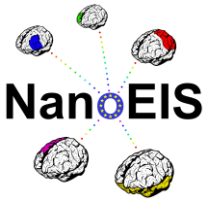
EU 7th FRAMEWORK PROGRAMME

Call FP7-NMP-2012-CSA-6



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Report on factors favouring specific desired outcomes for nanotechnology programmes at universities

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Introduction

The present document constitutes Deliverable D3.3 prepared in the framework of the project entitled "*Report on implementation strategies for nanotechnology programmes at universities*" (Project Acronym: NanoEIS; Contract No.: NMP4-SA-2012-319054).

This report has been prepared by AGH, project beneficiary number 6 and NUID UCD project beneficiary number 3 based on the activities performed within Work Package 3 "Assessment of EU education in nanotechnology" and more specifically on Task 3.2 "Education at the university level".

The document presents the conclusions drawn from the survey, which were based on the questionnaire distributed among the universities and the students. The distribution and content of the questionnaires is detailed in Appendix I.

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

We define the desired outcome of the university programme as the successful transfer of graduates to industry jobs. The strength of the EU in science related to topics and objects of the nanoscale is non-negotiable. However, most of the industrial applications of the nanotechnology are developed outside of Europe, in Far East Asia and US in particular. The successful passage of graduates to industry is a major concern for the educational programmes in EU, which strive to produce graduates that find jobs adequate for their education. The report is based on the conditional statistical analysis of the data provided by the respondents in the questionnaire survey. Some examples of implementation details obtained from the subsequent queries for programmes selected that participated in the analysis are given.

Results of the survey

The survey concentrated on the details of cooperation between the university programmes and the industrial partners and their impact on the career of graduates. 95% of the representatives that participated in the survey indicated that graduates are prepared to work in R&D companies, and 74%, 68%, 46% indicated chemical, electronics and consumer industries as potential employees (see Section 3.3 of the Report D3.2).

Nevertheless, the data provided by the respondents indicating their actual career choice suggests that most often graduates (above 41%) enter research with over 7% entering education and 5.5% getting employed as the academic staff (Fig. 1). For clarity of the further analysis, we grouped the replies to (Fig. 2):

(1) research, academia & education
(2) R&D
(3) Industries
(4) Other (including managements, finance, consulting, and other public services).

The data, illustrated in Fig. 1, shows that 54% of respondents find a career in research, academia & education, while 23% and 14% move into industry and R&D respectively.

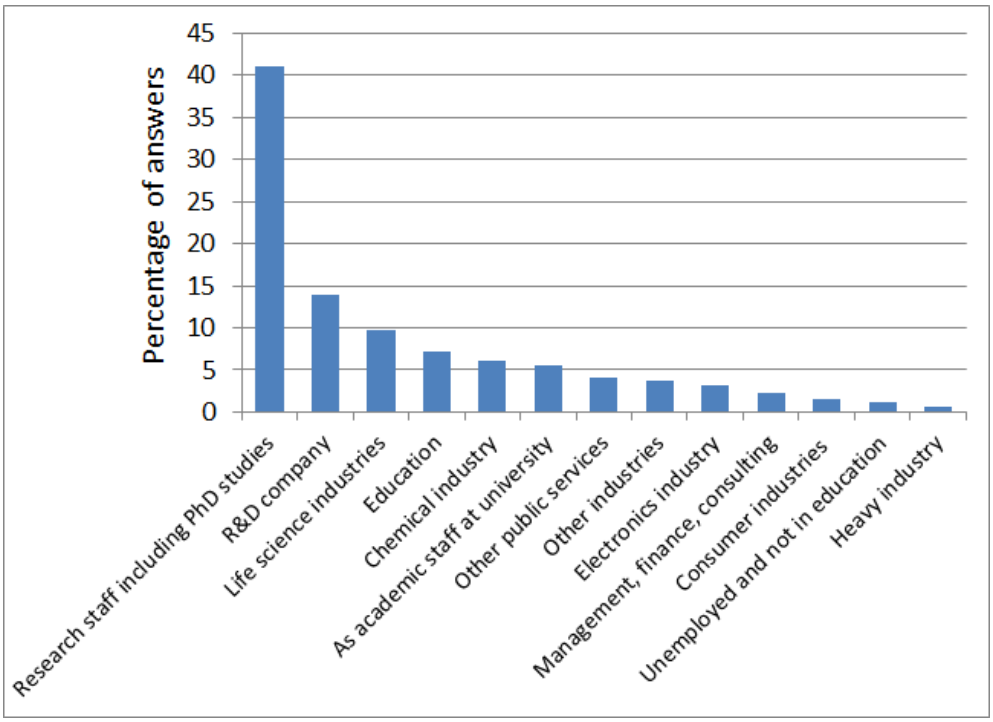

Fig. 1 *Career of graduates according to the follow-up data of the university programmes*

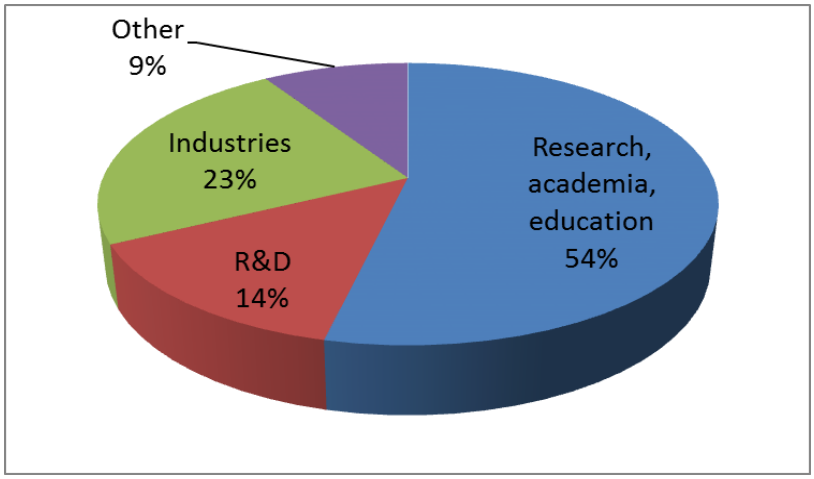

Fig. 2 *Career of graduates according to the follow-up data of graduates, the data of Fig. 1 grouped over wider categories – see text.*

The result of the survey clearly indicates that most of graduates of the university programmes in nanoscience and nanotechnology staying in research/academia/education and only a minority find employment in industry and R&D companies. This partly reflects the scientific strength of Europe and the broad opportunities to work in academia for graduates of the programs that focus with nanoscience and nanotechnology. It could also play a role that many academic programs are rather young, so many graduates may be young postdocs that later on move to industry. However, the apparent preference for staying in research, academia and education is not universal, so it is possible to identify under which circumstances a transfer to industry is much more readily undertaken.

However, the major concern that motivated the NanoEIS project and the FP7 call itself was the challenges that are faced with the transfer of graduates to industry. The present report analyses how the various forms of cooperation of the universities with the industrial companies within the educational programmes that were declared within the survey affect the future career of graduates in the context of transition to industry and R&D companies.

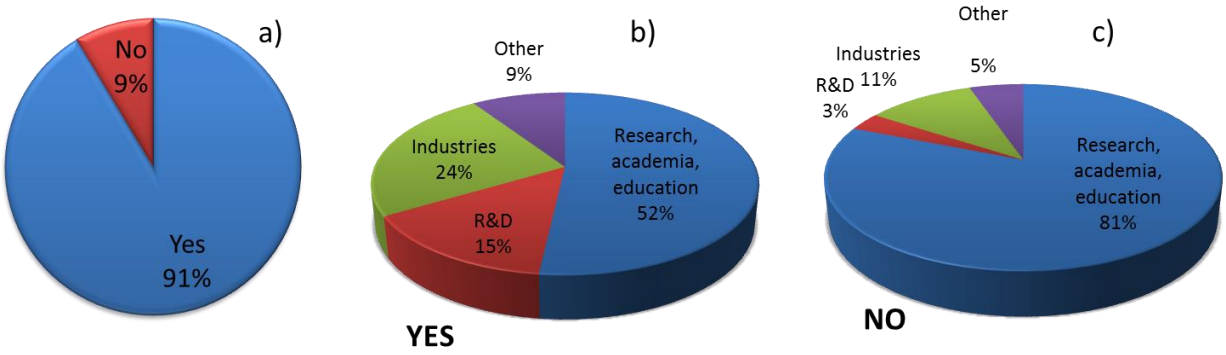

Fig. 3. (*a) Distribution of answers to question 22 of the university survey ("Does your university collaborate with industrial companies which are future employers of your graduates?"). Follow up of the graduate's career for answers "yes" (b) and "no" (c).*

The most general question on the cooperation with industry was “Does your university collaborate with industrial companies which are future employers of your graduates?” Since 32 of 35 answers to this question were “yes”, the follow-up of graduates of the programmes that gave the positive answer, [Fig. 3(b)] is nearly identical to the sample average [Fig. 2]. However, the follow up of the three programmes which declared no cooperation of their university with industry (note: the question concerned the university and not the programme itself) given in Fig. 3(c) is quite significant. More than 80% of graduates stay in research/academia and education, with only 3% and 11% of graduates working in R&D companies or industry.

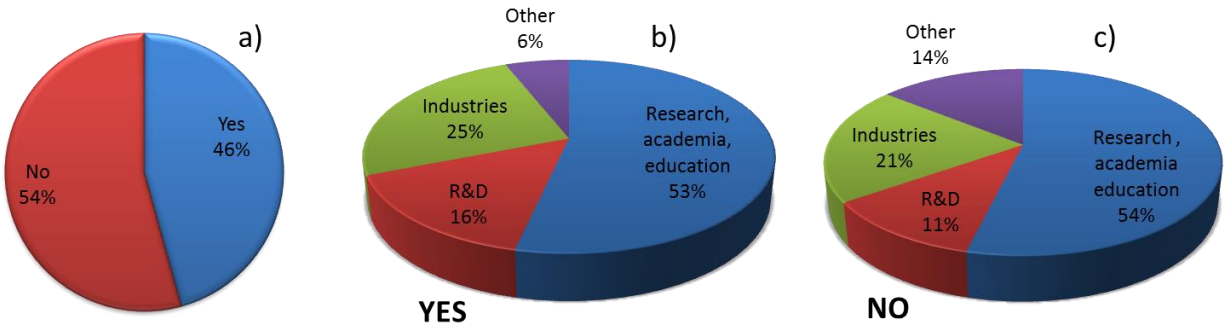

Fig. 4 (a) *Distribution of answers to question 17 of the survey (“Is your curriculum developed in collaboration with industry?”). Follow up of the graduates’ career for answers “yes” (b) and “no” (c).*

Another question of the survey concerned the collaboration with industry in setting up the curricula, which was selected by slightly less than a half of respondents. According to interviews with the respondents this collaboration is usually implemented by advisory boards with industrial stakeholders which meet on a periodic basis (once a year for instance). However, several respondents that are strongly linked to industry occasionally skip the formalisation of the consultation process [e.g.Physics and Nanotechnology by Technical University of Denmark, Microtechnology and Nanostructures by Saarland University]. Then, the curriculum is continuously updated by direct or indirect discussion / contacts of the coordinator of the programme and the teachers with the industrial partners. The industrial supervision on the content of the programme does have a distinct albeit moderate effect on the follow up. Namely, it increases the percentage of graduates pursuing their career in R&D and industrial companies by 9% leaving unaffected the flux of graduates to research and education.

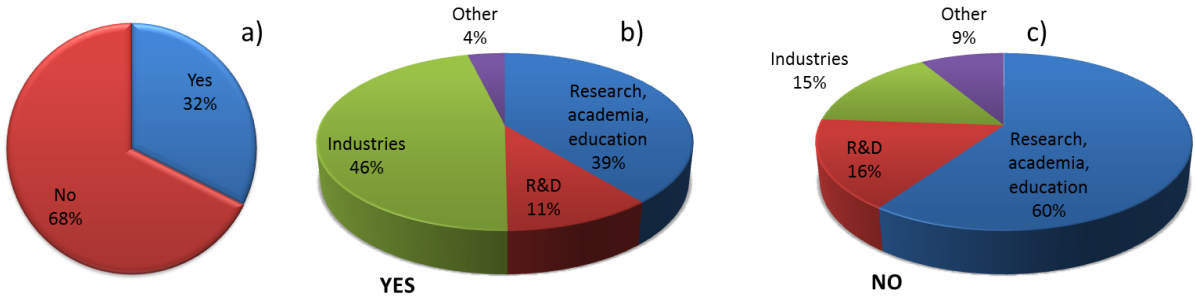

Fig. 5 (a) *Distribution of answers to question 20 of the survey ("Does your programme involve modules/courses which arose as a result of industrial demand"). Follow up of the graduates' career for answers "yes" (b) and "no" (c).*

Question 20: "Does your programme involve courses which arose as a result of industrial demand", obtained 1/3 of positive answers [Fig. 5(a)]. The programmes which are declared to react to the needs of the industrial job market have as many as 46% of the students entering industry after graduation [Fig. 5(b)] instead of 15% for the courses with negative answers [Fig.5(c)]. Remarkably, the number of graduates that are hired by R&D companies drop for the positive answer from 16% to 11%. A more drastic drop is found for the research & academia (60% to 39%). The programmes that declare to include modules/courses introduced by the industrial demand seem therefore to have a vocational character.

Some respondents [Saarland University, Dublin Institute of Technology, Swiss Master of Advanced studies in Nano & Microtechnology] indicated that the entire course is focused on the demands of industry. Otherwise, the replies for separate modules were: regulation and nanosafety (NanoFar Erasmus Mundus PhD programme, note that these competences were indeed found required and largely missing in university curricula by the NanoEIS project; see deliverable D 3.2), Nanomaterials synthesis and processing, Micro and Nanosensors, Nanoenergy, Nanophotonics, Nanofabrication and nanoprocessing (Master in Nanoscience and Nanotechnology by University of Barcelona).

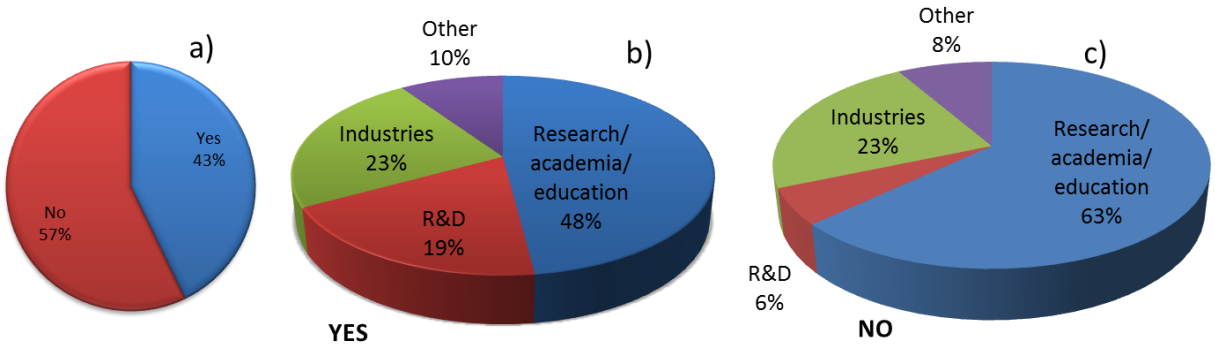

Fig. 6 (*a) Distribution of answers to question 20 of the survey ("Does your programme involve modules/courses taught by experts from industry?"). Follow up of the graduates' career for answers "yes" (b) and "no" (c).*

Question 18 concerned participation of the industrial experts in implementation of the educational programme ("Does your programme involve modules / courses taught by experts from industry?") with 43% of positive answers [Fig. 6(a)]. The effect on the careers is very pronounced,

although somewhat surprising: the percentage of graduates that are hired by the industries is left unchanged [cf. Fig. 6(b) and Fig. 6(c)]. However, when the industrial experts participate in the educational process, the percentage of graduates hired by R&D companies is tripled. In quite a few cases, the courses of Nanoscience and Nanotechnology employ or intend to employ the experts from industry to teach the legal, social and business – related modules: intellectual property rights (Saarland University, Erasmus Mundus Monabiphot), entrepreneurship, commercialisation (Nanofar).

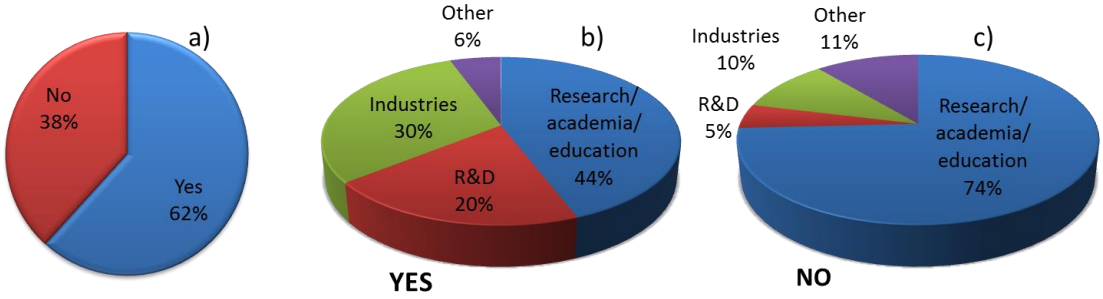

Fig. 7 *(a) Distribution of answers to question 23 of the survey ("Do your students take part in internships at industrial companies or realise projects commissioned by these companies"). Follow up of the graduates' career for answers "yes" (b) and "no" (c).*

A majority of university programmes [Fig.7 (a)] organise internships for students at industrial companies or give the students an opportunity to get involved in projects realised with or for industry. This kind of contact of the students with industry during the education has the largest impact on the career of graduates as compared to all the other implementation strategies analysed within the present survey. Industry or R&D companies [Fig. 7(b)] employ half of graduates of the programmes that implemented these practices. When the student is not offered this kind of contact with industry during their education, only 15% of graduates, find employment in R&D and industrial companies [Fig. 7(c)].

According to the interviews with the respondents, the direct personal interaction of the students with industry is based on preparing the diploma theses with the industrial partner. The internships are offered rather rarely and if are, is mostly related to the diploma theses. The internships are usually optional, but mandatory ones are also encountered (2 months by NanoFar Erasmus Mundus for instance, 7 months by Technical Institute of Dublin).

Conclusions

Concluding, the transfer of graduates in nanoscience and nanotechnology programmes to industry and R&D companies is largely facilitated when the students participate in cooperation with industry or undergo industrial internship training. This single factor was established by the present study as the most effective one for successful start of industrial carriers of graduates. Programmes that include courses taught by industrial experts produce graduates, which are three times more likely to find employment in R&D companies. Courses introduced by industrial demand to curricula increase three times the flux of graduates to industry, but reduce somewhat the one for the R&D companies. Cooperation with industry in setting up the curricula has a positive but quite limited effect on the transfer of graduates to industry and R&D companies.

Appendix I The distribution and content of the questionnaires used in the present study.

In order to gather information on:

- the university offers,

- implementation strategies

- and students feedback,

two separate questionnaires were prepared to be answered:

i) by representatives of Universities and

ii) by the students and graduates.

The questionnaires were prepared in an electronic form and made accessible online in March 2013 at the project webpage (www.nanoeis.eu). It was disseminated using different channels and tools such as NANO*futures* Platform, with more than 900 members, or the NANO*futures* LinkedIn Group. Moreover, the project coordinator gave a presentation at EuroNanoForum 2013 in Dublin advertised by NANOfutures and by AGH group as well as by other participants of the NanoEIS project.

The survey was open for 9 months (with a closing date of 31.12.2013). A total of 317 responses were received for both the student & graduate questionnaire and 43 responses were received for the universities questionnaire. Respondents from outside of Europe were not considered, leaving a data set of 139 and 35 replies for student & graduate questionnaire and the universities questionnaire, respectively.

Based on the replies obtained early by June 2013 a selection of university programmes for in depth study was performed at Milestone MS3 of the project. The analysis conducted was based on data of the questionnaire, the public data and the interviews of representatives by e-mail and by phone. The implementation strategies (details of the cooperation with the industry, the structure of the curriculum) have been also analysed and the conclusions are presented within this document. Results and conclusions obtained will be the basis for setting recommendations for best practices and preparing the report on the educational market in nanotechnology in Europe later in the project.

A.I.2 The university questionnaire

The questionnaire to be answered by university respondents contained 29 questions and was divided into four parts:

1) *general information* data that are useful for identification of the course

2) the *programme details* for the content of the curriculum

3) the *career of the graduates* for the targeted jobs and follow up of the former students of the course and

4) *cooperation with the industry*

The questionnaire started with a cover letter explaining the motivation for the survey:

Industry requires interdisciplinary competence of the employees. NanoEIS will study how such studies were developed and how they reflect the needs of the job market. Our purpose is in no way to perform an evaluation or setting up a ranking, but we are looking for the best practices and

teaching methods in the field of nanotechnology education. The project will establish recommendations for the further development of education on the university levels and on successful methods to ensure that training content is compatible with job market needs, in order to facilitate successful careers for the graduates.

The representatives of the universities responding to this questionnaire will be consulted on any data that will be published in the deliverables or reports of the project. We will not publish any information about the responding institution without the consent of the contact person that responds to the questionnaire.

Next, the questions of the query followed.

GENERAL INFO

1. General Info

University name/address

Nano programme name

Name of contact person *

Email Address *

Gender *

○ Female ○ Male ◉ Other

2. Programme type

○ BSc (undergraduate) ○ MSc (graduate) ○ PhD ○ post-graduate ○ summer school ○ e-learning ○ Other

If you are responsible for more than one level of education (BSc, MSc, PhD, postgraduate), please fill a single form per level.

3. Traditional scientific disciplines involved in your programme

☐ Physics ☐ Medicine ☐ Chemistry ☐ Electrical engineering ☐ Biology ☐ Material Science

☐ Biotechnology ☐ Mechanical engineering ☐ Other

4. What is the starting year of your programme?

5. How many students graduate your programme each year?

○ <10 ○ 10-20 ○ 20-50 ○ >50

6. What percentage of students are EU citizens?

○ <20% ○ 20-50% ○ 50-80% ○ >80%

PROGRAMME DETAILS

7. Does your programme involve cooperation with others? (e.g. departments, universities, laboratories, business schools)

○ Yes ○ No

8. Does your programme contain modules/courses taught by experts from other universities or laboratories?

○ Yes ○ No

9. Have students an opportunity to spend part of their studies at another university?

○ Yes ○ No

10. What is the place of e-learning in your course?

○ All the modules use e-learning techniques exclusively

○ Some modules use e-learning

○ E-learning is not used

11. What skills/knowledge are acquired/developed during your programme?

☐ Characterisation/Metrology ☐ Nanomanufacturing ☐ Nanostructures/Composites

☐ Health & safety issues ☐ Pilot lines/Scaling up processes ☐ Nanocoatings/Smart surfaces

☐ Regulation ☐ Communication/Education ☐ Nanoelectronics ☐ Standardisation

☐ Strategy ☐ Nanooptics ☐ Modelling/Simulation ☐ Human Resources Development

☐ Nanobiotechnology ☐ Environment/Disposal/Recycling ☐ Sales/Marketing

☐ Nanochemistry ☐ Design ☐ Management/Finance ☐ Other

GRADUATE CARREER

12. In your opinion, what are the carrier prospects for the graduates?

☐ Heavy industry (e.g. steel, oil, gas, automotive) ☐ In R&D company ☐ Electronics industry

☐ As academic staff at university ☐ Chemical industry ☐ As research staff including PhD study at university ☐ Life science industries (e.g. pharma, medical, bio) ☐ Management, finance, consulting

☐ Consumer industries (e.g. food, cosmetics) ☐ Education

☐ Other industries ☐ Other public services

13. If you provide the BSc programme: What percentage of students continue their study in MSc degree?

○ <10% ○ 10-20% ○ 20-50% ○ >50%

Why?

14. How many months does your graduate follow-up survey cover?

15. What percentage of graduates found employment?

a) Unemployed and not in education h) In R&D company b) Heavy industry (e.g. steel, oil, gas, automotive)

i) As academic staff at university c) Electronics industry j) As research staff including PhD study at university

d) Chemical industry k) Management, finance, consulting e) Life science industries (e.g. pharma, medical, bio)

l) Education f) Consumer industries (e.g. food, cosmetics) m) Other public services g) Other industries

16. Do you inquire your students about the motivation for selection of your programme? Please copy the most popular reasons.

COOPERATION WITH INDUSTRY

17. Is your curriculum being developed in collaboration with industry?

○ Yes ○ No

18. Does your programme involve modules/courses taught by experts from industry?

○ Yes ○ No

19. Do you intend to expand your programme with modules/courses taught by experts from industry?

○ Yes ○ No

20. Does your programme involve modules/courses which arose as a result of industrial demand?

○ Yes ○ No

21. Do you intend to expand your programme with modules/courses directly resulting from industrial demand?

○ Yes ○ No

22. Does your university collaborate with industrial companies, which are future employers of your graduates?

○ Yes ○ No

23. Do your students take part in internship at industrial companies or realise a projects commissioned by these companies?

○ Yes ○ No

24. What percentage of your students are delegated by their company to improve qualifications?

25. What percentage of your students are former employees of industry?

26. In your opinion, what are the main nanotechnology skills/knowledge offered by your programme and required by industry?

☐ Characterisation/Metrology ☐ Nanomanufacturing ☐ Nanostructures/Composites ☐ Health & safety issues ☐ Pilot lines/Scaling up processes ☐ Nanocoatings/Smart surfaces ☐ Regulation ☐ Communication/Education ☐ Nanoelectronics ☐ Standardisation ☐ Strategy ☐ Nanooptics ☐ Modelling/Simulation ☐ Human Resources Development ☐ Nanobiotechnology ☐ Environment/Disposal/Recycling ☐ Sales/Marketing ☐ Nanochemistry ☐ Design ☐ Management/Finance ☐ Other

27. In your opinion, what should be the educational level of the employees in high-technology industrial companies?

○ PhD ○ Master ○ Bachelor ○ Vocational training ○ Other

28. Is your institution running diversity programmes (gender, sexual orientation, religion a.s.o.)?

○ Yes ○ No ○ I don't know

29. Comments

A.I.2. The student & graduate survey

The survey for the students and graduates prepared for the project is shown below. Its online version was published at http://nanoeis.eu/questionnaire/student.

1. General info

Email Address

Country *

Are you a student?

○ I am currently studying. ○ I graduated.

Gender *

○ Female ○ Male ○ Other

2. What type of programme?

○ BSc (undergraduate) ○ MSc (graduate) ○ PhD ○ post-graduate ○ Summer school ○ E-learning

Please enter the programme name:

3. What traditional scientific disciplines does/did your studying concern?

☐ Physics ☐ Medicine ☐ Chemistry ☐ Electrical engineering ☐ Biology ☐ Material Science ☐ Economics ☐ Mechanical engineering ☐ Other

4. If applicable: In which sector are/were you employed during your carrier?

☐ Heavy industry (e.g. steel, oil, gas, automotive) ☐ In R&D company

☐ Electronics industry ☐ As academic staff at university

☐ Chemical industry ☐ As research staff including PhD study at university

☐ Life science industries (e.g. pharma, medical, bio) ☐ Management, finance, consulting

☐ Consumer industries (e.g. food, cosmetics) ☐ Education ☐ Other industries

☐ Other public services

5. What nanotechnology skills/knowledge acquired during your studies are or will be useful for your job?

☐ Characterisation/Metrology ☐ Nanomanufacturing ☐ Nanostructures/Composites

☐ Health & safety issues ☐ Pilot lines/Scaling up processes ☐ Nanocoatings/Smart surfaces

☐ Regulation ☐ Communication/Education ☐ Nanoelectronics ☐ Standardisation

☐ Strategy ☐ Nanooptics ☐ Modelling/Simulation ☐ Human Resources Development

☐ Nanobiotechnology

☐ Environment/Disposal/Recycling ☐ Sales/Marketing ☐ Nanochemistry ☐ Design

☐ Management/Finance ☐ Other

6. In your opinion, what are the main nanotechnology skills/knowledge, which are not offered by your programme but required at the job market?

☐ Characterisation/Metrology ☐ Nanomanufacturing ☐ Nanostructures/Composites

☐ Health & safety issues ☐ Pilot lines/Scaling up processes ☐ Nanocoatings/Smart surfaces

☐ Regulation ☐ Communication/Education ☐ Nanoelectronics

☐ Standardisation ☐ Strategy ☐ Nanooptics ☐ Modelling/Simulation ☐ Human Resources Development

☐ Nanobiotechnology ☐ Environment/Disposal/Recycling ☐ Sales/Marketing

☐ Nanochemistry ☐ Design ☐ Management/Finance ☐ Other

7. After graduation: have you attended or do you intend to attend any postgraduate course to improve your qualifications in nanotechnology?

○ Yes ○ No

8. In your opinion, what changes should be introduced in the nanotechnology programmes in order to increase the employability of graduates in industry?

☐ Curriculum programme should be developed in collaboration with industry

☐ Programme should involve modules/courses taught by experts form industry

☐ Programme should involve modules/courses which arose as a result of industrial demand

☐ Students should have an opportunity to take part in internship at industrial companies or realise a projects commissioned by these companies

☐ More general knowledge should be transferred

☐ Other

9. Is your institution running diversity programmes (gender, sexual orientation, religion a.s.o.)?

○ Yes ○ No ○ I don't know

10. Comments

The survey concerned the data on the level of education followed, traditional disciplines involved, nanotechnology specific competences acquired by the student/graduate as well as those which he/she perceives missing. The job experience is also inquired.