EU 7th FRAMEWORK PROGRAMME

Call FP7-NMP-2012-CSA-6

NanoEIS

Nanotechnology education for industry and society

Grant Agreement N° NMP4-SA-2012-319054

Deliverable number: D3.4

Report on best practices for involving employers in setting up and maintaining programmes

Document Details

Due date of Deliverable: M36

Lead Contractor for Deliverable: NANOfutures ASBL -PRODINTEC

Dissemination Level: PU

Contributors:

NANOfutures asbl

PRODINTEC

CERTH

NIA

NUID UCD

AGH

PAN

Table of Contents

1. Introduction

The present document constitutes Deliverable D3.4 in the framework of the NanoEIS project entitled "*Nanotechnology education for industry and society*" (Contract No.: NMP4-SA-2012-319054).

NfA, NIA, NUID UCD, AGH and PAN have prepared this report in the framework of activities performed within Work Package 3 "*Assessment of EU education in nanotechnology*" and more specifically on T3.3 "*Analysis of the cooperation in the training process between stakeholders*".

The document aims to:

- Analyse the level and method of involving employers or focus on industry needs on the development of studies in nanotechnology in selected best practices
- Identify the barriers for cooperation in the training process across the identified courses and their influence for success
- Develop recommendations for best practice education at secondary school and university levels

This deliverable will be available to the general community due to its public nature.

2. Best practices examples

For the majority of firms, the most important link to a university is through recruitment of skilled graduates. Education and training remains one of the key roles of universities, especially in lower income countries where the lack of skilled workers is a major bottleneck hindering the competitiveness and innovative capacity of firms. A first step is to establish a consultative process whereby the voice of relevant business managers is considered in curriculum development, so that university programs better respond to industry needs.

This section enumerates the most relevant examples of best practices, both in Europe and USA and Canada, in involving the industrial employers in education programmes at university level for nanoscience and nanotechnology. The examples were extracted from the analysis of existing university offers performed by the NanoEIS project within WP3. For the final selection, it was taken into account their effect on the follow up of the graduates (analysed in Deliverable D3.3 of the project), the originality of the education strategies and the interaction with the industrial employers.

2.1 EUROPE

<u>Secondary school level</u>

The involvement of the industrial companies in nanoscience and nanotechnology programmes targeting the high school students is nearly absent. These programmes are developed and supported rather by academia and not by industry, which seems understandable, as the students at the high-school level are more likely to be interested in basic scientific input. However, starting from the study performed in WP3 (whose main results were included in deliverable D3.1), the following best practices in involving industrial companies were identified:

Local German programme in Baden Württemberg (Germany)

http://www.schule-bw.de/schularten/ (German only)

Description

Program for high-achieving students in Secondary school (Gymnasium) to promote the sciences (NST is one of the topics included). More than 70,000 students learned the one-year-long program.

Performed by:

Regional Ministry of Education, Youth and Sport

Addressed to:

Students on various academic levels. So far, more than 70,000 students have participated in this programme.

Best practices in involving industrial companies

Visits of students to industrial facilities

Nanotechnology: What a small world (Israel)

http://nano.ort.org.il (Hebrew only)

Description

An ORT Israel school network innovation for teaching nano as a full, separate subject in science classes. The project (started in 2011) is a one-year (30 hour) program for junior High Schools. Eight modules were developed (in Hebrew) for teaching the topic from its basic orientation to ELSA issues and future applications.

Performed by:

ORT Israel

Addressed to:

Junior High Schools students.

Best practices in involving industrial companies

Visit of the students to an industrial facility, where they hear a lecture and have a tour.

Contipro for Science (Czech Republic)
https://www.contipro.com/contipro/csr-education/contipro-for-science
Description
Contipro Biotech, Inc. is a company that manufactures hyaluronic acid and derived applications, located in a small town in the Czech Republic. In order to interest and train future local workers, they established a secondary school program in 2010. There are two components of the program: one is comprised of monthly lectures for school students and teachers about science and technology, given by professors from Czech universities (two to three of the lectures dealt with nano). As part of the other program component, 10 students are trained each year in an internship program in the company's R&D centre.
Performed by:
Contipro Biotech, Inc.
Addressed to:
Students on various academic levels.
Best practices in involving industrial companies
An industrial company initiated the programme. Students participating in it are trained as interns in the company.

MSc, BSc and PhD level

Since the industrial companies are more interested in attracting the workforce from graduate university students or PhD students, rather than from Secondary schools, the number of programmes involving industry at these levels is much higher. Below, the more relevant ones are described:

Science with Nanotechnology at Dublin Institute of Technology (Ireland)
http://www.dit.ie/study/undergraduate/programmes/dt227/#d.en.48984
Description
The course is a Physics and Chemistry degree with a focus on nanoscience and nanotechnology and lasts 4 years. Dublin Institute of Technology finds employment for a period of seven months for each student in an appropriate and relevant workplace, according to his or her profile. The work places comprise national and international companies and facilities. The industry placement is planned for seven months during the 3rd year of studies. The aim is to give the students relevant job experience in order to facilitate entering into the job market. In addition to the scientific modules, students will take a series of professional development modules on topics such as Entrepreneurial skills, Invention, Innovation and Commercialization Skills and the role of science and technology in society. These modules will help graduates to apply the scientific

knowledge gained on the degree in a meaningful real world manner.

Performed by:

Dublin Institute of Technology

Addressed to:

BSc students

Best practices in involving industrial companies

Industrial companies host the students as interns for seven months.

Bachelor in Microtechnology and Nanostructures by Saarland University (Germany)

http://www.uni-saarland.de/en/campus/study/academic-programmes/first-degree-programmes/m/microtechnology-and-nanostructures-bachelor.html

Description

The basic idea behind the center and the school is formation of the students in an environment of excellent researchers of various and interdisciplinary profiles with close relation to industrial companies.

The program combines fundamental aspects of physics with engineering sciences and a focus on miniaturization. The programme attaches considerable importance to developing an interdisciplinary approach to understanding and using microfabricated and nanostructured systems. The training is completed by multidisciplinary elements and general elective courses, including language courses, business-related modules and tutor activity and a project seminar.

Performed by:

Saarland University

Addressed to:

BSc students.

Best practices in involving industrial companies

- Some special or elective courses, e.g. industrial property rights, are taught by experts from the industry. The selection of courses taught with industry is supposed to expand with sensor technology, automation, nanotechnology, characterization etc.
- Although the curriculum is not developed with any formal industrial advisory board the industry the University aims to keep the course continuously updated according to indirect and direct discussions with industrial partners. The University declares that the whole programme was developed to answer the demand of the industry in micro- and nanotechnologies.
- The course allows the students to pursue their Bachelor thesis projects in an industrial envi-

ronment or in collaborative projects with industrial partners. Specifically, the university has two research institutes (Institute for New Materials INM GmbH and Centre for Mechatronics and Automation ZeMA GmbH), which are both organized as companies with limited liability (GmbH). I would estimate that up to 50% of a class complete their Bachelor´s thesis there.

- The students participate in a 8 week industrial internship before the actual start of the studies. The main idea is for students to get a first glimpse of working in industry and also some experience of working at a lower level – later on, the graduates will lead workers and should also have some experience with what it looks like from the other perspective. Note, that this is a German standard to engineering courses and this one is in a 50% an engineering type of studies.

iNANO center programmes (Denmark)

http://inano.au.dk/education/

Description

The formation of the bachelor level has a fundamental (and not applied) character and covers maths, physics, chemistry and computer science. The Master level is fully elective. By advice of the industrial members of the advisory board the course evolved from fully interdisciplinary in format similar to the BSc level, to three optional directions (nano-physics, nano-chemistry, nano-bio) so that the industrial employers could readily identify themselves with a "nano" graduate. Some courses are led by the industrial experts and the students can choose to prepare their master thesis in an industrial project led by or with a company.

At PhD level iNANO provides as one of the options for PhD study an industrial PhD Programme, which is a special, company-focused PhD project. The project is conducted in cooperation between a private company, an Industrial PhD student and a university.

There are two types of Industrial PhDs that are led by iNano.

1. Three-year industrially focused PhD project where the student is hired by a company and enrolled at a university at the same time. The company receives a monthly wage subsidy while the university has its expenses for supervising etc. covered. The PhD student works full time on the project and divides his or her time equally between the company and the university. This type is supported by The Danish Council for Technology.
2. A co-financed PhD: a grant is applied for which the company is set to contribute 1/3 of the PhD stipend. The project is of course defined together with the company. Many of these projects receive funding from the Danish Strategic Research Council or the Advanced Technology Foundation.

The industrial company-focused PhD supported partially by the government is also indicated as a good practice example.

Performed by:

Aarhus University

Addressed to:

BSc and PhD students.

Best practices in involving industrial companies

- The Center works with an advisory board formed by experts of which 2/3 comes from the industry. There is one board meeting per year where the BSc and MSc programmes structure and content are presented to the board members.
- The center collaborates with about 100 industrial companies, which interact with the students along the education process.
- In the industrial PhD programmes, the students are hired by industrial companies to perform research projects.

Swiss Master of Advanced Studies in Nano and Micro Technology (Switzerland)

http://www.nanofh.ch/nmt-master/

Description

The master course is a result of the joint effort of all the professors and lecturers of 7 Swiss Universities of Applied Science (UAS) specialized in the various fields of micro- and nanotechnology. The course is implemented with participation of institutions with internationally recognized experience in nanotechnology such as EMPA, PSI, the universities of Basel, Neuchatel and Geneva. Moreover, the program is based on partnership with industry, serving in particular the R & D needs of SMEs.

The courses consists are grouped in several modules (Micro and nanotechnology, Nanotools for surface analysis and modifications, Surface functionalisation in nanoscale, Components, Systems and Design for Nano and Micro Technology, Nanomaterials, Biological and Medical applications of nanomaterials).

About half of the students have been previously employed by the industry. About 1/3 of the participants in these courses are engineers from industry who study in parallel with their industrial career and who want to acquire particular skills or competences. About 1/5 of the participants of the courses are formally delegated by their companies. As an additional benefit of this fact, the students with no previous professional experience cooperate with peers who are active in their profession, gives you an additional important training opportunity, and provides you with a sizable network of professional relations at the end of the course.

Performed by:

Swiss Universities of Applied Science coordinated by University of Applied Sciences Western Switzerland

Addressed to:

MSc students

Best practices in involving industrial companies

- The program offers ½-time jobs in various locations compatible with the curriculum.

- The flexibility of the program allows to already employed people to follow it and acquire new skills and competences.

Joint Doctorate "NanoFar" - European doctorate in Nanomedicine and Pharmacetical Innovation and Master course on Molecular Nano and Biophotonic for Telecommunications and Biotechnology MONABIPHOT (Erasmus Mundus programmes)

http://www.erasmusmundus-nanofar.eu/

http://www.monabiphot.ens-cachan.fr/

Description

The international Erasmus Mundus programmes contain industrial partners as required by the EC.

NanoFar is related to the industrial medicine. The training environment offered by NanoFar project includes the associate industrial partners. 2-month internship in one of the associate partners is mandatory. 10% of the students are former employees of the industry. The curriculum is developed with the help of pharmaceutical, biotech industries.

Experts from the industry give courses on scale-up and drug delivery systems and Entrepreneurship / commercialization should be taught by industrial experts soon. The industrial partners offer internships and teach some of the modules. In MONABIPHOT the industrial internships are usually finalized by a Master thesis.

Performed by:

NanoFar: Universities of Santiago de Compostela (Spain), Nantes-Angers (France), Nottingham (UK) and Liège-Louvain (Belgium).

MONABIPHOT: Ecole Normale Superieure de Cachan and Institut d'Alembert (France, coordinators).

Addressed to:

PhD and MSc students

Best practices in involving industrial companies

- Internships in industrial companies.

SFI (Science Foundation Ireland) Industry Fellowship Programme (Ireland)

http://www.sfi.ie/funding/funding-calls/open-calls/sfi-industry-fellowship-programme-2015.html

Description

This programme has been designed to facilitate the bi-directional movement of academic and industry researchers, and in doing so allowing industry and academics to work closely together. The aim of the Programme is to stimulate excellence through knowledge transfer and training, allowing access for researchers to new technology pathways and standards and will facilitate training in the use of specialist research infrastructure. Fellowships can be awarded to academic researchers wishing to spend time in industry worldwide and to individuals from industry anywhere in the world (including Ireland) wishing to spend time in an eligible Irish Research Body.

Performed by:

Science Foundation Ireland (SFI).

Addressed to:

Academic and industry researchers

Best practices in involving industrial companies

- Access to state-of-the-art facilities to complement the training of industrial researchers.
- Internships of academic researchers in industrial companies.

Enterprise Partnership Scheme (Ireland)

http://www.research.ie/scheme/enterprise-partnership-scheme

Description

This funding scheme allows private enterprises and public bodies to engage in a partnership, where awards, which are co-funded (by IRC and the industrial partner) are awarded to PhD students and Post-doctoral fellows. The funding mechanism gives researchers the opportunity to gain additional beneficial experience and insight into the commercial arena while completing their research, while providing industry with access to experience and infrastructures relevant to them.

Performed by:

Irish Research Council (IRC)

Addressed to:

PhD students and Postdoctoral fellows

Best practices in involving industrial companies

- Internships of academic researchers in industrial companies.

2.2 USA AND CANADA

Associate degrees

An associate degree is an undergraduate academic degree awarded by community colleges, technical colleges, bachelor's degree-granting colleges, vocational schools, and universities upon completion of a course of study usually lasting two years.

In the United States, and some areas of Canada, an associate degree is often equivalent to the first two years of a four-year college or university degree. Due to unemployment, there is high demand for people with skills that often require no more than an associate degree, such as lab technicians, etc.

While all associate’s degree programs report some level of employer involvement, the degree and type of involvement varies from initial consultation about program design, to ongoing involvement in curriculum development, internships, funding assistance and job placement. Employer involvement in many associate’s degree programs, however, may indicate an emerging need for technician-level skill development in nanotechnology.

Center for Nanotechnology Education and Utilization (CNEU)

A major factor in their Partnership’s success and national reputation has been its Industry Advisory Board, which has guided every phase of the development of the NMT Partnership. The NMT Advisory Board is comprised primarily of representative companies in Pennsylvania that utilize nanotechnology.

CNEU supports a wide range of industry outreach activities. For example, industry representatives regularly participate in job fairs held at CNEU for capstone semester students. These job fairs are excellent forums for acquainting companies with the skills that students attending the nanofabrication capstone semester are developing and for giving the students a better understanding of how nanofabrication is used by industry.

It also offers workshops for industry. These can be tailored to industry needs or cover the general field of nanotechnology. Topics in the general workshops include: what is nanotechnology, where is it going, and how is it changing business? These workshops cover the basic fabrication approaches of nanotechnology and their use in manufacturing, current, and future directions in nanotechnology. Attendees at these workshops have been managers and technical specialists from companies using or planning to use nanotechnology. Industries attending these workshops have included semiconductor, microelectronics, medical devices, biotechnology, pharmaceutical, and materials manufacturers.

The Learning Factories of The College of Engineering at Penn State University

Learning Factories concept provides a University-Industry partnership. The industry provides sponsorship for student-design projects, which are created on demand from industrial clients with detailed specification. Such interaction enables to closely match the industry needs with the knowledge and skills provided by the educating entity.

3. Barriers identified

It is clear, not only in the field of nanoscience and nanotechnology, that when companies and universities work in tandem to push the frontiers of knowledge, they become a powerful engine for innovation and economic growth. This cooperation has been most explicitly developed in the area of research and innovation in general, thanks to the numerous initiatives seeking to encourage university-business collaboration in this area. In contrast, the promotion of business-university collaboration in the field of education has been relatively underplayed.

The reasons for this situation are diverse. In its report "*Measuring the impact of university-business cooperation*"[1], the European Commission identifies the following:

- Uncoordinated HE, STI and regional policy
- Limits to HEIs' autonomy and/or underdeveloped accountability schemes
- Limited incentives to HEIs
- Fragmented sub-national governance, weak leadership
- Intra-regional & inter-institutional competition
- Exclusion of HEIs from strategy development & implementation
- Weak management, lack of entrepreneurial culture
- Tensions between regional engagement & pursuit for world class excellence
- Lack of incentives to individuals

The main barriers to the implementation of partnerships between universities and companies in the specific field of nano education and training are described below.

Culture divide between university and industry

Even today, differing work cultures, objectives, values, and ways of moving forward continue to act as a brake on effective collaboration between the academia and the business world[2].

This cultural divide can be overcome. In a study performed by Science Business Innovation Board, which main results were included in the "Making industry-university partnerships work" report[3], the experts that contributed believe that this would require strong university leadership, faculty who understand business, and incentives and structures for academics to bridge that gap.

Minor impact on company productivity or competitiveness

Industry-university collaborations often produce interesting outcomes, especially when performing research and innovation collaborative activities, but those outcomes have minor or no impact on company

---

[1] http://www.dges.mctes.pt/NR/rdonlyres/658FB04A-909D-4D52-A83D-21A2AC4F2D38/8090/UniversityBusiness.pdf

[2] *Technopolis Group, University Business Cooperation, 15 Institutional Case Studies on the Links Between Higher Education Institutions and Business, October 2011.*

[3] http://www.sciencebusiness.net/Assets/94fe6d15-5432-4cf9-a656-633248e63541.pdf

productivity or competitiveness. Industry-university collaborations must be aligned with the company's research and development strategy and address a tangible need of the company. If not, there is high risk of investing in projects that have little or no impact.[4]

Employer involvement in degree programs is inconsistent

Employer involvement in nanotechnology degree programs varies across programs, even among those with a workforce development mission. As it was shown in section 2 of this document, the degree and type of involvement varied from initial consultation about program design, to ongoing involvement in curriculum development, internships, funding assistance and job placement. At higher levels of education, where motivations for program development are more variable, employer involvement of any kind is less common.

4. Summary and Recommendations

Nanotechnology education is still emerging. The variation among nanotechnology degree programs in everything from content, to teaching methods, to level of employer involvement is neither surprising, nor problematic. It is simply the way that postsecondary institutions attempt to deal with newly-defined areas of knowledge. With only the beginnings of consensus around the "big ideas" that are important to teach in nanotechnology there is still considerable work to be done to identify the most effective content, form and teaching methods in this area.

In addition, the value of formal degree programs for meeting employer needs is still unclear. Since many nanotechnology degree programs are new, so in consequence, little is known about the success of graduates in the labour market. Degree programs may, however, prove to be more useful as the field of nanotechnology matures.

Given that there is some reported level of employer involvement in some associate's degree programs in the USA, these degrees may be a useful tool for addressing the technician-level skill needs of nanotechnology employers. Overall, however, it is difficult to determine how important formal nanotechnology degrees are to addressing the skill and workforce needs of employers for more highly skilled workers. Previous research on the skill needs of nanotechnology employers indicates that, at least in the present job market, employers prefer to hire highly skilled workers who have earned a degree in a traditional discipline. Furthermore, while formal degree programs represent an institution-level commitment to imparting nanotechnology knowledge, the motivations for starting nanotechnology degree programs at bachelor's level and above are often not directly connected to meeting the skill needs of employers. Thus, more information on the employment outcome of graduates is needed to understand how effective various program models are at meeting the emerging skill and workforce needs of nanotechnology employers. In this respect, process studies of postsecondary education approaches in nanotechnology are particularly important to help policymakers to identify program elements that are important to foster the development of particular types of program models in the future. Finally, as new research on effective pedagogy, program structure and course content associated with nanotechnology workforce education emerges, the value of the degree program models will become more apparent.

---

[4] *http://osp.mit.edu/sites/osp/files/u8/bestpractices.pdf*

To further the goal of creating a skilled nanotechnology workforce, EU should consider supporting degree programs that have strong employer involvement. Policymakers should also promote greater involvement of employers in nanotechnology curriculum development. Evidence of interdisciplinary cooperation across departments and disciplines, as well as strong connections to nanotechnology research facilities and related programs, may also be important considerations for targeting research areas where EU may wish to direct additional assistance. Such partnerships may be important for establishing career ladders that allow students to acquire increasing levels of skill, knowledge and academic credentials over time.

As far as the nanotechnology programmes at the university level in EU are concerned according to the analysis performed within the project indicates the following best practices to be recommended

- Setting up the curriculum in consultation of the industrial employers has a detectable positive effect on the transfer of the graduates to the industry. According to D3.3. Deliverable of the NanoEIS project Report on factors favouring specific desired outcomes for nanotechnology programmes at universities prepared within this work package, the flux of the graduates to the industry and R&D companies is increased but only by 9%.
- A more direct commitment of the industrial partners in the education processes other than a mere consultation of the programme is needed to take a have a more distinct effect.
- The factor which is more effective for a successful employment of the graduates in the nanotechnology is the direct contact of the student with the industrial companies and their representatives along the education.
- The form of the contact, which is most effective, are the internships in the companies and the projects realized in or with the industrial companies, which increase (see D3.3.) the graduates transfer to the industry by 35%.
- The presence of the modules taught by the industrial experts increase by a factor of 3 the flux of the graduates to the R&D companies dealing with nanotechnology.
- The survey presented in D3.2 indicate, that the internships in companies and projects realized with the companies are most wanted and considered missing by the students and graduates, so their inclusion in the curricula is recommendable as a factor for making the programmes more attractive for the candidates.
- In order to increase the direct contacts of the students with the industry it is a recommendable practice to form a wider environment for the university courses in nanoscience and nanotechnology, including the participants from the industrial companies.