Letter from EUROPE

This letter deals with ***Education and Training*** *2010. The expression was coined by the European Commission to characterize the activities improving the quality and effectiveness of education and the progress through agreed instruments.*

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Higher Education in Europe

Higher education plays an essential role in all societies, creating new knowledge, transferring it to students and fostering innovation. Europe has around 4,000 higher education institutions, with over 19 million students and 1.5 million staff. Education institutions throughout Europe are working to modernize, both in terms of the courses they offer and the way they operate.

The modernization agenda for universities is part of the *Lisbon Strategy*, an action and development plan for the European Union. It was set out by the European Council in Lisbon in March 2000, and the European Commission published in 2004, a modernization agenda for universities which was welcomed by the Member States and the main stakeholders in higher education. The main fields of reform are:

- Curricular reform: Introducing throughout Europe the bachelor-master-doctorate system, fostering competence based learning, flexible learning paths, recognition, mobility.
- Governance reform: University autonomy, strategic partnerships, including those with enterprises, quality assurance.
- Funding reform: Diversified sources of university income better linked to performance, promoting equity, access and efficiency, including the possible role of tuition fees, grants and loans.

Towards the European Higher Education Area – The Bologna Process

Reforms in education are promoted by the *Bologna Declaration of the European Ministers of Education* (June 1999). The *Bologna Process*, in which 46 countries in the wider Europe are participating, is a collective effort of public authorities, universities, teachers and students, together with stakeholder associations, employers, quality assurance agencies, international organizations and institutions aiming at lifelong learning and development. The priorities of the Bologna Process are:

- Introduction of the three cycle system (bachelor/master/doctorate) to harmonize education and academic degrees. The cycles are defined in terms of *credits* (or *credit points*, cp) of the *European Credit Transfer and Accumulation System (ECTS)*:
  - 1st cycle: typically 180–240 ECTS credits, awarding a Bachelor's degree.

ENGINEERING DEGREE • Measurement Science and Technology Courses (credit points, cp*)	COUNTRY	INSTITUTION**
Automation Engineering (Master Degree after Bachelor) • Measuring and microsystems technology (3 cp), Environmental measuring technology (3 cp), Non-contact measuring processes (3 cp)	 Austria	University of Applied Sciences Vienna
Materials Engineering (Master Degree after Bachelor) • Materials characterization techniques, principles and measurement procedures (6 cp)	 Belgium	Catholic University of Leuven
Automation and Measurement (Bachelor Degree) • Measurement in electro-engineering (6 cp), Measurement of physical quantities (6 cp), Medical diagnostics techniques (5 cp), Electronic measurement systems (5 cp)	 Czech Republic	Brno University of Technology
Biosystems Engineering (Master Degree after Bachelor) • Measuring technique for mechanical systems, gases, liquids (5 cp), Sensor technology (5 cp)	 Denmark	University of Aarhus
Electrical Engineering (Bachelor Degree) • Measurement and sensor techniques (5 cp)	 Finland	Arcada University of Applied Sciences
Sensor Systems Technology (Master Degree after Bachelor) • Physical sensors, Optical sensors, Sensor-actor-networks, Real-time data processing (30 cp), Chemical and bio-sensor systems, Automotive sensors applications (30 cp)	 Germany	Karlsruhe University of Applied Sciences
Mechanical Engineering (Master Degree after Bachelor) • Physics and measurement methods (3 cp), Microscopic measurement methods (3 cp)	 Netherlands	Eindhoven University of Technology
Mechatronics (Bachelor Degree) • Fundamentals of metrology (4 cp), Metrology and measurement systems (4 cp)	 Poland	Technical University of Lodz

Table 1 Engineering Education in Europe: Examples of Degrees in Engineering, and Measurement Science and Technology Courses of Study

* One credit point (cp) corresponds to 25 to 30 hours of work for students.
** European universities awarded for excellence in supporting mobile students (2009)

- 2nd cycle: typically 90–120 ECTS credits (a minimum of 60 on 2nd-cycle level). Usually awarding a Master's degree.
- 3rd cycle: Doctoral degree. No ECTS range given.

- Recognition of qualifications and periods of study
- Quality assurance.

One academic year corresponds to 60 ECTS-credits that are equivalent to 1,500 to 1,800 hours of study. The new model comes closer to the North American and Japanese systems. It gives greater weight to practical training and to intensive research projects. The way credits are measured reflects how hard a student has worked. The new evaluation methods reflect not only a student's performance on exams, but also his or her lab experiments, presentations, hours spent on study, innovation capacities, and so forth.

ECTS makes teaching and learning more transparent and facilitates the recognition of studies (formal, non-formal and informal). The system is used across Europe for credit transfer (student mobility) and credit accumulation (learning paths toward a degree). It also informs curriculum design and quality assurance. Institutions which apply ECTS publish their course catalogues on the web, including detailed descriptions of study programs, units of learning, university regulations and student services. Course descriptions contain learning outcomes (what students are expected to know, understand and be able to do) and workload (the time students typically need to achieve the learning outcomes), expressed in terms of credits.

Higher Education and the role of Measurement Science and Technology

Almost all engineering degree educations include courses on Measurement Science and Technology with at least five credit points corresponding to about 150 hours work for students as exemplified by Table 1.

The institutions named in Table 1 belong to 65 higher education institutions from 16 countries which have been awarded in 2009 with special European quality labels in recognition of their efforts to make it easier for students to study abroad. These labels are given to universities which have shown excellence in applying the European Credit Transfer and Accumulation System (ECTS) and the Diploma Supplement (DS), two European instruments that make teaching and learning more transparent and facilitate the recognition of studies and qualifications. Criteria for the ECTS label are, amongst others, are that all relevant information for foreign students (information package, course catalogue) are available in English.

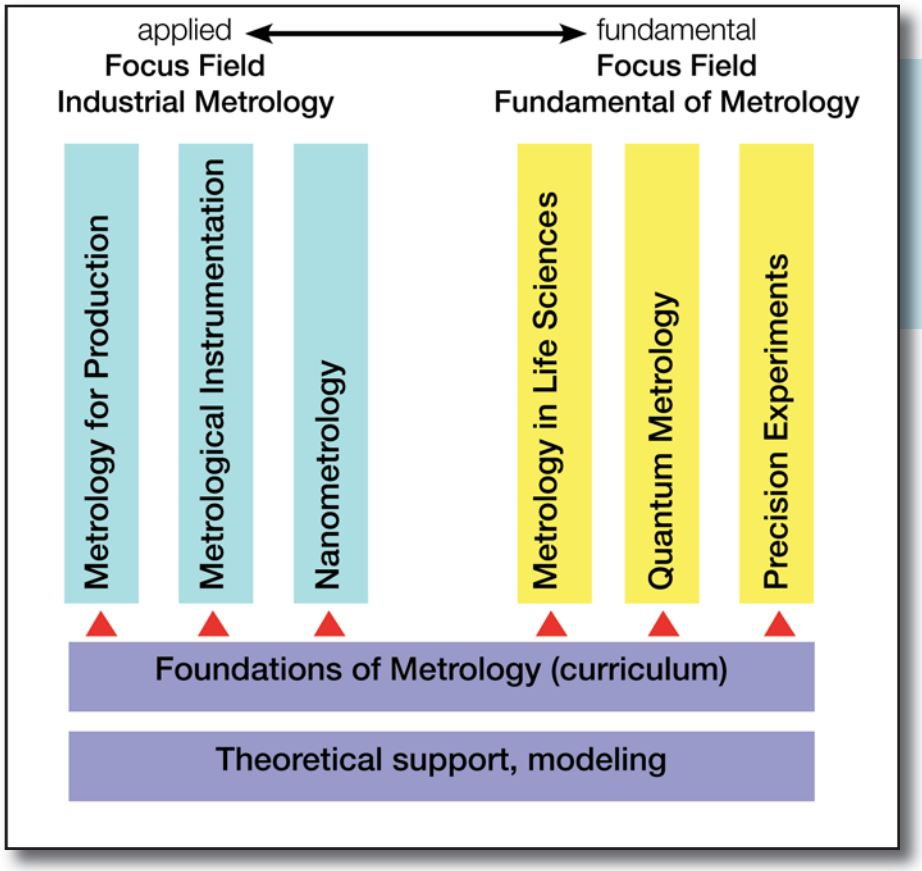
Concerning education in Chemistry, nine European universities have recently joined forces and have formed a consortium, which offers a jointly delivered Master's degree program Measurement Science in Chemistry (MSC) (www.msc-euromaster.eu). The jointly delivered study program is a fully Bologna-compliant master's level program with the volume of 120 ECTS points. The program is open to students worldwide with bachelor's degrees in chemistry (or related). The intention of this consortium is to offer master-level education in analytical chemistry adapted to today's job market requirements for analytical chemists, especially focusing on the quality assurance of analytical measurement results. This course covers the most advanced topics of MSC, including the key concepts of analytical quality – traceability, validation, measurement uncertainty, etc.

Training in Metrology in Chemistry

To facilitate the training of Metrology in Chemistry to laboratory staff, researchers, educators, decision-makers and accreditation assessors, the European TrainMiC program has been created (www.trainmic.org). The vision of TrainMiC is to improve the quality of analytical results by promoting and providing a European-wide, harmonized training program via a network of national providers sharing resources, including materials, training systems.

TrainMiC is operational across many parts of Europe via national teams. These teams use shareware pedagogic tools which have been harmonized at European level by a joint effort of many experts across Europe working in an editorial board. The trainers use presentations – e. g. on sampling, validation of measurement procedures, traceability, uncertainty, statistics, reference materials, interlaboratory comparisons, internal quality control – to provide theoretical training covering the topics related to metrology in chemistry and the require-ments of standards and guidelines (e.g. *ISO/IEC-17025*, *ISO Guides 34* and *35* and *ISO-17043*).

The educational material has been translated into ten different languages. The Joint Research Centre Institute for Reference Materials and Measurements of the European Commission (JRC-IRMM) of-



fers coordination and fosters the European dimension (http://irmm.jrc.ec.europa.eu/html/homepage.htm).

Training in Industrial Metrology and Fundamentals of Metrology

As a unique training center for the science and app lication of traceable measurements, the *Braunschweig International Graduate School of Metrology (IGSM)* was established in 2007 by the Technische Universität (TU) Braunschweig and the Physikalisch-Technische Bundesanstalt (PTB) (http://igsm.tu-bs.de).

The University of Braunschweig focuses on scientific-technical fields with a strong Focus Field need for metrology. Three departments combine their expertise in the graduate school: the departments of (i) Electrical Engineering, Information Technology, Physics, (ii) Life Sciences and (iii) Mechanical Engineering.

The PTB is the national metrology institute of Germany, operating a number of worldwide unique facilities, mostly related to the primary implementation of the SI units. The PTB contributes to the graduate school with scientists and engineers with many years of experience and exceptional equipment. The TU Braunschweig provides all the necessary training capabilities.

The structure of the International Graduate School of Metrology is divided into two focus fields: *Industrial Metrology* and *Fundamentals of Metrology*.

- Industrial Metrology consists of *Metrology for Production*, *Metrological Instrumentation* and *Nanometrology* and is devoted to innovative concepts for the measurement infrastructure according to the demands of industry and trade. It includes topics such as in-line metrology, production engineering and next-generation electronics and other micro- and nanosystems.
- Fundamentals of Metrology consist of *Metrology in Life Sciences*, *Quantum Metrology* and *Precision Experiments*. It comprises all fundamental research aspects related to the implementation an dissemination of the units. Research efforts aim at utilizing quantum effects and universal physical constants to implement next-generation primary standards.

The curriculum of the graduate school comprises also the mandatory lectures *Foundations of Metrology*. The lectures cover the basic metrological methodology, an overview of the base and derived units, the state-of-the-art technologies, how to implement them and the global measurement system. It aims at a common, broad and comprehensive metrological background and helps to overcome the fragmentation of the topics in the natural and engineering sciences.

The curriculum is supplemented by internships in local industrial calibration laboratories for students in the focus field "Industrial Metrology," and by guest researcher opportunities in renowned research laboratories abroad for students in the focus field "Fundamentals of Metrology." The lectures and courses are held in English.

The *Summer School of Metrology* takes place at attractive places around Braunschweig every two years and lasts about one week. It took place for the first time in 2008, with Nobel Prize winner Klaus von Klitzing as one of the lecturers. Leading international speakers are invited to give lectures on the latest advances in metrology. The summer school gives the students an opportunity for international networking and integration into the metrological community.

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