Training Microsystems Technologies in an European eLearning Environment

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Abstract—The paper presents the ongoing activities within an European project for development of eLearning courses in microsystem technologies. It is a two-year project within the Leonardo da Vinci programme and the partners are from small and medium enterprises in microelectronics, training organisations and universities from four European countries – Romania, Bulgaria, France and Germany. The project is aimed at implementation of innovative approaches for performance-centred learning and development of new instruments in instructional design of task-performance-centred courses for education in Microsystems design and technology.

Keywords-Microsystems technology education, performance-centred approach; e-learning, European project

I. INTRODUCTION

Scientific research, technological development and innovation are at the heart of the knowledge-based economy, a key factor in growth, the com petitiveness of com panies and employment [1]. “The shift to a knowledge based economy is of crucial importance to competitiveness and growth. Business and citizens in the EU have been slower in embracing this new economy than in the United States.” [2] Micro- and today nanoelectronics is the most rapidly developing science. All specialists in the field need regular re-training. In this most rapidly developing science which represents the basis of the e-economy and the e-society the continuous training is crucial.

The shortage of engineers in micro- nanosystems and the systematic decrease of students in electronics at the university can be a threat to the European economy competitiveness. The informal Meeting of Ministers of Ed ucation and M inisters of Research in Uppsala underlined the importance of increasing recruitment to science and technologi cal disciplines, including a general renewal of pedagog y and links to working life and industry throughout the whole educational and training system [3]. In many publications at the 3rd European workshop "Microelectronics Education" it was stated that "a new breed of engineers must be created and the way we create them has to change" [4] from the classical engineering schools to multi-disciplinary research and design centres. So, a part nership between small and medium enterprises (SME) and universities for delivering training in Microsystems technologies has crucial importance for the competitiveness of the European Union on the world market for electronic systems.

Additionally, it is important to be mentioned that Europe’s electronics industry is increasingly moving east. Multinational OEM (Original Equipment Manufacturer) and EMS (Electronics Manufacturing Services, contract manufacturers) companies invested a great amount of capital and built up high-tech plants in Romania during the last years. The reasons why Romania is an ideal investment location in Europe include, firstly, the well-trained, creative and flexible human capital, in particular highly educated engineers and skilled workers. The informal Meeting of Ministers of Education and Research in Uppsala underlined the importance of increasing recruitment to science and technological disciplines, including a general renewal of pedagogy and links to working life and industry throughout the whole educational and training system [3]. In many publications at the 3rd European workshop "Microelectronics Education" it was stated that "a new breed of engineers must be created and the way we create them has to change" [4] from the classical engineering schools to multi-disciplinary research and design centres. So, a partnership between small and medium enterprises (SME) and universities for delivering training in Microsystems technologies has crucial importance for the competitiveness of the European Union on the world market for electronic systems.

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Bulgaria has also strong traditions in microelectronics (in 1989 the foundry in Botevgrad worked on a technology of 2 μm which was the top technology at that time) and the last 5 years a number of new SMEs in the field are created (HIC, EPIQ, Milexis, Centillion, Nanotoolshop, etc.) and M SysTech project is designed to meet their needs of qualified and trained personnel.

II. RATIONAL OF THE PROJECT

In the 21st century the high level research is increasingly complex and multidisciplinary; it is increasingly costly; high level research requires a constant increase in “critical mass”. Microsystems are developing on the highest level of research and the continuous training is crucial. This project is aimed at meeting the needs of qualified and trained personnel.

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There are very few individual research teams or laboratories or companies that can reasonably claim to be able to respond to the technological challenges. In nan o-era an integrated approach is needed, and in the development of innovative SMEs, universities and research organisations in the research and training actions and it is a key factor for strengthening the European RTD potential. The Internet-based courses within the mSysTech project will provide new opportunities for cooperation between vocational training institutions, universities and SMEs in the sharing of knowledge and educational resources: the distributed support system in four European countries created in the IPCI project will be enlarged with two new countries within the proposed project.

III. OBJECTIVES

This project is aimed at adapting and integrating innovative performance-centred training approaches into engineering education and training organisations and SMEs in microsystems technologies. The focus is on the transfer of innovation in two new countries: Romania and Bulgaria and in the multidisciplinary area of microsystems. Its objectives are:

- identifying and analysing user requirements of managers, engineers, students and technical staff in multidisciplinary science of microsystems technologies,
- selecting ICT-based innovative content to meet these requirements and analysing the feasibility of the performance-centred approach to train this content,
- adapting and implementing the e-learning environment with training materials with simulations, demonstrations to improve skills in microsystem technology.

The primary target groups concerned are: students in engineering education and vocational schools, professionals from SME in electronics and Microsystems, educated but unemployed people (e.g. engineers, physicists) looking for additional training for employment.

The project main result will be an e-learning environment with innovative pedagogical approach and the use of state-of-the-art multimedia materials to train the newest technological achievements in the sciences representing the basis of e-Europe. It will provide performance support to the individuals undertaking self-directed learning.

The following courses are already developed:

- **Microsystems Design and Technology** by Institut National Polytechnique Grenoble, Centre interuniversitaire de microélectronique, NanoTech.

  The objective of the course is to show the physical background and the approaches that are used in the design of MEMS-based sensors and actuators. The course gives an overview of microsystem technology and its applications. The course is suitable for students who aim for R&D tasks. Following issues are discussed using examples of different MEMS devices design:
  - Modelling and simulation of MEMS devices
  - Different types of transduction processes used in MEMS
  - MEMS based accelerometers
  - MEMS based pressure sensors.

- **Packaging Technologies** by Politehnica University of Bucharest, Center for Technological Electronics and Interconnection Techniques (Fig. 1).

  The objective of the course is to introduce the learners in microsystems packaging technologies, including design,
analysis, fabrication, assembling, characterization and testing. In addition, this course introduces the most recent developments of micro-/nanofabrication technologies. The course covers the research and innovation in the following major topics:

- Fundamentals of Microsystems packaging;
- Packaging materials;
- Electronic design, CAE-CAD-CAM and EDA of microelectronic systems;
- Modelling and simulation of electronic/microelectronic structures;
- Assembling technologies based on RoHS & WEEE European Directives;
- Measurement, characterization and testing of Microsystems.

- Thermal Management of Microsystems by the Technical University of Sofia, Department of Microelectronics.

This course deals with effective thermal management of highly miniaturized system-on-package (SOP)-based systems (Fig. 2). The learners will be able to define the most appropriate method of design and packaging of different Microsystems for effective heat evacuation and minimisation of the hot spot effect; to evaluate the reliability and to identify the possible defects due to overheating in order to ensure the reliable functioning of the microsystem. The course covers the following major topics:

- fundamentals of thermal management of Microsystems;
- thermal sources in systems on package (digital SOP, RF SOP, Optoelectronic SOP, MEMS);
- fundamental heat transfer modes;
- thermal characterisation: numerical methods for the thermal characterisation; evaluation of thermal analysis software for Microsystems; experimental methods for thermal characterisation;
- thermal management technologies: passive methods of thermal management (high-conductivity packaging materials, thermal vias, heat spreader, extended surfaces, heat pipes [5]); active methods of thermal management (liquid loops, spray cooling, thermosyphon, thermoelectric cooling, etc.);
- power minimisation technologies.

- Photomasks Data Preparation by Xyalis Ltd, Grenoble.

Main goal of this course is to present the techniques used in micro- and nanocomponents photomask data preparation. This course will allow students to fully understand all the issues related to this critical step of chip development as well as the methods used to reduce both costs and delays. The course introduces the basics of photolithography and the various types of masks used. A detailed description of the multiple constraints and of all the patterns required on masks is provided:

- process control modules
- measurement structures
- alignment marks
- identification patterns
- chips

The different steps of mask data preparation will be explained:

- input data manipulation, validation, fracturing, OPC (optical Proximity Correction)
- assembly of various devices
- constraints and optimization
- inspection techniques
- repair techniques.

- Photolithography and X-ray Masking by photolab GmbH.

The course deals with all the aspects of photolithography: process control, measurement structures, alignment marks, identification patterns, and chips.

- photolithography, direct imaging, X-ray masking, alignment, metrology.

The course covers the following major topics:

- fundamentals of photolithography and X-ray masking;
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- process control modules;
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- alignment marks;
- identification patterns;
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MEMS related issues are detailed (Fig. 3). The last module gives an overview of advanced research and state of the art in photomask development.

The courses available on internet will improve the accessibility of the learning materials and the delivery of training in all contexts: at home, in the university or vocational school, and the most important - on-the-job.

V. THE APPROACH

Focusing on learning or knowledge transfer rather than performance results in people who know what to do but never do it [6]. Learning technologists must recognize that their jobs do not end with training. Learning management should be a part of the entire organization, then cycled back into the next iteration of training. Learning technologists must take an interest in - if not responsibility for - their full cycle. They need to embed performance support into the organization's infrastructure, rather than simply serve as information distribution systems. Learning technologists must recognize that their jobs do not end with training. Training systems need to increasingly model apprenticeships rather than simply serve as information distribution systems. Our learning and support systems should aspire to mimic the knowledge base and performance support help people be connected when they are mobile [8], be competent when they are inexperienced, be reflective when they are hurried, and be resourceful when they are challenged. Our system is Web-based.

VI. HOW INSTRUCTION IN PSS IS DIFFERENT FROM TRADITIONAL COMPUTER-BASED TRAINING

Computer-Based Training (CBT) systems are often set up to enforce sequencing of sections determined by the task analysis [9]. The enforcing of a sequence relies on the system keeping learner's records. The system checks the learner's record to determine if the learner has completed the required prerequisite sections satisfactorily before allowing the learner to enter a new section of the lesson.

In PSS enforcing the viewing of prerequisites is not present. It is up to the learners to determine if they need to view the prerequisites. Links to the prerequisites are provided, but viewing them is not mandatory.

Learner's records should not be kept, if at all possible. One of the main purposes for keeping learner's records is to enforce the sequencing of instruction. Because the learners choose their own sequence in PSS, there is no need to keep learner's records for sequencing purposes.

Lesson segments are as mall as possible. In PSS, the learners usually enter the instructional component to learn a specific task. The lesson segment should cover the task in a self-contained manner. The lesson component covers more information, the learner takes longer to complete the original task.

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It is easy for the learner to use the instructional component. We do not make the learner sit down and learn a specific task. The learner enters the component to learn a specific task. The lesson component covers more information, the learner takes longer to complete the original task.

The primary targets of the SysTech system are the students in engineering education and the teachers who need help people be connected when they are mobile [8], be competent when they are inexperienced, be reflective when they are hurried, and be resourceful when they are challenged. Our system is Web-based.

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education related to their further work, learning competencies necessary for the workers in ‘an intelligent organization’. So, the instruction in the training modules is designed following the PSS technology.

VII. PROJECT OUTCOMES AND INNOVATION

The main expected outcomes of the project are:

- System for on-line course development with a performance support system (PSS) for developers;
- Virtual Performance Centred Environment for Training in Micro- and nanoelectronics, and Microsystems technology;
- Training materials for 3 courses in microsystem design and technology, packaging and thermal management; Internet-based tutorials;
- Database to facilitate access to training and professional realisation of women in the sector of micro- and nanoelectronics, an d microsystems and to provide equal opportunities for women and men.

The innovation contributed by this project involves:

- new approaches to the use of existing methods: distributed performance support system

The project considers the concept of a performance support system from a new theoretical perspective in where distributed cognition and distributed learning are underlying concepts. Learners have opportunity to interact not only with particular content but also with peers, instructors and other experts.

- new products in response to existing problems: training courses in Microsystems technology

The courses are developed in response to the training needs described above.

- new processes: distributed learning

Distributed learning rather provides new perspectives and dimensions of the classical distance learning concept. Distributed learning in the context of PSS does not ignore the importance of organising learning content and its sequence, but emphasises on creating a learning environment that enables an interaction with learning resources, peers, instructors, and external experts, located at different places, with no time constraints. Learners gain a great control on constructing their learning. Distributed learning changes the role of the instructor from knowledge transmitter to coach or facilitator.

- new forms of cooperation between partner organisations: distributed curriculum.

The idea for distributed curriculum or a Virtual Technical University is not so novel. For example in USA the National Technological University is providing distance learning with distributed curricula, i.e. the departments from different universities which are the best in some area develop the corresponding course and it is delivered in a common virtual university.

In the proposed project we will apply the same approach in the development and delivery of the distributed curriculum in microsystems with the difference that we will involve not only training organisations but the main users as developers – the SMEs. The notion of distributed PSS introduces the concept of distributed instruction as we’ll. It applies embedded content management facilities with tools, templates, and guidelines for designing courses from reusable learning objects in a shared repository. The mSysTech is an open course initiative with an attempt to build a case of good practice based on the collected experience.

VIII. SUMMARY AND CONCLUSION

In this manuscript we present a work in progress within the European Community project “e-Trai ning Microsystems Technologies”. The project is aimed at implementation of innovative approaches for performance-centred learning and development of new instruments in instructional design of task-performance-centred courses for training in microsystems. At this stage in the project lifecycle we have already developed the IPCI environment with its main components, and with an integrated environment for the training materials development. Four courses are being designed and the learning materials of three courses are under development by the teachers.

As a new technology, IPCI will move the traditional teaching system to the less related to the job learning. In this project, these system have a strong potential to help the employees in corporate setting thanks to the PSS is already proved, for the students there are some doubts and we have to study the effectiveness of these systems. And we expect to learn more about the effectiveness of this approach through experiment planned for the pilot test.

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