518300-LLP-2011-IT-COMENIUS-CNW

# Chemistry Teachers' Training in Greece

Lifelong Learning Programme

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# Chemistry Teachers' Training in Greece

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**ABSTRACT**

*In the first part of this report we attempt to make a comprehensive presentation of the existing structures and initiatives for pre-service and in-service science teacher training in Greece, with an emphasis on chemistry teachers. In regard with pre-service training we refer to the chemistry and primary education departments of Greek universities and the obligatory program EPPAIK at ASPETE. In regard with in-service training we referto the obligatory "Initial Training" program and three optional programs ("Major Training", "Project Training", "ICT in Education") all organized by the Institute of Educational Policy, as well as the training initiatives undertaken by the regional Science Laboratory Centers (EKFE). In addition, we refer to the Masters programs related to physical sciences education and the initiatives undertaken by the Association of Greek Chemists, which are addressed to both in-service and pre-service chemistry teachers. In the second part of the report, we present an assessment of the Greek national science teachers' training scheme based on related published research and on the analysis of the material obtained during the workshop on teacher training. Both positive and negative aspects of the teacher training system are presented. In addition, we refer to the obstacles Greek teachers face for effectively implementing their acquired skills and knowledge and to specific proposals in regard with the content and type of teacher training. Finally, in the third part of this report we examine the so far achieved and the anticipated impact of the "Chemistry is All Around Network" project. Several aspects of this impact are examined, some of which being the choice of the suitable teaching resource by the teacher, the areas in which teachers and scientific experts could effectively collaborate and specific educational policy and design issues which could serve the aim of preparing and retaining high quality chemistry teachers in Greece.*

## 1. National Situation on Teacher Training

In the first part of the report, we will make an attempt to present the structure and organization of the Greek teacher training system emphasizing on science (and most specifically chemistry) education. We will refer separately to pre-service and in-service teacher training institutions and initiatives, by briefly describing their characteristics, the methods employed and their content.

### 1.1 Initial (Pre-service) Teacher Training

In the Greek educational system, the main route for becoming a science teacher in secondary school is by obtaining an undergraduate degree (B. Sc.) from one of the related university departments. By related departments we refer exclusively to the Physics, Chemistry, Biology and Geology Departments (all belonging to the Faculty of Science). The studies in these departments last four years and until very recently (2010) all corresponding degree holders (i.e. Physicists, Chemists, Biologists, Geologists) were considered to hold a "teaching-related" first degree and were automatically entitled to work as science teachers in the Greek secondary school system (either public or private). However, since the available teaching positions in the public schools are much less than the science graduates, all science degree holders of the four disciplines mentioned above, who are interested in getting such a teaching position need to sit in a national selection exam. This exam is administered by the Higher Council for Personnel Selection (ASEP) and it usually takes place every two years (the first such examination took place in 1998 and the most recent one in 2009). In this exam, the four different specializations are competing separately. However, the successful competitors are entitled (and usually asked) to teach all science-related courses (physics, chemistry, biology, geology and geography) when they get their placement in a public secondary school. As a result, it is often the case that the chemistry course is not taught by a chemist.

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In May 2010, a new law was voted by the Greek Parliament (No. 3848/2010) which established the prerequisite for a "Certificate of Aptitude for Teaching" (CAT) for all science degree holders in order to be entitled to practice the teaching profession of all science-related courses in secondary education. According to the new legislation, all university departments which belong to the Faculty of Science, need to introduce specific changes in their programs of study by including a specific amount of education-related courses (both theoretical and practical), if they are interested in providing their graduates with the CAT thus qualifying them for practicing the teaching profession. Alternatively, a science degree holder can get the CAT by obtaining a Masters degree in Education. We need to note however, that this new legislation has not yet been put into practice. In fact, additional specific official clarifications need to be given in order to allow for its correct and complete implementation by the five existing chemistry departments of the country.

In the following part of this report we will report to the courses related to chemistry education which are offered by the different chemistry departments of the country. The presented information was obtained via the official websites of the corresponding departments. As mentioned before, in Greece there exist 5 chemistry departments at the following universities: University of Athens, University of Thessaloniki, University of Ioannina, University of Patras and University of Crete. At this point, we note that when we refer to the different courses offered we will use the symbols, L, P and PS for the Lecture, Practical and Problem Solving part of each course, respectively.

Starting with the program of study of the Department of Chemistry at the Aristotle University of Thessaloniki (AUTH) (effective since 2010) [1], there exist seven courses, directly or indirectly related with chemical education, all offered in the 4$^{th}$ year of study. In the majority of them, the lectures (L) are accompanied by practicals (P) and/or problem solving (PS) classes as well. The titles of these seven courses are the following:, Structuring - Presentation and Dissemination of Chemical Information (L-P), History and Epistemology of Physical Sciences (L), Pedagogy (L), Psychology (L), Development of chemistry related multimedia material and distance network teaching (L-P), Didactics of Chemistry and the use of the experiment in chemistry teaching (L-P), Informatics in the chemistry laboratory (L-PS-P). All seven courses make part (together with seven additional courses) of the specialization entitled "Theoretical Chemistry and Chemical Education" which is one of the four possible specializations offered by the chemistry department of AUTH during the last year of study. Students are required to successfully pass the examinations in 8 (out of the totally offered 14) courses of the chosen specialization, in order to get their chemistry degree (B.Sc.). It is worth noting, that AUTH is the only Greek university whose chemistry department offers a specialization which is directly related with chemistry education.

Moving on to the program of study of the Department of Chemistry at the National and Kapodistrian University of Athens (UOA) [2], we note that a student needs to have passed a total of 32 courses for the completion of the chemistry degree (B. Sc.). 23 of these courses are obligatory and the remaining 9 are elective from a total of 34 options. The elective courses are organized in 11 different thematic cycles. One of these thematic cycles is entitled "Chemistry and Education" and it offers four courses: Didactics of Chemistry (L), Psychology of Learning and Cognitive Psychology (L), Introduction to Pedagogy (L), History of Physical Sciences (L). However, we need to note that only the first of the above four courses of the "Chemistry and Education" thematic cycle is taught within the chemistry department of UOA and has been assigned with a specific number of didactic units. The other three courses are offered by other departments of UOA and they can be selected by the interested students, however they do not officially count for covering the degree requirements. In addition, the grade achieved in these three courses is shown in the official transcript; however it does not count for the calculation of the official GPA (Grade Point Average) of the degree.

Moving on to the program of study of the Department of Chemistry at the University of Ioannina (UOI) [3], we note a situation similar to UOA. The students need to have completed a total of 233 didactic units in order to get the B. Sc. in Chemistry. There is only one course related to chemistry education, entitled "Didactics of Chemistry" (L) which can be elected among a total of four options by the students, and it is assigned with 3 didactic units. Within the same group of the four elective courses, there is also the option of a course related to "History of Chemistry" (L). In this way, interested students are not motivated to select both courses (Didactics of Chemistry and History of Chemistry), since only one of the two can count for obtaining the degree.

The Department of Chemistry at the University of Patras (UPAT) [4] follows a route similar to UOA and UOI as far as offering courses in chemistry education is concerned. More specifically, it offers students the possibility of attending an elective course entitled "Didactics of Physical Sciences" (L). This course belongs to

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a group of nine elective courses of which the students need to select two. These two courses have to be taken during the first two years of the study. Finally, after careful search of the website of the Department of Chemistry at the University of Crete (UOC) [5], there is no evidence that it offers some course related to chemistry education to the undergraduate students.

A special note needs to be made on the existence of a pre-service chemistry teacher training program which is obligatory only for prospective secondary school chemistry teachers who hold an undergraduate degree which is not officially considered “teaching-related” (i.e. it is neither Physics or Chemistry or Biology or Geology). Chemical Engineering is an example of such a degree; the respective graduates need to successfully attend this pre-service training program in order to be entitled to find a job as chemistry teachers. This pre-service teacher training program is state-funded and offered by the School of Technological and Pedagogical Education (ASPETE). It is known with the acronym EPPAIK [6]. It has one-year duration (20 hours per week) and provides training in psychology, pedagogy, student evaluation methods, teaching methodologies and techniques. It involves mostly (ca. 75%) theoretical but also some practical courses (ca. 25%). The theoretical courses are offered by following a blended teaching approach, ie lectures and on-line communication for the delivery of different assignments. The practical courses are concentrated on educational technology and multimedia applications as well as teaching exercises (video recording of short teaching sessions given by the trainees and subsequent feedback by trainer and colleagues). The content of the offered courses is mostly concentrated on general principles and less in specific issues related with chemistry education. According to the new legislation (Law No 3848/2010) the graduates of the program EPPAIK at ASPETE, are considered to be holders of the “Certificate of aptitude for teaching”.

We note that ASPETE with its current name was officially established in 2002, it is however the natural continuation of the School originally known with the acronym SELETE which was established in 1959. The main (and largest) campus of ASPETE is located in the metropolitan area of the Greek capital (Marousi). However, the School has branches in seven Greek cities (Thessaloniki, Patras, Ioannina, Volos, Heraklion Kritis, Sapes Rodopis and Rhodos Island), thus giving the possibility for covering the need for pedagogical and didactic training for prospective secondary school teachers who do not hold a “teaching-related” first degree, all over the country.

In addition to the undergraduate programs of study of the different chemistry departments and the program EPPAIK organized by ASPETE, there are numerous Masters programs that are offered by different Greek universities and which are related with science education. We will make a short reference to these programs, which are of course optional, and which are open for attendance either before entering the teaching profession (pre-service) or for in-service teachers. The Masters programs we will refer to are either specifically dedicated to chemistry education or they are more general programs related with teaching of physical sciences. We will not refer to Masters programs which are specialized to some other discipline of physical sciences, for example Physics. Our search resulted in the identification of the following nine Masters programs (in 11 departments of 7 different universities):

1) “Chemical Education and New Educational Technologies” with two specializations namely “Didactics of Chemistry” and “Novel Methods in chemistry teaching”. This Masters program, known with the acronym DIXINET, is co-organized by two chemistry departments (National and Kapodistrian University of Athens, Aristotle University of Thessaloniki) and the Department of Chemical Engineering of the National Technical University in Athens [7,8].

2) “New Technologies in Chemical Education” offered by the Department of Chemistry of the University of Ioannina [9].

3) “Physical Sciences in Education” organized by the Department of Primary Education of the National and Kapodistrian University of Athens [10].

4) “Didactics of Physical Sciences” organized by the Department of Primary Education of the Aristotle University of Athens [11].

5) “Physical Sciences in Education” organized by the Department of Primary Education of the University of Ioannina [12].

6) “Didactics of Physical Sciences, Environmental Education, New Technologies” organized by the Department of Primary Education of Democritus University of Thrace [13].

7) “Didactics of Physical Sciences” organized by the Department of Primary Education of the University of Western Macedonia [14].

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8) “Didactics of Physical Sciences: Didactic processes, Educational programs, Evaluation and Information and Communication Technologies in Education” organized by the Department of Preschool Education of the University of Patras [15].
9) “Didactics of Mathematics and Physical Sciences” organized by the Department of Primary Education of the University of Patras [16].
We note that a quite limited number of participants are accepted each year in each one of the above listed programs (less than 50) which usually have a total duration of two years. The majority of the above listed programs are offered every year, however this frequency is becoming lower due to the acute economic crisis in the country during the last five years (from 2008 till today).
In all of the above listed Masters programs the methodology of blended learning is followed. There is usually a combination of traditional lectures, practical exercises involving experiential learning, on-line communication with the trainer and face-to-face meetings. The science teacher who is a holder of a Masters degree in the field of didactics, besides the knowledge acquired, has additional practical benefits: He/she receives bonus points in the national teacher selection exam and in the case for in-service teachers there are additional points given in their evaluation in order to get a promotion to a higher rank (eg. school principal or school advisor). The participants in a Masters program are given the possibility to familiarize themselves with the latest advancements in educational research and the science of learning and cognition. The familiarization with the latest advancements in the scientific research related with chemistry (or other physical sciences) per se, are outside the scope of the above listed Masters programs.
Finally, we’ll note from the above, that the majority of Masters programs in the field of physical sciences education is organized by departments of primary education. In fact, in Greece most related active scientific research in the field is actually conducted by academic personnel who hold positions in a department of primary education. This introduces us to the next part of this section, in which we will make a brief presentation of pre-service teacher training programs offered by the several (a total of 9) primary education departments in Greece, by concentrating on physical sciences.

In the Greek primary school, which lasts six years, chemistry is not taught separately but as part of a general science course (“Fysika”) and only during the last two years. In order to become a primary school teacher, one needs exclusively to be a holder of an undergraduate degree (B. A.) from a department of primary education (which belongs to the Faculty of Education). The studies in these departments also last four years and all such degree holders are automatically entitled to work as primary school teachers in all of its six levels. In this way, they are also asked (and entitled) to teach the general science course (“Fysika”) offered in the last two years of primary education. Similar to the case of secondary education, all holders of a B.A. in Primary Education, need to sit in a national selection exam in order to a get a teaching job in a public primary school. The following 9 universities offer an undergraduate program of Primary Education: National and Kapodistrian University of Athens (UOA), Aristotle University of Thessaloniki (AUTH), University of Patras (UPAT), University of Ioannina (UOI), University of Western Macedonia (UOWM), University of Crete (UOC), University of Thessaly (UTH), University of the Aegean (UAG) and Democritus University of Thrace (DUTH).
The majority (8 out of 9) of the above listed primary education departments offer (at least) one obligatory course dedicated to Didactics of Physical Sciences, and four of them also offer up to four elective courses related to the same topic. The single department which does not offer an obligatory course, it offers 2 elective courses in the topic.
In the topic of Information and Communication Technologies in education (and/or specifically in the teaching of physical sciences), the situation is similar: the majority (8 out of 9) of the departments offers 1 or 2 obligatory courses and several (up to 8) elective courses. The single department which does not offer an obligatory course, it does offer 2 elective course in that topic. Finally, all departments offer a course in environmental education (elective in most cases).
It is thus concluded that primary education departments do offer (on average) systematic (but not necessarily sufficient) training in teaching methodologies of physical sciences to the prospective primary school teachers. On the other hand, the issue of incomplete knowledge of content (teachers’ misconceptions and lack of understanding of certain aspects of physicochemical phenomena) is evidenced by several studies conducted by Greek researchers (see Section 2.2 below), even though there are also some obligatory courses (usually up to three) related with basic physics, chemistry and biology.

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In the final part of this section, we will refer to the educational initiatives undertaken by the Association of Greek Chemists (EEX, [17]). The Association of Greek Chemists was founded in 1988 and it is an institution governed by public law. It possesses seven scientific divisions with one specifically dedicated to chemical education. In addition, it has 10 regional branches which cover geographically the whole country. One of the several aims of EEX is "...the scientific progress, updating, training and continuous development of its members..." and in this way, it often undertakes different interesting initiatives towards this end. These initiatives usually have the form of one-day training workshops or seminars, they often make use of the experiential teaching approach and they are addressed to both pre-service and in-service chemistry teachers. They take place mostly during the core of the school year (October – May) with an average rate of 4-6 events every year and with a strictly controlled number of participants (usually less than 40). At the end of each event the participants are given an official certificate of attendance, which can be used as proof of additional qualification during some evaluation for advancing in the educational hierarchy (for in-service teachers). The topics of the training seminars are related to topics such as teaching methodologies (involving ICT applications and laboratory teaching approaches) and student evaluation. Occasionally, they aim at the update of the teacher community with the latest advances in scientific research as well as novel applications of different experimental techniques (for example related to analytical chemistry, see [18] for a recent example). The updating is done via the active involvement of a representative from the academic/research community. This latter type of initiatives clearly also fosters the cooperation between teachers and scientific experts.

### 1.2 In-service Teacher Training

In respect with in-service teacher training in Greece, we have already made extensive reference to two possibilities/initiatives in the previous section, namely the existing Masters Programs related to the topic of chemistry education and teaching of physical sciences and the initiatives of the Association of Greek Chemists. These two pre-service teacher training structures are both optional and they are also available to in-service chemistry teachers.

Subsequently we will refer to five additional in-service training programs/initiatives available for chemistry (and science) teachers, thus providing a comprehensive review of the existing structures in Greece. Namely, we will refer to the following: (a) "Initial Training" ("Eisagogiki Epimorfosi"), (b) "Major Training" ("Meizona Epimorfosi"), (c) "ICT in Education", (d) "Project Training", and (e) Training provided at EKFE.

In Greece, the organization of teacher training programs in secondary and primary education is, in the largest part, implemented by the "Organization of Teacher Training" (OEPEK.) (established in 2002, [19]) in combination with the scientific collaboration and support by the "Institute of Educational Policy" (established in 2011, [20]). Both organizations are private legal entities supervised by the Greek Ministry of Education and Religious Affairs. The first four programs listed in the previous paragraph are the main ones which are run by these two legal entities. The funding of all training programs run by OEPEK/IEP is in its largest part available by the European Social Fund.

Starting with "Initial Training" ("Eisagogiki Epimorfosi") we note that since 1992, it is an obligatory training program for all newly appointed chemistry (and science) teachers in the Greek public school system. It takes place during the first year of service in 16 different Regional Training Centers (PEK) all over the country. The program has a total duration of 100 hours and it is divided in three phases: Phase A (45 hours) taking place usually in September ie at the beginning of the school year, Phase B (35 hours) taking place usually in November and Phase C (20 hours) taking place usually in June ie in the end of the school year. During the first 12 years of its application, the "Initial Training" was mostly devoted to theoretical lectures on different educational topics. Since 2004 however, as noted in the 2011-12 guide for the trainees [21], "the emphasis has been put mostly to the practical didactics and the training program has been enriched with virtual and sampling teaching sessions".

The expected results of the training program (as described in [21]), involve among others the following: development of skills for designing the teaching session according to the philosophy of the "New School" (utilization of ICT in education, differentiation of teaching, etc), comprehensive management of all pedagogical issues that may occur, utilization of the suitable evaluation methods, utilization of all available teaching tools for dealing with problems in student behaviour and for preventing school failure, management of the uncertainty which is inherent in the teaching profession and requires for the teacher to be constantly open to changes.

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The first phase (Phase A) of the program involves training mostly via practical workshops (experiential learning) in the following six different thematic areas: (i) Principles of organization and administration of education, (ii) Principles of management of the school classroom, (iii) Scheduling and organization of the curriculum and design of lesson plan – Teaching approaches and strategies that promote active involvement of the student and reflective learning, (iv) Novel teaching methods (student project, cooperative teaching method, virtual teaching sessions etc), (v) Evaluation (student, teaching practice, teacher self evaluation) and (vi) Utilization of ICT in education.
The second phase (Phase B) of the program involves the attendance of sampling teaching sessions in real classrooms. There is a short preparative pre-attendance section and a post-attendance evaluation and discussion section.
Finally, the third phase (Phase C) involves mostly the involvement of the trainees via discussion and reflection on their experiences during their first year of service (difficulties faced, examples of good practices, re-consideration of own perceptions and personal beliefs, etc.).
The trainers in the "Initial Training" program are mostly experienced teachers with additional academic specialization in some education-related field (holders of Masters and/or Ph.D. degrees). The "Initial Training" program makes use of several training techniques in order to achieve the expected results: Lecturing, Discussion, Working groups, Brainstorming, Execution of a pre-designed activity, Simulation/role playing, Case study/Problem solving.

Subsequently, we move on to a short presentation of the "Major training" program ("Meizona Epimorfosi") [22]. This is an optional training program available (among others) for science teachers. Till today, it has been implemented only once (on a pilot basis) between June – December 2011. It was organized by the Greek Pedagogical Institute, the legal entity which was recently (December 2012) substituted by the Institute of Educational Policy (IEP). A total of 8000 primary and secondary school teachers, of which 842 secondary school science teachers (i.e. physicists, chemists, biologists and geologists), successfully completed the program. The program had a total duration of 200 hours of which 55 were devoted to face-to-face meetings and the remaining 145 hours involved distance learning. The face-to-face meetings (seminars) were divided into three time periods each lasting 3 consecutive days (1$^{st}$ period: June, 2$^{nd}$ period: September, 3$^{rd}$ period: November/December). The 40-60 days period in-between the face-to-face meetings involved interaction of the trainee with the training material (ca. 500 pages), attempts for practical application of the training material in the trainees' classrooms, critical evaluation, and/or writing assignments.

It took place in 57 training centres (25 primary schools and 32 EKFE) all over the country. The participants were also asked to submit their evaluation on-line, however the results of the evaluation questionnaires have not been published yet. Finally, a collection of good teaching practices was produced by the trainees, some of which are already available in an on-line database [23]. At the moment, the plans for the organization of the next edition of the "Major Training" program are unknown.
According to the reference framework [24], the "Major training" program is based in the following principles: active participation of the trainee, knowledge discovery via ICT approaches and e-learning, direct application of the training experiences in the classroom, flexibility (in the interaction between trainer and trainee, in the use of the training material) and social interaction (cooperative learning and group activities).
The main motivating factors for participating in the "Major training" program are the following: bonus points and acquisition of certificate for pedagogical training for utilization during teacher evaluation for advancing in the professional hierarchy, the connection of the training with the real needs of the teachers, the large flexibility of the program in respect with place, time and rate of learning.

"ICT in Education" is the third available in-service training program organized by OEPEK/IEP [25]. This program is divided in two phases. The first phase (Level A) lasts 48 hours and it aims in the acquisition of basic computer skills (word processing, spreadsheet handling, presentation programs and internet). Teachers need to successfully pass a certification exam. After having received the Level A Certificate, teachers can apply in order to attend the "ICT in Education" course at Level B, which has a total duration of 96 hours. In order to be accepted at Level B, teachers must have a teaching position during the training period, in either a public or a private school, since one of the training activities involves the parallel application of the acquired knowledge and skills in their classrooms. The Level B "ICT in Education" training program is open to teachers who have a first degree (B.Sc. or B.A) in the following disciplines: Science (either physics or chemistry or

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biology or Geology), Mathematics, Classics, English, French, German, Informatics, Primary education, Pre-school education.
"ICT in Education" at Level B started in 2009 and until the end of 2013, more than 27000 teachers of all above listed specializations are expected to have attended it (in at least four training periods). All participants receive a certificate of attendance, however they are asked to sit in an official exam in order to acquire official certification for utilization of "ICT in Education" at advanced level (Level B). This exam is administered usually a few months after the end of the training period and it involves mainly practical exercises/activities of the acquired skills (for example teaching design of a specific topic via an educational scenario based on ICT).
The main aims of the "ICT in Education" – Level B training program can be summarized as follows: understanding the requirements and possibilities for utilization of ICT in the teaching process, effective use of ICT for the participation of both teachers and students in web-based learning communities, getting comprehensive information on the main existing educational software, different internet tools and services (wikis, blogs, podcasts, rss feeds, social networks, etc.), learning management systems and distance learning platforms, utilization of educational software and/or ICT tools for teaching the subject of their specialization, understating the principles for designing an educational activity via the use of ICT, effective use of the interactive blackboard in the teaching process, development of communication skills (with students and colleagues) via the use of web-based technologies.
The possibility of receiving a good personal evaluation and bonus points for advancing in a higher rank in the professional hierarchy remains the most obvious motivating factor for a participating teacher. However, even teachers who are not interested in a higher rank, are often applying for receiving the Level B "ICT in Education" certification, since it is one of the most important and useful tools for being able to exert the teaching profession according to the philosophy of the "New School" (active learning, cooperative learning, student-centered teaching approach, individualization of the teaching approach). The philosophy of the "New School" was recently introduced (2010) in the Greek educational system (Public Law No 3848, Government Gazette A' 71/19-05-2010). Its implementation however can be a long lasting process, since rather drastic changes are required in the design of pre-service and in-service teacher training programs.

"Project Training" is the fourth available in-service training program organized by OEPEK/IEP [26]. This optional training program is addressed to upper secondary school teachers of different specializations (chemistry being one of them) who already have or are interested in getting involved in the teaching of the new course entitled "Project". In an effort to start the implementation of the "New School" philosophy, the obligatory course entitled "Project" was first introduced in the national curriculum of the 1$^{st}$ grade of the Greek upper secondary school in 2010. This course aims at involving a small group (ideally less than 10) of interested students in the design, execution and final presentation of a research assignment via group work. Even though the "Project" is a group effort, each student is evaluated individually by the teacher according to the degree of his/her personal contribution. The research assignment can be related with different kinds of topics or topic combinations (interdisciplinary), with science being one of them, and it can be taught by an individual teacher or a small team of teachers (2 or 3). The assignment has to be completed within one school semester and if required it can be extended throughout the whole school year.
This specialized teacher training program lasts 12 hours (attended during two consecutive days). It takes place in the regional training centers (PEK) and so far it has been organized twice (June and September 2011) with the participation of ca. 1000 teachers each time. The teachers belonged to several different specializations, with chemistry being one of them. The content of the training course involves the following topics: design of the project assignment, the role of the teacher for student support during project execution, for the collective team work and the processes of implementing the different phases of the research work, the evaluation process (of the team work as a whole and the contributions of each individual student as well) and finally the experiential approach of some "model" projects available in the "Teachers' guide" which is available on-line for all trainees.

This section will be concluded with a reference to the in-service training provided at the Secondary Education Science Laboratory Centers (EKFEs). The EKFE is an educational structure established in 2002 (Public Law 2986/2002, Gov. Gaz. A' 24/19-02-2002). Currently, there are 58 EKFEs located all over the country. The main aim of an EKFE is the active support of all aspects of laboratorial teaching of physical sciences to all in-service science teachers in the school units which are within the specific educational geographical district. In addition, we note that even though the role of the EKFE is applied mainly in secondary

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education, an EKFE is entitled by law to provide similar support to all primary school teachers for the teaching of the course “Fysika” in the last two grades of primary school. An EKFE is comprised by a chairperson (Head) accompanied by a small team (usually up to 5) experienced in-service science teachers of different specializations and (theoretically but quite rarely) by primary school teachers as well. The Head of the EKFE needs to be an experienced in-service science teacher (either physicist or chemist or biologist or geologist) who also has proven additional academic and or professional qualifications (Masters, Ph. D. degrees, Training certification in ICT, etc.).
The support provided by an EKFE includes both the technical part (eg. lending of instrumentation, production and/or distribution of educational CD-ROMs) as well as the pure educational part (performing “live” experiments to groups of science teachers followed by practical advice for their successful implementation in class, etc.). An EKFE serves as a model school laboratory and acts as a center for information and update of teachers on new teaching material and resources (including ICT based laboratory applications). Most EKFEs have active websites/portals and some also make use of web-based communication tools (wikis, blogs, etc.).
The in-service training initiatives of the EKFE are organized with varying frequencies depending on factors such as motivation of the EKFE personnel, time period, etc. However, the philosophy behind the EKFE is its operation as a support center for continuous training of science teachers.

## 2. Assessment of the National Training of Science Teachers

In this part of the report, an attempt will be made to give an assessment of the training provided to Greek science teachers (emphasizing as much as possible on chemistry teachers) by using the following sources of information: (a) the reviewed national publications and paper in combination with the related comments posted by non-national teachers and experts and (b) the results of the national workshop on the topic of “Teacher Training”.

### 2.1 Analysis of National publications

In the first part of this section, we will present an assessment of the training provided to Greek chemistry teachers, by using the information provided in the literature (national publications and paper available at the “Teacher Training” section of the “Chemistry is All Around Network” portal) and the related posted comments. By reviewing selective international research publications [27-32], one can point out the following main characteristics and factors that influence the quality and effectiveness of a chemistry teacher training program: (a) the duration of the program; research shows that the one-shot, episodic, fragmented approach does not allow for rigorous, cumulative learning, (b) the focus of the activity on content learning (i.e improving and deepening the teacher’s content knowledge of chemistry), (c) the opportunity for active learning (hands-on activities, active engagement of the teacher in the meaningful analysis of teaching and learning), (d) the promotion of coherence (consistency of the program with teacher’s goals, encouragement of continuous professional communication among teachers, integration of the training into school daily life and into an organized school reform effort) and (e) the incorporation of time for teachers to plan for implementation as well as provision of technical support.

By moving on to the Greek reality, we will first note that most published and actively conducted research in the field of chemistry (and science) teacher training is focused on two themes: the (in-service) teacher training initiatives on ICT in education and the training initiatives among pre- and in-service primary school teachers. In regard with the issue of teacher training on ICT, studies have shown that despite the several educational reforms and the increasing number of training programs, the teachers’ needs have not been satisfied to a substantial degree [33]. The comprehensive review of Vosniadou and Kollias [34] examines the evidence from various evaluation studies regarding the effectiveness of ICT training programs and their influence on teacher attitudes and practice. One of the main conclusions of this study is that “the reality indicates that the introduction of ICT has not brought about significant changes in teacher practices in the Greek school”. The authors argue that in the cases where ICT is used in the schools, the innovation usually stays in the periphery and does not touch the everyday “traditional” teaching practice of subject matter. The “traditional” teaching practice is characterized by a teacher-centered environment and it is dominated by a transmission-oriented philosophy and the teachers’ perceived needs “not to lose control of their class” and to “cover the material”. One of the reasons that computers failed to bring about the desired educational changes is stated to be the lack of the clearly articulated educational objectives to accompany the technological innovations. In this way, it

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is proposed that besides changes in the teacher training programs, major changes should simultaneously take place in the national educational objectives and curricula in order to take advantage of the characteristics of ICT that facilitate training. More specifically, the following principles are proposed: (i) materials and tasks that are meaningful for the students, (ii) bring schools closer to real life, (iii) curricula with less breadth and more depth, (iv) testing the understanding and not the ability to memorize, (v) moving towards a more decentralized educational system and last but not least (vi) “give more freedom to the individual teacher to do the job of educating”.

In regard with pre-service science teacher training programs, recent research [35] conducted among primary school student-teachers gave the following results: pre-service teacher university education is usually characterized by the fragmentary nature of the courses offered and by the rather large differences among the pedagogies of different course categories, namely content-specific courses (eg. General chemistry) and education-related courses (eg. Methodologies for teaching physical sciences). In this way, student teachers end up rather “confused” and often claim that their undergraduate education is insufficient in helping them to choose and implement a specific teaching strategy by following clear criteria. The authors point out the need for science teachers to master both pedagogical and content knowledge and be aware of their links. A positive step in this direction is the training of the perspective teachers via the use of specific teaching-learning sequences (TLS), which seem to produce promising results in achieving this goal.

In another work related with pre-service teacher training [36], the design, implementation and evaluation of a laboratory course on the subject of “Air Pollution” has been examined. This has been a short one-shot course administered among 78 pre-service primary school teachers, based on a combination of experimental study and the use educational software. The importance of this type of courses lies in the interdisciplinary nature of all subjects which are related with environmental topics and in bringing out the need of comprehensive training for the conceptual understanding of science. Significant progress was achieved in regard with the student teachers’ understanding of air pollution. More specifically the course did improve teachers’ correct use of terms and accuracy of scientific descriptions, as they were able to refer to concrete forms of air pollution and name specific pollutants. However, it was also noted that in some cases, the percentages of correct answers (in the post-training test) remained quite low, bringing out the issue of persisting misconceptions and/or lack of true understanding. The existence of misconceptions of the teacher can have a detrimental effect on the learning of the pupil. In order to alleviate this major problem, the authors propose “a wider use of hands-on activities in relation with the existing software simulations” and “additional time for teaching (separately) each environmental problem”. From the above, it is evident that, as also noted in the international literature, the episodic one-shot training program is just not enough.

The lack of a satisfactory level of knowledge of basic chemical concepts among primary school teachers’ and the existence of several misconceptions despite their age and experience, which are subsequently passed on to the students, have also been pointed out by other Greek researchers [37, 38]. In one of these works [37], the effect of the implementation of an in-service training course on primary teachers’ understanding of four chemical phenomena has been investigated (hydrogen combustion, iron rusting, burning candle, sugar heating). The training course involved the study of these four chemical phenomena via experiments that were performed by the trainer accompanied by active participation of all teachers in discussions on the observations as well as explanations. The training intervention seemed to significantly improve teachers’ descriptions and explanations of the phenomena. However, the progress wasn’t equally spread across all four phenomena that were studied. As noted by the authors, “post-intervention, teachers seemed better able to manage the combustion of hydrogen and the heating of sugar, than the burning candle…”.The research findings indicate that those teachers who showed a better understanding of the particulate nature of matter are more likely to understand chemical changes also at the macroscopic level. Despite this course’s encouraging results, the authors conclude, in accordance to other studies as well [39], that one single “shot” is not enough and they recommend “continuous and long-term in-service training programs” with factors such as “duration, timing and frequency” playing a decisive role for their effectiveness.

Finally, it is possible to indirectly assess the main aims and limitations of pre-service teacher training programs, by analyzing the criteria that are examined during the national teaching staff selection exams. In a recent study [40], a qualitative and quantitative content analysis was used, for reviewing and analyzing a total of 1081 pedagogical and teaching-related exam questions which were employed in secondary school teacher recruitment examinations prior to 2007. The analysis of the data shows that the teacher pedagogical

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competences that are mainly assessed are related to general pedagogic knowledge, teaching methodology with emphasis on lesson planning and selection of suitable teaching objectives and student evaluation. On the other hand, there are several pedagogical competences which are examined to a very small extent in the recruitment exam, and which thus seem to be considered issues of minor importance by the different pre-service teacher training programs and curricula. These competences are the following: understanding the needs of the students, the pedagogical approach adopted by the teacher to the subject taught, the evaluation of the curriculum and textbook used, skills in curriculum intervention and textbook adaptation to the existing context and needs of the students, intercultural and special needs education.

## 2.2 Analysis of workshop material

We will then move on by presenting an assessment of the training provided to Greek chemistry teachers, by focusing on the analysis of the workshop material. The workshop on “Teacher Training” took place in May 2013 and it was designed in such a way that it would encourage the interaction between chemistry teachers and scientific experts. There were a total of 15 participants, of which 10 were teachers and 5 were experts. The participants were divided into 3 groups of 5 persons each. In each group there was at least one scientific expert. The group members were given a specific topic related to teacher training to think on and express their views. At the beginning, they were left free to interact with each other (within the group) for a specific amount of time (ca 20 min). Subsequently, a representative from each group gave a short (5-8 min) presentation of the main conclusions that each group had reached in respect to each discussion topic. There were three main discussion topics: a) Importance of teacher training by focusing on the participants’ personal experiences and the information provided by the Papers and Publications of the project database, b) Different teaching approaches/methods of a chemistry topic and c) Proposals for teacher training by focusing on issues such as the content of teacher training, the type of teacher training and the responsibility for teacher training.

In relation with pre-service training, the majority of the participants reported that during their undergraduate education they received intensive and in-depth academic training in the subject of their specialization (chemistry. physics, biology, chemical engineering) but very limited training related to psychology, pedagogy or chemistry education. The courses related to these latter subjects were few and always belonged to the category of elective or elective-obligatory in the best case. A few of the participants had some exposure to teaching methodologies by attending some seminars on a voluntary basis, however all participants stated that they entered the teaching profession by considering their own science (physics/chemistry/biology) teachers as a prototype.

A special note needs to be made on the usefulness of the one-year pre-service training course, referred to as EPPAIK [6], that is obligatory for all college graduates not holding a “teaching-related” degree (for example engineering majors) in order to be entitled to work as chemistry teachers. As noted by one of the workshop participating teachers, who is a graduate in chemical engineering, this training course proved to be very useful for facing the challenge of the teaching praxis, even though it provided general knowledge and not directly related to chemistry education. It is important to note however that only a limited number of such college graduates gets accepted in this training program every year and in addition that the typical science college graduates do not have the possibility to attend it, even on a voluntary basis.

In general, all participants felt that teacher training in Greece is treated with a “light” and “superficial” manner. This opinion of theirs is based on the fact that in Greece there is no officially established system for providing accreditation for entering the teaching profession. It is also related with their assessment of the in-service teacher training and the fact that the chemistry course is degraded in the Greek educational system as evidenced by the little time allocated to chemistry teaching.

In relation with in-service training, workshop participants made reference to both negative and positive experiences. The obligatory three-phase initial training received by the regional training centres (PEK) was assessed as “not really very useful”, because it provided mostly theoretical information.

Two additional teacher training initiatives which are not obligatory and which were assessed by the workshop participants who had attended them are the following: (a) The practical courses organized by the different regional EKFE (Secondary Education Science Laboratory Centre) and (b) the practical courses provided by the two phases of the programme “Teachers’ training on ICT in Education”. The participants felt that both these programs have been useful for their professional development, but they did not seem to have clear educational objectives and focus.

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More specifically, in relation with the training provided at EKFE the participants referred positively to the possibility of attending "live" experiments by more experienced teachers, before one can move on and also show these experiments to his/her students. On the other hand they also made reference to the following factors that tend to reduce the effectiveness of the initiative: the limited length of the program, the lack of active participation of the trainee (in most cases) and the training content (the experiments presented are usually not accompanied by a suitable teaching approach).
In respect with the training on ICT in Education, the participants felt that especially the second phase of the programme has been most useful. This is due to the fact that a teacher is given the possibility to learn about the use of interactive blackboards, the existence of different educational software and also the methods of how to exploit them in the classroom. The main drawbacks of this program are its optional status, the limited available number of trainees and its sporadic nature.
The program of "Major Training" ("Meizona epimorfosi") is an optional training program that had been attended by most workshop participants and which received mostly a positive assessment. Special reference was made to the fact that this specific program had a clear aim and orientation related to the cooperative teaching approach and group management issues. However, this program is still in the phase of development and has so far been applied on a pilot scale with a limited number of participants (ca 850 science teachers).
Finally, one should make a special note in relation with the training acquired via the attendance and successful completion of the Masters' program in "Chemical Education and New Educational Technologies". A large part of the workshop participants has already completed the program and they consider it overall a very useful and rewarding experience. This Masters program is the only one in Greece which is dedicated to chemistry education by providing high level theoretical knowledge and practical training. Its unique drawback seems to be the limited number of teachers it can serve (currently ca. 20 teachers every year), due to limited available funding by the Greek State.

Besides the assessment of pre-service and in-service training programs, the workshop gave valuable insights to a closely related issue which refers to the obstacles teachers face in their effort to apply in class all knowledge and skills acquired during their training. This issue is of central importance, since even the best trained and highly qualified teacher, needs a suitable "environment" in order to successfully implement his/her skills and expertise. The major obstacles teachers face in their efforts to use novel teaching approaches in class, as identified via the analysis of the workshop material, are the following:
(a) the anchoring of upper secondary school to the Panhellenic exams for entering tertiary education institutions which de-motivates students for engaging in the joy of learning science
(b) the closed curriculum and student evaluation method which are imposed horizontally in both lower and upper secondary schools of the whole country. Teachers are under constant pressure to "cover the material" by following specific page numbers from a unique textbook,
(c) the competitive co-existence and conflict between the official school education and the private tutoring system ("Frontistirio"). In Greece, private tutoring is very popular among all student types, especially for math and science courses. In "Frontistirio" students are mostly trained in learning problem solving techniques, in order to be able to get a good grade in the school exams.
(d) the lack of basic materials from the large majority of science laboratories of public schools.

The analysis of the workshop material resulted in several proposals and suggestions related with different issues related to teacher training, namely the content of training, the characteristics of the training program (type of training) and the responsibility for teacher training.

In respect with the content of training, the workshop participants proposed that a chemistry teacher training program should include the following topics:
(a) laboratory techniques and active learning methods appropriate for each separate age group, together with practical advice for successful implementation (for example group management)
(b) use of ICT in the teaching process – results of related research – evaluation of these methods
(c) pedagogical dimension of teaching based on findings of educational research
(d) psychological dimension of teaching (adolescents' psychology, cognitive level of students and how to address different student types)
(e) Interdisciplinary subjects (connections between chemistry and other disciplines such physics and biology)
(f) Update on new scientific knowledge and general current trends in science – Transformation of this knowledge into school knowledge that can be didactically exploited in a real classroom.

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In respect with the type of training teachers wish to receive, the following suggestions were made: In-service training should be continuous and systematically organized with a constant rate (for example for one week every year). It should be oriented mostly to active participation and not passive transfer of theories. Taking into account the phenomenon of professional burn-out which often characterizes the teaching profession, it is preferable that in-service training is not done in parallel with work. Within the same context, it is proposed that teachers should be given the possibility to get a leave of absence for a few weeks (or months) every few years in order to participate in longer organized training programs. In addition, it is recommended that teachers are given the possibility to update their knowledge on the current scientific trends by participating in special training programs that are done in collaboration with research centers and universities, or in exchange programs with foreign countries.

In respect with who should be responsible for the organization of the teacher training programs, the main suggestion made is the following: It is not necessary to have or create a separate institution or organization that is responsible for teacher training. An active collaboration and commitment between already existing institutions (for example between the University and School domains) could be more effective. Certainly, it is important that this collaboration is done by following a specific context and set of guidelines. Even in the case that a separate organization is necessary to exist (eg. for managerial purposes), what remains the most important issue is the assurance of active collaboration.

Finally, the following two proposals, related with important educational issues which affect the teaching process and/or the successful implementation of the skills of a well-trained teacher, were also made:

(a) Emphasis on deep knowledge of content and overcoming of misconceptions held by the teachers. If not changed, teachers' misconceptions tend to be passed on to their students, as also evidenced by recent research conducted among primary school teachers [37-39]. In addition, as stated by the participants "students appreciate a lot a teacher who knows his/her stuff and in addition, the teacher's self-confidence for his/her knowledge can act as an effective motivational factor for the students".

(b) Re-organization of the Greek curriculum design and content which needs to be updated in order to incorporate modern and real-life applications of the chemistry concepts taught. In the current situation, students fail to understand why they have to learn the specific material; at the same time, teachers are also not in a position to help students realize the connections of the different pieces of knowledge with each other and with real life. According to the workshop participants, emphasis should be given in acquiring more in-depth knowledge and not try to learn a little bit of everything. Quality should be preferred relative to quantity.

## 3. The Impact of the Project on Teacher Training

In this part of the report, we will make an attempt to describe the impact of the project on teacher training. Our presentation will be divided into two main parts, namely the impact on the teachers already involved in the established network and the anticipated impact on teacher training in the country.

### 3.1 Impact of the project on involved teachers

In order to describe the impact of the project on the teachers who are already involved in the "Chemistry is All Around Network" we will make use of the following sources of information: the workshop material, the comments uploaded by the Greek teachers (and experts) on non-national publications, papers and teaching resources, the use of the material uploaded on the project portal and the collaboration initiatives that have taken place between teachers and experts.

The choice of the suitable teaching approach for increasing the effectiveness of the teaching process is one of the main issues discussed during the workshop and on which the project seems to produce a definitive impact. The following principal ideas/proposals were brought out, in regard with this issue:

(a) Teacher flexibility: Workshop participants agree on the need to be trained to the interchangeable use of a variety of teaching approaches and tools for teaching the same topic. This is due to two facts: On one hand, no single teaching method is perfect and the use of more than one can guarantee that the advantages of one can make up of the disadvantages of another. On the other hand, students tend to get easily bored and lose interest. In this way the teacher should constantly aim at keeping them alert and motivated by employing different approaches (eg. inquiry, concept mapping, problem solving, traditional) as well as different educational tools (simulations (preferably interactive), lab work, interactive and classical blackboard)

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(b) Use of ICT based teaching resources: The availability of a multitude of ICT based teaching resources on the project portal seems to be a significant source of inspiration for the teachers involved in the project. Both those teachers who have already used simulations and virtual laboratory experiments in their teaching practice (for example the application “Phet”) as well as those who still do not have this experience, all express their willingness to train themselves to incorporate this type of activities in the classroom. Some of the teaching resources which have been specifically been pointed out for immediate classroom testing are the following: Phet, The Chemistry of Things, An Introduction to Chemistry, Jmol, JuniorLAB, The Wonderful World of Chemistry, ChemVLab+, Virtual Chemistry Experiments (by Prof. David Blauch). Besides self-training, the involved teachers point out that they need to get special guidance and training on the teaching design via the use of ICT and on group management. The use of ICT tends to give students the impression that they are simply playing a game and that they do not need to engage in any type of learning process. In addition, students who are more interested in computers or have more related experience, tend to finish earlier the ICT-based assignment and subsequently they can get more easily bored

(c) Cooperative teaching approach: In order to make effective use of the ICT-based chemistry teaching tools, teachers need to get extensive training in the cooperative teaching approach. This approach is essential also for the effective use of teaching in the laboratory (see below). One of the major outcomes of the workshop is the realization among all involved teachers for the need to get training in their group management skills. Students tend to learn faster and more easily when they co-operate, however this result can be reached only via the successful implementation of the corresponding teaching approach.

(d) Teaching in the laboratory: Even though the use of virtual laboratory experiments can be very useful in several cases (insufficient lab infrastructure, non-experienced teacher who is worried about student safety, inherently dangerous experiments), the effectiveness of the real laboratory teaching-learning, if suitably implemented, remains unsurpassed. The project has given the possibility to the involved teachers to enrich their views, ideas and practical knowledge on laboratory teaching applications. There exist several laboratory applications in the “Teaching Resources” database which propose interesting experiments via the use of cheap, safe and very common everyday life materials. Several such experiments were also mentioned and discussed during the workshop by some of the teachers who had already tried them in their classes (for example measurement of the melting point of common materials such as candle, butter and chocolate). With this type of experimental activities, students can get actively involved in the experiment preparation and performance. Subsequently, they can get more easily motivated to analyze and discuss the data that they themselves have obtained. Guiding the students to active experimentation that can be performed with cheap and safe materials, is a good starting point for the teacher to start re-thinking his role as educator; he/she can start considering himself more as a facilitator of the acquisition of knowledge and less as the main transmitter of knowledge.

The comments uploaded by the teachers and experts on non-national publications bring out the following issues on which the project has produced a considerable impact:

(a) The project has provided a unique opportunity for teachers to engage in self-training by following the advice and clear directions that are provided by some publications and/or available teaching resources. This has been especially noted by primary school teachers who often “lack confidence in teaching science” as mentioned in one of the comments.

(b) Awareness of own beliefs and attitudes: The involved teachers have been informed of the importance to gain awareness of how they perceive themselves as chemistry teachers. As also evidenced by recent research, this awareness is a good starting point for self-reflection and self- improvement.

(c) Awareness of own misconceptions and lack of understanding: The involved teachers are expected to gain increased consciousness of the problem that their own misconceptions and lack of true understanding of different chemistry topics can negatively influence their effectiveness as teachers, their self-confidence and the image created by their students.

(d) Teachers’ mastering of the English language and need for constant update: The exposure of the involved teachers to a large variety of interesting material (teaching resources, educational research findings etc) available only in English has brought out the need for good knowledge of the English language, with this not meaning to undermine the importance of all national languages. However, English is the most popular language among the scientific community worldwide. By mastering the English language, the aim of keeping informed with the latest scientific advancements will become more amenable.

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In regard with the use of the material uploaded on the "Teaching resources" section of the portal we will make reference to the following:
(a) The opportunity for the teachers to be exposed and get substantial information and knowledge on interdisciplinary activities and real life chemistry applications.
(b) One of the Greek Associated Schools who have officially joined the network, namely the 1st Lower Secondary School of Ilioupoli, has exploited several teaching resources available in the portal database via the organization of a one-year project with a small group of students. The initiative was undertaken by the two teachers who act as contact persons and it was very successful. The students participated voluntarily and enthusiastically as they considered this type of project very original. They were asked to work in small groups for strengthening and testing their knowledge of chemistry via ICT based teaching resources.
(c) Another Greek Associated School (1st EPAL Ymittou) is planning to organize a short six-month project with a group of ca. 12 students by exploiting the possibility of conducting simple chemistry experiments via the use of cheap and common materials (no standard chemicals), which are related with everyday life chemistry.
Besides the two initiatives mentioned above, it is worth noting that teachers in all involved schools are expected to test at least one ICT based teaching resources of their choice in their chemistry classrooms during the forthcoming school year (2013-14), by following a specific educational scenario. Their experiences and written assessment will be used in order to produce a set of guidelines for the successful implementation of chemistry related ICT based teaching resources in the teaching practice.

Finally, in regard with the collaboration initiatives that have taken place between the involved teachers and experts in the project the following remarks can be made:

The interaction of the two groups has been very fruitful. All experts have agreed to "open" their research laboratories at least twice until the end of the project period in order to provide a short tour to a small group of students and their teachers who would be interested to get a feel of an original research environment. In addition, some of the experts have also offered the possibility for short-term visits/internships (for example 2-4 weeks) of every interested teacher, in their laboratories. Most interestingly, some experts decided to get more actively involved in the systematic organization of initiatives which are organized by their respective institutions and which are related with the popularization of science.

### 3.2 Anticipated impact of the project on teacher training in Greece

The anticipated impact of the project on teacher training in Greece, will be described based on the so far expressed interest for exploitation of the project results, the comments of Greek researchers on non-national publications and the workshop material. We will also make reference to specific proposals on how the cooperation between teachers and experts can bridge the existing gap between the academic and school domains.

The project has already started in having an impact on teacher training also outside the main core of the partnership. For example, the Secondary Education Science Laboratory Center of Laconia (EKFE Laconias) located in Sparta in southern Greece voluntarily contacted the Greek project manager after having searched the project portal and asked for possible ways of exploiting the project results in the area of teacher training. As mentioned earlier in this report, the role of EKFE is related to providing practical support and training to in-service science teachers in order to help them apply the laboratory teaching approach in their classrooms. EKFE Laconias has already joined the project as an Associated Partner and it is expected to play a significant role in enhancing the project impact on teacher training. In addition, EKFE Chanion which is located on the island of Crete has already created a link to the project portal and as the visibility of the project increases more EKFEs all over the country are expected to play an active role in exploiting the project's results related to teacher training.
Besides EKFEs, several regional branches of the Greek Chemists' Association are gradually expressing their interest in the project; the Branch of Peloponnese and Western Greece has already joined the "Chemistry is All Around Network" as an Associated Partner and strong interest in the same direction, has also been expressed by the corresponding branch of Crete. The Association of Greek Chemists is quite active in providing in-service chemistry teacher training seminars.
Tertiary education institutions which are directly or indirectly connected to chemistry (and science) teacher training are also expected to exploit the relative project results. For example, scientific experts who are involved in the interuniversity graduate program on "Chemical Education and New Educational Technologies"

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will supervise several Masters thesis final dissertation research projects on topics that make direct or indirect use of the material available on the project portal (for example systematic testing and evaluation of the different teaching resources). Special interest on the project results is also anticipated by the several faculties of primary education all over the country, since there are several faculty members in these institutions who are involved in teaching courses related to science teaching methodologies and who at the same time conduct active research in the field of science education.

Certain important issues have been brought out via the comments on non-national publications and the analysis of the workshop material, which should be taken into account by educational policy makers in the design and content of more effective pre-service and in-service teacher training programs:

(a) The issue of chemistry teachers' beliefs, personal theories and knowledge they bring, when they enter a pre or in-service teacher education program: Research has shown that these beliefs unconsciously influence the teachers' decisions and actions in the classroom. Consequently, they should be identified and taken into account by the teachers themselves and for the correct design of a teacher training program.

(c) The issue of teachers' needs: Knowledge of these needs can be a starting point for designing more effective teacher training programs. An effort was made to identify these needs by analyzing the material collected during the workshop (vide infra).

(c) The issue of persisting teachers' misconceptions in different chemistry subjects (not solely basic general chemistry but also more specialized topics such as organic chemistry). A lot of discussion is being made in different aspects of our project (workshop and publications) concerning this important issue. The design of both pre and in-service teacher training programs (especially those for primary school teachers) is expected to give special emphasis in overcoming these misconceptions.

(d) The design of the training scheme: Should the study related to the core of the teaching profession (didactics, pedagogy, psychology etc) be done concurrently with the academic chemistry study ("concurrent model") or it should be an independent study program undertaken after completion of the latter ("consecutive" model)? Very little consideration has been given by the Greek State in relation with this issue of central importance, which is also closely related with the absence of an official system for obtaining certification to enter the teaching profession.

(e) Establishment of the mentoring system and systematic in-job pre-service training: The successful implementation of the mentoring system in the Ireland should be taken as a perfect example of a good practice that should be established also in Greece. In fact, the discussion of the role of the mentor in the Greek school system was initiated in 2009, however it was never applied in practice and has remained on paper ever since. In addition to mentoring, the establishment of obligatory full-time teaching practice (in-job training) for all student teachers is also a good practice example (from the Irish system) that should be adopted in Greece as well. It is anticipated, that the project will revive the discussion on these two major issues. It should also be mentioned, that the successful implementation of both practices is closely dependent on the active involvement of the related university faculties. Universities are expected to provide training to the prospective mentors and act as the liaison between the mentor and the mentee. In the case of in-job pre-service training the universities are expected to provide systematic supervision.

(f) Teacher collaboration: The positive influence of teacher collaboration on the effectiveness of the teaching practice has been evidenced in other educational systems (eg. in Portugal). In this way, training in collaboration is considered an important topic that has to be taken into account in the design of teacher training programs.

(g) Increased ratio of practical exercises: Following the example of other countries (Poland, Ireland) which is evidenced by the respective uploaded publications/papers (and comments), it is expected that Greek educational policy makers give special emphasis to the increase of the practical exercises in the curricula of courses such as didactics of chemistry, pedagogy and psychology, administered to student teachers.

The interaction and cooperation between teachers and scientific experts is promoted by the project and it is actually expected to produce significant impact. Based on the analysis of the workshop material as well as the meticulous analysis of the comments on the publications/papers and teaching resources, the major possibilities in this field are the following:

(a) The connection of the chemistry taught in school with real life applications is a field in which the cooperation between teachers and scientific experts can bring out promising output. As also thoroughly discussed during the workshop, this initiative can definitely awaken student's interest. However, it often

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requires a lot of in depth knowledge from the teacher, since real life phenomena involve, in most cases, very complicated chemistry. Such are the fields of biochemistry/medicinal chemistry and environmental chemistry. Even though there exist some easy to use real life chemistry applications (eg common materials which act as acids and bases etc.) however, what should be done is a systematic collaborative effort between scientists and teachers in order to transform the advanced and complicated academic knowledge into school knowledge that could be didactically exploited in an average secondary school classroom.
(b) Another area in which the cooperation between scientific experts and teachers is anticipated to have considerable impact is the design and development of ICT based teaching resources and related teacher training programs that are founded on specific educational scenaria and pedagogical concepts and which are in accordance with the national curricula. This is an issue of major importance, since very often the numerous existing ICT based teaching resources possess high academic quality and accuracy but they lack the educational design that could make them suitable for direct use in a secondary school classroom. Issues related to student evaluation methods on the knowledge acquired via these resources and connections of the material with the curriculum need to be addressed.
(c) As noted in the Italian contribution in the “Papers” related to the “Teacher training” topic and freely available in the project portal [41], “the insufficient communication (via the type of language employed) between school teachers and students”, can become a major problem when it comes to understanding science. Recent research related with the Greek student population [42], has found out that the narrative elements found in popularized science articles of the press, attract students’ interest and motivate them towards further reading. It is further noted that the use of emotional/”poetic” language with a lot of metaphors and analogies is preferred by the students, who tend to avoid science articles that present their data in a rigorous scientific way. In this way, the cooperation of experts and teachers could be very fruitful also in the field of production of educational material (textbooks, ICT applications, etc.) that makes use of language which is attractive and familiar to the student but at the same time does not sacrifice scientific accuracy. Exploring the ways via which press science can be transformed into school science [43], is an active research field in which the current project is anticipated to have impact via expert-teacher cooperation.
(d) The identification of the existing misconceptions related to numerous chemistry topics among chemistry teachers requires systematic research by the experts in cooperation with the teachers.

The possibility of teacher self-training, also mentioned in the previous section, is anticipated to contribute to the project impact also to teachers who are not involved in the project. The same can also be achieved via the possibility of teachers to get to know the existence of international platforms in which they can share experiences and exchange views on the teaching and learning of chemistry topics that create special difficulties to the students (for example organic chemistry).

## 4. Conclusions

By taking into account the extensive presentation of the three preceding sections, the following basic conclusions can be made.

The main conclusions related with the national situation on teacher training regarding pre-service teacher training are the following:
(a) The majority of the chemistry departments in Greek public universities offer the possibility of some pre-service teacher training to their students via optional courses related to chemistry education. These courses include usually both a theoretical and a practical part. As a promising example of good practice, one may refer to the Department of Chemistry of the Aristotle University of Thessaloniki which offers its students the possibility to select a specialization directly related to chemistry education. The obligatory one-year training program known with the acronym EPPAIK is a good example of a pre-service training program focused in educational topics, which is however addressed solely to prospective science teachers who hold a non “teaching-related” degree
(b) The prospective primary school teachers do receive a systematic (but not necessarily sufficient) training in methodologies for teaching physical sciences in the nine different university departments of the country.
(d) There exist several Masters’ programs related to teaching of physical sciences, with the majority of them being organized by departments of primary education. Special reference can be made however to the inter-university, inter-departmental Masters program specializing in chemistry education and entitled “Chemical Education and New Educational Technologies” (known with the acronym DIXINET)

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(e) The Association of Greek Chemists undertakes occasionally teacher training initiatives which are also related with update on the recent advances in scientific research.
The initiatives (d) and (e) of the above list are available for both pre-service and in-service teachers.

The main conclusions related with the national situation on teacher training regarding in-service teacher training are the following:
(a) The "Initial Training" ("Eisagogiki Epimorfosi") is an obligatory training program for all in-service chemistry (and science) teachers during their first year of service. It lasts 100 hours, takes place in three phases and involves mostly practical exercises and activities. It is organized by the Institute of Educational Policy (IEP) and co-financed by the European Social Fund (ESF).
(b) Three optional science teacher training programs, also organized by IEP and co-financed by ESF, are available for in-service science teachers in order to help them implement the philosophy of the "New School": "Major Training" ("Meizona Epimorfosi"), "Project Training" and "ICT in Education". The "ICT in Education" program is run in two phases with the second one providing specialized theoretical and practical skills for incorporation of ICT based methods and tools in the teaching practice.
(c) Together with the existence of the several Masters program related to teaching of physical sciences and the training initiatives of the Association of Greek chemists (see above), another important source of constant in-service training to science teachers are the initiatives and support provided by the Secondary Educational Science Laboratory Centers (EKFE) located all over the country.

The main conclusions related with the assessment of the national training of science teachers are the following:
(a) Research indicates the introduction of ICT in the Greek educational system in the '90s did not bring the anticipated results in teacher practices, the main reason being the lack of clearly articulated educational objectives to accompany the technological innovations.
(b) Research also indicates the existence of several misconceptions and lack of understanding of basic chemical concepts and phenomena by primary school teachers. Successful examples of training courses that combine different approaches (experiments and use of educational software) can be found in the literature. However, one-shot is not enough and continuous, systematic long-term in-service training is required.
(c) Research shows that pre-service university education is usually characterized by the fragmentary nature of the courses offered, which results in student teachers claiming that their undergraduate education is insufficient in helping them choose and implement a specific teaching strategy by following clear criteria.
(d) There is research evidence that teachers' competences such as understanding the needs of the students, curriculum evaluation and intervention, textbook adaptation to the existing needs are underestimated in Greek pre-service teacher training programs.
(e) As shown from the analysis of the workshop material, science teachers feel they received very limited pre-service training related to science education and that in general science teacher training in Greece is treated with a "light" and "superficial" manner. However, they referred positively in regard with the one-year training course EPPAIK.
(f) In relation with in-service training, the workshop participants referred to the obligatory "Initial training" program as not being very useful. One the other hand, they made positive comments in regard with the practical courses organized by EKFE, the "ICT in Education" training program (especially its second phase) and the "Major Training" program.
(g) The attendance and successful completion of the Masters program in "Chemical Education and New Educational Technologies" (DIXINET) was considered a very useful and rewarding experience.
(h) Special reference needs to be made on the several obstacles faced by the teachers in their effort to apply in the classroom the knowledge and skills acquired during their training, namely the anchoring of upper secondary school to the university entrance examinations, the closed curriculum and student evaluation method, the conflict between the official school education and the private tutoring system, the lack of basic infrastructure from the school science laboratories.

The main conclusions related with the impact of the project on teacher training are the following:
(a) The choice of the suitable teaching approach for increasing the effectiveness of the teaching process is one of the main areas on which the project is affecting the involved teachers. Issues related to teacher's flexibility, use of ICT approaches, the cooperative teaching approach and the laboratorial teaching approach are those which are related with this area.

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(b) The project also has a significant impact on the involved teachers in regard with the following issues: possibility of self-training, awareness of own beliefs and attitudes, awareness of own misconceptions and on the needs for mastering the English language and for constant knowledge update.
(c) The so far produced material (especially the teaching resources database) has already been exploited by involved teachers, via the form of short projects with small student groups.
(d) New possibilities for active communication between involved teachers and scientific experts have appeared.
(e) Educational structures of different types (tertiary education institutions, EKFEs, branches of the Association of Greek chemists) are anticipated to exploit the project results in several ways.
(f) The importance of certain issues related to the effectiveness of pre-service and in-service teacher training programs has been highlighted and should be taken into account by educational policy makers. These issues are related with the following: teachers' needs - beliefs and personal theories, persisting teachers' misconceptions in different chemistry topics, design of the training scheme, establishment of the mentoring system and systematic in-job pre-service training, teachers' collaboration, increased ratio of practical exercises in teacher training curricula.
(g) The collaboration between teachers and experts is expected to have impact in areas such as the following: transformation of complicated academic knowledge into school knowledge, design and development of ICT based teaching resources which are founded on firm educational scenaria and pedagogical concepts, exploitation of the communication code used in press science in order to enhance student motivation for learning school science.
(h) Teachers are given the possibility to participate in the exchange of ideas, opinions, knowledge and experience via joining specially design international platforms.

Finally, in order to enhance the already significant anticipated impact of the project on teacher training, the following additional proposals can be made in relation to the programming of the activities of the upcoming final project year:
(a) The participating teachers will be asked to test in the classroom one teaching resource of their choice available on the portal database, by following an educational scenario they will have designed in advance. The educational scenario in addition to their own personal evaluations/suggestions and those of the participating students, will be used for producing a short "Teachers' guide" to the successful application of the specific teaching resource in a real classroom.
(b) During the national workshop of the third year (scheduled to take place in winter 2014) the teachers will be asked to openly discuss their experiences from the testing of the teaching resources. The workshop material will be analyzed meticulously in order to produce a short comprehensive "Teachers' guide" to the successful application of ICT based teaching resources. This guide will be incorporated in the National Report of the final project year.

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