Training new Skills for the New Jobs in Nanoelectronics

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Abstract: The NanoSkills project presented in this paper 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). The project brings together VET providers, higher education institutions, small and medium enterprises, professional organizations 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.

1. INTRODUCTION

Nanoelectronics is developing on highest level of research. In this most rapidly developing science which represents the ground of the e-economy and the e-society the continuous training is crucial [1]. There are very few individual research teams or laboratories or companies that can reasonably claim to be able to respond to these challenges.

In nano-era an integrated approach is needed. The interaction of innovative SMEs, universities and research organisations in the research and training actions is a key factor for strengthening the European RTD potential [2].

In the presented project we adapt the approach of the big enterprises in the sector to share the research and development facilities and expertise despite the competition (or just to be competitive).

2. WHY WAS THIS PROJECT DESIGNED

The preliminary need analysis related to the sector of micro- nanoelectronics was summarised in the introduction. Here we summarise the needs of target audiences and of the professional education.

2.1. Needs related to the target groups

The continuous professional development is a hallmark of the knowledge society. All specialists in the field of electronics need regular re-training but nanoelectronics is not just designing nanoscale semiconductor devices but the physical principles are different as well the technology. So, there are real needs of courses in nanoelectronics design and technology.

2.2. Needs related to VET

This project is designed to support the implementation of the "New Skills for New Jobs" strategy: “Nanoelectronics is a field that is still developing posing future skill needs ... The main driver of the sector is the rapid technological change. However, the VET systems do not adjust as quickly. Thus, the rapid technological progress in production is confronted with the slow absorption by the VET systems. Consequently, a modernisation of the VET system with modifications in respect to more flexible and modular training offers is essential.”

So, we need a new partnership between education and work to address the need of synergy between the education and industry, to foster the development of competencies, technological and entrepreneurial skills for the new jobs in nanotechnologies. The ICT has opened up a whole new potential to address the need
of widespread access to VET, on-the job and just-in-time.

3. PROJECT OBJECTIVES

The purpose of our project is to foster synergy and to exchange experience and resources of developers and users of vocational education and training (VET) for development of training courses in the emerging interdisciplinary sector of nanoelectronics. Its specific 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. Engineers from other sectors could follow only specific distant education courses and obtain certificates to be recruited in the nanoelectronics sector.

4. TARGET USERS

The short-time target groups concerned are the trainees:

- 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.

- educated but unemployed people (e.g. engineers, physicists, chemists) looking for additional qualification for employment.

This project targets the sector of electronics’ design and manufacturing and most precisely the nanoelectronicsand 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. As no one training organisation can afford the extremely expensive infrastructures, equipment and maintenance of clean rooms for nanotechnology, collaboration and sharing of facilities and trainers’ expertise is of high institutional interest for all stakeholders.

The long term target groups are the same as the short term targets and from more VET providers and enterprises will be involved and other European countries as well.

Other users of project results will be:

- VET providers, trainers in HRD departments and university teachers in other sectors;

- managers in SME, universities and colleges;

- experts in public unemployment and social work institutions;

- producers of training materials.

They would find useful our experiences gained in the credits of learning units definition for ECVET development and the assessment methods of non-formal learning., and the lessons learnt in adjusting
VET and practice-oriented HE programmes to make them more compatible with each other. They may transfer our experiences in their sectors and using our recommendations will be developed on how to enhance permeability and progression between VET and practice-oriented HE.

5. SURVEY

To analyse the industry training needs a survey has been submitted at the European level [3] in the different countries of the project partners: France, Italy, Germany, Switzerland, Bulgaria and Israel.

We have first established a list of courses according to the miscellaneous competences available in the various universities which are involved in the project. The courses have been selected to cover as much topics as possible in relationship with nanoelectronics. Fifteen different courses have been proposed:

- Bioelectronics
- Carbon Nanotubes for Field Emitter Applications
- Characterization and use of carbon nanotubes
- Defaults and Non-invasive Testing of Nanodevices
- Design of Nanoscale MOS ICs
- Impact of nano-metric effects on ULSI system performances
- Magnetic Microsystems applications
- Microsystems simulation & characterization
- Nano-materials
- Nano-positioning and Electrical Nano-probes for Nanoelectronics
- Nanoscale sensing elements and device production
- Nano-structures for optical and magnetic applications
- Next generation lithography
- Organic Thin Film Devices
- Scanning Probe Microscopy Applications for Nanoelectronics

In order to easily collect the feedback from all potential customers, a WEB based survey has been set up. In order to define the priorities, it was important to collect not only the feedback of each person answering the survey but also to have an idea of the number of persons involved. By the way, a manager may answer for all his related team.

Thanks to SITELESC which is partner of the project, the survey has been submitted to many representatives of the microelectronic companies including the largest in the area as (ST Microelectronics, NXP (Philips), E2V, ATMEL, Infineon (Siemens)).

We have collected 85 answers. This is a reasonable score considering the short delay we had to do this analysis in order to start courses development as soon as possible and in the time frame of the project. 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. The chart (Fig. 1) shows the repartition of the responsibility level of the persons who answered the survey.

Fig. 1. Users profile

It is important to notice that about 40% of the persons who answered the survey are group leaders or general managers. Repartition of others is almost homogeneous between technicians, engineers and teachers. We can conclude that the results from this survey are very representative of the real global needs.

After a detailed analysis of the needs (Fig. 2), both in term of interest and in term of potential trainees, a selection has been made among the proposed topics.

Fig. 2. Industry needs
The following courses will then be developed:

- Microsystems design and characterisation
- Nano structures for optical and magnetic applications
- Nanoscale sensing elements and device production
- Impact of nano-metric effects on ULSI system performances
- Design of Nanoscale MOS ICs
- Nano-materials Scanning Probe Microscopy
- Applications for Nano-electronics (Some parts of this course will be taken from Nano-positioning and Electrical Nano-probes for Nano-electronics)
- Carbon Nanotubes for Field Emitter (cold cathode) Applications. Some parts of this course will be taken from Characterization and use of carbon nanotubes.

6. WORK IN PROGRESS

The learning outcomes are being defined for each course with the corresponding credits after assessment, adopted by all partners. Each course is 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. Credits for each learning outcome unit are determined and specific tests for measuring knowledge and skills are designed and tested for recognition of formal and non-formal learning.

At this of the project Web-based learning materials are under development and professional videos of some lectures and of the practical work in the clean rooms and laboratories. The videos are made by the experts from Tel Aviv university. Live WebCasts of an event, with an interactive talkback facility, can further enhance the quality of the experience. Such a portal was built by Tel Aviv University for European NOE Nano2Life (http://n2lvip.tau.ac.il) and maintained during the whole life cycle of the project. The site as it is at the moment content around 300 lectures on Nano bio topics.

One of the laboratories developed in NanoSkills, based on live recording, is the experimental fabrication of nanogaps. In this laboratory custom electronic boards are used as control of the fabrication of the nanogaps. These boards are connected to a silicon chip, where some gold wires are pre-deposited, in which the nanogaps are created by electromigration. All the fabrication process is controlled by software application. So, in the laboratory different parts are present: PCB boards, a silicon chip and a software control.

![Fig. 3. Screenshot of a WEB based Lab](image)

Tests of the ECVET application to VET qualifications and recommendations how to enhance permeability and progression between VET and practice-oriented HE will be done. So the universities are being sharing 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.

7. WHAT IS INNOVATIVE

The innovations that the project offers are:

- The content of the courses: nanotechnology is an emerging multidisciplinary science and new jobs in the sector require new professional skills.
- New approach - collaboration of different stakeholders:
  
  1) training providers and users (SMEs and professional associations) to develop vocational skills considering the labour market needs and
  
  2) VET and HE providers to contribute to the improvement of transparency and recognition of competences and qualifications and to make them more compatible with each other and to facilitate and promote progression from VET to HE.

- Recognition of qualifications and competences in the sector, including those acquired through non-formal and informal learning through assessment procedures of learning outcomes;

- Enriching the collaboration of LLP countries with Switzerland and a third country – Israel.

8. SUMMARY

In this manuscript we presented a work in progress within the European community project “Training new skills for the new jobs in nanotechnologies”. At this very early stage in the project lifecycle we have defined the learning outcomes and selected the first courses and their design is under development.

The main 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 and informal contexts; on the VET system: contribution to the ECVET creation, promotion the progression from VET to HE.

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