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European Chemistry and Chemical Engineering Education Network

Final Report

Public Part

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Executive Summary

The European Chemistry and Chemical Engineering Education Network (EC2E2N) received funding for a project for the period October 2012 to September 2015. This network has built upon the work begun in 1996 by the European Chemistry Thematic Network (ECTN) and the European Chemical Engineering Education Network (ECEEN). The project brings together 108 partners from 28 European countries and 7 International partners (from Australia, Canada, USA, Egypt, Kazakhstan, South Africa). The network involves all actors in higher education in chemistry and chemical engineering in Europe. There are schools, universities, industries, national chemical societies, and research centres in this new network. The partners are mainly European universities but also include the European Association for Chemical and Molecular Sciences (EuCheMS), the European Federation of Chemical Industry (CEFIC), National Chemical Societies, and the European Commission Joint Research Centre. These actors are collaborating in the development of a knowledge based economy, in chemistry and chemical engineering, looking towards Europe 2020. The project:

- **Has worked to enhance excellence in school and university teaching.** It has done this by collecting good practice examples to support teacher training courses for both secondary and tertiary teachers; by developing a test for future teachers; and by providing a resource for teachers in the form of a database of expertise in different teaching methods.
- **Has also worked to enhance professional abilities.** This was achieved by helping to re-train adult learners with a chemical background in both generic and subject specific competences, addressing professionals active in industry or education as well as unemployed scientists. Modules on generic and subject specific competences were created as well as a database of existing subject-specific training possibilities.
- **Provided support to help enable sustainable entrepreneurship.** Educational activities suited to train younger generations of chemists to become entrepreneurs were established. Also, five existing spin-off companies have been brought together to create a network and a cooperative infrastructure to help these companies has been built. A European survey of employment in chemistry and chemical engineering was supported.
- **Has promoted chemistry** by providing a series of case studies covering areas where chemistry has a major role to play (energy, health, water, food, innovative materials), and by creating on-line tests for the general public in these areas and, more generally, for chemistry in everyday life. Videos on topics on chemistry in everyday life have also been produced.
- **Has supported innovative ICT-based products by developing a virtual education community.** This was done through the creation of a web portal, an on-line repository for learning objects as basic units of e-courses, and by holding awareness raising workshops for teachers and other staff to acquaint participants with all issues concerning the Virtual Education Community.
- **Has helped to broaden student horizons by enhancing mobility for students** in chemistry and chemical engineering. This was achieved by carrying out a survey on current mobility, for both study and work placements which was analysed to determine obstacles and aids to mobility. Some tools available to aid mobility were identified and evaluated and recommendations made for new tools that may be needed.
- **Has provided integrated descriptors for all levels of post-secondary education,** including master programmes combining chemistry, chemical technology and chemical engineering, and developed the basis for a quality label for short cycle studies connected to chemical knowledge.

The European Chemistry Thematic Network Association (ECTN) will ensure that the outcomes of this project will be sustained by creating work groups to develop and publicise the outcomes.

Please visit the websites: www.ectn-assoc.org and www.ec2e2n.net

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1. Project Objectives

Strengthening teachers' competences is a particularly important concern. This project aims to **increase the quality of science teacher training** by providing best practice examples in at least 10 different areas and a self-evaluation test in these areas.

The project also aims to **improve the training and re-training of professional chemists** by carrying out a survey and needs analysis, by creating modules on generic and subject-specific competences and creating a database of subject-specific training possibilities. This will both provide training opportunities where they do not already exist and provide easy access to information about existing training possibilities.

Another objective of the project is to **support sustainable entrepreneurial activities** by creating a training initiative for entrepreneurship and formalising a spin-off/start-up cluster and a support infrastructure for this cluster. All sectors are calling for such initiatives, and this part of the project will help increase entrepreneurial activities and make them more sustainable.

There is a need to **inform and educate the public** about the **role and impact of chemistry in everyday life**, both to allay the fears concerning chemical activities and to **create an interest in studying the subject** to provide the scientists of the future. This project aims to address this issue by providing case studies in several areas where the impact of chemistry is crucial, and also by providing an internet-based test on chemistry in everyday life.

While a virtual campus for chemistry/chemical engineering has been created in a previous project, this project aims to **create a virtual learning community**, together with **awareness raising workshops** and a **web portal** for this community. This is thus **exploiting the potential of ICTs to enrich teaching and improve learning experiences** in the chemistry sector.

The project has the objective of **enhancing mobility** in the chemistry/chemical engineering sector and of promoting more study and industrial placement opportunities abroad. Its aim is to do this by surveying the current situation to obtain data that will enable a detailed analysis of the situation thus allowing recommendations to be made to enhance mobility in this sector. The aim is also to **increase industrial placement opportunities abroad** by investigating the possibility of networking the opportunities amongst the project partners.

The project aims to **create guidelines and the basis for a quality label for short-cycle studies in chemistry**. This will complete the set of guidelines (first, second and third cycles) established by the European Chemistry Thematic Network over the past 10 years. The project then aims to provide an **integrated set of guidelines** for all post-secondary education in chemistry with the Europe 2020 strategy in mind. This is called for by all sectors of the chemistry and wider education community and will help to provide the appropriately trained chemists required for Europe 2020. The aim is also to create **guidelines for master level programmes combining chemistry, chemical technology and chemical engineering**. This will help in the establishment of more such programmes, as such interdisciplinary studies have been identified as being important for the future.

It should also be noted that the project will also supply a platform for the dissemination, exploitation, and hence valorisation of the outcomes of this and previous projects in this sector.

2. Project Approach

Each of the eleven work packages of the project had a group leader and co-leader, and a varying number of partners constituted the working group associated with the work package. The leader was a member of the network management committee and reported to that committee twice a year on the progress made by the group. In this way the management committee could monitor the progress of all the work packages. The groups met either physically or on-line once per year and also at the annual plenary meeting of the network. The work done and future work of all the work packages was presented to the network for evaluation and discussion at the annual plenary meeting. The working groups also met during the annual plenary meeting to further advance their work and consider contributions from network partners who are not specially members of the group. This methodology ensured that the progress of each work package was closely monitored (by the Management Committee and the whole network), that all project partners were involved in the activities and could contribute to all work packages, and that any problems were quickly identified allowing remedial action to be taken as necessary. For the second and third annual meetings there were external evaluators present who reported to the management committee on the progress and relevance of the work being carried out.

The work was disseminated by presentations at annual meetings, via the project web site, or in the project electronic newsletters, which are sent to over 1400 individuals. The work has also been presented at several international conferences or meetings. Articles have been written for publication in other newsletters such as that of the European Association for Chemical and Molecular Sciences (of which the membership is all the national chemical societies in Europe).

After the end of the project, the European Chemistry Thematic Network Association (ECTN) will continue to send out newsletters, maintain the website, and publicise and develop the work carried out by this project through the creation of work groups. The ECTN is a well established Association with about 120 universities as members and has developed a good reputation within the European chemistry community for its activities in all aspects of higher education in the chemistry sector.

For the work package on Excellence in School and University Teaching:

Following a survey carried out in a previous Erasmus Academic Network project, ten important areas for teacher education were identified, and good practice examples were collected in these areas, with each area being a separate chapter of a book. Each area had an author or co-authors assigned to it and the whole group were involved in the final revisions and evaluations of the texts. The group used Dropbox to share the documents.

A leader was assigned to each of the three major activities of this work package: Good practice examples in teacher training; an Internet-based test for trainee teachers; and a database of teaching expertise.

For the work package on Enhancing Professional Abilities:

A work package leader and co-leader were appointed. The group has carried out a survey of the current situation in Europe concerning the training of professional chemists through an on-line questionnaire sent to academics and industrial chemists and chemical engineers. A database of training opportunities in Europe was created. An analysis of labour market needs was based on a questionnaire sent to industry and government stakeholders as well as to educational authorities. Learning modules on generic competences and subject specific competences were created and three intensive one-week workshops were held to guarantee actual training in these competences.

For the work package on Sustainable Entrepreneurship:

It became clear that data on the employment of chemists and chemical engineers on a European scale was not available. This group therefore decided to cooperate with the European Commission Joint Research Centre (Institute for Reference Materials and Measurements), the European Association for Chemical and Molecular Sciences, and the European Chemical Industry Council (Cefic) in order to carry out a survey via a questionnaire which includes questions on entrepreneurship training. The questionnaire was distributed via the national chemical societies.

The working group took advantage of an opportunity to jointly organise, with COST and EUREKA, a strategic event entitled 'COST Actions – A Great Opportunity as Incubators for Molecular Science and Technology'. This was a great help in advancing the progress of setting up a cluster of spin-off companies. A memorandum of understanding was created for the cluster of spin-off companies to provide a clear and strong basis for the cluster.

One of the objectives of the work package was to create a training programme for entrepreneurship. Once this had been done the group held a training event in order to trial the programme with master-level students.

For the work package on The Impact of Chemistry on Everyday Life:

The group had an overall leader and a co-leader who was responsible for the production of an Internet-based test on chemistry in everyday life.

The first task of this group was to provide case studies of areas in which chemistry play an important role in everyday life. A number of areas were identified and partners were appointed to each area to take charge of producing a case study.

For the internet-based test, a template for the submission of questions in a suitable format was designed to make it easier for the group to put the questions into the test software. Questions were solicited from each of the case study authors as well as to the network partnership in general. In addition to the full test, a demonstration quiz was produced (in five languages) that is freely available on the web.

For the work package on The Virtual Educational Community:

The group organised awareness raising workshops to inform and train academics in a range of issues concerning the virtual educational community and the production of learning objects.

The group created a site (GLOREP) that will be a repository for learning objects (any digital file containing material that can be used for teaching and learning such as videos, presentations, tests, etc.).

For the work package on Broadening Student Horizons:

This was aimed mainly at enhancing student mobility by identifying obstacles and identifying possible aids for mobility.

The group has carried out a survey of student mobility in partner institutions as a basis for identifying obstacles to mobility. The group consisted of partners who are very active in student mobility and individuals who are responsible for student exchange within their departments. This ensured a good expertise and knowledge of the area.

For the work package on Re-Tuning for Competences in Chemistry/Chemical Engineering for Europe 2020:

The group leader (as well as several members of this group) has been an active member of the chemistry group that was part of the Tuning Educational Structures in Europe projects which have provided a great deal of important work on learning outcomes, ECTS credits, generic and subject-specific competences, and descriptors for bachelor and master programmes across Europe. Thus there was an expertise and a continuity that provided significant help to the work of this group and ensured the quality of the output.

The group carried out a survey of short cycle education in all European countries for courses in which there is some chemistry content. This forms the background to the descriptors for short cycle studies. In addition to short-cycle studies (usually programmes of up to 120 ECTS), the valorisation of intensive courses was also addressed.

The remaining work packages concerned project management, dissemination, quality assurance, and exploitation of project outcomes.

The project approach concerning the **work package on project management**, has been partially described in the introduction to this section. The role of the management committee was to monitor the progress of the project, to identify any problems arising, to monitor project expenditure, and to ensure that the proposed outcomes of the project were achieved. This was done through regular meetings where the work package leaders presented their work and outlined the future work to be undertaken.

The **dissemination work package** was concerned with ensuring that the work of the project was disseminated to the target audience. This was the responsibility of the management committee. It was achieved by creating and maintaining a web site (www.ec2e2n.eu), producing and distributing a project leaflet, issuing regular newsletters, organising annual plenary meetings in 2013, 2014 and 2015, presenting the work of the network at several international conferences, and producing posters for each of the seven implementation work packages. To help with this work a web master was appointed as well as a newsletter editor.

The **quality assurance work package** had the task of monitoring the progress of the project and evaluating the work carried out during the final two years of the project. To achieve this, three external evaluators were appointed. They attended the 2014 and 2015 annual meetings and reported to the management committee. One external evaluator also attended a management committee meeting before the 2014 annual meeting. This enabled the work package leaders to take account of the evaluations and act on any necessary items arising from the evaluation.

At the annual meetings, all participants were asked to complete a questionnaire to provide an internal evaluation of the project.

In addition, visits to the project web sites were monitored. The number of visits increased as the project progressed. The monitoring of the web site visits highlighted the importance of the on-line newsletter in encouraging people to visit the site.

The **exploitation work package** had the task of ensuring that the outputs from the project will be maintained, disseminated and developed after the end of the project. This task will be carried out by the European Chemistry Thematic Network Association (ECTN), an association that was created during a previous network project to ensure that project outcomes are exploited. It has been very successful as a number of its activities, such as European quality labels (Eurobachelor, Euromaster and Eurodoctorate Eurolabels®) and on-line testing (the EChemTest), show. The approach for the exploitation of outcomes for this project is to create work groups that will continue the work of the various work packages where necessary.

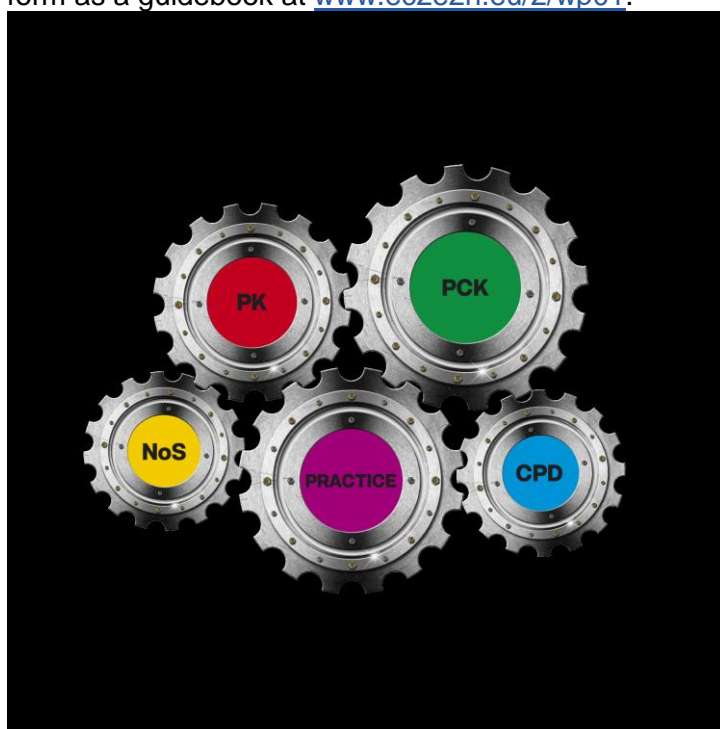
The project outputs will also be distributed to important actors (academics, teachers, and industrialists) in chemistry and chemical engineering higher education, on a USB key, so that they have direct access to these outputs. The USB key has the network logo on it to act as a reminder of its contents.

3. Project Outcomes & Results

3.1 The work package on Excellence in School and University Teaching:

A collection of 12 good practice examples related to school chemistry teacher pre-service training, supplemented by 2 case studies, based on national and international experience of their authors has been prepared.

The examples form a collection that has been published as a hard copy and in electronic form as a guidebook at www.ec2e2n.eu/2/wp01.



A Guidebook of Good Practice for the Pre-Service Training of Chemistry Teachers

The chapters of this book are as follows:

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Each chapter consists of

- Reasons - Why is that particular topic important in pre-service teacher (PST) education?
- Theoretical framework (literature review)
- Good practice example(s) – example of a practical approach to introduce key aspects of that topic to PSTs
- Recommendations/implementations for teacher education/conclusions
- References, recommended bibliography

A knowledge-based platform (called Starfish database of expertise in teaching methods) on which information and people can be functionally connected in a network that can grow and develop in a sustainable way, has been created. Two distinct types of record are currently being input into the database:

- (a) *Personal profiles* of individual university chemistry and chemical engineering educators (lecturers and other university teaching staff) which present details of their experience and areas of expertise in teaching and learning.
- (b) Short descriptions of a range of topics related to the teaching and learning of chemistry and chemical engineering at university level. These items are categorized in the 15 major topics listed below:
 - *Interactive Lecturing*
 - *Practical Work*
 - *Group Work*
 - *Context Based Learning*
 - *Teaching with Technology*
 - *Research Based/Led/Focused/Informed Teaching*
 - *Work Based Learning*
 - *Tutorials*
 - *Assessment*
 - *Pedagogical Issues*
 - *Quality Assurance*
 - *Evidence-based Teaching Methods*
 - *Analogy-based Teaching*

- *Learning Outcomes and Constructive Alignment*
- *Supporting Learners.*

The descriptors are linked to lecturers with relevant expertise, who are willing to answer questions, partake in discussions or even consider entering into advisory or cooperative arrangements.

The database can be accessed via the website

<http://starfish.innovatievooronderwijs.nl/information/395/>. A Google Form to enable individuals to provide personal profiles to be loaded into the database can be accessed at the following website:

https://docs.google.com/forms/d/18RMh_bBC8TdXSr19O9ALEE0h4l3Nb9zQOr_oMtUbPtA/vjewform

A **database of 284 test items (EChemTest)** has been developed. These questions are suitable for:

- (a) The assessment of teachers' pedagogical content knowledge. The questions cover 13 topics:
- Atom & Periodical System
 - Interactions Between Chemical Entities (Bonding)
 - States of Matter
 - Acids, Bases & Salts
 - Mixtures
 - Energy (Thermochemistry)
 - Chemical Reactions
 - Properties of Gases
 - Kinetics
 - Electrochemistry
 - Solution Chemistry
 - Organic Chemistry
 - Equilibrium

and 'b) Understanding of Chemistry Concepts - Students' alternative conceptions /conceptual difficulties, covering 10 topics:

- Nature & History of Science/Chemistry
- Remedies for alternative conceptions
- Curricula and frameworks
- Approaches of instruction
- Laboratory instruction (safety, management, motor skills, experiment development etc)
- Affective dimensions (interest, motivation, attitudes and values)
- Socio-scientific issues (STS, CBL, sustainability)
- Students' cognitive development & reasoning-argumentation
- Knowledge about representations/visualisations
- Assessment & Evaluation in Chemistry

In order to ensure the validity and the reliability of the evaluation process we set up an evaluation form. The proposed level of difficulty of each question has been also reviewed. It was decided to base it on the Bloom taxonomy:

- Basic (Bloom' Taxonomy: Recall)
- Medium – Intermediate (Bloom' Taxonomy: Understanding & Application)
- Advanced (Bloom' Taxonomy: Analysis, Evaluation, Creation)

This test is intended to be used by the teacher trainers for formative evaluation of their future as a teacher in chemistry. For the moment this test can be taken in written form. An electronic demonstration version of the test will be produced shortly and put onto the project web site.

3.2 The work package on Enhancing Professional Abilities:

The work package is aimed at retraining adult learners with a chemical background in both generic and subject-specific competences, and thus implementing a virtual community constantly aware of the possibilities for enhancing professional abilities. The initiative is addressing professionals active in industry or education, as well as unemployed scientists. A survey and needs analysis for in-service training has been carried out to identify areas where training is needed for both employed and unemployed chemists and chemical engineers. 250 chemists and chemical engineers replied to the on-line questionnaire. 52% of the respondents were from academic institutions and 48% from the non-academic sector. The results of this questionnaire can be found at: www.ec2e2n.eu/2/wp02. Training modules on generic competences have been developed. The two modules developed concern **linguistic competences** and **managerial competences**, two areas identified from the questionnaire as being the most important. These modules can be viewed at the website <http://educ.chem.auth.gr/courses/>. Two on-line modules for subject-specific competences have been created. They are on the topics of chromatographic techniques and spectroscopic techniques and interpretation of data. These modules can be found at <http://www.intensiveschool.eu>.

EC2E2N 2 Pilot on-line courses

Chromatographic Techniques

Gas Chromatography Mass Spectrometry

IR Spectroscopy Applications

NMR Spectroscopy

Small Angle XRay Scattering

UV-Vis Spectroscopy

Software for a database on training opportunities for professional chemists has been developed and the database is available online at:
http://ecampus.chem.auth.gr/third_cycle/index.php/k2-showcase/cpd

3.3 The work package on Sustainable Entrepreneurship

In the previous EC2E2N project, the possibilities for Higher Education Institutions of the Chemistry and Chemical Engineering Education Network to develop activities stimulating student training in entrepreneurship and promoting the acquisition of related skills were

investigated. Tasks of that project were an analysis of the chemistry curricula of some member Institutions (in order to point out possible entries for entrepreneurship and self-employment best suited to foster innovation in production to market), the determination of possible best practice examples, suitable ways of networking already existing entrepreneurial activities, and the evaluation of how to identify a European umbrella organization able to take care of it.

The conclusion of this first EC2E2N project was that member institutions of the thematic network Association are able to activate initiatives along such a direction and to assemble a European umbrella organization for entrepreneurship based on academic research and teaching.

THE PURPOSE OF THE SUSTAINABLE ENTREPRENEURSHIP WORK PACKAGE OF EC2E2N2

The purpose of this work package was to leverage on that previous study and actually build such initiatives and a European umbrella so as to establish educational activities suited to train younger generations of chemists to become entrepreneurs and be self-employed; to open new ways of channelling innovation into the production market; and to offer to the few existing chemistry spinoff and start-ups of the Network a solid umbrella infrastructure allowing them to compete on the European scene and efficiently target the related market. Three start-up companies are partners in this project and significantly contributed to this particular work package.

BACKGROUND WORK

Transversal background EC2E2N2 activities carried out to the end of providing an appropriate operating ground for the sustainable entrepreneurship work package consisted in a) the design and execution (jointly with the European Commission/Joint Research Centre (JRC), the European Association for Chemical and Molecular Sciences (EuCheMS), and the European Chemical Industry Council (Cefic)) of a European Employment Survey for Chemists and Chemical Engineers;

b) the co-organization of the Strategic Event "COST Actions – A Great Opportunity as Incubators for Molecular Science and Technology" held in Brussels on March 26-28, 2014 (jointly with COST and EUREKA).

Background Activity A) The European Survey for chemists and chemical engineers (4440 returned questionnaires (3830 after purging the ones containing irregular answers) with preliminary results published in *Analyt Bioanalyt Chem*, DOI 10.1007/s00216-014-8191-z). This has led to the writing of a second paper co-authored by R. Salzer, P. Taylor, N.H. Majcen, F. De Angelis, S. Wilmet, E. Varella. The paper provides a detailed analysis of the participation, of the structure of the questionnaire and of the evaluation method used for the data collected in the Survey. It provides also details on the level of education owned by the interviewed people, as well as on the job of their first employment, the country of work, the contractual forms, the employment sector, the requested qualifications, the job functions, the continuing education and the salary. In other words this paper provides the most updated and complete radiogram of chemists' employment in Europe and has to been published in *Chemistry – A European Journal*.

Background Activity B) The Strategic Event "COST Actions – A Great Opportunity as Incubators for Molecular Science and Technology" (<http://www.cost.eu/events/actionsincubators>). This was a high level brainstorming of the members of the ECTN Administrative Council and of the WP3 leader with COST and EUREKA experts. Such initiative focused on the analysis of the challenges to be faced and future strategies to be developed by SMEs in Europe leveraging on contributions of COST, Solvay Brussels School of Economics, European Industrial Research Management Association, BCNP consultants GmbH, and Eureka experts. Further indications on how to

establish a start-up in a research environment and how to network companies within Eureka were provided by analysing some success stories, legal issues, patent and venture capital aspects.

The outcomes of the Background Activities provided a solid ground for the achievement of the three tasks of the project.

The design of a sustainable entrepreneurship post-master programme has been achieved. In brief, the programme, targeted towards Master students in chemistry and in similar degrees, is as follows:

1. Design of an enterprise in innovative educational services in chemistry

From the idea to the project: market research, methods for target specification and decision making evaluation

Market objectives and potential customers: comparative (competitive/collaborative) evaluation against standards and market players

2. Development and optimisation of the product

Product lifecycle, analysis of needs and methods of specification

Component analysis methods for function, materials and process selection

3. Technological foundations

Emerging trends in present technologies and computer methods for product layout and analysis

Social impact of emerging technologies: hazards, risks and safety

4. Implementation and management of innovative enterprises

Economic analysis and financial resources and risks

Commercial strategies, quality policy, evaluation, auditing

5. Some examples of good practice

The birth and evolution of some spinoffs and start-ups

Moreover, by going beyond the original commitment of the project, the programme has been implemented as a module of the core course of a ITN Erasmus⁺ Doctorate in Theoretical Chemistry and Computational Modelling (TCCM).

The module was delivered at the TCCM ITN Erasmus⁺ Doctorate in September 2015 and consisted of the following:

DAY 1 -Technological foundations for innovative entrepreneurship in computational services in chemistry, Design of an enterprise offering innovative computational services in chemistry;
DAY 2 - The success stories of the innovative computational chemistry SMEs clustered by the project;

DAY 3 - Design, establishing and management of innovative start-ups, Guidelines for the development and optimisation of the product of a SME.

By leveraging on the convergent input of both the already mentioned background activity B (the strategic Event co-organized with COST and Eureka in Brussels) and the European Employment Survey for Chemists, the roadmap for clustering a set of spinoffs and start-ups operating in the field of innovative distributed computing services has been designed. On that ground a cluster of 5 highly innovative EU spinoffs/start-ups (Master-up srl, IT; Krebs Inc, AT; eXact-lab srl, IT; Arctur d.o.o.,SI; Polymechnon, GR) has been formed.

Moreover, by going beyond the original commitment of the project, the cluster has signed a MoU (see A. Laganà, DRAG a cluster of spinoffs for Grid and cloud computing Virt&I-comm 5.2014.16), to cooperate in:

- research based education using multimedia and networking, in general, and in particular the activities of the Virtual Education Community of the European Grid Infrastructure (EGI) and of the European Chemistry Thematic Network (ECTN),
- accomplishment of the goals of distributed Competence Centres (CC) providing ICT services to Science and Technology communities, in general, and in particular to the Chemistry, Molecular, Materials Sciences and Technologies (CMMST) Virtual Research Community (VRC),
- participation to bids related to European Projects, Institutions and Companies addressed to spinoffs, start-ups and SMEs, in general, and in particular to the calls of Horizon 2020.

To the end of enhancing the effectiveness and fully exploiting the potentialities of the cluster of 5 SMEs, an umbrella organization was defined and the related embryo support infrastructure was designed and created within ECTN. This is the Virtual Education Community (VEC) Standing Committee (SC) of ECTN.

Moreover, by going beyond the original commitment of the project, the members of the VEC SC, thanks to the cooperation with the EGI (European Grid Infrastructure) Virtual Organization (VO) COMPCHEM, have been able to

a) establish the Chemistry, Molecular and Materials Science and Technologies (CMMST) Virtual Research Community (VRC)

b) submit a proposal to the Call EINFRA-9-2015 for assembling a Virtual Research Environment (VRE). The proposal was not funded but in a meeting held in September 2015 in Fulda (DE) the CMMST research groups of the Universities of Aachen (DE), Perugia (IT), Chieti (IT), Toulouse (FR), Nancy (FR), and Westminster (UK) decided to proceed in a bottom up fashion in implementing an experimental VRE on which ground a future application.

Both initiatives are meant to exploit the potentialities of Grid and Cloud computing by relying on the technical and market support of the DRAG cluster of SMEs. This will be the ground on which distributed knowledge (developed and stored for the purpose of providing innovation services) will be utilized for e-learning both under the form of Learning Objects (that are progressively improved thanks to their shared usage and to its association with a credit system rewarding proactive users) and under the form of materials to be used for self assessment procedures. Such services will be designed not only for academic activities but also, for the more general purpose of enhancing molecular sciences knowledge jointly with ECTN (Higher Education), EurChem (Professional), CEFIC (industrial) and EUCHEMS (general). This will imply, in the medium and long range, a transfer of technologies to the market and a transformation of the presently used credit system into a proper business model.

3.4 The work package on the Impact of Chemistry on Everyday Life:

While it is known that chemistry plays an important role in daily life and is at the heart of innovations and developments in new sources in energy, in health and in materials for example, it is also associated with the negative terms pollution, risk and danger. The public feel that they are poorly informed and this lack of information is the cause of fear towards chemistry.

In this workgroup the general objective was to provide effective examples demonstrating the power of chemistry in everyday life.

The specific objectives include:

- (1) Case studies in the areas: energy, health, water, food and innovative materials
- (2) A new internet-based test for chemistry in everyday life aimed at the general public

RESULTS

(1) The case study articles were prepared and have been published on the web at (www.whatischemistry.unina.it/wp4/). The list of 12 case studies are:

1. ***Weight Watching, Serendipity and Alternative Sweeteners*** by Arne van der Gen, University of Leiden
2. ***From dish to engine: transforming waste vegetable oil into biodiesel*** by Anna Maria Cardinale, University of Genova;
3. ***Drugs*** by Gustavo Avitabile, University Federico II of Naples
4. ***Polymers in our life*** by Jadwiga Laska, State Higher Vocational School in Tarnów
5. ***A trip inside a microchip: sand grain with big memory*** by Francesca di Monte, Associazione Culturale Chimicare
6. ***Poisons surround us*** by Anna Kolasa, Jagiellonian University, Kraków
7. ***The Silent Assassin: Sources and Toxicity of Carbon Monoxide*** by Bill Byers, University of Ulster, Anna Maria Cardinale, University of Genova)
8. ***Old and New Pollutants damage our “blue fuel”, but chemistry can save us*** by Luigi Campanella, Susanne Heidi Plattner; Sapienza University of Rome
9. ***Pollutants in indoor environments*** by Santino Orecchio and Salvatore Barreca; Università di Palermo
10. ***Chemical detectives*** by Michał Woźniakiewicz, Jagiellonian University, Kraków
11. ***Water. Do you really know it?*** by Franco Rosso; Associazione Culturale Chimicare
12. ***Wolfram, a folk with chemistry: farts and tobacco*** by Laureano Jiménez Esteller, University Tarragona

In addition, a series of videos that had been produced in Spanish by Rovira i Virgili University, Tarragona, Spain, have been translated to provide English sub-titles. These videos provide examples of chemistry in everyday life in a fun way. The titles are:

Marathon
Carbonated soft drinks
Stiffness
Cholesterol
Invisible ink
Love
Farts
Tobacco

They can be accessed via the network web site at: www.ec2e2n.eu/2/wp04.

(2) A new EChemTest® question database focused on various aspects of chemistry in everyday life has been created, consisting of over 300 questions. The question database content is divided into two difficulty levels (basic, advanced) and into 10 thematic groups:

- Natural materials, natural resources, minerals, and their use in everyday life
- Plastics, innovative materials and their use in everyday life
- Cleaning agents, cosmetics
- Chemistry in agriculture
- Food and health chemistry

- Chemistry of life
- Chemistry and Energy
- Industrial Chemistry
- Environmental Chemistry
- Concepts/terms/ideas that are commonly known but often misunderstood

In total, 471 questions were considered and processed. Each question submitted was initially reviewed by two independent reviewers; the final database content was reviewed by a panel consisting of 11 experts.

Three new EChemTest® tests have been designed based on the database content:

- A regular EchemTest® variant – a test consisting of 30 questions (20 basic, 10 advanced); the total number of questions used for this variant is 306; the question database content was divided into 30 ‘baskets’ for this purpose; for each individual test solved by the user at the test session, the test consisting of 30 questions will be composed by the system by random choice of one question from each basket; the test variant can be used in the regular EChemTest® test sessions for students, as well as for individuals;
- the quiz variant – a test consisting of 15 questions (10 basic, 20 advanced); the total number of questions used for this variant is 277; the question database content was divided into 15 ‘baskets’ for this purpose; for each individual test solved by the user at the test session, the test consisting of 15 questions will be composed by the system by random choice of one question from each basket; the quiz variant can be used for general public at science fairs, etc.
- A demonstration version of the quiz variant that will be freely available on the test web site (www.echemtest.eu) consisting of a fixed selection of 15 questions. This demonstration test is available in 5 languages (English, German, Dutch, Italian and Polish). Other languages will be added later.

3.5 The work package on the Virtual Educational Community:

To acquaint the academic community with issues concerning the virtual educational community, three awareness raising workshops were held (in Perugia, IT in July 2013; in Genoa, IT in May 2014; in Seville, ES in July 2014). In addition, a workshop on Digital Learning Objects was held at the 5th European Chemistry Congress held in Istanbul in September 2014. This involved training in the creation and distribution of digital learning objects. A workshop on ‘Digital Learning Objects: Best practice examples’ was organized in March 2015 in Cologne, Germany. The aim has been to encourage the use and sharing of digital learning objects in teaching. This has been further encouraged by holding contests to create learning objects (see the web site <http://ecampus.chem.auth.gr/contest>). Given the success of these contests, they will continue on an annual basis after the end of the project. Guidelines for digital learning objects have been developed. These have been produced as part of a book entitled ‘Innovative Approaches to Chemistry and Chemical Engineering Education’ in collaboration with work package 7 (see below).



A final workshop was held in Perugia, IT in September 2015. This workshop concentrated on tools for e-learning and e-assessment.



Tools for e-Learning and e-Assessment: Glorep and EOL

Perugia, September 14-15, 2015



A web portal for the virtual educational community has been developed. It can be found at <http://educ.chem.auth.gr:5080/openmeetings>

The site features audio and video conferencing, meeting recording and file sharing, a file explorer, a moderating system, a multi-whiteboard and chat feature, user and room management, a private message centre, the possibility to plan meetings with an integrated calendar, and a polling and voting system.

The group also produced the web pages for the annual plenary meetings of the network which are located at http://ecampus.chem.auth.gr/ec2e2n2_annual_meeting_2014/ and http://ecampus.chem.auth.gr/ec2e2n2_annual_meeting_2015/

A presence on social media has been developed (<https://www.facebook.com/DLOChem>).

3.6 The work package on Broadening Student Horizons:

The participants in this group recognized the utility of drawing up a short updated document on the Undergraduate, Graduate and PhD system in different countries.

The information required concern the following points: A) Entrance Requirements To University or Higher Education Systems. B) Undergraduate Degree /Duration Years. C) Most Suitable Period for Mobility /Duration Months. D) Graduate Degree /Duration Years. E) Graduate Degree Most Suitable Period for Mobility. F) Teaching Language, Knowledge of language required. G) Compulsory Number of Credits or Exams to be acquired during mobility. H) PhD/Duration. This is available on the web site of the group at <http://www.ec2e2n.net/2/wp06>



Compatibility of Course Structures of Chemistry and Chemical Engineering in the EU

European Chemistry and Chemical Engineering
Education Network 2
<http://www.ec2e2n.net/>

Work Package 06
Broadening Student Horizons

Group Leader – Prof. *Gabriella Borzone*
Università di Genova – Italy

Co-group Leader – Prof. *Otilia Mo*
Universidad Autonoma Madrid – Spain

This report is available at:
www.ec2e2n.eu/2/wp06



Lifelong
Learning
Programme

A survey of mobility in a number of partner institutions has been carried out. An analysis of the results suggests the following:

- (i) All Institutions follow a policy in establishing/confirming a Bilateral Agreement and provide public calls for the allocation of mobility grants.
- (ii) As suggested by the Erasmus guide, transparent procedures for selection of outgoing students are based on: a) year of study, b) number of credits achieved, c) mark average, d) suitability of field of study, e) compatibility of course structures, f) language knowledge.
- (iii) The need for the student of an institutional expert reference person (the Departmental Coordinator, the Reference contact person, the Erasmus Teaching committee) able to provide information and help students to design individualized study plans or Learning Agreements, was highlighted.
- (iv) In all cases the Institutions provide Language Courses for Outgoing Students as well as for Incoming Students, and in some cases online Language courses are also available.
- (v) Concerning the *recognition of credits*, all Institutions apply the ECTS System and only in one case there is a request of extra work at the end of the Erasmus period.
- (vi) Only in 2 cases there is a use of the *Eurobachelor®/Euromaster®* information among the responsible partners in the Erasmus programme involved in Chemistry /Chemical Engineering mobility.
- (vii) An aid to the student mobility concerns the transmission from partner country of information and a short and updated description of the method of assessment and of the grading system used.

Some obstacles and aids to mobility have been inserted.

1. Special emphasis has been given to the so-called “Mobility Window”, that is the year and semester suggested by the Institution as the more convenient both for outgoing and for incoming students.
2. Important information provided within this survey concerns the compulsory number of credits or exams required by the sending Institution and/or by the receiving Institution that the student should acquire during the mobility period.
3. The WP6 partners underlined the need to know the competence of the student in the Country language, the entry level language required by the receiving Institution and the teaching language in the host Country.

Key Parameters to be considered by the coordinator of student mobility

- o language of the programme or offered courses (for incoming and outgoing students),
- o similar content (rather large compulsory part) but different distribution between semesters, FLEXIBILITY
- o differences in the beginning of a semester,
- o students' foreign language skills.
- o significant differences in the methods of evaluating the student achievements
- o tutorial support when the students are coming back from abroad.
- o create a methodological framework for monitoring progress in promoting and removing obstacles to mobility.
- o Internship information: List of the available traineeships at the host institutions or in companies.

The experience gained by two HEIs with students involved in industrial placement mobility is described in the document “Tools available to aid mobility: help for students and institutions. Case-studies of internships in Chemical Engineering at Porto University and in Chemistry at the University of Cologne” by Luís F. A. Martins, Luís M. Madeira (PT - Faculdade de

Engenharia da Universidade do Porto), by Heike Henneken (DE - Colonia University) and Gabriella Borzone (IT-Genoa University). This is available on the network web site at <http://www.ec2e2n.net/2/wp06>.

The group has also developed recommendations for a student feedback template, with the aim to help other students wishing to study abroad (see <http://www.ec2e2n.net/2/wp06>).

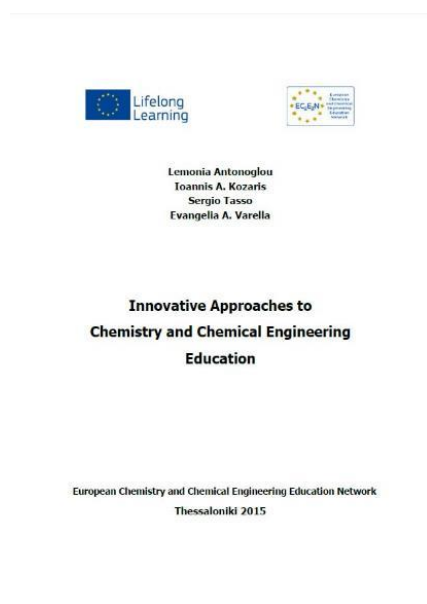
3.7 The work package on Re-Tuning Competences for Chemistry/Chemical Engineering for Europe 2020:

The work package has integrated the competences for all types of post-secondary chemical studies, in order to meet the challenges of the **European Modernisation Agenda for Higher Education**.

It serves as a model for the harmonisation and mutual completion of post-secondary studies in the **European Higher Education Area**.

In this context, two documents have been developed. They are entitled:

- **A Quality Label for Short Cycle Higher Education in Chemical Sciences.**
- **Validation of Intensive Study Programmes in Chemical Sciences.**



This book is available on the web at:
www.ec2e2n.eu/2/wp07

These documents appear as two chapters in the book entitled “Innovative Approaches to Chemistry and Chemical Engineering Education’ – pages 35-71 and 72-91, respectively. This book is available on the web at www.ec2e2n.net/2/wp07

At a first stage, for the Quality Label for short cycle studies, the situation in the European Union has been systematised, in what concerns:

- **Post-secondary non-tertiary education at Level 4** in the European Qualifications Framework for Lifelong Learning, with no possibility of transition to first cycle studies;
- **Post-secondary non-tertiary education at Level 5** in the European Qualifications Framework for Lifelong Learning, with possibility of transition to first cycle studies;
- **Short cycle higher education.**

Curricula purely dealing with chemical sciences are not often encountered in short cycle higher education. Nevertheless, topics related to chemistry and chemical technology are frequently included in study programmes dealing with:

biotechnology; environmental studies; restoration; agriculture; domestic sciences; engineering; health care; and product development.

Relevant results for post-secondary non-tertiary education and short cycle higher education have been summarised.

The descriptors for short-cycle studies have been developed on the basis of:

- The Descriptors defining Levels 4/5/6 in the **European Qualifications Framework for Lifelong Learning**;
- The Descriptors referring to Short Cycle and First Cycle in the **Qualifications Framework for the European Higher Education Area**;
- The **Descriptors for the First Cycle in Chemistry (the Chemistry Eurobachelor)**. and
- The **International Standard Classification of Education**;
- The **International Standard Classification of Occupations**;
- The **Directive for Recognition of Professional Qualifications**

The basis for a **Quality Label for Short Cycle Higher Education in Chemical Sciences** has been developed on the basis of existing Eurolabels[®]. It deals with:

- Learning Outcomes;
- Contents;
- Distribution and recognition of credits;
- ECTS and Student Workload;
- Modules and Mobility;
- Methods of Teaching and Learning;
- Diploma Supplement;
- Quality Assurance.

The validation of non-formal and informal learning outcomes acquired in intensive programmes – intensive schools and seminars/workshops – has been discussed with a special focus on chemical sciences.

All validation aspects have been dealt with, *i.e.*:

The identification and documentation of learning outcomes;

The definition of standards;

The adoption of appropriate assessment procedures;

The assessment of learning outcomes with respect to the standards;

The certification;

The reliability of the body proceeding to validation.

This work package has also produced guidelines for curricula combining chemistry and chemical engineering. These guidelines also appear in the book entitled 'Innovative Approaches to Chemistry and Chemical Engineering Education' on pages 92-128. This is available on the work package web site at www.ec2e2n.net/2/wp07.

For dissemination purposes a web site has been created at <http://www.ec2e2n.net>

Also, eighteen electronic newsletters have been published. These are available at

<http://www.ec2e2n.info>

A publicity leaflet has been produced and is available for download on the project web site.

European Chemistry and Chemical Engineering Education Network

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2014 EVENTS

Following the first EC2E2N project, the new project application entitled **EC2E2N-2 "Chemistry and Engineering Skills for Europe in 2020"** officially started for a 3 years period: October 1, 2012 to September 30, 2015

This is a large consortium, with partners from 29 EU countries (including the Republic of Serbia and Makedonia), and 6 different Third Countries. The partners include universities, national chemical societies, the European Chemical Industry Council (CEFIC, which represents nearly 30,000 small, medium and large companies), the European Association for Chemical and Molecular Sciences (EuChemS - whose members are all the European National Chemical Societies), three spin-off companies, and one of the seven institutes (IRMM) of the European Commission Joint Research Centre which has a responsibility for knowledge transfer. Thus the consortium brings together all the actors in chemistry/chemical engineering in Europe, and, through the membership of the partner associations, has access to virtually all chemists in Europe!

Anthony Smith
Network Coordinator
coordinator@ec2e2n.net

Subject: Lifelong Learning Programme - Call for Proposals 2012 (ERAC/27/12) - Erasmus Programme: Erasmus Network
Reference: 526259-LLP-1-2012-1-FR-ERASMUS-ENW Project Title: European Chemistry and Chemical Engineering Education Network 2
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EC2E2N Newsletter

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EC2E2N-2 Plenary Meeting and ECTN Association General Assembly

to be held at **Universidad Autonoma de Madrid Campus (Spain)**
April 24-26, 2014 - Visit the website

Dear Newsletter Readers,

Welcome to our Newsletter website. Created in 1999 for internal Network purposes only, the News rapidly grew up and is now disseminated outside of the Network and outside of Europe as a Newsletter.

Originally dedicated to the ECTN Association and the European Chemistry and Chemical Engineering Education Network information and work progress, it now includes contributions from various origins dealing with Education in Chemistry and Chemical Education, from/within the European Higher Education Area and the extended European area. A Guest Editor organization has been setup to enlarge the scope and to broaden the dissemination.

Now published regularly 5 times a year on a bimonthly schedule, the electronic bulletin is sent by e-mail to all members and registered readers (free service). Since the International Year of Chemistry in 2011, it now integrates within the yearly editorial line, at least one special edition dedicated either to a specific geographical area or another topic related to Chemical Education.

Pascal Mimero
Newsletter Editor

Today is Fri May 16 20:38:23 UTC+0200 2014

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4. Partnerships

Two of the major aims of this project were to increase mobility (of students, teachers and young researchers) and to provide descriptors and a European quality label for short-cycle studies, as well as to provide integrated European descriptors for all levels of Higher Education looking towards Europe in 2020. These aims clearly need European cooperation and as large a representation of European countries as possible. This project has partners from 28 European countries. The approach used for the descriptors and quality label were similar to that used very successfully by the Tuning project in which chemistry was one of the subject area groups and lead to the chemistry Eurobachelor and Euomaster labels.

For mobility, there are very different situations across Europe with flows often out of balance, in either one direction or the opposite one, and different percentages of mobility. By having a European and a sectoral approach to the study of mobility, for both studies and industrial placements, significant conclusions were drawn and recommendations made. It is of benefit to have partners from outside Europe providing input into these mobility issues, especially to provide information on student mobility in their countries and information on their higher education programmes.

The lack of knowledge of chemistry/chemical engineering by the general public is a European (and global) problem which generates fear of the subject. Thus it is a European cooperation that is needed to address this issue, using case studies appropriate to all countries and a test on chemistry in everyday life that is available in several languages.

The identification and promotion of best practice examples of teacher training will benefit from having a European view of what is going on, as a national view is not wide enough. The creation of a test based on these best practice examples will benefit teacher trainees in all countries.

Given the international nature of the chemical industry, the survey and needs analysis for the training of professional chemists in generic and subject-specific skills needs a European perspective. The workshops held as part of this project also greatly benefited by being of a European rather than national character, allowing a much greater exchange of ideas and opportunities for networking, as well as providing an opportunity to trail the training modules produced for generic competences.

Since we are operating in the European Higher Education Area, it is absolutely necessary that the studies proposed in this project have a European dimension.

For dissemination purposes in particular, it has been important that the network has the European Chemistry and Molecular Science Association (EuCheMS), the European Chemical Industry Council (CEFIC), and the European Commission Joint Research Centre as partners. This enabled the project to have input from a wide range of actors in the chemistry/chemical engineering sector, and for the outcomes to be widely distributed. The European Chemistry Thematic Network Association (ECTN) will take over the work of the project in order to exploit and develop the outcomes. The ECTN has strong links with international bodies such as EuCheMS, the International Union of Pure and Applied Chemistry (IUPAC), the Asian Chemical Education Network, and the Federation of African Societies of Chemistry. This enables the outcomes of this project to be widely distributed.

5. Plans for the Future

The coordinator will put all the outcomes of the project onto USB keys and distribute them to project partners and key academics, teachers and industrialists.

For **dissemination**, the network will continue to publish 4 newsletters per year, maintain and update the project web site.

All work package leaders have produced a poster to highlight the outcomes of their work. These posters will be used at subsequent conferences.

Visits to the various web pages of the project will continue to be monitored.

Concerning the **exploitation of project outcomes**, the European Chemistry Thematic Network Association (ECTN) will take over the running of the web site and continue to issue newsletters. The Association will also set up specific working groups to continue the work of the project beyond the lifetime of the project funding.

The working group dealing with **excellence in school and university teaching** will continue working as a work group within ECTN and in close collaboration with the EuCheMS Division of Education. The group will encourage teachers to provide input for the database of expertise in teaching methods. The demonstration Internet-based test for trainee teachers will be put on-line and act as an incentive for the use of the full test.

The working group concerned with **enhancing professional abilities** will continue to develop and test the modules on generic competences (linguistic competence and managerial competences) and subject-specific modules. Funding for intensive courses will be sought so that these modules can be used effectively.

The entrepreneurship training programme developed in the **sustainable entrepreneurship** work package will be used in future intensive courses to be held by network partners for master students and doctoral candidates. There are plans already being discussed by ECTN, EuCheMS, CEFIC and EC JRC, to repeat the European employment survey that has been so successful. For innovative chemistry sectors a joint initiative with COST and EUREKA will be considered for:

- making synergy with important European players in the sector of fostering innovation
- developing an accreditation scheme for Academic spinoffs.

The working group on the **Impact of Chemistry on Everyday Life** will continue to be active as a work group of ECTN. This will ensure that work continues to publicise the case studies and the Internet-based test for chemistry in everyday life. The tests will also be translated into many more European languages. Further discussions concerning the best way to reach the target audience (primary and secondary schools and the general public) for this test will be held.

The activities of the working group concerned with the **Virtual Educational Community** will become part of the Virtual Education Community Standing Committee of ECTN. This will ensure that the web sites, the learning object competition and the grid repository for learning objects will be fully exploited and developed.

The activities of the **Broadening Student Horizons** working group will continue as a work group of ECTN. This will enable the work carried out to be exploited and amplified in the future. In particular, it is expected that a document on language training for mobile students will be produced.

Some of the work of the group entitled **Re-Tuning Competences in Chemistry/Chemical Engineering for Europe 2020** will be carried on by the Label Committee of ECTN. This committee runs the Eurobachelor, Euromaster and Chemistry Doctorate Eurolabels®. Again this will ensure that the work is further developed, exploited and kept updated.

6. Contribution to EU policies

This project has contributed to two of the objectives of the Lifelong Learning Programme, namely the encouragement of the best use of results, innovative products and processes and the exchange of good practice in order to improve the quality of education and training, and also by contributing to the development of quality lifelong learning. It has done this, for example, by creating examples of best practice in teacher training and tests for trainee teachers, by creating learning modules for professional chemists, the basis for a quality label for short cycle courses, a virtual learning community, and descriptors for all post-secondary education. These can all lead to an improvement of the quality of education and training.

The development of quality lifelong learning with a European dimension has been addressed by improving the quality of teacher training through identifying best practices and developing a database of teaching expertise; by providing training modules for professional chemists; by providing a support structure for a cluster of spin-off companies; by enhancing student mobility through the identification of barriers and the development of tools to aid mobility; and by providing the basis for a European quality label for short courses and an integrated set of descriptors and guidelines for all post-secondary education in chemistry. The valorisation of intensive courses has also been addressed.

The project also supported the achievement of a European Area of Higher Education, particularly through the provision of descriptors for all post-secondary education in chemistry, based on Learning Outcomes.

The development of innovative practices in education and training at the tertiary level and their transfer is one of the main reasons for the existence of the network. With partners from 29 European countries and 6 countries from outside Europe, it is inevitable that the transfer of the innovative practices described above will occur from one country to another. The network is also an ideal forum for enhanced multilateral cooperation. By working together on the various work packages of the project and meeting at working group meetings and annual plenary meetings, there is ample provision for cooperation. This is evidenced by the number of spin-off activities (such as intensive courses, European quality labels for bachelor, master and doctoral programmes in chemistry, and internet-based chemistry tests) that have resulted from previous projects carried out by the network.

The project also addresses the Education and Training 2020 strategy in which two of the four long-term objectives are making Lifelong Learning a reality and enhancing creativity and innovation, including entrepreneurship, at all levels of education and training. The work package on sustainable entrepreneurship, for example, has produced and trialled a training programme for entrepreneurship. It has also created an initial cluster of spin-off companies that will provide mutual help in their development and sustainability.

The Europe 2020 strategy also has a Youth on the Move initiative which has been addressed by the part of this project which has looked at barriers to student mobility as well as aids for student mobility. Youth on the Move also calls for more workplace and entrepreneurial learning experiences. This is addressed by the work package on sustainable entrepreneurship which has developed an entrepreneurial training programme.

