Innovations in Bulgarian Higher Education in Electronics

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Abstract - This paper describes innovations in Bulgarian higher engineering education - distance learning, virtual technologies and multimedia in electronics as outcomes of a three years international project. In compliance with the project objectives a new unit - an Innovative Center for Open&Distance Learning and Multimedia - was established at the Faculty of Electronicst. A hybrid model which combined face-to-face instruction with the approaches of distance learning and multimedia methods was designed to integrate modern learning methods and technologies into traditional university teaching.

Introduction

Human resources development is a priority of a new order in Bulgaria because of the very flexible national labor market and the new private sector. An increasing number of young people and professionals need to cope with problems such as increasing unemployment, the high degree of labour mobility and different requirements for professional qualifications in an increasingly internationalised environment. Hence the need of alternative models of education and flexible approaches in distance learning.

At the Technical University - Sofia (TUS), as is the case in all universities in the country, part-time students have face-to-face sessions approximately twice a year for about two weeks. In between nothing much is done assist their learning, the result being that a lot of students do not reach a level of proficiency adequate for a MSc degree. Another group of problems are those related to financial difficulties and inability to take time off work to study. The Technical University wished to create an alternative model of tuition for these students and give them an opportunity to follow the courses offered. It was considered that the Open & Distance Learning (ODL) approach could solve these problems if successfully integrated in the university educational environment. Another source of concern was the fact that in the Department of Electronic Engineering certain areas appear as "black-spots", generally less well understood by the students because of the level of abstraction in the learning content and the existing deficiencies in the traditional teacher-centered instructional methods. The teachers estimated that new technologies, in particular simulation-based and project-driven learning approach using proper professional ECAD tools, CD-based interactive multimedia and WEB-based applications, would contribute to making the subject matter of these "black-spots" more concrete and more understandable. It was also realized that graduates in electronics have poor communication and interpersonal skills, as well as poor skills in using professional software with user interface in English. The former inhibits students from taking active roles in team-oriented projects and presenting the results, while the latter limits their ability to analyze and solve complex problems [1].

To address these problems an international EU funded project was designed and conducted by the TUS in which the European good practices in the field of ODL and virtual technologies were adapted, and the first step of synchronizing educational standards was made.

Experiences about distance learning and collaborative learning are gathered within several DELTA projects, e.g. Co-Learn [6] and the Jitol project [7]. In the MODEM project work is integrated in a simulation-based learning in order to enlarge the efficiency for training and learning [4]. Our project focused on the development of a simulation-based project-driven learning environment in a hybrid model for distance education found to be the most suitable for the successful integration into traditional university teaching.

Project Goals and Objectives

The goal of the TEMPUS project was:
Storing the new infrastructure for transferring and dissemination of Open and Distance Learning methodology, implementing multimedia and hypermedia, training and updating academic staff on ODL methodology and developing curricula with interdisciplinary orientation. The main objectives were to:

1. Create a new institutional unit for ODL;
2. Develop and implement ODL methodology and virtual technologies as an innovation in higher engineering education;
3. Train trainers;
4. Develop curricula and materials for ODL;
5. Provide students with state-of-the-art learning environment and computer communication as a delivery tool for distance education and training;
6. Provide educational and training services;
7. Assist ODL initiatives on the institutional and national level;
8. Promote European partnership and adapt the international good practices in management and implementation of ODL.

In compliance with these objectives and corresponding to the restructuring of the Bulgarian higher education, a new unit - the Innovative Center for Open&Distance Learning and Multimedia (ICODLM) - was established and the pilot experiment of new curricula for simulation-based, project driven learning was centered at the Faculty of Electronics.

New infrastructure established

The Center has been recognized as a distinct unit within the structure of the TUS, with respective organizational and management structure and staff. The organizational structure of the Center consists of two parts:

- Permanent in terms of the Center managing board and academic and administrative staff and
- Contracted in terms of different educational or training programs offered.

The infrastructure of the Center has been implemented as an essential training and production environment to achieve project objectives. The Center has the following component parts:

- an Administration Office
- a Tutor's Room for distance communication,
- a Multimedia Development Lab,
- an Educational Multimedia Lab and
- a Multimedia Presentations Class.

The Multimedia Development Laboratory is the main unit in the ICODLM infrastructure. Its functions are to develop and produce printed materials, audio tapes, video tapes, interactive multimedia on CDs, WEB-based applications, transparencies and slides, and disseminate ODL materials. It consists of the following working places (Fig.1): Graphics and desk-top publishing, Audio processing, Multimedia and computer animation development, Digital video processing - Media 100.

The Local Network with functions such as: centralizing the management of resources and peripherals, exchanging different kinds of information (graphics, text, animation, digital video, etc.), access to Internet services, sharing peripherals (printers, scanners, CD writers, etc.), is shown in Fig. 2.

The Multimedia Development Lab proved fully adequate to the needs of the developers of teaching materials. A total of 21 distance learning materials were produced there: coursebooks, video programs, interactive multimedia products - CD- and Web-based applications.

The Educational Lab features 8 PC-based multimedia workplaces needed for the

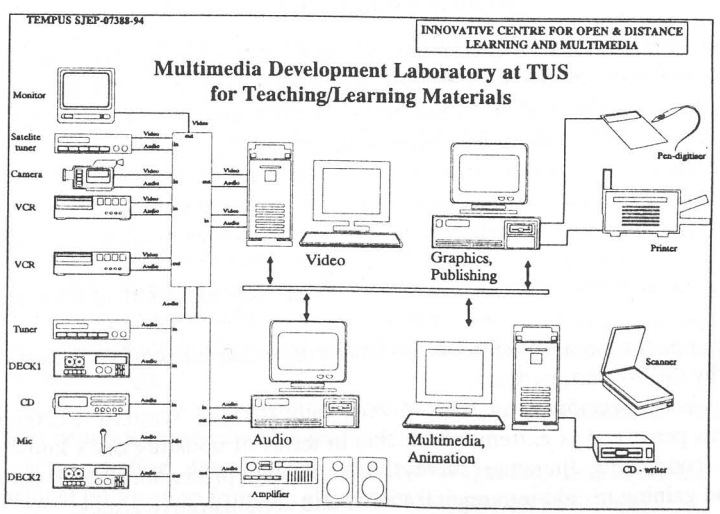

Fig. 1

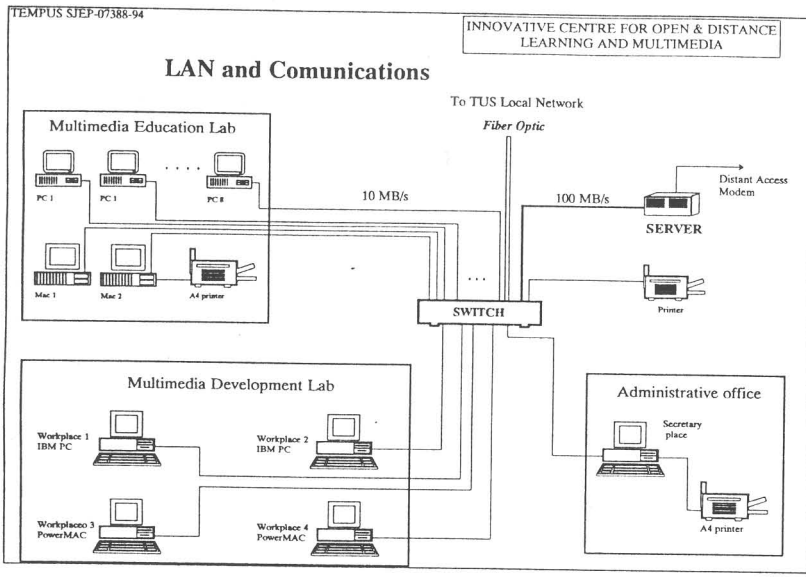

Fig. 2

pilot experiment and subsequent student training. It provides state-of-the-art learning environment and a delivery tool for distance learning and training.

Academic staff training

The development of ODL was a relatively new initiative in Bulgarian higher education. For the successful development and implementation of the new courses intensive teacher training had to be performed. To this end several guidelines were adopted from the PALIO trainer development program [10].

The existence of a team of professionals (more than 15 people involved) with respective motivation, professional awareness and confidence was a good basis for implementing entirely new learning methods and technologies in higher education in Bulgaria.

Training the academic staff for the ODL Center was addressed in four definite modes:

1. International training workshops for Bulgarian academic staff - 23 workshops conducted by the Western partners;

2. Individual specializations for the academic staff at Western Universities. Training was perceived as extremely valuable in terms of updating one's knowledge and skills, conducting literature surveys, establishing professional and personal contacts and gaining insight into organizational and administrative issues.

3. On-going learning-by-doing assignments for Bulgarian academic staff for curriculum and multimedia teaching materials development.

4. M.Sc. Program on Educational and Training Systems Design at the University of Twente completed by 2 university lecturers.

Parallel theoretical training and learning-by-doing assignments proved extremely adequate for trainer training, accounting for increased motivation for training and improved efficiency in curriculum and materials design.

The Bulgarian project team received significant managerial, methodological and technological support by the Western Europe project partners CAMPO, SCIENTER and UETP-Toscana, Italy, University of Twente, the Netherlands, University of Lille, France, University of Edinburgh, U.K.

Learning Environment

The courseware design and teaching materials for the pilot experiment in the University degree course in electronics were done taking into consideration the possible solutions suggested in the needs analysis, namely:

- ODL approach as an alternative to the part-time studies at TUS as an opportunity for increased enrolment and low drop-out;
- Project-driven learning with simulations in a virtual environment with professional ECAD tools to fill in certain 'gaps' in instruction stemming from the high level of abstraction in the learning content;
- Multimedia as the most appropriate tool for increased motivation and efficiency of learning.

Hybrid Model

A hybrid model for distance training courses was developed. The respective delivery and support systems were defined. The hybrid model was found to be the most suitable for the successful integration of modern learning methods and technologies into traditional university teaching. It combines the ODL approaches and multimedia methods with face-to-face instruction and practical work in technological laboratories (Fig.3).

Delivery System

A technology-based learning environment with an object-oriented client/server Internet architecture was designed. Its structure includes:

1) self-learning room in which course modules for stand-alone learning mode are provided (Web-based or CD-based interactive multimedia materials allowing flexible self-paced learning);

2) group-working room providing possibilities for collaborative learning, i.e. computer network enriched with a social network;

3) library including downloadable electronics guides, course-books, additional professional information from the electronics industry and research;

4) simulation and project design technological laboratory built on three types of

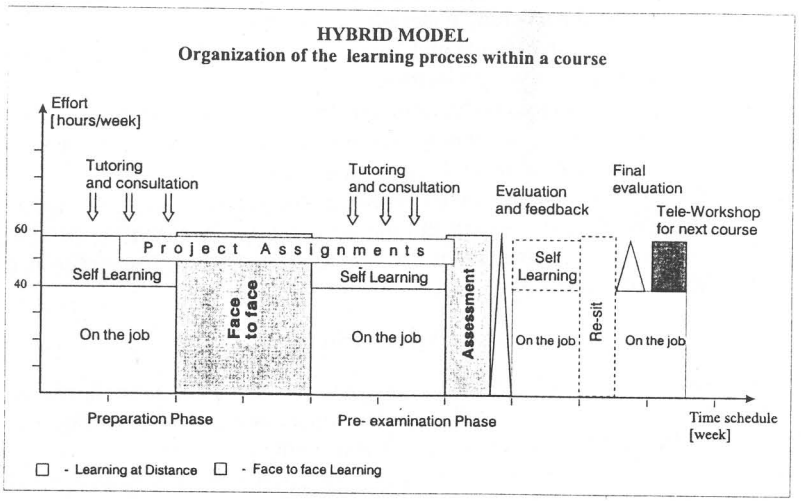

Fig. 3. Hybrid Model - principal organization of the learning process

instructional simulation objects: recorded and/or real-time Demo, mimic and/or problem Tasks and guided Exploration;

5) information desk, including students enrolment facilities, course information and schedules, etc.

The object-oriented approach is used to develop reusable units and implement modularity as a main principle in course design [2].

The client/server architecture supports the organization of enrolment and course delivery. It also allows information and media exchange on a consumer/provider basis.

The Netscape SuiteSpot open platform was adopted in order to ensure more effective information management, communication, collaborative work and efficient administration and security infrastructure. An Enterprise Server (Web server) ensures sharing and managing information over the Web. Collaboration and knowledge sharing among teams takes place via a Netscape Collabra Server (News server). Learners can participate in private "virtual meetings" that break down barriers of time and distance. Asynchronous communication provided by a Messaging Server (Mail server) quickly delivers email with embedded sound, graphics, video files, HTML forms, Java applets, and desktop applications. Netscape conference and Microsoft NetMeeting tools were chosen for synchronous collaboration and information exchange.

The entire Web-based information system is built on the Enterprise Server, Directory Server and Calendar Server. The Directory Server is used for centralized administration and course organization. The Calendar Server is used for scheduling meetings and conference rooms, organizing learners, tutors and teachers.

Teaching Methods

The traditional trainer-centered didactic approach was re-designed from a student-centered learning perspective which stresses on active, project-driven, simulation-based learning. The virtual environment was built on three types of instructional simulation objects: recorded demo, problem tasks, free/guided exploration.

The demo shows how to control the simulation package and the behavior of the modeled domain in time. Active processing of knowledge can be expected to be more efficient in terms of the learning objectives than a passive textual description [3].

In a task learners receive instructions to follow an action sequence or solve a problem on their own. The problem task gives the learner more degrees of freedom. It is used to exercise or assess the learner's knowledge. It has greater practical value if the learner is monitored during execution of the task (by tutor, peer or computer system). This monitoring allows for feedback and guidance in problem or special situations. Thus the learner is guided through the problem, given appraisal and/or critics or misconceptions are clarified.

The exploration provides learners with all the functionality of a simulation package. Learners have full control over the model and gain experience with the simulation package on their own [4]. The classical scientific cycle of exploration, hypothesis, experiment, prediction and conclusion is supported by the subgroups of free-, guided-exploration. Free and guided explorations are useful in observing the simulated domain and generating ideas, which can lead to a hypothesis and later on to experiments to accept or reject the hypothesis. In the guided exploration feedback is given on events of interest by monitoring and the attention of the learner is directed.

Simulation

The motivation for the use of hyper-media and simulations in an educational context is that it supports an active learning approach and maximizes learner control. It is claimed that an active learning approach facilitates learning [9]. Learners appear to be more engaged and have better motivation. Simulations enable learning by doing, thus knowledge and skills are acquired in an active way. Learners can make their own errors and learn from these. They can explore the modeled domain. They can do some experimenting to generate and evaluate hypotheses etc. Moreover, simulations are powerful in situations where it is difficult or impossible to provide training.

Use of professional simulation and modeling tools is an important asset in both education and training in the domain of electronics. Hands-on experience in using these simulations gradually becomes a 'condition sine qua non' for a professional to carry out his job [4]. In the MODEM project the simulation environment was based on Virtual Wafer Fab®, running under UNIX. Within the TEMPUS project we selected MicroSim® DesignLab®, a circuit simulation package.

Project-driven team learning

The approach adopted [8] sought to enhance the role of project-driven learning. The innovation here was that besides the traditional individual project work, collaborative learning was introduced for students to tackle complex problems in groups rather than individually. Developments in electronics have shown that projects in the field are so complex that team work is essential.

The learning situation is based upon giving the teams extended projects to work on. Each team consists of three persons as a minimum, lead by a 'project manager'. This organization was aimed at improving the students' communication and interpersonal skills. Teams were provided with the information needed in multiple form: 1) the Internet, 2) workbooks, 3) video taped lectures and 4) CD ROMs. The learning context and organizational setting within the simulation-based learning environment was extended by the use of telematics which provides opportunities for:

1. small groups executing a specific task as a workshop
2. discussion groups with peer students
3. tele-assistance of the tutor during task execution and/or exploration
4. detailed advice by contacting domain experts.

The telematics component gives an impetus to more active and constructive learning [5] with more emphasis on inter-personal collaboration, social networking, peer exchange and group activities. This only works if the computer network is combined with a social network.

The social/human network [9] enables collaborative working to support the individual learning. However, this implies that the social network is made explicit with its different roles, e.g. 'team manager', 'expert', tutor. In addition persons playing these different roles are addressable via the user interface. The communication supported by the network is a combination of synchronous (teleconference, screen sharing etc.) and asynchronous (e-mail) data exchange.

Pilot Test

The pilot test was performed with fifty 3rd-year regular students and twenty 4th-year part-time students in Electronics at the TUS, in 60 learning hours. The students were volunteers with fluent English. The evaluation focused on usability of the learning materials, instructional effectiveness and learners' attitudes.

For instructional effectiveness testing the techniques recommended by Tesmer [11] were used: expert reviews, one-on-one and small group tests. The knowledge tests and projects assessment are to be performed during the examination session which just started. The techniques chosen for usability assessment were: direct and distance observation (through the sharing application function of NetMeeting), interviews, questionnaire and textual communication files. Interviews and questionnaires were used for learners attitudes study.

As the examination session has just started, only preliminary data from the pilot test are available, those related to the learners' attitudes and usability assessment.

Students liked the possibility to create their own learning path. They enjoyed the multimedia used: the clear graphics with animation, the interactive exercises, the simulations with professional software system. Feedback was considered understandable and useful. In general, students liked the instructional methods used; most of the regular students (64%) stated they preferred this self-paced mode of learning to the face-to-face education. All part-time students were positive to the hybrid model of education.

During the tests some functional defects were identified and removed. On the whole, the usability criteria were met and in the questionnaire students assessed most of the usability aspects of the prototypes with the maximum number of points.

The main problems encountered were related to the reliability of the Internet communication for the distance group work on projects. The conclusion made was that the availability, cost and integration of on-line multimedia limits the scope of applications, particularly those involving live video communications and application sharing.

Conclusion

Distance education is a new initiative in Bulgaria and the project achievements fully contributed to the present needs of the structural reform of the higher engineering education in the country. It introduced the most advanced educational and information technologies and created new infrastructure with relevant functions, structure and management. The dissemination of project results started in a horizontal integration with other faculties and external institutions, particularly the Regional Distance Education Study Centers within the framework of the National Center for Distance Education. Relying on the experience already gained, a new international project started in 1998 under PHARE Multi-Country Program for Distance Education.

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