TOWARDS A EUROPE INSPIRED TRAINING OF CHEMISTRY TEACHERS

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1 Introduction

The objective of the present paper is to discuss the activities of the TFA (Tirocinio Formativo Attivo) course for Chemistry teachers (held at the Department of Chemistry, Biology and Biotechnology of the University of Perugia (Italy) with the support of the Department of Mathematics and Informatics during the first half of the year 2015) and analyse its outcomes. In particular, the paper focuses on the introduction of teaching practices and European standards developed by the European Chemistry Thematic Network (ECTN) [1-8] in the training of TFA teachers of the Umbria Region schools.

More specifically the TFA course has been taken as a test-bed for training the future teachers of the Umbria Region schools on the innovative approaches to e-learning characterizing the synergistic Virtual Research Environment (VRE) model fostered by the Chemistry, Molecular & Materials Sciences and Technologies (CMMST) Virtual Research Community (VRC) [9] as proposed in a joint project of INSTM, EUCHEMS, ECTN and other European Institutions submitted to H2020 on January 14, 2015 [10]. In this spirit, the sessions of the TFA course were devoted both to familiarize the attendees with the European Chemistry Syllabus and to structure its contents as Learning Objects (LO) knowledge units designed to be self contained and modular, correspond to definite fractions of the credits of the European Credit Transfer System (ECTS), support teaching and learning as well as self evaluation activities (especially the electronic ones because shareable and reusable).

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In addition, EOL (Exams On Line) [12] and GLOREP (Grid LO REPository) [13] were analysed. EOL is an open source web based distance assessment software made of the PHP language parser, of the Apache web server enabled to invoke the PHP language parser and of either the Firebird or the MySQL RDBMS. This allows EOL to operate both the front-office and the back-office agent to support the running and reporting of EChemTest. GLOREP is a distributed system of LOs based on a Client/server communication paradigm that consists of the following components: a server bearing a CMS (Drupal [4]) offering the needed repository management activities at back-end-level (like backup, protection, access control) and providing, through a web portal, various services for clients (like up/download LOs, file management) at front-end level. GLOREP handles also a set of clients requiring the services offered by the server, an internet type connection allowing clients to use available facilities after authentication and virtual Organizations (like COMPCHEM) providing access to remote file systems where the LOs are stored.

2 The UNISTUDIUM platform

The reference platform adopted to support the activities reported here is UniStudium (www.unistudium.unipg.it). At present "UniStudium" is in testing version for all the TFA courses of the University of Perugia and is an integral part of the Educational programme of most of the Departments. Unistudium is based on the e-learning software Moodle (Modular Object-Oriented Dynamic Learning Environment) that is an international de facto standard and offers several functionalities useful for teaching and learning activities.

Both EOL and GLOREP have been developed at the University of Perugia and operate on Moodle. Therefore, in addition to being open source (and therefore no subject to licence related constraints), EOL can straightforwardly import the libraries of question and answers developed in Moodle and easily interact with GLOREP and its mechanisms for a synergistic reuse and improvement of distributed knowledge. This is facilitated by the "moodledata" module (also developed at the Perugia University) that enables interoperability between UniStudium and GLOREP and allows LOs to be shared and simultaneously used by different computers. This has allowed TFA attendants to start sharing the courses materials among them and with teachers. Moodle is, in fact, a modular, dynamic and object oriented environment based on a constructionist approach to learning that maintains that knowledge is achieved through the production of tangible objects. Its software is written using PHP and Javascript and allows its users to design and develop customized additional functionalities.

3 The ECTN approach

The ECTN Virtual Education Community (VEC) is indeed a cluster of geographical dispersed education operators (students, teachers and researchers) sharing competences, software, and hardware on the public network. This is a peculiar feature of ECTN (a thematic network made of 136 Universities of 32 European countries started on 1996 and funded within the Socrates initiative). At the beginning, the leadership of ECTN resided clearly in the hands of three British Professors: Richard Whewell, Terence Mitchell and Anthony Smith. They were University Professors in Scotland, Germany and France, respectively, and had a high European profile. United Kingdom had also the leadership in terms of number of partner Institutions with more than 10% of share, followed in a sequence by Italy, France, Germany and Spain. The projects run by ECTN span a large variety of activities ranging from (in brackets the leading University) Food Chemistry (Aveiro, PT) to Biological Chemistry (Leiden, NL), Image of Chemistry (Köln, DE), Industrial Placements (Nottingham, UK), Safety (Cracow, PL), Multimedia in Chemistry Education (Perugia,

IT), Chemistry and Cultural Heritage (Thessaloniki, GR), Training New Teachers (Keele, UK), Teaching Evaluation by Students (Brussels, Be).
However, the landmark ECTN subproject was the Core Chemistry one led by the University of Bologna (IT) that worked out a harmonized curriculum for the average European student. The Core Chemistry Group produced documents which were published in two books in 1997 and 1998 considering also the mathematics and the physics requirements for chemistry students. The group then continued to work in the ECTN2 project on 'Core Chemistry for the Future' (2000-2002) [14]. This work provided the foundations for designing a subproject on Tuning Educational Structures (Dortmund, DE) leading to the definition of Eurolabels® and related procedures of accrediting for that Higher Education Institutions. Such work provided also the foundations for the subproject on EChemTest® (Lyon, FR) leading to the design and implementation of e-test libraries on Chemistry subjects at different levels of knowledge.

The work was important also to the end of defining a Syllabus specifying the chemistry knowledge that schools should provide their students with. The EChemTest libraries of questions related to these sections of the Syllabus named GC1 (General Chemistry 1 for the basic school knowledge of chemistry) and GC2 (General Chemistry 2 for access to University) are those considered for the TFA courses. This year the focus was, as already mentioned, on the access to the University (the case of the basic school chemistry knowledge was considered in the year 2014).

4 On implementing the General Chemistry Syllabus teaching as LOs

During the TFA course the items of the GC2 section of the Syllabus have been articulated into seven LOs (see Table 1 and the more detailed information given in the individual contributions section) by properly aggregating its ten topics for a total of fifty front teaching hours (corresponding to a University propaedeutic course of seven ECTS (European Credit Transfer System) Credits).
The seven LOs are "Atomic structure" (LO1), Chemical reactions (LO2), Chemical bonds and States of matter (LO3), acid base equilibrium (LO4), Thermodynamics and Redox rections (LO5), Chemistry of elements (LO6), and Organic Chemistry (LO7). All LOs correspond to 7 ECTS credits with the exception of LO3 (Chemical Bonds and States of Matter) that corresponds to 8 ECTS credits. Each of them, however, have been further structured in smaller units (powerpoint files) as indicated in detail in Table 1. Examples of implementation of 4 LOs in Italian language are given as annexes of the paper. For each of them a set of multiple response questions (large enough to allow a random selection of well diversified samples) was prepared for being managed using and appropriate e-tests software managers. In this respect during the TFA course preference was given (contrary to the routine EChemTest procedure) to open source tools such as Moodle [11] and EOL [12] and emphasis was given as well to the adoption of the LO approach for further developments of the support material to the courses.

TABLE 1: ARTICULATION OF THE GC2 LEARNING OBJECTS

Learning Object	Subunits/powerpoint files		Hours	Total
LO 1 Atomic structure	LO1_a LO1_b LO1_c	Atomic model, isotopes – Electronic structure and s,p,d,f orbitals Periodic Table and relationships with the properties of the elements Quantities of matter, mole and Avogadro number	LO1_a 3/7 LO1_b 2/7 LO1_c 2/7	7
LO 2 Chemical reactions	LO2_a LO2_b LO2_c	Chemical equations and their balancing (masses and concentrations) Reaction rate (order, molecularity, kinetic systems) and its determination Transition state, activation energy, catalysis and collision models	LO2_a 2/7 LO2_b 2/7 LO2_c 3/7	7
LO 3 Chemical bonds and States of matter	LO3_a LO3_b LO3_c:	Electronegativity. Ionic, covalent and metallic bonding Dipole-dipole and hydrogen bonds. van der Waals interaction Solid, liquid, gas phase models and diagrams	LO3_a 2/8 LO3_b 2/8 LO3_c 2/8	8

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	LO3_d:	Solutions, colligative properties and concentrations	LO3_d 2/8	
LO 4 Acid base equilibrium	LO4_a LO4_b LO4_c	Acids and bases, Kw ionic water product, pH Acid base equilibrium and constants, titrations and buffer solutions Equilibrium constant and Le Chatelier principle (P, C and T variation)	LO4_a 2/7 LO4_b 2/7 LO4_c 3/7	7
LO 5 Thermodynamics and Redox	LO5_a LO5_b LO5_c:	Endo- and exo-thermic reactions, Enthalpy, Energy and Hess law Redox and oxidation number, balancing and metal activity series Electrode potentials, electrolysis and Faraday law	LO5_a 3/7 LO5_b 2/7 LO5_c 2/7	7
LO 6 Chemistry of elements	LO6_a LO6_b LO6_c	Properties of elements and compounds of the periodic Table Transition Metals and multiple oxidation states and related compounds The elements of life	LO6_a 3/7 LO6_b 2/7 LO6_c 2/7	7
LO 7 Organic Chemistry	LO7_a LO7_b	Homologous series, functional groups IUPAC nomenclature, isomers Organic reactions (substitution, addition, elimination, polymerization)	LO5_a 3/7 LO5_b 4/7	7

5 Beyond individual contributions

In addition to the common critical analysis of the Syllabus, to the preparation of a certain number of questions and answers related to the subject considered, to the asssemblage of a set of slides providing a power point presentation of the subject to be implemented on the GLOREP distributed repository of LOs, the attendants have elaborated some critical notes on the educational strategy adopted by the TFA that are summarized here.

Strong points

The use of the Moodle platform

Such platform is extensively used by at the University of Perugia and local schools. It has shown to be very useful in the practices carried out during the course

The Virtual Education community

The activities of the VEC are of extreme interest to the end of both standardizing the different educational methodologies and fostering synergistic approaches through the evaluations of individual contributions and their rewarding by means of a credit system.

The ECTN Certification

The accreditation processes of ECTN and related certification show to be very useful for student mobility

The GC2 level

The GC2 level is important to the end of guiding the students to better follow/undertake Molecular science studies

Distributed repositories

Distributed repositories are useful to enforce virtuous cycles in education by allowing people to share and improve each other educational software

Relationship between LO and front teaching

The general correspondence of LOs with a clear fraction of the ECTS credit is important and adds useful modularity to learning objects.

Suggestions for improvement

The Virtual Laboratory

The section on the use of Virtual Laboratory looks very useful as an approach to best practices in Chemistry laboratories yet it is not adequately developed.

A more suitable approach for schools

The proposed approach, although valid for HE studies, is not compliant for schools with modern views in which teaching for competences is more oriented towards cross relationships with subjects of integrated science using innovative methods developed within transversal disciplines (pedagogy, didactics, etc.). Moreover modern views of teaching aim at a more proactive learning associated

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with real life situations rather than theory. Furthermore, the slide format of most of the LOs available for front teaching in GLOREP remains excessively front teaching oriented if it is not complemented with proactive means like self-assessment.

6 Conclusions

The TFA course has shown to be useful for training new chemistry teachers on the introduction of the use of electronic tools in educational activities. At the University of Perugia this task was jointly undertaken by the Departments of Chemistry, Biology and Biotechnologies and of Mathematics and Informatics. In particular, TFA activities have shown how the teaching of the General Chemistry at a European level using ICT technologies can be articulated with the following program objectives: "Introduce and analyze ICT technologies meant to support networked learning and the establishing of Virtual Education Communities. Design and assemble General Chemistry learning modules of European level aimed at fostering the development of a solid knowledge of Chemistry and Chemical Technologies using an ICT platform. Exploit Chemistry related knowledge management techniques on distributed repositories by building self assessment tools and related support materials ."
The subtask playing the major role in this have been:

- The analysis of the GC2 European Syllabus for Chemistry in Schools and its articulation into a suitable list of LOs and lectures;
- The valorisation of Open Source instruments like Moodle and EOL;
- The introduction of the use of GLOREP, the distributed repository manager developed in Perugia, for producing Learning Objects as support materials to self evaluation procedures.

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ANNEX 1: VIRT&L-COMM.7.2015.2: Learning Object - Il Legame chimico
ANNEX 2: VIRT&L-COMM.7.2015.3: Learning Object - La struttura atomica
ANNEX 3: VIRT&L-COMM.7.2015.4: Learning Object - Chimica Organica

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