

Euro-Israeli Cooperation for On-line Education in Nanotechnologies

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Abstract— The paper presents a Tempus project aimed at adapting, modernising and restructuring existing Israeli curricula in Nanotechnologies; developing new certified courses, testing the innovated curricula and disseminating the results. The universities share their infrastructure, technological and human resources, they recognise the common certified modules but each university keeps its autonomy regarding the national diploma delivery.

Keywords-nanoelectronics, technology, e-learning, curriculum, Tempus project.

I. INTRODUCTION

“There’s plenty of room at the bottom,” declared physicist Richard Feynman back in 1959, in after-dinner remarks that became known as the founding “mission statement” of nanotechnology. And indeed, as the scale at which scientists work becomes smaller and smaller, a growing number of students are crowding into nanoscience degree programs.

To meet the challenges of the future, nanotechnology education needs to keep up with developments in the scientific sector. EduNano – an e-learning initiative funded under the European Union’s TEMPUS framework – is an important step in that direction. By modernizing curricula and promoting the mobility of both students and teachers, EduNano harnesses the power of distance learning to democratize the nanotechnology knowledge base, and to provide a variety of learning opportunities for different target audiences.

EduNano’s offerings – geared toward students, teachers and industrial professionals – express the multidisciplinary nature of nanoscience research. Created through a partnership of eleven academic institutions from Israel, France, Italy and Bulgaria, and relying on the wide-ranging knowledge of these institutions’ academic and technical staff, EduNano covers everything from introductory topics to the latest techniques.

II. WHY WAS THIS PROJECT DESIGNED?

This project aims at transferring knowledge between EU higher education institutions and institutions in Israel and between Israeli institutions to modernise university curricula in nanotechnologies. The project focus is on common MSc degree level courses development for the new skills needed for the new jobs in the multidisciplinary nanoelectronics and a new job organisation. The problems and the needs are best identified in [1]: “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. The shortage of European scientists may hamper growth in these sectors and result in the relocation of knowledge-intensive activities.” 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.”[2]

“Technological change also influences the organisation of work, which affects the demand for

different levels of skills. Work organisation is now characterised by decentralised decision-taking, just-in-time operation, job rotation, teamwork and multitasking. The OECD [3] has paraphrased this as ‘high-performance work practices’, emphasising that these new requirements lead to higher skill needs.” And the conclusions of DG EMPL project [4]: “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.”

The Israeli government, jointly with the Israeli National Academy of Sciences, has identified the nanotechnology as a national priority for the country and has set national goals for advancing nanotechnology in Israel to achieve critical mass and world class infrastructure. A formal initiative was appointed in the frame of Israel National Nanotechnology Initiative (INNI) to lead and guide the collective efforts and promote the research & development with emphasis on strong collaborations between academia and industry. The key to development of nanotechnology-based industry in Israel is promotion of academia–industry collaboration. That is why a new and expanded syllabus of studies at the universities was established with emphasis on gaining knowledge on broader range of areas that can complement and strengthen the nanotechnology now and in the future and lead to the continues growth and expansion of the nanotechnology in Israel.

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 (as Motorola & ST Microelectronics etc). No one university can afford the necessary infrastructure, clean rooms, technology and experts in all fields of the multidisciplinary nanotechnology.

III. OBJECTIVES

This project’s focus is on common courses development for the new skills needed for the new jobs in the multidisciplinary nanotechnologies. It is transferring knowledge between EU higher education institutions and institutions in Israel and between Israeli institutions to modernise university curricula in nanotechnologies.

Its specific objectives are:

- To analyse the educational needs in nanotechnologies 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 nanotechnologies and the needs of improvement of transparency of qualifications.

- To design syllabi and course content and assessment for regular and continuing education courses in nanotechnologies to meet the user

needs and to determine the credits for each course unit, based on ECTS.

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 select innovative content for the defined learning outcomes and video-record lectures and practical work in the high-tech laboratories of partner institutions.

This objective addresses the needs of skills and competences for ‘high-performance work practices’ in the new work organisation.

- To adapt/develop new e-learning courses with modular structure for the innovated curricula of partner universities and to establish a platform and procedures for knowledge sharing inside Israeli academy, industry and students.

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 perform a pilot test and 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.

IV. TARGET USERS

Within the presented project we target the following groups of users:

- Students in nanotechnologies in physics, chemistry, electronics, biology.

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.

- 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 international 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 education in different nanotechnologies. 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.

V. PROJECT PARTNERS

The project consortium includes highly qualified university teachers and researchers in the field of nanotechnologies, and experts in educational technology as well.

The project is based on a multilateral partnership between higher education institutions in the EU and Israel. It involves six higher education institutions from different geographical regions of Israel including all Nano centres in the country; two industrial partners, and three higher education institutions with expertise and experience in nanotechnologies and curriculum development from the EU Member States.

Conceived as a framework for interuniversity cooperation, the EduNano consortium includes six Israeli institutions – Bar-Ilan University, Ben Gurion University of the Negev, the Hebrew University of Jerusalem (HUJI), Tel Aviv University (TAU), the Technion, and the Weizmann Institute of Science – as well as Italy's Politecnico di Torino, the Grenoble Institute of Technology in France, and Bulgaria's Technical University of Sofia, which serves as the program's overall coordinator.

Universities are not the only parties participating in the EduNano initiative. Elbit Systems – an Israeli electronics firm – is actively involved, as is the Samuel Neaman Institute for Advanced Studies in Science and Technology (SNI).

“EduNano has brought academic and industrial experts together to brainstorm, share their knowledge, and promote a new, interactive conversation for the betterment of society,” says Dr. Ron Blonder, Senior Scientist at the Weizmann Institute's Department of Science Teaching who is involved in establishing the initiative's pedagogical approach. “Through TEMPUS, the EU is expressing its conviction that education is a sound investment – one that will enable tomorrow's researchers, engineers and technicians to move nanotechnology forward.”

VI. PROJECT METHODOLOGY

The background of this project was the experience of the partners' institutions from France, Bulgaria and Italy in developing performance support systems (PSS) [5] for education and training in nanoelectronics from the Leonardo da Vinci projects NanoTrain and NanoSkills

and the Erasmus curriculum development project NanoEl. The rationale was to transfer all these experiences and successfully implemented innovations to the partner country - Israel and to develop new eLearning materials in the multidisciplinary sector of nanotechnologies. The content of the courses developed in the previous projects was selected, adapted and upgraded with new content (because the new technologies require multidisciplinary knowledge and skills, e.g. in quantum mechanics, biotechnologies etc., and the nanosystems are just emerging) for the needs of Israeli universities, VET teachers and SMEs.

Nanotechnologies cover different scientific areas not only nanoelectronics. So, in this project new courses were developed to enrich the nanotechnology curriculum: in physics, engineering, biotechnology. The topics and contents were selected according to the current needs of industry and on technological forecasts.

The engineering education involves the use and application of skills for finding solutions, making decisions, and thinking effectively, i.e. problem-solving skills [6]. So, instructional strategies and tactics for higher-level skills were used in the course design. In this project discovery inductive strategy is implemented (when it is possible from pedagogical point of view) in an interactive Web-based instruction (related most to problem-solving).

Specific tasks were designed for competences training [7], e.g. group work and tasks to manage a team or plan a new work organisation for implementation of new technology.

Each university participating in the project developed courses in its best fields of expertise and is benefiting now from courses developed by other universities in their areas of specialization. For each Nano centre to develop high quality courses for its own students is not cost effective. This pooling of resources enables the building of a repository of high quality fully online courses for the benefit of all participating Nano centres and universities.

By the end of the project we will establish a business model with the support of Israel National Nanotechnology Initiative (www.nanoisrael.org) to fund and maintain the project by the partners, so it will remain functional after the end of the funding of the project.

VII. WORK IN PROGRESS

Through domain/job analysis the necessary knowledge, skills and competences in nanotechnologies were defined in terms of learning outcomes. A survey on the necessary competencies was developed by SNI and evaluated by the partners first, on-line, and then peer-reviewed during the second project meeting. The survey was distributed to 200 Nano-companies and researchers in order to meet the industry employment needs and the

needs of the researchers/teachers to help provide students with the most relevant skills and competencies in this field. According to the need analysis and towards the learning outcomes defined, 20 courses for the new skills in nanotechnology training are under development (see the list of the courses in section "Development of programmes and courses").

To facilitate the mobility of students between institutions in Israel and Europe, to each course credits had to be provided, compatible with European Accreditation Transfer System (ECTS) requirements. To achieve these goals HUJI organized two meetings of institutional representatives including Bologna Process consultant and module coordinators. The first meeting introduced the Bologna process principles by the consultant. By the end of this meeting a general module plan was introduced. In the second meeting lead also by the consultant, each participant introduced his module structure and its logic was discussed. In addition more detailed discussions about grading system, diploma supplement and quality assurance were performed.

Syllabi of the 20 courses were designed and credits for each course were determined. The courses were developed with three different foci. First are full-semester academic courses, which will allow different universities access to the same class. These courses had to be approved by each academic program individually, and they cover introductory topics, such as physics of nano-systems, basic biology for physics students, basic photonics for non-engineering students, etc.

The second class of courses are full academic courses focusing on technology. These courses are similar to courses already existing in most universities, but they complemented and enhanced by documented demos, which will allow improved learning for students. These courses should be extremely valuable to people from the industry.

The third type of courses are of a small scope, covering a particular topic. They are used as introductory courses for graduate student training, or for people from the industry. Those courses will be most valuable in enhancing the training of users in new technologies.

To achieve the third project objective, the TAU Computing Division organised two training workshops on the video-recording technique and course development in EduNano Moodle environment. The contents for the defined learning outcomes were designed and the video-recording of lectures and practical work in the Nano laboratories of partner institutions was done.

The project Web site is: <http://edunano.eu/>. The EduNano platform address is: <http://edunano-lms.tau.ac.il/>

The access as a guest:

username: demouser

password: user1-Demo

We are on the stage of the implementation. The pilot test is being conducted with different groups of learners

from the universities, high schools and SMEs. Specific evaluation methods are used and corresponding tools designed for assessment of knowledge (e.g. multidisciplinary tests); of skills (e.g. tasks for finding solutions for new problems, or, how to find procedures to solve new problems); of competences (e.g. tasks to manage a team or plan a new work organisation for implementation of new technology).

Because of the differences of national laws in each country, we considered that at this stage planning accreditation of joint or multiple BSc or MSc degrees is not realistic. Each course was designed for specific learning outcomes, with credits for each course unit to be assigned after assessment, and adopted by the partner institutions delivering the corresponding curriculum. These credits were used for students' mobility in Europe and when the credit system will be adopted in Israel - in the regular credit transfer system of the country.

The successful students from the 6 Israeli universities had 1 week mobility in Grenoble and Torino for two practical courses in clean rooms. The practice was evaluated very high by the students, and the most appreciated was the multi-disciplinarity of the training content. "The whole experience was a great experience, and it was really mind opening to new approaches and ideas, and that was great!" "Overall it was very insightful for me to see a more engineering approach to molecular electronics. It opened my mind to new possibilities and ideas."

After successful assessment the students obtained 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 are being used to measure the students and teachers attitudes, satisfaction, to reveal problems if any and to improve the courses and the collaborative course delivery.

So, the universities share their infrastructure, technological and human resources, they recognise the corresponding to their curriculum courses/credits but each university keeps his autonomy regarding the national diploma delivery. To facilitate the implementation of the results during the project lifetime, if necessary, the new courses were added to the list of electives to avoid complicated procedures of a whole curriculum change.

Quality assurance (QA) plan was developed by the external evaluator from Open University Netherlands. Quality assessment is based on a careful procedure of self-evaluation by the institutions involved in the project followed by external evaluation by peers. The formative evaluation was done during all project meetings: peer review of syllabi, contents, video-recording procedures and multimedia materials production. Based on evaluations the project steering committee of the project made the necessary decisions and planned activities for their implementation.

VIII. INNOVATION

In this 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).

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 nanobionanotechnology in Israel and EU countries,
- Virtual mobility: In this project the mobility is mostly virtual thanks' to the e-learning courses and only for the practical modules 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.

The successful implementation of this project should lead to the foundation of a broader repository of online courses for Israeli academia in a large diversity of disciplines.

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

IX. EXPECTED IMPACT

We expect an impact of this curriculum development project on:

- the approach: in sharing facilities and expertise of 6 Israeli and 3 European universities in the new science of nanootechnology to provide the best education for the new jobs in the sector;

- the target groups: the contribution 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;

- the educational system: each university “keeping” its students and at the same time the students and the teachers profit from the collaborative curriculum; improvement of university engineering education through innovation of educational curricula with the newest scientific and technological content and clearer relationship between learning processes in the university and at the real workplace.

X. CONCLUSION

In this manuscript we presented a work in progress within the Tempus project “Education in Nanotechnologies”. As embodied in the needs analysis survey of the EduNano project, the motivation driving high-quality education in the nanosciences is the necessity to train a skilled work-force at all levels, which will be expected to assume key roles in the evolving technologies [8]. The highly interdisciplinary nature of the nanosciences places pressure on the educators to provide relevant instruction in widely-ranging fields. Suitable technical education requires a hands-on learning environment which entails well-equipped laboratories housing often expensive equipment. To achieve this, funding will need to be allocated for many programs similar to EduNano project.

We would like to conclude with the words of Dr. Efrat Bodner, administrative manager of the Institute of Nanotechnology and Advanced Materials at Bar-Ilan University: “The TEMPUS program moves beyond the traditional model of collaboration between universities. Instead, it fosters international communication between communities of teachers and students. It promotes high-level learning and collaboration that takes place dynamically, right in the classroom.”

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REFERENCES

- [1] New Skills for New Jobs, matching labour market and skills needs, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, {COM(2008) 868 final}
- [2] Eurofound, European Monitoring Centre on Change (2008), ‘The future of the European biomedical healthcare sector: Four scenarios’.
- [3] OECD Employment Outlook 1999.
- [4] 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.
- [5] Martínez-Mediano, C., Castro, M., Mileva, N.; Stoyanov, S., Kicken, W., Díaz, G., Riopérez, N., Tzanova, S., San Cristóbal, E., Martín, S., Internet-based Performance-centered Learning Environment for Curriculum Support and its application in mLearning, The Future of Global Learning in Engineering Education IEEE EDUCON 2010, April 14th - 16th, 2010, Madrid, ISBN 978-1-4244-6569-9, pp. 819-824.
- [6] S. Tzanova. An European Project for Internet-based Performance Centred Instruction in Microelectronics Proc. Conference on Educational Multimedia, Hypermedia & Telecommunications, Montréal, 2005, 215-218.

[7] Tzanova S., Codreanu N., Training Microsystems Technologies in an European eLearning Environment, The Future of Global Learning in Engineering Education IEEE EDUCON 2010, April 14th - 16th, 2010, Madrid, ISBN 978-1-4244-6569-9, pp. 113-118.

[8] Cohen S., Blonder R. and Barokas J., Online Nanoeducation Resources in Global Perspectives of Nanoscience and Engineering Education, Winkelmann K., Bhushan B. (Eds.), 1st ed. 2016, Springer, pp. 171-192.