all participants' Web browsers to a specific Web page; Q&A - allows the Instructor to send questions to participants and to collect the answers; Screen Sharing - allows sharing a screen with other participants; Whiteboard - allows to presenting files, drawing objects, and entering text; Audio and Video - allow to speaking with other participants and, if using video, visualised by them.

The whiteboard facilities like presenting files, split the table, draw objects, indicators, web browsers, or audio and video communication, are presented in fig. 7, as a SPICE circuit interactive simulation.

6. Applications in Bio-Electronics

In this paragraph, the course entitled "Biodevices and cellular nanoelectronics" (BioNEC), with adjacent applications is included in this e-learning environment.

The bio-compounds analysis [27], or membranar potential measurements can't be performed within a technical university endowment. Therefore some simulations are used to replace some difficult experiments. The following examples are implemented in the LearningSpace environment.

The first example concerns the simulation of a biosensor with the glucose-oxidase receptor placed on nanoporous compound, [28]. This application is performed by the Atlas device simulator from Silvaco. The standard materials from microelectronics are available in the Atlas library, as Si, SiO2, TiO2, etc. The bio-materials, like enzymes, are defined as ambient with their specific electrical properties, (e.g. dielectric permittivity [28], thermal conductivity, etc), fig. 8.a.

The analyte concentration versus the gate voltage is extracted from standard experiments, [29]. Applying electrical stimulus, the biosensor activity can be tested in Atlas, fig. 8.b.In a second example, a portion from a cellular membrane is simulated, using the SOI structures format, [30] within a semiconductor device environment. In order to simulate the membrane as insulator, surrounded by the intra-cellular i.c. and extra-cellular e.c. environments with semiconductive properties, the structure from figure 9 can be adopted. The membrane is defined by:

region   num=1   y.min=0.005 y.max=0.015 material=ambient (lipid)
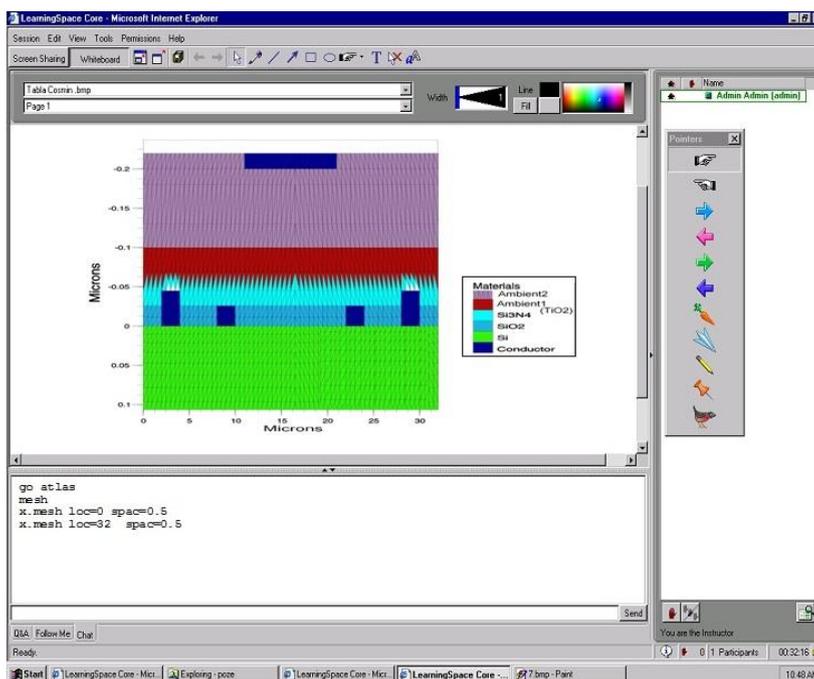
(a)
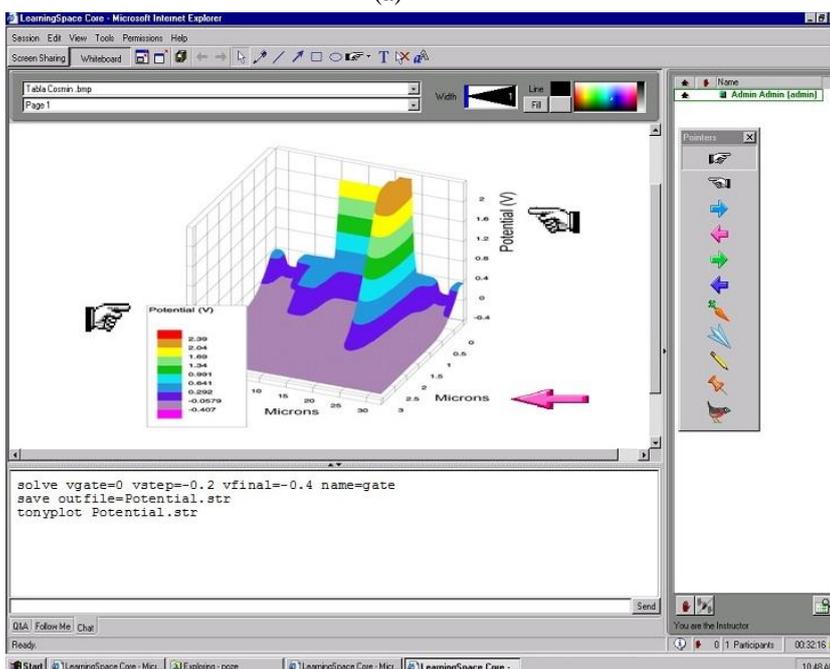
(b)

Fig. 8. (a) A biosensor capturing, using Ambient1 as nanoporous TiO_2 and Ambient2 as glucose-oxidase layer; (b) the potential distribution at V_G=2V, which corresponds to a maximum glucose concentration.

The i.c. and e.c. environments were simulated by Silicon layers [31] with doping concentration about $9x10^{19}cm^{-3}$, accordingly with the K^+ concentration ~ 150mM, that means $150x10^{-3}$ mol/dm^3= $6,023x10^{23}$ x 150 x 10^{-3} ions / 1000 cm^3 = $9x10^{19}$/cm^3 positive electrical charges per 1 cm^3, equivalent with $9x10^{19}cm^{-3}$ holes concentration in semiconductor:

doping   uniform conc=9e19   p.type reg=2

Three electrodes are defined instead of three adjacent ionic channels: conductor 1, conductor 2, conductor 3, against the conductor substrate, fig. 9.a. The electrical potential distribution is numerical computed by the Poisson equation solving, which is applied in solid-state or liquid materials, while a spatial electrical charge distribution still exists. The scope is the potential distribution extraction over the bilipidic membrane under Resting potential or Action Potential. Figure 9.b presents the simulation results for a local depolarization with an Action Potential of -60mV, corresponding to beta cells, [32].

The users can check the action potential propagation from e.c. environment, over the bilipidic layer, till the i.c. environment at y>15nm, fig. 9.b.

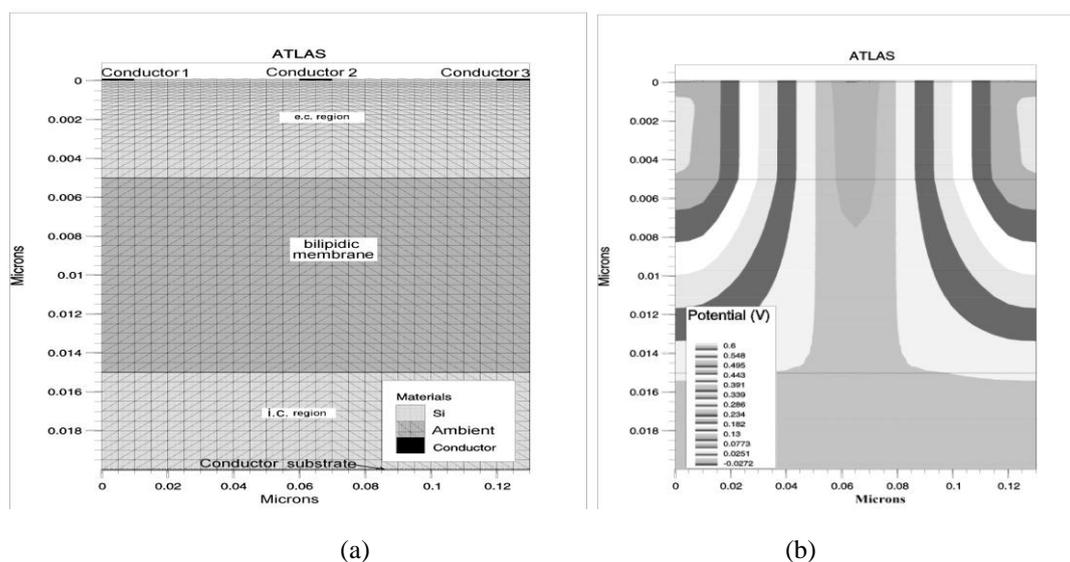(a)   (b)

Fig. 9. The meshed membrane in vicinity of the e.c. and i.c. environment, captured in Atlas.

Another example is developed in order to provide some intracellular phenomena, without biological microscopy. The first application consists in an animation of the insulin exocytosis at a glycemic stimulus. The Adobe Flash CS 4 is a dedicated tool for the animation description, while the Adobe Photoshop CS 4 is used to process the images. When the glucose molecules bind to specific receptors [32], the Ca-channels are opening and the insulin exocytosis occurs, fig. 10.
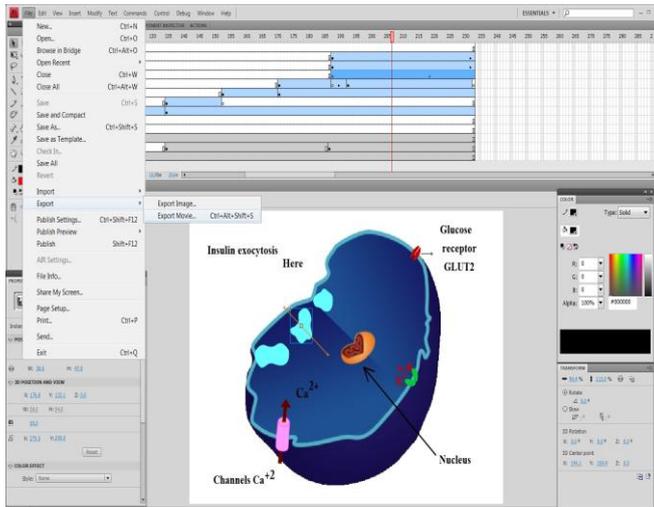
Fig. 10. The final work-frames for the insulin exocytosis.

The next animation is performed in Sothink SWF Quicker Software. It uses Flash in order to animate a series of images, describing the synapse work regime into a movie of the entire process. Figure 11 presents some sequences from this movie, for the electrical pulse transmission along axon. When the action potential – the green zone – opens the Ca-channels, the neurotransmitter exocytose occurs. The neurotransmitter is recovered into the terminal buttons after the Calcium reuptake and ensures the preparation for a new pulse transmission. The biological phenomenon was learned from the cellular biology literature and developed as a software application. Previous animations were developed at the BioNEC discipline, in the applicative section. However, the biological properties description in different software applications, represents a continue challenge, [33].
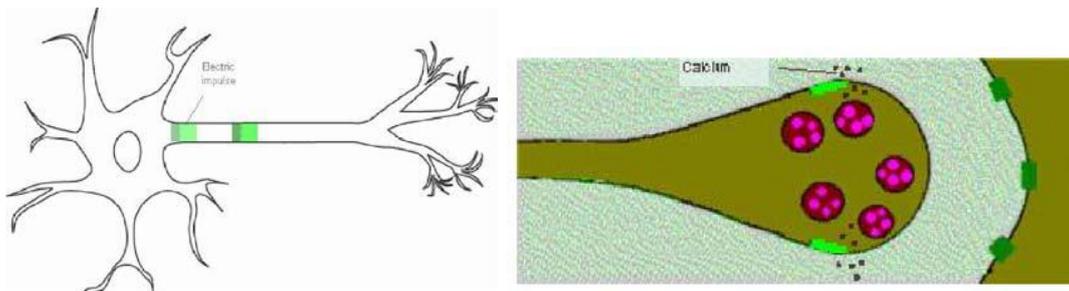

Fig.11. Intermediates steps for the intra- and inter- neuronal electrical pulse transmission.

An important conclusion can be emphasized at this sub-paragraph: the software engineering from our electronics faculty is proper for a collaborative work among master engineers, medicine and biology students, since to offer each other learning subject, [34-36].

7. The impact from students

   The final score of the students from the last academic year, at the BioNEC discipline, is provided in this section. The master students have the possibility to access the next chapter when they obtained a score higher than 60%, for each chapter. Following a successful access of all course chapters, the on-line examination begins. After the test time expired the result of the on-line examination is immediately available on-line, fig. 12. The final mark, between $1 \div 10$, is established by a weighted average from each chapter besides to a final essay, on Lotus LearningSpace platform, fig. 13. The Lotus scoring algorithm ensures objective results. In fig. 13, the results from last year - after 5 years of Lotus e-Leaning experience and from previous academic years, from the pioneering Lotus times or under classical learning method, are comparatively presented.

	Last Name	First Name	Logon Name	Score	Completion Date	Time Spent	Progress
	Ban	Sorin Mircea	ban	80	Jan 16, 2013	00:25:45	Completed
	Bartha	Remus	bartha		Jan 16, 2013	00:00:00	Completed
	Preda	Cosmin	cosmin	80	Jan 16, 2013	00:17:25	Completed
	Chelarescu	Alexandru	chelarescu	80	Jan 16, 2013	00:14:02	Completed
	Cimpian	Ioan	cimpian	80	Jan 16, 2013	00:10:36	Completed
	Craciun	Adrian	craciun	80	Jan 16, 2013	00:22:54	Completed
	Danchiv	Andrei	danchiv	76	Jan 16, 2013	00:06:41	Completed
	Enachescu	Razvan	enachescu	76	Jan 16, 2013	00:38:14	Completed
	Gheorghe	Daniel	gheorghe	80	Jan 16, 2013	00:10:41	Completed
	Preda	Daniel	preda	80	Jan 16, 2013	00:22:53	Completed
	Stanica	Andrei	stanica	80	Jan 16, 2013	00:09:42	Completed
	Taloi	Alexandru	taloi	80	Jan 16, 2013	00:13:32	Completed
	Vladoiu	Florin	vladoiu				Not Started

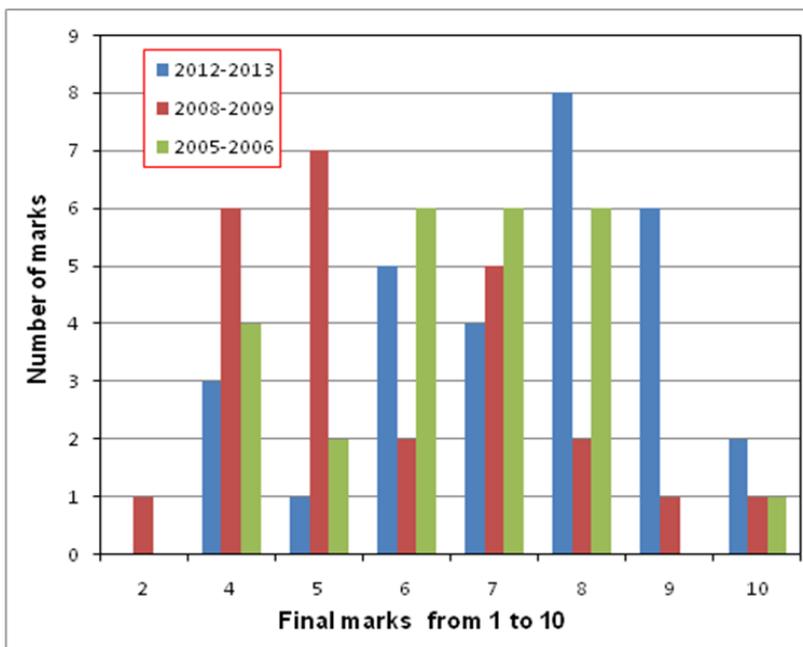Fig.12. Lotus page with examination results.

Fig. 13. The final marks from BioNEC discipline: in 2012-2013 year after 5 years of Lotus e-learning, in 2008-2009 year after 2 years of Lotus e-learning and in 2005-2006 year after classical learning.
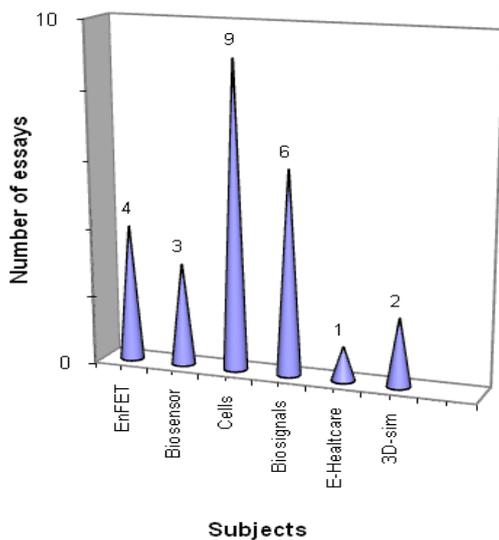

Fig. 14. The preferred subjects from the BioNEC course.

The marks evolution shows a Gaussian distribution with a peak around 7 and 8 during the classical learning method. In the first two years of Lotus implementation, without enough feed-back from learners, the Gaussian peak of the marks is centred around 5-7. But a revival occurs in the lasts years,

when the marks are centred around 8-9 score.

In order to receive a feed-back concerning the course content, from the students, the final mark was partially composed by a short essay, containing one preferred subject. The results of the preference percentage are available in fig. 14, for the 2008-2009 academic year, highlighting the un-expectable predilection toward the cellular phenomena sections.

In this way, the applications content can be regarded from the user point of view and improved. The students have to discover many bridges between biology and electronics, like the electrical conduction over a threshold voltage of 15mV for incident stimulus in the excitatory cells, as in the MOS devices.

8. Conclusions

The implemented system is accessible from anywhere and has a high degree of flexibility. All the components are running on a single machine. The personalized user interfaces are easy to use, most of the tasks being automatically done by the system, which in addition, offers a very flexible and friendly management. The configuration was oriented for the optimization of the lecture and examination and tracking students' progress. The collaboration module allows the use of live sessions enhanced tools, like whiteboards, follow me sets, chat, screen sharing and audio-video communications. The implemented e-learning system, based on Lotus LearningSpace 5.01 package, was tested and validated with integrated micro-bio-electronics course and laboratory.

The main advantages of the micro- and bio-components descriptors are the virtual laboratories with simulations tools or internet instances, offering haptic experimental results with an extremely low cost endowment. The main deficiencies are related to a poor variety for the bio-shape capturing, a difficult and incomplete description in electronics software tools of the extremely high and complex biological properties encountered in the living matter or biomaterials. Therefore, the future work has to be focused on this direction.

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