Master Degree Modules in Nanotechnologies for Electronics

Progress Report  Public Part
Project information

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Beneficiary organisation: Politecnico di Torino
Project coordinator: Slavka Tzanova
Project coordinator organisation: Technical University of Sofia
Project coordinator telephone number: +359887775405
Project coordinator email address: slavka@ecad.tu-sofia.bg

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Executive Summary

The NanoEl project focuses on sharing the technological and human resources available at each partner university to develop teaching modules/courses in the highly interdisciplinary area of nanotechnology; certified, based on ECTS, to be used in the partners’ MSc programmes in nanotechnologies.

Its main target audiences are:
- the students in micro- and nanoelectronics. They need high-quality educational materials, and continually brought up-to-date courses, because of the essence of nanotechnologies - the most rapidly advancing sector now a day. They need education related to their further work and for the complexity of the knowledge and skills, necessary to perform successfully the tasks in this multidisciplinary science determines the needs of “practical training”.
- their teachers. They need infrastructure, modern equipment and facilities for teaching nanotechnologies, they need techniques for course delivery allowing easy changes and upgrade because of the fast developing science of the subject matter, i.e. ICT-based materials.
- university management. It is convinced of the necessity of European dimensions in higher education, particularly with regards to curricular development, interinstitutional cooperation, virtual mobility of students and academic staff, and integrated programmes of study, training and research.

From institutional point of view the targets are the higher education institutions providing accredited MSc. degrees in micro- and nanoelectronics. As no one university can afford the extremely expensive infrastructures, equipment and maintenance of clean rooms for nanotechnology, collaboration and sharing of facilities and teachers’ expertise is of high institutional interest for the universities.

The project objectives are:
- To analyse the educational needs in nanoelectronics and nano-bioelectronics through problem and job analysis, and to define the necessary knowledge, skills and competencies of engineers in the sector in terms of learning outcomes.
- To design syllabi and course content for regular and continuing education for master degrees in nanoelectronics and nano-bioelectronics based on ECTS and recognised in all partner countries.
- To develop lessons for higher order skills and learning materials for e-learning mode of delivery.
- To develop lessons for practical work in the high-tec laboratories of partner institutions as a part of the partners’ MSc degree programmes.
- To start the implementation of the joint modules/courses delivery.

There are few individual research teams, laboratories or companies that can claim to be able to respond to the technological challenges. To meet these needs in this project three European universities share infrastructure, technological and human resources and they will recognise the common, based on ECTS, certified modules, to be used in the partners’ MSc programmes in nanotechnologies.

Each course is being designed by the best laboratory/department in the field which disposes with the necessary infrastructure and facilities for practical work. They are developing e-learning courses and recording the practical work in clean rooms in
nano/biotechnologies. After a successfully passed test, the students will perform the practice in the partners' laboratories.

The learning outcomes are defined for each course with the corresponding credits after assessment, adopted by all partners. These credits will be transferred to the MSc programme in nanoelectronics at the partner university where the student is enrolled. So the universities will share their infrastructure, technological and human resources, they will recognise the common certified modules but each university will keep his autonomy regarding the national diploma delivery. The implementation of the joint courses will start during the third project year as a part of the regular curricula of the MSc degrees at each university.

The added value for the students will be in the highest quality of the specialised courses developed by the best departments in the field, the opportunity to train practical skills and competences in the laboratories with advanced equipment and facilities.
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1. **Project Objectives**

- To analyse the educational needs in nanoelectronics and nano-bioelectronics through problem and job analysis, and to define the necessary knowledge, skills and competencies of engineers in the sector in terms of learning outcomes. This objective addresses the need of definition of new skills for new jobs in nanoelectronics and the needs of improvement of transparency of qualifications.

- To design syllabi and course content for regular and continuing education for master degrees in nanoelectronics and nano-bioelectronics based on ECTS and recognised in all partner countries. This objective targets the interdisciplinary sector of nanotechnologies and the needs of closer cooperation in the university sector using the infrastructure, technology and expertise of partners' universities.

- To develop lessons for higher order skills and learning materials for e-learning mode of delivery. This objective addresses the needs of skills and competences for 'high-performance work practices' in the new work organisation.

- To develop lessons for practical work in the high-tec laboratories of partner institutions as a part of the partners' MSc degree programmes. This objective addresses the need of sharing an expensive infrastructure, clean rooms maintenance, technology and even experts in all fields for effective education in the multidisciplinary science of nanotechnology.

- To start the implementation of the joint modules/courses delivery. This objective addresses the necessity of striking a balance between what is offered in the educational system and what is needed in the sector.

Teachers and managers are being involved in the need analysis, in the learning outcomes definition and in the whole process of syllabi, content and learning materials development and delivery process. They were involved in the definition of credits of courses with regard to the ECTS and in the elaboration of a table of reference of grades in each country.

Students from the MSc degree, especially in their first year and from the bachelor degrees in electronics which are potential users of the courses from the next year were involved in the need analysis and in some tests of e-learning prototypes.

The implementation of the joint modules/courses delivery will start during the third year of project lifetime with the pilot test and as a part of the regular curricula (the elective specialised courses) of the MSc degrees at each partner university.

The added value for the students will be mostly in the highest quality of the specialised courses developed by the best departments in the field, the opportunity to train practical skills and competences in the laboratories with advanced equipment and facilities.
2. Project Approach

Because of the differences of National lows in each country, we considered that at this stage planning accreditation of joint or multiple MSc degrees is not realistic. So, the universities are sharing their infrastructure, technological and human resources, and they will recognise the courses/credits but each university will keep his autonomy regarding the national diploma delivery. To facilitate the implementation of the results during the project lifetime, the new courses are added to the list of electives to avoid complicated procedures of a whole curriculum change in each country.

Each course is designed by the best laboratory/department in the field with the necessary infrastructure and facilities for practical work. After successfully passing the test of the e-learning course, the students will perform the practice in the partners' laboratories, followed by practical assessment. The mobility will be no more than a week of practice.

Each course is designed for specific learning outcomes, with credits for each course unit to be given after assessment, and adopted by all partner institutions. These credits will be transferred to the MSc programme at the partner university where the student is enrolled. ECTS credits are fully recognised but the grades according to the norms of the country are still required, a system for transfer of local grades in the three countries is already set.

In e-learning materials development, a prototyping approach is used. Expert review and design walkthrough in all stages of prototypes production provide information and corresponding feedback to developers for ensuring the quality of content and usability aspects of prototypes, and they help to validate the efficiency of chosen methods and media as early as possible. Learners are involved in the evaluation process at all stages. Interviews and questionnaires to gather data on learners’ and teachers attitudes and opinions will be used during the pilot test.

Quality assurance (QA) is an integral part of the internal management of all partner institutions following the standards in the European Higher Education Area and the new courses are objects of these QA procedures. Quality management of the WPs: project evaluation by two external evaluators: one expert in nanotechnologies and one expert in educational sciences; evaluation of intermediate and final reports by LLP Executive Agency.

The last year of the project is devoted to the implementation of the joint delivery of the courses. To facilitate the implementation of the results during the project lifetime, the new courses will be added to the list of electives in September 2012 to avoid complicated procedures of curriculum change in each country. After the end of the project the services and training modules developed will be integrated in the regular MSc degrees of the partner institutions and with this purpose they are being developed.

The added value for the students will be in the highest quality of the specialised courses developed by the best departments in the field, the opportunity to study more courses from the home institution and most important – the opportunity to train practical skills and competences in the laboratories with advanced equipment and facilities.
3. **Project Outcomes & Results**

Quality assurance plan

Need analysis report with learning outcomes for each course

Syllabi of courses in:

- Microsystem design and characterization,
- Bioelectronics,
- MOS fabrication and characterization,
- Introduction to nanosensors,
- CNT as electrode materials,
- CAD for nanoscale transistors,
- ULSI devices and novel simulation techniques,
- Scanning probe microscopy applications for nanoelectronics.

First prototypes of the e-learning courses (http://moodle6.tau.ac.il/nanoel/)
4. Partnerships

There are few individual research teams, laboratories or companies that can reasonably claim to be able to respond to the technological challenges. Even the big companies in the sector work with a common use of R&D resources. No one university can afford the necessary infrastructure, clean rooms, technology and experts in all fields of the multidisciplinary science of nanotechnology.

So, to responds to the needs identified for training new skills for new jobs, in this project three (four with HEIG-VD) European universities share their infrastructure, technological and human resources and recognise the common certified, based on ECTS, modules, to be used in the partners’ MSc programmes in nanotechnologies.

The European added value is in the closer cooperation in the university sector for sharing technical and scientific high tech facilities to deliver certified courses, based on ECTS, to be used in the partners’ MSc programmes in nanotechnologies and promoting transparency of qualifications and recognition methods.

The added value of the collaboration of partners from different European countries is:

- In the content of the courses: nanoelectronics is strategic multidisciplinary science and it is in the bases of all economical sectors. The subject matter of the courses is the main contribution to the national, European and could have added value to the world education in high-technologies (proposal for a TEMPUS project in nanotechnologies with Israel was designed);

- In the new forms of co-operation between partner organisations - sharing the technological facilities and infrastructure in addition to the expertise;

- In the larger impact of results and experiences;

- In the larger opportunities for valorisation of project results.

The innovative solutions provided by this project are:

- Sharing of resources, which a single university can not afford, for improving the education in high technologies for the new jobs in nano- bionanotechnology in the LLP countries,

- Enriching the collaboration in sharing resources with – Israel and Switzerland.

- Virtual mobility: In this project the mobility is mostly virtual thanks’ to the e-learning courses and only for the practical modules a short student mobility of one week will be necessary. In traditional scheme of common degree delivery and even within Erasmus mobility programme the students need to stay 4 semesters abroad and to follow the courses delivered in their country during additional semesters.
5. Plans for the Future

The development of the Web-based learning materials in Moodle and the last video records of some lectures and of the practical work in the clean rooms and laboratories will be finalised; organisation of a workshop for evaluation of prototypes of the learning materials.

The following practical modules for practical work in the laboratories and or clean rooms of partner institutions will be developed as a part of each partner's MSc degree programmes:

- Single nanogap “in situ” fabrication and characterization
- Electronic molecules and nanowire/rods/tube characterization
- Non-invasive testing of nanodevices
- Introduction to DNA microarray technology and application to comparative genomic hybridization
- Scanning Probes Microscopy
- Remote access to CADENCE for ICs design

Student guides for each practice and videos on the clean room practice are under development.

At this last stage before the implementation of courses, training of tutors will be performed. Later the teachers from each partner university will train all tutors involved in the teaching of concrete courses in their institutions.

The implementation of the joint modules/courses delivery will start during the third year of project lifetime with the pilot test and as a part of the regular curricula (the elective specialised courses) of the MSc degrees at each partner university.

The courses developed in this project will enter from September 2012 as elective courses with the corresponding credits based on the ECTS in the regular curricula of the MSc degrees in each partner university. So, not all students will study all courses but minimum 15 students per partner institution will be involved in the pilot test. First the e-learning courses (each one for 3 months) will be delivered with distant tutoring (e-mail, Skype, Flashmeeting for group sessions). After successful test on the e-learning module of each module the learners could make the practical work in the clean rooms available in the partner universities. The student mobility will be for maximum 1 week.

The practical modules assessment will be with practical tests and will depend on the results of the tasks to be performed in the laboratory.

After successful assessment the student will obtain a certificate with the corresponding credits and the local grade of the host institution system with corresponding grade of the student's home institution system.

Questionnaires and interviews will be used to measure the students and teachers attitudes, satisfaction, to reveal problems if any and to improve the courses and the collaborative MSc degree courses delivery.
The formative evaluation will continue during the second half of the project lifetime, with learning materials production, developers and tutors training, and the implementation stage - the pilot test.

With the experiences gained and lessons learned during the pilot test, the consortium will decide whether to continue with this scheme of collaborative use of courses in the MSc degrees of each university or to apply for accreditation of the MSc programme with a joint or multiple degrees. The decision will depend on the eventual changes in the national lows of each country which today differ a lot and at this stage the accreditation of joint degree is non-realistic. During the final project meeting an exploitation agreement will be signed for the further use of courses and continuation of the collaboration at the MSc degree level. The possibilities for collaboration at PhD level will be examined during the project lifetime and decisions for collaborative tutoring of PhD students will be taken (co-tutoring between INPG and TUS exists since 2000).

The project results will be reported in journals and on national and international conferences. The on-going activities and intermediate results will be reported on conferences in education and in nanotechnology in order to obtain duly feedback and to improve the processes and products of the project, and to extend the project network with new potential users.

By the end of the project a Demo CD will be produced and a leaflet in the languages of participating countries and in English. The last month of the project an open workshop for dissemination of project results will be organised.

The experiences with collaborative MSc courses and student tutoring will be transferred to a Doctoral degree level. The practice with collaborative tutoring of PhD students by INPG and TUS started in 2000. We will work on its enlargement with Italy and the other European countries.
6. Contribution to EU policies

The project addresses the needs of training new skills for new jobs and the needs of sharing facilities and expertise in high-technologies. The problems addressed by the project and the solutions proposed are in conformity with the conclusions and suggestions of the studies financed by the EC:


The grant application clearly falls within the scope of the LLP and Erasmus programmes. It targets higher education students. It is aimed at improving the quality of lifelong learning through sharing facilities and expertise in nanoelectronics courses development where no one university can afford sufficient infrastructure and equipment.

The proposal addresses the priorities of ERASMUS curriculum development with its aim to share the technological and human resources available at each partner university to develop teaching modules/courses in the highly interdisciplinary area of nanotechnology; certified, based on ECTS, to be used in the partners’ MSc programmes in nanotechnologies. The courses clearly define and promote learning outcomes and competences in nanoelectronics (first project objective) in line with national and European qualifications frameworks, aiming at future skill needs in the sector.

We develop this project to improve the education for new competences in the new jobs in nanotechnologies and not to strive for few probable goals. With regard to the differences of national lows in each country we considered that at this stage to plan accreditation of joint or multiple MSc degrees for the next two years is not realistic.

For the knowledge and cognitive skills training the learning materials are ICT-based and the content is based on the last research results and practices in the most rapidly developing science. The e-learning allows virtual mobility of students and easily update of the contents which should be innovated every year. It addresses the priority to use ICT tools for student mobility and the programme objective to develop innovative ICT-based content.

All project objectives, activities and results would support the achievement of the European Area of Higher Education.