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Training of Chemistry Teachers: International Experience and the Greek Case

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Abstract

In the first part of this work, we make an attempt to present the main characteristics and factors that influence the quality and effectiveness of a chemistry teacher training program by reviewing selective international publications. In the second part, we specifically examine certain aspects of the same subject as applied in the Greek reality, by reviewing relevant publications. The international experience shows that a teacher's professional development programme that is coherent with school practice and teachers' goals, that has sufficient duration, that focuses on content knowledge and that involves active learning, is more likely to produce enhanced knowledge and skills. More empirical research work is required in order to establish predictors which lead to teachers' empowerment via the application of a training programme. In Greece, secondary school science teachers have in-depth academic training in the content subject but a fragmentary and non-systematic pre-service educational preparation for entering the teaching profession. Despite the increase of in-service training programs, the teachers' needs remained largely unsatisfied. Researchers have pointed out the need for teachers to master both pedagogical and content knowledge and be aware of their in-between links, in order to effectively implement the chosen teaching strategy. In addition, research has pointed out that primary school teachers often hold several misconceptions in regard with chemical phenomena and effort is made to design and implement targeted in-service training programmes for overcoming this problem. The establishment of the interuniversity Masters programme entitled "Chemical Education and New Educational Technologies" aims at providing scientific and educational training to Greek chemistry teachers; it constitutes a successful example which needs to find more followers and state support.

1. International Experience

A policy priority in Europe is the increased qualification requirements for science teachers [1]. Literature review indicates that there is a correlation between quality science teachers' education, their qualification and quality practices in teaching and students' learning [2]. From this perspective, the teacher education literature has served to diffuse information and ideas for improving teachers' performance and students' achievement. Teacher education consists of two branches, the pre-service and the in-service teacher training. The latter is also referred as teachers' professional development. In today's context, pre-service teacher training is considered as a preparation of the teacher for effective participation in a continuous teaching–learning process [3].

The most useful professional development emphasizes active teaching, assessment, observation, and reflection rather than abstract discussions [4]. Professional development that focuses on student learning and helps teachers develop the pedagogical skills to teach specific kinds of content has strong positive effects on practice [5].

In a survey conducted in USA [6], teachers reported that their knowledge and skills grew and their practice changed when they received professional development that was coherent, focused on

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content knowledge, and involved active learning. Hands-on work that enhanced teachers' knowledge of the content and how to teach it produced a sense of efficacy—especially when that content was aligned with local curriculum and policies. In this survey, the effect of different characteristics of professional development on teachers' learning was investigated. The analysis focused on both "structural features"—characteristics of the structure or design of professional development activities; and "core features"—dimensions of the substance or core of the professional development experience. The following three structural features were examined: (a) the *form* of the activity; (b) the *duration* of the activity; and (c) the degree to which the activity emphasizes the *collective participation* of groups of teachers from the same school, department, or grade level, as opposed to the participation of individual teachers from many schools. Furthermore, the following three core features of professional development activities were also examined: (a) the degree to which the activity has a *content focus* (for example, the degree to which the activity is focused on improving and deepening teachers' content knowledge in chemistry); (b) the extent to which the activity offers opportunities for *active learning,* such as opportunities for teachers to become actively engaged in the meaningful analysis of teaching and learning; and (c) the degree to which the activity promotes *coherence* in teachers' professional development, by incorporating experiences that are consistent with teachers' goals, and by encouraging continuing professional communication among teachers. From the above characteristics, the duration (an intensive professional development program), the focusing on academic subject matter (content), the form of the training activities (active learning), and the integration of training into the daily life of the school (coherence) are suggested from the survey's results as more likely to produce enhanced knowledge and skills [6].

The significance of teachers' perceptions about how coherent their professional development experiences were for their learning has been revealed by Penuel and his colleagues [7]. The researchers also found that the incorporation of time for teachers to plan for implementation and provision of technical support were significant for promoting their ability to implement an educational program. Professional development seems more effective when the training program is not in isolation (as in the traditional one-shot workshop) but rather a coherent part of a school reform effort [5].

Of all used professional development activities, short duration workshops have been criticized as the most ineffective practice [8]. Reviewing nine studies, Guskey and Yoon noted that the professional development efforts that brought improvements in student learning focused principally on ideas gained through the involvement of outside of school experts [8]. The traditional episodic, fragmented approach does not allow for rigorous, cumulative learning [9]. A number of different types of collaborative, job-embedded professional learning activities can improve teacher practice and student achievement. Peer observations of practice, analysis of student work and student data, and teachers' study groups are reported as more effective activities than others [5]. It thus seems clear that effective professional development requires considerable time, which must be well organized, carefully structured, purposefully directed, and focused on content or pedagogy or both [6, 8].

In the review of Stolk *et al*., it is concluded that there is little empirical evidence for the connection between the actual activities in professional development programmes and the intended and realised learning outcomes of these programmes [10]. Therefore, the researchers combined the professional development strategies, the events for teacher-based curriculum design, and the goals for professional development with a theory for (teacher) learning into a framework for professional development of teachers [11]. The implementation of the proposed framework aiming to investigate processes of professional development was conducted using a sample of six experienced chemistry teachers [12]. The findings indicated that the teachers' empowerment was not carried out as intended.

Recently, van Driel *et al.* provided an overview of the current state of research on professional development in science education. From a total of 44 studies, all referring to science teacher professional development, it was found that most of the professional development programmes were aimed at enhancing teacher cognition as well as classroom practice. All studies applied most of the characteristics drawn from research on what makes professional development effective. However, organisational conditions were not usually taken into account and the role of facilitators and their impact on the outcomes of a professional development programme were rarely examined [13].

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2. The Greek Case

In Greece, science teachers have only an academic training and a degree in the subject of their specialization (chemistry, biology, physics), but no general or special educational preparation for the teaching profession. Recently, as the qualifications of prospective teachers are being reconsidered, and new training programs are being developed, the Chemistry Departments have included in their undergraduate programmes elective courses in Chemistry Education. All newly appointed chemistry teachers at the secondary education public system attend an obligatory training course in teaching methodologies organized by the National Ministry of Education. In-service education is centralized and designated for a small number of participants at the beginning of their career; it becomes decentralized later through the establishment of the Regional Training Centres [14]. Although there have been many educational reforms regarding teachers' training policy in recent years and the number of training programs has increased, they have not been able to satisfy teachers' needs to a substantial degree [15, 16]. At the same time, the optional character of in-service training is in contrast with the need for ongoing teacher training. The lack of encouragement and motivation offered by the Greek school administration is also linked to the unwillingness of Greek primary teachers to participate in in-service training [15].

In-service teacher training has been of informative nature and non systematic [17] and relevant courses mainly aim at the development of teachers' familiarity with ICT (use of word-processing, spreadsheet, presentation programs and internet). The 'Teachers' training on ICT in Education' programme is the most widespread in Greece. The second phase of the programme, which is dedicated to providing teachers with the pedagogical skills for computer integration in the classrooms (the first phase which included training in technical skills has been attended by the majority of early childhood teachers), commenced in spring 2008 and only a very small number of teachers attended it. Many studies were conducted to examine the effectiveness of training on ICT. Vosniadou and Kollias reviewed studies of teacher attitudes and teacher practice with respect to ICT, in order to identify the factors that can facilitate or hinder the use of ICT to more qualitative and effective learning environments. Taking the reviewed studies into consideration, the authors proposed (a) the objectives of teacher training and (b) the particular changes in educational objectives at national level as crucial factors of the teacher training on ICT in order to enhance the learning process [18].

The need for science teachers to master both pedagogical and content knowledge and be aware of their links, is pointed out in the work of Psillos et al [19]. In that study, it is noted that pre-service service teacher university education is often characterised by the fragmentary nature of the courses offered and by the rather large differences between pedagogies of different course categories, namely content courses and courses such as didactics of science. The authors present the application of specific teaching-learning sequences as an integral part of pre-service teacher education which can help student teachers develop clear criteria when choosing their teaching strategy.

A lack of a satisfactory level of primary teachers' understanding of basic chemistry concepts seems to have a negative effect on the quality of chemistry education as a whole. In fact, it has been found that teachers hold several misconceptions which are similar to those of the pupils, despite their increased age and teaching experience. [20, 21] For overcoming this problem, an in-service primary teachers' training course was developed and the effect of its implementation on teachers' understanding of four chemical phenomena was investigated. The findings of the implementation provide useful recommendations for teachers' training and science curricula design towards improved teaching and learning of chemical phenomena [21].

A recent study [22] examines the possibility of improving pre-service primary teachers' education in scientific subjects via a short course based on laboratory practice and use of educational software in the topic of air pollution. The course seems to improve teachers' "correct use of terms and accuracy of scientific descriptions". However, it is apparent, as also proposed by other researchers [8, 21, 23], that one "shot" is not enough; continuous, long-term in-service training programs are strongly recommended by carefully taking into account factors such as duration, timing and frequency.

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Especially for secondary chemistry teachers, few opportunities are offered for professional development focusing on subject matter or on pedagogy. An exception is the interdepartmental program of graduate studies leading to the acquisition of a Masters degree, entitled “Chemical Education and New Educational Technologies” which is organized by the Chemistry Departments of two Greek Universities (Athens and Thessaloniki) and the Department of Chemical Engineering of the National Technical University of Athens. The programme aims at providing scientific and educational training at graduate level to pre-service and in-service chemistry teachers in Greece [24].

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