

Training New Skills for the New Jobs in Nanotechnologies

Final Report

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Project information

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Executive Summary

The NanoSkills project is intended to support the development of sectoral qualifications system and frameworks by definition of qualifications of engineers and technicians in nanotechnologies in terms of learning outcomes to promote transparency and recognition of vocational education and training (VET).

Its main target audiences are:

- professionals from SME in electronics and microsystems, who permanently wish to develop their competencies through recurrent education, working on projects and inspiring networks of peers;
- engineers from other sectors, e.g. from the chemical and biological sector, to be re-trained for the designing of electronic and optical components in particular in nano-optics and nano-electronics.

This project targets the sector of electronics' design and manufacturing and most precisely the nanoelectronics and nano- bioelectronics. From institutional point of view the targets are the VET providers, HRD departments at the enterprises in the sector of nanotechnology and higher education institutions providing practice-related vocational education in micro- and nanoelectronics.

The project objectives are:

- Networking of project partners from SMEs, VET organisations, universities and social work institutions to share ideas, methodologies and experiences in order to improve the quality of the continuing VET to face the rapid technological change in the sector of nanotechnologies.

This objective addresses the needs of more responsive VET to the needs of the labour market.

- Analysis of labour market needs in nanoelectronics and nano-bioelectronics through problem and job analysis, and definition of necessary knowledge, skills and competences for engineers and technicians in the sector in terms of learning outcomes.

This objective addresses the need of definition of the new skills for the new jobs in nanoelectronics and the needs of improvement of transparency of qualifications.

- Development of Web-based training courses with modular structure to be used on-the-job as a performance support and just-in-time.

This objective addresses the needs of more flexible and modular training and the needs of new skills for 'highperformance work practices' in the new work organisation.

- Design the evaluation of learning outcomes of knowledge, skills and competences and perform a pilot test with quality assurance procedures based on EQARF and related to the certification process and the European Credit system for VET.

This objective addresses the needs of recognition of both, formal and non-formal learning in the sector.

The project brought together VET providers, higher education (HE) institutions, SMEs, professional organisations (http://www.sitelesc.fr/default.asp?cat_id=27) to assess future skills needs and promote business input into course design, as stated in the "New Skills for New Jobs" initiative and to develop special courses for upgrading knowledge in the sector of nanoelectronics technologies.

Through job analysis the necessary knowledge, skills and competences in nanotechnology engineering were defined. For the learning outcomes defined nine courses for the new skills in nanotechnology training were developed:

- Microsystems design & characterization
- Next generation lithography
- Nanoscale sensing elements and device production
- Impact of nanometric effects on ULSI system performances
- Design of nanoscale MOS ICs
- Nanomaterials for electronics
- Organic thin film devices
- Carbon nanotubes for field emitter (cold cathode) applications
- Scanning probe microscopy applications for nanoelectronics.

Each course was designed by the best laboratory/department in the field which dispose with the necessary infrastructure and facilities for practical work. There are e-learning courses and m-learning performance support modules. In the clean rooms paper based job aids cannot be used, neither laptops. Only smart phones are allowed and that was the reason to develop m-learning modules for support materials of the practical training in clean rooms.

Credits for each learning outcome were determined and specific tests were designed for recognition of formal and non-formal learning.

The implementation of the joint modules/courses delivery started in the third year of project lifetime with the pilot test followed by the field trial. The pilot test was conducted with small groups of learners from the SMEs and partner universities – a total of 21 trainees. The usability and the pedagogical effectiveness were measured with the usability and reflective questionnaires developed.

In the field trial more than 350 persons have used the courses, of which 90 are trainees from the industry and others are students. They were from SMEs, professionals with different from microelectronics background, students from the last year of their MSc degree in electrical engineering. In the field trial students from MSc degrees in nanoelectronics from the partner universities were involved and comparison, adjusting of credits in HE and VET was made. Tests of the ECVET application to VET qualifications and recommendations how to enhance permeability and progression between VET and practice-oriented HE were done.

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1. Project Objectives

- Networking of project partners from SMEs, VET organisations, universities and social work institutions to share ideas, methodologies and experiences in order to improve the quality of the continuing VET to face the rapid technological change in the sector of nanotechnologies.

This objective addresses the needs of more responsive VET to the needs of the labour market.

- Analysis of labour market needs in nanoelectronics and nano-bioelectronics through problem and job analysis, and definition of necessary knowledge, skills and competences for engineers and technicians in the sector in terms of learning outcomes.

This objective addresses the need of definition of the new skills for the new jobs in nanoelectronics and the needs of improvement of transparency of qualifications.

- Development of Web-based training courses with modular structure to be used on-the-job as a performance support and just-in-time.

This objective addresses the needs of more flexible and modular training and the needs of new skills for 'high-performance work practices' in the new work organisation.

- Design the evaluation of learning outcomes of knowledge, skills and competences and perform a pilot test with quality assurance procedures based on EQARF and related to the certification process and the European Credit system for VET.

This objective addresses the needs of recognition of both, formal and non-formal learning in the sector.

The target users were involved in the survey for the need analysis, in the job analysis and learning outcomes definition. The selection of courses to be developed was done with regard to the analysis of training needs. The target users were involved in the evaluation of syllabi and e-learning materials as well.

The expected impact on the target users is: the opportunity to have certified training of new skills for the new jobs in nanotechnologies; recognition of learning outcomes achieved in formal and, where appropriate, non-formal contexts; on the VET system: contribution to the ECVET creation, promotion the progression from VET to HE.

2. Project Approach

The main target groups, professionals from SME in electronics and microsystems, engineers from other sectors, e.g. from the chemical and biological sector and university trainers were involved in all stages starting from the survey for need analysis.

Nanoelectronics is a new science and it changes every 3-6 months. The physical principles, effects used in nanoelectronics are different from those in microelectronics, even the materials used are new instead of those with traditional semiconductor devices. So, a) there is no one training organisation competent in all areas of nanoelectronics, and b) there are no existing courses available or if any, at least 50% of the content should be updated every year. The project partners - training providers defined the areas/topics in which they would be able to provide training and a corresponding list of topics was proposed to the users.

Enterprises in the sector of micro- nanoelectronics were reached to participate in the on-line survey for needs analysis and competences definition (including the largest companies in the sector: ST Microelectronics, NXP (Philips), E2V, ATMEL, Infineon (Siemens) as well the universities providing training in this area. We have collected 85 answers. If we consider that most of the answers have been provided by managers leading large teams, the analysis should cover the needs of about 14500 persons. About 40% of the persons who answered the questionnaire are group leaders or general managers. Repartition of others is almost homogeneous between technicians, engineers and teachers.

The qualifications in the sector were defined with the involvement of users - the enterprises and the professional organisation. Definition of knowledge, skills and competences was done by job analysis with involvement of SMEs. In learning outcomes definition the instructional designers worked with the professionals and managers as well. They were consulted on the assessment methods for non-formal learning outcomes of engineers and other professionals to obtain new qualification in nanotechnologies.

Each course was designed for specific learning outcomes, with credits to be given after assessment, and adopted by all partner institutions. In e-learning materials development, a prototyping approach was used. Expert review and design walkthrough in all stages of prototypes production provided information and corresponding feedback to developers for ensuring the quality of content and usability aspects of prototypes. Trainees were involved in the evaluation process at all stages. Interviews and questionnaires to gather data on learners' and tutors' attitudes and opinions were 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 an external evaluator.

The last year of the project was devoted to the implementation of the courses. The pilot test was conducted with small groups of learners from the SMEs and partner universities – 21 trainees. The usability and the pedagogical effectiveness were measured with the usability and reflective questionnaires developed.

In the field trial more than 350 persons have used the courses, of which 90 are trainees from the industry and others are students. They were from SMEs, professionals with different from microelectronics background, VET students wishing to continue their studies in HE institutions and students from the last year of their MSc degree in electrical engineering. In the field trial students from MSc degrees in nanoelectronics from the partner universities were involved and comparison, adjusting of credits in HE and VET was made. Tests of the ECVET application to VET qualifications and recommendations how to enhance permeability and progression between VET and practice-oriented HE were done.

3. Project Outcomes & Results

- Need analysis report. Enterprises in the sector of micro- nanoelectronics were reached to participate in the on-line survey for needs analysis and competences definition (including the largest companies in the sector: ST Microelectronics, NXP (Philips), E2V, ATMEL, Infineon (Siemens) as well the universities providing training in this area.
- Competence matrix with the learning outcomes of nine courses with learning outcomes for each course in English, French, Bulgarian, Italian and German.
- Syllabi of nine new courses in English, French, Bulgarian, Italian and German:
 - Microsystems design & characterization,
 - Next generation lithography,
 - Nanoscale sensing elements and device production,
 - Impact of nanometric effects on ULSI system performances,
 - Design of nanoscale MOS ICs,
 - Nanomaterials for electronics,
 - Organic thin film electronics,
 - Carbon nanotubes for field emitter (cold cathode) applications,
 - Scanning probe microscopy applications for nanoelectronics.
- Nine e-learning courses (www.nanoskills.eu/elearning)
- Instructional videos on clean room procedures and lectures video recording
- Establishment of video infrastructure for video streaming and storage
- Three m-learning modules for the practical training in clean rooms:
 - Microsystems
 - Photolithography
 - Nanosensors
- Measurement instruments: usability questionnaire and reflective questionnaires
- Assessment tests
- Implementation report
- Evaluation reports
- Exploitation agreement
- Seven papers published:
 - Morey-Chaisemartin P., Tzanova S, Schintke S., Demarchi D., Barokas J., Wleklinski F., Melique J.-M., Beisser E., Industry needs analysis for developing new skills in nano-electronics, European Workshop on Microelectronic Education (EWME 2012), 9-11 May, 2012, Grenoble, pp. 74-76.

- Tzanova S., Schintke S., Demarchi D., Moreys-Chaisemartin Ph., Training new Skills for the New Jobs in Nanoelectronics, International Spring Seminar on Electronics ISSE 2012, May 9-12, Bad Ausseen, ISBN 978-3-85465-015-7, CD-ROM.
- Dzhenkov, Y., Image Intensifier Power Supply, International Spring Seminar on Electronics ISSE 2012, May 9-12, Bad Ausseen, ISBN 978-3-85465-015-7, CD-ROM.
- Tzanova S., Schintke S., Demarchi D., Moreys-Chaisemartin Ph., An European Project on Web-Based Education in Nanoelectronics, Proc. of Web-Based Education WBE 2013, 13-15 Feb., Innsbruck, pp. 832-838.
- Kafadarova N., Stoyanova-Petrova S., Some Practical Considerations in mLearning Content Development, Proceedings of INTED2013 Conference, 4-6 March 2013, Valencia, pp.4743 – 4748.
- Tzanova S., Delova M., Schintke S., Demarchi D., Morey-Chaisemartin Ph., Barokas J., Web-Based Training for the New Skills for New Jobs in Nanoelectronics, Proc. of Information Communication Technologies in Education, 1-4 July 2013, Crete, poster.
- Stavrov V., Shulev A., Hardalov Ch., Todorov V., Roussev I., All-silicon Microforce Sensor for Bio Applications, Smart Sensors, Actuators, and MEMS VI, 24-26 April 2013 Grenoble, France, Proc. of SPIE Vol.8763 87630Y-1-6.
- Demo CD
- Demo of video-recorded training materials in YouTube:
<http://youtube/NoqXTX5FJv4>
- Project leaflets in all partner languages

The last month of the project an open workshop for dissemination of project results was organised.

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 or training organisation can afford the necessary infrastructure, clean rooms, technology and experts in all fields of the multidisciplinary science of nanotechnology. The NanoSkills project brought together VET providers, higher education (HE) institutions, SMEs, professional organisations to assess future skills needs and promote business input into course design, as stated in the "New Skills for New Jobs" initiative and to develop special courses for upgrading knowledge in the sector of nanoelectronics technologies. The project has an important geographical coverage: partners from France, Germany, Italy, Bulgaria, Israel and Switzerland.

The European collaboration of developers, trainers, users from the labour market, social partners in the development of courses for these new jobs in nanotechnologies is the main contribution to the national, European and could have added value to the world vocational training because:

- the interdisciplinary science of nanotechnology requires collaborative approach, and no one laboratory can afford all facilities and expertise in this new sector;
- sharing knowledge and expertise on European level has been done;
- it supports the development of the ECVET system and the EQF;
- the results can be exploited not only all participating countries but through the Eurotraining programme – disseminated in all European countries.

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- and bionanotechnology in the LLP countries;
- Enriching the collaboration in sharing resources with Israel and Switzerland which are also partners in the NanoSkills project. Again about the participation of the Switzerland.

5. Plans for the Future

With the experiences gained and lessons learned during the pilot test and field trial, the consortium decided to continue with this scheme of collaborative use of courses. The e-learning environment will be maintained on the servers of eWorks and the videos on the servers of TAU for one year. All partners – developers of courses can host a copy of the whole system on their own Web infrastructure.

On the last project meeting the partners signed an agreement for the intellectual property rights. The e-learning courses will be used by all partners with a written agreement of the developer/responsible for the course. The practical training courses in clean rooms will be provided by the corresponding partners on a commercial basis.

The project partnership was enlarged with involvement of VET and HE providers from other sectors and co-operation with other Leonardo and Erasmus projects was established to transfer the project results, to continue the collaborative ECVET creation and to facilitate the compatibility, comparability and complementarity of ECTC and ECVET and to improve the validation of non-formal adult learning outcomes, within the learning community in Europe.

6. Contribution to EU policies

All project activities and results support the achievement of the European Area of Life Long Learning. The project targeted vocational education and training sector of LLP. It supported the improvements in quality and innovation in vocational education and training systems, institutions and practices by:

- increasing the cooperation between institutions providing learning opportunities to enterprises, social partners and other relevant bodies throughout Europe;
- developing training of vocational skills considering the labour market needs in the new jobs in nanotechnologies;
- fostering the integration of learning with working life by promoting ICT-based on-the job training;
- improving the transparency and recognition of qualifications and competences, through description of qualifications in nanotechnologies in terms of learning outcomes; contributing to the development of ECVET by defining credits for learning units and mapping the HE and VET. The patterns of interaction and integration are considered in national education and training contexts and at European level between ECTS, ECVET, EQF and the EHEA-QF.

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:

- “New Skills for New Jobs, matching labour market and skills needs”, Communication from the Commission to the European Parliament, {COM(2008) 868 final}
- “Investing in the Future of Jobs and Skills Scenarios, implications and options in anticipation of future skills and knowledge needs, DG EMPL project VC/2007/0866, “Comprehensive Sectoral Analysis of Emerging Competences and Economic Activities in the European Union”. Lot 7, Sector Report, Computer, Electronic and Optical Products, May 2009”.