Internationalised Master Degree Education in Nanoelectronics in Asian Universities

Slavka Tzanova
Department of Microelectronics
Technical University of Sofia
Sofia, Bulgaria
slavka.tzanova@tu-sofia.bg

***Abstract*— The paper presents a collaborative development of new courses in nanoelectronics, the most rapidly developing science now a days. It addresses cross cultural international issues and sharing facilities and expertise in nanoelectronics. Partner universities from Israel and Malaysia, India and China together with the European partners from Italy, Norway and Bulgaria (Hindus, Muslims, Jews, Buddhists, Christians) collaborate very well and the curriculum is a result of cooperative work of all partners. In the NanoEl-Asia project apart of the innovation of curricula through application of the EU approach in curriculum design (learning outcomes, credits etc.) we show how the people from different cultures and religions can collaborate successfully in the knowledge society.**

Keywords—engineering education, collaborative course development, nanoelectronics, nanotechnologies, open educational resources

I. INTRODUCTION

Every major world economy has identified the areas - nanotechnology, nanoelectronics, new materials, alternative energy, and bio-electronics - that will drive innovation and economic growth. The most fundamental driver is modernization of education in these areas.

The development of master courses in nanoelectronics is concerned with the development of curricula that meet and exceed performance expectations for engineering and high-tech industries. The developed curricula are based on the direct link between fundamental knowledge and specific examples of its application taken from up to date research and industrial challenges and solutions.

II. NANOEL-ASIA PROJECT

The project aims modernisation of curricula in China, Malaysia, India and Israel through sharing facilities and expertise in nanoelectronics courses development where no university can afford sufficient infrastructure and equipment. The Internet courses developed within the project provide new opportunities for cooperation between Asian and European academia in sharing of knowledge and educational resources.

The cultural differences are an advantage of our project. All project partners from different cultures and religions are working very well as a team and the cultural differences are enriching our collaboration.

This project's focus is on common courses development for the new skills needed for the new jobs in the multidisciplinary nanotechnologies for electronics. As a complement to partner countries' development strategies (these are the countries, non-members of European Union that can participate in Competence Building in higher Education projects, financed by the European Commission), the needs in European level are best identified in the Agenda for new skills and jobs (Strasbourg, COM (2010): "In knowledge-intensive and growing sectors such as nanotechnology, there will be even greater demand for scientists skilled in more than just one area of research. " and "The studies in this area (nanoelectronics) point to the urgent need to further develop scientific education and training with a particular stress on interdisciplinarity." And the conclusions of DG EMPL project "Investing in the Future of Jobs and Skills… for the Computer, Electronic and Optical Products Sector" (2014): "For some job functions special courses are needed. It is necessary to strike a balance between what is offered in the educational system and what is needed in the sector."

A. Background

NanoEl project is a continuing work. In the "Education in Nanotechnologies", a Tempus project with five Nano-centers from Israel, Italy, France and Bulgaria we designed the model of the shared learning environment, we developed new multimedia materials and piloted the collaborative delivery of courses and obtained good experimental data [11]. Both, the European and Israeli partners were very satisfied by the results of EduNano and enthusiastic to enlarge the collaboration with the Asian countries with developed industry in nanoelectronics.

In the EduNano project, the curricula in sciences have been modernized, in pharmacology, biology, electronics, chemistry, physics. In the new project, the focus is on the most rapidly developing applied science – the nanoelectronics.

B. Project Objectives

- To perform a detailed need analysis of the nanoelectronics industry (job analysis) and higher education (problem analysis) and to define the competence matrix with learning outcomes for the engineering jobs in the sector.
- To design curricula and develop learning content and tests to measure knowledge and skill for the defined learning outcomes.

- To record laboratory experiments in the clean rooms and to create videos of lectures and HTML theoretical courses.
- To design and develop innovative on-line educational modules for the innovated curricula of Partner countries higher education institutions and to install a system and define procedures for knowledge sharing between Asian and European teachers and learners.
- To start the exploitation of the systems and innovated curricula through pilot test and field trial during the last twelve months of the project.

The innovative character of the curricula, which are being implemented at the partner countries' universities, combine studies of the design of nanoelectronic devices, processes and manufacturing operations which integrate current research from various areas of nanoelectronics manufacturing [3, 5, 6]. The participating faculty members are able to draw on research expertise in the fields of solid state physics, design of nanoscale integrated circuits, nanomaterials, applications for superconductive materials, manufacturing processes. Both the development of new tendencies in micro and nano-electronics demand a thorough knowledge of basic engineering and scientific principles. The main innovating elements of the project are use of new approaches and EU – based methodology (course development for learning outcomes, use of ICT in education), online resources, interactive teaching, transition between the different systems of education and training at national level.

III. Development of New Courses

A. *Educational Need Analysis*

Through domain/job analysis the necessary knowledge, skills and competences in nanoelectronics were defined in terms of learning outcomes. A survey on the necessary competencies was developed by TUS and evaluated by the partners first, on-line, and then peer-reviewed during the second project meeting [1]. The survey was distributed to more than 40 institutes and around 100 researchers in India, to researchers and companies in Malaysia, India, China and in Israel in order to meet the labor market needs and the needs of the researchers/teachers to help provide students with the most relevant skills and competencies in this field. There were three questionnaires, one for the industrials, the second one for teachers and the third one – for students [2].

The questionnaire for industry and researchers was to define the contents to be taught. Teachers were asked about the methods and techniques they know or they would like to learn to use in on-line courses. The students were asked about their experiences and attitudes towards e-learning and their expectations. The need analysis report is one of the project outcomes.

As evident from the online feedbacks obtained, open educational resources (OERs) have not been so popular with the Indian students, however the blend of engineering with biology in nanotechnology as well as its social and ethical aspects were appreciated well by the scientific fraternity as well as the students. With the boom in nanotechnology and Nano electronics in the biomedical and healthcare sector the need to understand biological nanomachines as well as realize their impact of the society as well as establish ethical approaches has added value to the course and would enable students from basic sciences as well as engineering to understand the concepts well.

According to the need analysis and towards the learning outcomes defined, the syllabi of 22 courses for the new skills in nanoelectronics were designed and credits for each course were determined. With this the second project objective was also achieved. The syllabi of courses are downloadable from the project website at http://nanoel-asia.eu/Outcomes.html.

To achieve the third project objective, during the third project meeting, the leader of the workgroup on e-learning materials made a demonstration of e-learning course developments in Moodle. A short training video was also recorded and published in YouTube. A training workshop on the video-recording technique and publishing in Moodle environment is planned for the next meeting.

B. *Collaborative Development of New Open Educational Resourses*

The NanoEl-Asia project promotes very successfully the internationalization of higher education through collaborative development of curriculum by partners with very different cultures and religions. Their students will follow the courses developed and supported by the teachers from other institutions and from other countries. We develop the curricula in line with Bologna principles and tools. In all participating countries the 3-cycle system is implemented but the definition of learning outcomes that we apply in the course development is new for the Partner countries' teachers. The approach is student centered and the method and techniques to teach correspond to the students' needs and expectations defined by the need analysis. Each course is with credits, compatible with ECTS in order to allow future mobility of students.

A first collaborative NanoEl course, "Bio-Nano Electronics and BioMolecular Computing", developed in cooperation by Bar Ilan University, Politecnico di Torino and Tel Aviv University, with the addition of an external contribution by EPF Lausanne, has been officially recognized by the PhD Schools of Politecnico di Torino and Tel Aviv University (Fig. 1).

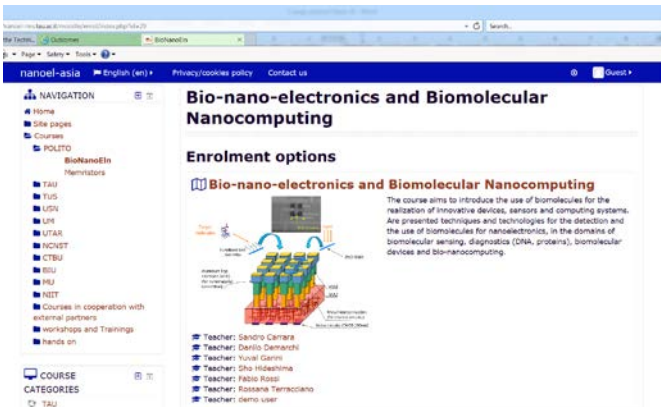

Fig. 1. The first page of the collaboratively developed course "Bio-Nano Electronics and BioMolecular Nanocomputing".

The following courses are developed with different e-learning materials:

- Microelectronics for ICT [7, 8], Design of Nanoscale MOS ICs and Nanomaterials [9-11] (Technical University of Sofia)
- Nano Materials and Nanotechnology and Materials Characterisation (University of Malaya)
- Carbon nanotube and applications and Graphene Nanoelectronics: From synthesis to device applications (UTAR)
- Top-Down ASIC Design Flow and Bio-sensing microsystems (CTBU)
- Advanced electronic devices, Introduction to VLSI circuits and Fabrication methodology for micro and nanosystems (Tel Aviv University)
- Bio-Nano Electronics and BioMolecular Computing and Memristor Technology for Cognitive Computing (Polito)
- Sensing at the Nanoscale and Nanoelectronic Device (Bar Ilan Univarsity)
- MEMS Design and Sensor Interface (University of South Norway)
- Raw materials for Nano-bio-structures and Socio-ethical and environmental aspects (Mumbay Univarsity)
- Nanotechnology for Solar Energy Utilization, Nanoelectronic Materials and Functional Nanostructures: Synthesis, Characterizations and Device Applications (NCNST)
- Introduction to Nanoelectronics: Science & Technology Basics, Nanoelectronics: Processes, Computation and Design, Nanoelectronics Systems: Future Nanoelectronic Devices and Manufacturing processes and Nanoelectronics Systems: Applications- Quality living with Smart Future, Present to Future Business Systems (NIIT University).

IV. IMPLEMENTATION

The project is on the stage of exploitation of new courses at all Asian 8 universities. The purpose of the exploitation is to ensure that the user needs are met, the project results are durably implemented, i.e. to ensure the sustainability of the project results.

The implementation of the joint modules/courses delivery started with pilot test with small groups of learners, 5 per university. There were some remarks and suggestions by the students to add more self-evaluation tests after each module, to add more explanations to some parts of the courses etc. The authors made the corresponding changes and improved the courses preparing them for the implementation – field trial. Now, during the last project year, the new courses are delivered as a part of the regular curricula of the MSc degrees at each partner university during two semesters with minimum 25 students per partner institution, i.e. with at least 275 students.

Because of the different academic curricula, not all courses are implemented in each partner university but only those corresponding to the scientific area of the corresponding curriculum.

The courses developed in this project that are not in the compulsory curriculum enter as elective courses in the curricula of the MSc degrees in the partner university. So, not all new courses will be delivered at each university but minimum 25 students per partner institution are involved in the field trial.

After successful assessment, the student will obtain a certificate from the university 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 are being used to measure the students and teachers attitudes, satisfaction, to reveal problems if any and to improve the courses.

The new courses have been already integrated in the regular curricula on nanomaterials, nanoelectronics and electrical engineering of the partner institutions. In the regular curricula of the universities the learning platform and the courses become self-sustainable. By the end of the project, an agreement will be signed by the partners for the intellectual property rights with a view of possible commercialization and of the possible use of the results only for educational purposes.

V. SUMMARY AND CONCLUSIONS

The paper presented the collaborative development of new courses in nanoelectronics, the most rapidly developing science now a day. In the NanoEl-Asia project apart of the innovation of curricula through application of the EU approach in curriculum design (learning outcomes, credits etc.) we show how the people from different cultures and religions can collaborate successfully in the knowledge society. The first half of the project lifetime has shown that our plans were realistic – partners from Israel and Malaysia, India and China together with the European partners (Hindus, Muslims, Jews, Buddhists, Christians) collaborate very well and the curriculum is a result of cooperative work of all partners.

The curriculum is composed by the courses developed by the best team in the subject matter, i.e. partners from Norway are best in microsystems and they develop the courses in microsystems; the partners from Chinese Academy of Science are best in nanotechnologies and they develop courses in technologies etc.

The expected impact is on:

- Local level: HEI will have modernized curricula and laboratories upgraded with new equipment; enterprises in the sector will have better educated engineers for the needs of the work place; young specialists better prepared for the labor market and as a result higher employability;
- National level: improvement of HE in the country following the national priorities and strategic development; the successful implementation of modernized curricula in nanoelectronics will encourage the curricular reform in other areas of HE in the country.

- Asian-EU level: internationalization of the HE; the advantages in terms of education effectiveness are course organization efficiency, instructors focusing on area of expertise, common experiences of students of different countries; learning improvement, thanks to the modernization of laboratories and curricula.

ACKNOWLEDGMENT

The project “Internationalized Master Degree Education in Nanoelectronics in Asian Universities” 573828-EPP-1-2016-1-BG-EPPKA2-CBHE-JP is co-funded by the European commission, program Erasmus+ CBHE. “The European Commission support for the production of this publication does not constitute an endorsement of the contents which reflects the views only of the authors, and the Commission cannot be held responsi-ble for any use which may be made of the information contained therein”.

REFERENCES

[1] K. Imenes, K. E. Aasmundtveit, “Educational Needs and Open Education Resources in Micro- and Nanotechnology”, IEEE Global Engineering Education Conference, Proc. of EDUCON 2018.

[2] S. Tzanova, “Euro-Asian Cooperation for Education in Nanoelectronics. Need Analysis”, Proc. of 40th International Spring Seminar on Electronics Technology, ISSE 2017.

[3] R. Gil-Ortego, M. Castro-Gil, S. Tzanova, E. Sicard, “Work in progress: MicroElectronics Cloud Alliance: The design of new open educational resources for a educational cloud”, Proc. of 2017 IEEE International Conference on Microelectronic Systems Education, MSE 2017.

[4] Gil-Ortego, R., Castro-Gil, M., Juarez F., Castaneda R., Tzanova, S., New Open Educational Resources framed in the Microelectronics Cloud Alliances Project: Strengthen the Collaboration between the Labor Market and Higher Education, Proc. of EDUCON 2019.

[5] S. Tzanova, M. Stankovski, S. Schintke, “Improvement of university teaching in micro- and nanoelectronics for the needs of the labour market”, 12th International Conference on Information Technology Based Higher Education and Training, ITHET 2013.

[6] S. Andreev, S. Tzanova, N. Spasova, Three Methods for PCB Via Metallization-Investigation and Discussion, 9th National Conference with International Participation, ELECTRONICA 2018.

[7] D. Tokmakov, S. Asenov, S. Dimitrov, “Research and development of ultra-low power LoraWan sensor node”, Proc. of 28th International Scientific Conference Electronics, ET 2019.

[7] S. Andreev, N. Spasova, “Investigation of the dielectric permittivity of anodic aluminum oxide substrates for multi-chip modules”, Proc. of 15th International Conference on Electrical Machines, Drives and Power Systems, ELMA 2017.

[8] S. Andreev, N. Spasova, D. Chikurtev, “Investigations on Heat Extraction in Multilayer PCB Structures”, Proc. of IEEE 27th International Scientific Conference Electronics, ET 2018.

[9] S. Sotirov, D. Tokmakov, “Wireless Current Measurement System Based on Integrated Fluxgate Magnetic Sensor for Isolated Current Sensing”, Proc. of 28th International Scientific Conference Electronics, ET 2019.

[10] S. Tzanova, Development of two cycle innovative curricula in microelectronic engineering: DOCMEN project, IEEE Global Engineering Education Conference, EDUCON 2018.

[11] S. Tzanova, J. Barokas, D. Demarchi, “Euro-Israeli Cooperation for On-line Education in Nanotechnologies”, Proc. of The Online, Open and Flexible Higher Education Conference, 19-21 Oct. 2016, Rome, Italy, pp. 881-892.