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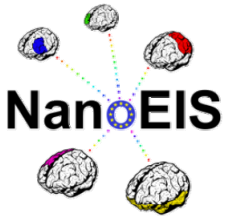

NanoEIS

Nanotechnology education for industry and society

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Executive Summary

This document aims to analyze how nanotechnology and Nano-science (NST) can be used in science and technology education in secondary school systems across Europe and associated countries to facilitate the transition to university, specifically in relation to the learning of science and technology. The document also aims to analyze other potential tools that could achieve this goal, such as the extent of information available (to students / teachers) about university education approaches and curricula, and collaboration between universities and schools.

The main findings of this report are that:

As a whole, the total exposure of NST is minor: from a few thousand students, up to 20% of all students at best (Ireland).

Information from and collaboration with universities is largely lacking. Most science teachers surveyed reported either no or limited collaboration and had mostly only general information about university requirements of the students. There is much to advance in this field of transition to university.

In all the countries investigated, most programs included no more than a few schools and the project ended within a year or two. It was expected that teachers would continue the NST in schools by themselves, even though many projects included much needed cooperation with universities and research centres.

In the broader context of STEM [Science, Technology & Math] in secondary education, we found great variation in the number of hours allocated to these subjects. Where the total amount of hours is small, introducing NST might encounter resistance due to trade-off with other subjects.

As we questioned the contribution of NST curricula to the transition of students to university we found some very optimistic reviews from involved teachers.

Another question that remains open relates to the role of schools in regards to the transition to university - we encountered only one national program that actually

introduces students to universities. Other schools and teachers do it (or not) voluntarily or as a local program at best.

On the same issue, we found that since the academic curriculum is mostly theoretical, when cooperating with schools that seek relevance to their students in the form of career choices, schools are left empty-handed.

Introduction

The present document constitutes Deliverable D2.3 in the framework of the Nano EIS project titled "*Nanotechnology education for industry and society*" (Project Acronym: NanoEIS; Contract No.: NMP4-SA-2012-319054). This is a preliminary report to address the deliverable D3.1.

This report has been prepared by ORT Israel in the framework of activities performed within Work Package 2 "*Mapping of best practices and stakeholder needs*" and more specifically on T2.3 "*Secondary school education and its contribution to facilitating transition into university*". The document aims to analyse how nanotechnology and nano-science can be used in science and technology education in secondary school systems across Europe and associated countries to facilitate transition to university, specifically to learning of science and technology. The document also aims to analyse other potential tools that could achieve this goal, such as the extent of information available to secondary teachers about university education and collaboration between universities and schools.

To gather this information we have conducted several surveys and interviews, reviewed recently published literature, surveys and relevant statistics. The methodology is elaborated further below.

Note that this is not a recommendation report. This report will draft the current image and trends by sampling six of the EU and associated countries' secondary school systems.

This report corresponds with several surveys taken in recent years among the young population of the EU and associated countries revealing that they don't want to learn science unless it is relevant to them. Hence the approach of existing best-practice NST programs is to show how NST is comprehensively and profoundly relevant to them, whether as consumers, employees or environmentally aware citizens and students. As the British scientist, Qasim Chaudhry, explained in a book he edited on the subject:

> "One of the lessons, hard-learned, from the GM debate is that the vast majority of European people are not really interested in science, do not understand it well and do not want to unless they have a personal need to."[1]

The following document is a preliminary report to the deliverable D3.1 which will make an assessment of nanotechnology education programs within science subjects or as independent courses. The complete report (due October 2014) will deal with the best practices in nanotechnology education at the secondary school level, and will provide an overview of materials and methods used in relevant secondary school teaching programs.

One of the most interesting best practices surveyed for this report is the Irish resource pack "Nano in my life". It is a 2-CD pack with 7 modules that provide an introduction to nanotechnology for secondary school students (to be elaborated in the body of this report). In a report that gathered teachers' feedback it was found that 88% answered "Yes" to the question "Do you feel your students' interest in science as a career has increased since studying the Nano in my Life modules?" (only 6% answered "No").

Therefore we see that teaching nanotechnology has a positive influence on students' motivation to study sciences and pursue a career in science & technology.

The Irish case demonstrates the rationale of the structure of this report. For each of the six countries surveyed we give:

- a brief overview of the status of science studies at the secondary school level
- one example of best practice via an NST implemented project
- A summary of how this facilitates the transition to university, specifically to learn sciences

We have not written about the EC-funded NST projects implemented with different levels of success in the countries surveyed[2]. The reason for that is we wished to write only about national projects that were the outcome of local initiatives.

[1] Chaudhry et al (2010) p. 45

Methodology

This is a semi-qualitative report and by no means a quantitative one.

All the data analyzed within this report was gathered through online questionnaires[3] and interviews with people from the education system in the selected EU and associate countries.

36 science teachers from all from over Europe who teach NST answered the online questionnaire. We are well aware of the peril of a possibly biased result from approaching only this section of teachers, yet knowledge in science is a prerequisite to be able to answer the questionnaire.

The questionnaire was distributed among these groups:

1. Participants at a seminar organized by the EUN in Brussels on April 2013.
2. ASTI (Association of Secondary Teachers in Ireland) – a post was published on a Facebook group page.
3. A request with the link was sent to all the EUN's newsletter subscribers.
4. The partners helped distribute the link.

We also approached 10 key figures, from Ministries of Education and academia, as well as several senior teachers for in-depth interviews.

We chose six countries that represent different geographic and cultural areas in the EU (including Israel). This selection gave us a snapshot of the status of the matters in question for this report.

Terminology

The EU and associated countries have significantly different secondary school systems, and this report reflects these variations. When examining the application of different curricula and special programs we referred to 9th grade and above only (i.e. 14-18 year old students).

In this report we will refer to the general and interdisciplinary subject of **N**ano **S**ciences and Nano**t**echnology with the abbreviation **NST**. Another abbreviation used in this report

[2] i.e.: Nanoyou, NanoChannels, Time4nano etc.

[3] The questionnaire can be found in the apendix at the end of this document

is **STEM** = **S**cience, **Te**chnology and **M**athematics.

Teaching nanotechnology in EU and associated countries: status and facilitation of transition to university

In a few surveys undertaken in recent years, it has been found that secondary school students in the EU and associated countries do not want to study sciences[4]. The problem increases when dealing with NST. In Europe, for example, 68% of survey respondents noted that Europe runs the risk of a shortfall of skilled research personnel for nanoscale science and technology if current educational trends continue[5]. These declared views are backed by the revealed decreasing preference to learn science and technology in secondary education in most EU and associated countries. The phenomenon does not stop there, for it is expressed by comparable trends in the universities.

In the following main part of this report we will present what schools teach in sciences in general and in NST in particular. Furthermore, we will present some best practices in teaching NST in the countries researched. Last, we will show what secondary schools do to facilitate the transition to universities.

The purpose of introducing these examples is to compare different approaches and their perceived impacts, in order to show which country and program present best practice. Since the introduction of NST is in its infancy most programs are still finding their way both in content and in methodology.

As mentioned above, few of the best examples for successful NST projects were funded by the EU (e.g. via Framework Programme 7) during the last year. However, in this report we surveyed only local projects.

[4] i.e.: Increasing Human Resources for Science and Technology in Europe (2004), Science Education Now: A renewed pedagogy for the future of Europe (2007).
[5] Yawson (2010)

NST in the broader perspective

One of the main objectives of introducing NST to the secondary school system is to invite students to learn and discuss scientific knowledge of social interest relative to materials (among others), so that students can evaluate critically what they read in newspapers or see on TV from a more objective perspective. In this manner, the hope is also to inspire more students to become interested in NST/sciences and to pursue STEM courses at University. Since NST curricula are flexible, it is up to the teacher to allocate the hours to workshops, labs or discussions. One key approach to NST is to expose and discuss the Ethical, Legal and Societal Aspects (ELSA) of it. ELSA draws attention to the relevance of NST to all students and invites them to investigate further 'under its hood'. Under this aspect of NST, participation of non-science & technology learning students is also achieved.

1. Ireland

1.1. Science studies in secondary schools

All children in Ireland receive compulsory (free) education between the ages of five and sixteen years, and must complete three years of post-primary education by age 18[6]. Approximately 90% of school-leavers take the terminal examination, the Leaving Certificate, at age 16–19.

The Irish secondary education system comprises three levels: the junior cycle, an optional transition year and the senior cycle. The students end their junior cycle with a state exam called the junior certificate and can choose to attend the transition year, a general education scheme that completes the junior cycle to a 4 year period, or can pass directly to the 2 year senior cycle, ending with a second state exam called the leaving certificate.

The curriculum at all levels is overseen by the National Council for Curriculum and Assessment[7].

[6] Education (Welfare) Act, 2000 (Section 17)
[7] http://www.ncca.ie/en/About_Us/

In Ireland the compulsory curriculum in natural sciences and technology is included only until the end of the 3-year junior centificate cycle, for 152 annual hours per student. Technology is taught 22 annual hours per student.[8]

Dr. Mary Colclough from TCD says that: "There is no reference to nanotechnology at the moment in the Irish secondary school curricula – but a national consultation report has recently been published on draft changes to the senior cycle science subjects, which includes "nano" in the new Chemistry syllabus."

1.2. Example of best practice for teaching NST

Nano in My Life

Short description:

CRANN (the **C**entre for **R**esearch on **A**daptive **N**anostructures and **N**anodevices) is a Science Foundation Ireland (SFI) funded Centre for Science, Engineering and Technology (CSET) and includes a dedicated funding stream for education and outreach programmes. It is based in Trinity College Dublin (TCD). CRANN's innovative educational package, 'Nano in My Life' was launched during Science Week 2011. There are seven modules, each using a range of teaching and learning approaches, designed to engage students and encourage active learning.

The pack was ordered by 196 schools – that's 26% of the secondary schools in Ireland.

Age: The programme introduces Transition Year and Senior Cycle students to NST, which is set to become part of the proposed new Leaving Certificate syllabi (for biology, physics and chemistry).

Materials developed: Each module contains teachers' notes, a Power Point presentation, video, timings, experiments and work sheets.

Website (for contact to receive a copy): http://www.crann.tcd.ie/Education-Outreach/School-s-Programme/Nano-in-My-Life.aspx

[8] Recommended annual taught time in full-time compulsory education in Europe 2012/2013, Eurydice - Facts and Figures. P. 28 and 44

1.3. Facilitating the transition to university

As in many countries, there exist some initiatives to promote Irish secondary students choosing a career in science, technology, engineering and maths. One example is Smart Futures (http://smartfutures.ie/), which is a collaborative campaign covering all Ireland. Among other things, they organise a so-called "Smart Futures STEM Careers Week" to raise awareness of careers in the STEM subjects. Also within this project, they organise school visits to universities.

University College Dublin (UCD), the largest university in Ireland, has several activities aimed at attracting students to university studies in general and to science studies in particular. Every year there is a dedicated "Open day" for final year secondary students (as well as their parents) organised in conjunction with the students making their choice of whether and what to study at university.

The National University of Ireland (NUI) in Dublin cooperates with teachers on an individual basis. Various Schools/Faculties organise their own schools' outreach e.g. School of Physics; Engineering; CRANN etc.

In the last 2-3 years, demand has increased for science places in Universities across Ireland. In 2012, 27% students had science, technology and engineering courses listed as their first place – which represented an increase in demand of 20%[9].

For this report we approached 2 high school science teachers from Ireland. This is how they answered our questions:

- Both teachers answered that they are encouraging their students to pursue a science degree at university.
- They are encouraging the students by: visits to universities, hosting alumni of the school who studied science at university, and emphasizing the advantages of STEM careers in the classroom.
- A Nanotechnology teaching pack prepared by universities is available in one of the schools for Transition Year.

[9] Irish Times, Monday Jan 7th 2013 – College Choice supplement

- The teachers reported that the ways in which students obtain information about options for academic education are: Guest Speakers, College prospectuses / brochures, on-site experience, personal contacts with university students, and the teacher's encouragement.
- In general the Irish teachers interviewed are satisfied with the ways in which students are encouraged to pursue an academic education in sciences.

2. Spain

2.1. Science studies in secondary schools

Spain has a decentralized education system, where responsibilities are distributed among the State, the Autonomous Communities, Local Authorities and schools. The Ministry of Education sets the general organization of the education system on the basis of minimum requirements for schools, minimum core curriculum and international cooperation in education.

The Autonomous Communities (17 regions) have the administrative responsibility within their territories of school creation and management, as well as new development of syllabi and regulation of levels, branches, grades and specializations, education inspection, supervision of textbooks and other curriculum-related materials.

The Spanish local authorities (provinces within regions) are responsible for building public schools, planning extra-curricular and supplementary activities, monitoring compulsory schooling and creating School Councils within their municipality[10].

In the Spanish system, the compulsory curriculum in natural sciences and technology is taught only until the 9th grade, for 77 annual hours per student. Technology is taught for 47 annual hours per student[11].

Students aged 12 to 16 attend the final years of secondary school which form part of the national compulsory education. At this level, NST is not a mandatory subject, chapter or

[10] Based on data from NanOpinion D1.4 : School mapping report (2013). Pp. 29-31

[11] Recommended annual taught time in full-time compulsory education in Europe 2012/2013, Eurydice - Facts and Figures. P. 29 and 45

topic. Students in the final years of secondary school follow a well-defined curriculum, but teachers have the possibility of making some changes and in this way integrate some short examples and experiments in Nanotechnology.

Students aged 16 enter the first year of the *Bachillerato* which is not compulsory education. At this level, the curriculum is more strictly defined since students have to acquire a certain level in order to pass an admission exam for university. NST is addressed as a topic in the first year of high school in chapters of a compulsory subject named *Sciences for the contemporary world* (to be elaborated in the following sub-chapter).

2.2. Example of best practice for teaching NST

Sciences for the contemporary world

Short description: as mentioned above this is a mandatory subject for first year of the *Bachillerato*. The materials were developed by the Didactic Institute at the University of Valencia, Spain and were commissioned and edited by the Spanish Ministry of Education. The majority of students in 10th grade learn this program (out of some 650,000 students). One of the topics in this subject is “new technology: nanotechnology”.

The subject is flexible and holds various possibilities for integrating NST-related lessons. The subject aims to foster students' understanding of the importance of science in society and it aims to provide basic knowledge that can help them read information and news about science from a critical and objective perspective.

Science for the Contemporary World is given 2 hours per week, under which NST is compulsory for 8 hours per year (excluding homework assignments). The purpose of the subject is to give the students a notion of the cutting edge of scientific research.

Age: 10th grade

Languages: Spanish & Catalan

Materials developed: lesson plan, an introductory text, subject web quest activity and subject debate on risks vs. benefits.

Cooperation with industry/academia: University of Valencia

Website http://leer.es/wp-content/uploads/web_cmc/index.htm
http://leer.es/wp-content/uploads/web_cmc/CMC_LibroEstudiantes/T_6_NuevasNecesidadesNuevosMateriales_estudiantes.pdf

2.3. Facilitating the transition to university

For this report we approached 3 high school science teachers from Spain (one of them from Catalonia). This is how they answered our questions:

- All three said that their school is specifically encouraging students to pursue a science degree at university.
- They are encouraging their students by: career consulting, visits to universities, hosting alumni of the school who studied science at university, and emphasizing the advantages of the STEM careers in the classroom.
- 2 teachers reported that their school science curriculum aims to prepare students to attend university. It is done through preparing them to pass an exam to go to the university.
- 2 teachers answered “Yes” to the question: Have you ever received information and direction on what the university requirements of science students are? But only one of them (from Catalonia) said that the information was useful.
- The ways in which students get information about options for academic education are: brochures handed out by the teacher and visiting open days.
- Students' exposure to options of pursuing higher education in the sciences is very minor as reported by the teachers that were surveyed. It consists of a one-day tour, or one hour a year for the whole class.
- In general all the teachers are dissatisfied with how students are encouraged to pursue an academic education in sciences

3. Austria

3.1. Science studies in secondary schools

The Austrian secondary school education system is divided into Level 1 (Grades 5-8) and Level 2 (Grades 9 to 13). At Level 1 pupil are already directed to different preparatory tracks leading to higher education, vocation or general. At Level 2 pupils attend one of the following options in school types, each preparing the pupil for a different track to higher education or vocation: (1) Polytechnic schools (i.e. schools preparing pupils for an apprenticeship or job); (2) Vocational schools and apprenticeships (dual system); (3) vocational secondary schools; (4) vocational colleges; (5) upper level of grammar schools (higher secondary schools of general education) or (6) integrative vocational education.

Most vocational schools include a general chapter in sciences and technology. The upper level track mainly offers the more extensive programs in science and technology.

In Austria the compulsory curriculum differs between the four main educational tracks. Natural sciences are taught only in the 9th grade, for 60 annual hours per student at the Gymnasium and 120 annual hours at the Realgymnasium. There is no compulsory curriculum for the Hauptschule and Neue Mittelschule tracks. There is no compulsory curriculum in technology in secondary education in all educational tracks[12].

Nanotechnology is not a mandatory chapter in the curriculum, though several projects have been widely disseminated in Austria over the past few years.

3.2. Example of best practice for teaching NST

The Sparkling Science project

Short description: The project was coordinated by the Austrian Ministry of Science and Research. It is a research program of the Federal Ministry of Science and Research (BMWF) which adopts an unconventional way of promoting young scientists that is unique in Europe. A project integrating people with such different backgrounds is rare, as is public education of students in NST.

[12] Recommended annual taught time in full-time compulsory education in Europe 2012/2013, Eurydice - Facts and Figures. P. 28 and 44

Started: 2008

Age: between 15 and 17 years old

Languages: German

Materials developed: meetings with role plays, discussion platform and quiz (teachers, students and scientists in the project), young researcher workshop with posters on highlights and problems in the project

Cooperation with industry/academia and integration of students of this age into research at the university.

Website: http://www.sparklingscience.at/en/

3.3. Facilitating the transition to university

The Austrian secondary school system is almost unique in its focus on career tracks from an early age. Therefore schools differ deeply in how they introduce students to sciences - including nanotechnology. A relatively vast cooperation of these schools with science centres and universities has significantly exposed students to university. Yet those who attend vocational tracks in other fields are not encouraged in that way.

For this report we interviewed 1 high school science teacher from Austria (Klostermarienberg). This is how she answered our questions:

- She said that their school is specifically encouraging students to pursue a science degree at university. Though science is an important subject in her school (which has been involved in certain NST projects), it focuses on economics.
- She answered “No” to the question: Have you ever received information and direction on what the university requirements of science students are? And said that she would like to receive more.
- The ways in which students obtain information about options for academic education are: brochures handed out by the teacher, visiting open days, posters at school and university websites.
- The exposure of the students to options of pursuing higher education in the sciences is up to 1 hour a year to the whole class.

Generally the teacher is not satisfied with how students are encouraged to pursue an academic education in sciences.

4. Italy

4.1. Science studies in secondary schools

Italy's school curricula are formulated at the national level by the Ministry of Education, University and Research (Ministero dell'Istruzione, dell'Università e della Ricerca) with no regional differentiation. Education is compulsory from age 6 to 16 and covers the first cycle of education which corresponds to 8 years and the first two years of the upper secondary education. The secondary school system (students aged 14–16) is based on Licei (students preparing for university) and Technical schools (Istituti).

The Licei have a curriculum based on highly specialized subjects. Each Liceo branch has further subdivisions with a characterization for science, humanities or art and has nationally standardized curricula. In the Licei, science is covered for the whole 5-year course and has dedicated time for ethical and societal discussions thanks to the presence of subjects like philosophy and law. With regard to science in the Istituti (technical and vocational schools), it's mostly given in the first 2 years, except when it is also a professionally qualifying subject[13].

In the Italy the compulsory curriculum in natural sciences is taught in Grades 9 and 10, for 132 annual hours per student (in 2 years). There is no compulsory curriculum in technology in secondary education[14].

NST is not a mandatory subject, chapter or topic in the curriculum in the Italian secondary schools curriculum.

The type of activities that could be carried out with students might take the form of hands-on experiments and activities with systematic data collection and analysis which will fit the Physics methodology. In Italy there is no tradition of conducting experiments,

[13] Based on data from NanOpinion D1.4 : School mapping report (2013). Pp. 23-26

[14] Recommended annual taught time in full-time compulsory education in Europe 2012/2013, Eurydice - Facts and Figures. P. 28 and 44

but this could be an excellent opportunity to integrate this. As a second choice, computer simulations could be useful if they offer real investigation tools on real data.
It is not possible to state the hours needed per week, if the number of hours dedicated to NST is not defined as a stand-alone topic in a subject but rather embedded into traditional curricula in an interdisciplinary manner. And optimal solution would be to have at least one or two hours per week to split between related subjects. That would make approximately 33–66 hours per year.

4.2. Example of best practice for teaching NST

Nanolab

Short description: an educational project of the Physics Department of the University of Modena and Reggio Emilia, Italy, for **science teachers** to integrate **nanoscience** into high school and undergraduate curricula.

Started: 2008

Age: high school

Languages: Italian and English

Materials developed: lesson plans, student sheets, presentations, experiments.

Cooperation with industry/academia: University of Modena and Reggio Emilia.

Website: http://www.nanolab.unimore.it/en/

4.3. Facilitating the transition to university

As described above, students at the *Liceo* are more directed towards higher education in universities. As every region and often even municipality emphasizes different things, some teachers have reported emphasis towards science careers and some have reported none on this matter. The same goes for cooperation with local universities on introducing nanotechnology into science education in schools, where some reported close cooperation while others reported occasional meetings. Information to students on

options in science education in university is given mainly via brochures, internet and the teachers.

For this report we approached 2 high school science teachers from Italy. This is how they answered our questions:

- Both of them (one from a *Liceo*) said that their school is specifically encouraging students to pursue a science degree at university.
- Both answered “No” to the question: Have you ever received information and direction on what the university requirements of science students are? They reported that they should get more.
- The ways in which the students get information about options for academic education are: the teacher or the school hands out brochures, visiting open days and university websites.
- Students' exposure to options of pursuing higher education in the sciences is through one-to-one meetings with the teacher, visits to universities, and by lessons given to the whole class devoted to this topic.
- The teacher from the *Liceo* is not satisfied with how students are encouraged to pursue an academic education in sciences and reported that the schools should allocate more time for it. The other teacher is satisfied.

5. Czech Republic

5.1. Science studies in secondary schools

Education in the Czech Republic is free and compulsory for primary education which lasts nine years, from the age of 6 to 15. Children can obtain their primary education at a variety of different schools that can also utilize different types of educational programs. Most commonly, children attend a regular 9-year primary school.

The Czech Ministry of Education, Youth and Sports is responsible for educational policy. This institution formulates the long-term policy objectives of the development of the education system every four years. The responsibility is distributed between the central government, the 14 regions and the communities. The communities are

responsible for compulsory schooling. They establish and administer primary schools. Schools have the status of legal entities.

School heads are given full responsibility for the quality of the educational process, the financial management of the school, appointing and dismissing teachers and relations with the community and the public. By law, the school organizing body must establish a School Council so that parents, pupils, staff, and the public can participate in the administration of the school. This means that the educational system has a certain level of local autonomy towards the general national objectives[15].

In the Czech Republic the compulsory curriculum in natural sciences and technology is taught only until the 9th grade, for 89 annual hours per student per year. Technology is taught 89 annual hours per student per year[16].

NST is not a mandatory subject, chapter or topic in the national curriculum but it is possible to integrate it into Physics, under the topic “atomic Physics” representing 10 hours in the curriculum of the fourth year of study in Chemistry and Biology subjects.

5.2. Example of best practice for teaching NST

Nové Talenty – New Talents

Short description: A project developed and implemented by the VSB- Technical University of Ostrava & the Technical University of Liberec. The project objective is to introduce and communicate science - the chosen subject is Nanotechnology - to various target groups such as secondary-school students, teachers, the private and public sectors.

Age: high school and others

Language: Czech and English

Materials developed: Two demonstration centres open to public and high-school students, one in each university; Materials for teachers; Street-labs; science communication workshops for researchers.

[15] Based on data from NanOpinion D1.4 : School mapping report (2013). Pp. 11-13

[16] Recommended annual taught time in full-time compulsory education in Europe 2012/2013, Eurydice - Facts and Figures. P. 28 and 44

Website: http://www.talenty-pro-vedu.cz/cz/realizatori.php

5.3. Facilitating the transition to university

For this report we approached 2 high school science teachers from the Czech Republic. This is how they answered our questions:

- Only one of them said that their school is specifically encouraging students to pursue a science degree at university.
- One of the schools' science curriculum aims to prepare students for university (especially in technical institutes).
- The teacher answered "Yes" to the question: Have you ever received information and direction on what the university requirements of science students are? They reported that the information was irrelevant.
- The ways in which students obtain information about options for academic education are: the teacher or the school hands out brochures, posters at schools, visiting open days, university websites and from their parents.
- Students' exposure to options of pursuing higher education in the sciences is very minor (one-to-one meetings with teachers) or not at all as reported by the teachers surveyed.
- In general the teachers are not satisfied with how students are encouraged to pursue an academic education in sciences.

6. Israel

6.1. Science studies in secondary schools

School attendance is mandatory and free from age 6 to 18. Formal education starts in primary school (grades 1–6, ages 6 to 12) and continues with middle school (grades 7–9, ages 12 to 15) and secondary school (grades 10–12, ages 15 to 18).

Most of the secondary schools follow an academic curriculum in science and humanities with the final objective for students to have access to university. The Israeli school system also offers vocational secondary schools educating technicians and practical

engineers preparing for higher education, studying towards a vocational diploma, or acquiring practical skills to enter the job market directly, or to meet the needs of the Israeli army.

The Israeli Ministry of Education is in charge of the formulation of the school curricula.

There is no defined integration of NST in the curriculum, but there are several possible entry points. NST can be integrated into Biology in secondary school classes. It should be presented within the subject of genetic engineering, genetic cures, disease diagnostics and ecological topics. NST can also be integrated into human anatomy, physiology, and micro-organisms classes with approximately 2 to 3 hours per month as a possible goal to start.

The Teacher Coordinator additionally specifies that activities organized in class around NST should be run with audio-visual resources and includes the development of projects by the students directed by scientists and engineers.

As part of the ORT Israel school network (one of NanoEIS partners), a program of NST education dedicated to middle schools (grades 7–10) was developed. However, no plan to integrate NST is foreseen at the national level[17].

The compulsory curriculum in natural sciences and technology is taught until the 10th grade. In the 9th grade, science and technology is taught for 180 annual hours per student. In secondary school, which starts from 10th grade, 72-180 annual hours per year are allocated, depending on the student's track[18].

6.2. Example of best practice for teaching NST

Nanotechnology: what a small world

Short description: An ORT Israel school network innovation for teaching NST as a full separate subject in science classes

Started: 2011

Age: secondary school

[17] Based on data from NanOpinion D1.4 : School mapping report (2013). Pp. 20-23

[18] The Israeli ministry of education, the science and technology administration: http://cms.education.gov.il/educationcms/units/madatech/englishsifria/scienceandtechnologyadministration/odot_aminhal_eng.htm

Languages: Hebrew

Materials developed: portal that covers the entire topic of NST. Including teachers' guide, presentations, virtual activities etc.

Cooperation with industry/academia: visits to universities and the NT industry

Website: http://nano.ort.org.il

6.3. Facilitating the transition to university

For this report we approached 3 high school science teachers from Israel and the head of technology studies in the Ministry of Education. This is how they answered our questions:

- Only one of them said that their school is specifically encouraging students to pursue a science degree at university.
- All three teachers answered that the school's science curriculum aims to prepare students for university by exposing them to cutting edge science, and by teaching them part of the material in the university curriculum.
- All three teachers answered "No" to the question: Have you ever received information and direction on what the university requirements of science students are?
- The ways in which students obtain information about options for academic education are: university websites, their teachers and from their parents.
- Students' exposure to options of pursuing higher education in the sciences is very minor (by one-to-one meetings with teachers) or not at all as reported by the teachers surveyed.
- In general the teachers are not satisfied with how students are encouraged to pursue an academic education in sciences.

Conclusion & Summary

The teaching of NST is in its infancy. Most curricula are no more than 5 years old and most are still in the experimental phase. As a whole, the total exposure of NST is minor: from a few thousand students to 20% of all students at best (Ireland).

Information from, and collaboration with, universities is largely lacking. Most teachers reported either no or scarce collaboration and mos had only general information about the universities' requirements of the students. In the schools, very little time is allocated to inform and create interest in studying science and technology at university. There is much to advance in this field of preparing students for the transition to university.

In all the countries investigated we found several NST programs implemented over the last 5 years, yet most included no more than a few schools and the project ended within a year or two. It was expected that teachers would continue the NST in schools by themselves, even though many projects reviewed here needed significant cooperation with universities and research centres.

In the broader context of STEM in secondary education, we found great variation in terms of the number of hours allocated to these subjects. Where the total number of hours is small, introducing NST might encounter resistance due to trade-off with other subjects.

As we questioned the contribution of NST curricula to the transition of students to university we found some very optimistic reviews from involved teachers.

Another question is about the role of schools with regards to the transition to university - we encountered only one national program that actually introduces students to universities. Other schools and teachers do it (or not) voluntarily.

On the same issue we found that since the academic curriculum is mostly theoretical, when cooperating with schools that seek relevance to their students in the form of career choices, schools are left empty-handed.

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Appendix: NanoEIS Questionnaire to Educators on Nanotech in Education

Dear Teacher/Educator,

As part of our research on secondary school education and its contribution to facilitating the transition into university, we would appreciate if you could dedicate a few minutes to complete the following questionnaire.

This is part of an EU commissioned report on Nanotechnology Education for Industry and Society (NanoEIS).

General questions for educators

1. Country in which you teach
2. Are you a science teacher?
3. What grades are you teaching?
4. How many years have you been teaching?
5. What is your highest education qualification?
6. What is your source of knowledge about Nanotechnology?
7. Do you teach nanotechnology?
8. If you do teach nanotechnology, how many hours do you teach annually?
9. What is the name of the framework/project/other under which you teach nanotechnology?

Specific questions

10. Does your school specifically encourage the students to pursue a science degree at university?

    If so, please tell us how.

11. Does your school science curriculum aim to prepare students for university?

    If so, please tell us how.

12. Have you ever received information and direction on what the university requirements of science students are?
13. Was that information useful?
14. How do your students get information about options for academic education?

15. Does your school integrate visits to science centres in the curriculum?
16. Does your school integrate visits to Nanotechnology industry in the curriculum?
17. Have you exposed your students to options of pursuing higher education in the sciences?
18. Are you satisfied with the ways students are encouraged to pursue an academic education in sciences?
19. If you teach nanotechnology and are willing to share your experience, please write your full name and email below.