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**‘CHEMICAL EDUCATION AND NEW EDUCATIONAL TECHNOLOGIES’:
AN INTER-UNIVERSITY PROGRAM FOR GRADUATE STUDIES**

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ABSTRACT: In response to the general directive by the Greek Ministry of Education for the development of inter-university programs of graduate studies in Greece, the Chemistry Departments of the *Universities of Athens, Thessaloniki and Ioannina*, and the Department of Chemical Engineering of the *National Technical University of Athens* have initiated a program for graduate studies entitled “*Chemical Education and New Educational Technologies*”. The goal of the program is to provide scientific and educational training at graduate level to serving and prospective secondary chemistry teachers in Greece. For 1998-99 and for 1999-00 thirty-five and thirty-seven students respectively were selected and are attending the courses taught in Athens and in Thessaloniki. The two-year study leads to the master’s degree, after which the students can continue for the doctor’s degree in any of the participating departments. During the first three semesters, every student has to attend taught courses, and to do practical work in science and in educational technology; in addition, in the second year he/she has to carry out a small research educational project. It is hoped that our students will be able to transfer the chemical knowledge in a more efficient way, taking advantage of (a) the guidelines offered by research in chemistry and science education and (b) the vast development of new educational technologies. [*Chem. Educ. Res. Pract. Eur.*: 2000, 1, 405-410]

KEY WORDS: *inter-university graduate programs; Greece; chemical education; new educational technologies; secondary chemistry teachers*

INTRODUCTION

The appearance, evolution and establishment, during the past forty so years, of science education (including chemistry education) as a distinct scientific discipline [that deals with the “systematic investigation of learning grounded on a theoretical base” (Herron & Nurrenbern, 1999)] in the developed countries has led to the gradual reconsideration of the role and training of science teachers. While, it is known that in some countries (e.g. Germany and UK) there have been, for a long time now, either special educational degrees in tertiary institutions for science teaching, or special teacher’s colleges, in other countries, including Greece, teachers have only an academic training and a degree in the subject of their specialization (chemistry, mathematics, physics, etc.), but

no general or special educational preparation for the teaching profession. The same problem exists also in the USA, where “universities do not generally offer many science courses designed especially for secondary teachers” (Watson, Jr., 1992).

Chemistry has high conceptual demands as a school subject. Its triple nature, macro, submicro and representational or symbolic (Johnstone, 1991, 2000), is unique. In spite of its short history, chemical education research has dealt with many crucial questions relative to the nature of chemical knowledge and the difficulties experienced by students in learning chemistry (Herron & Nurrenbern, 1999). A wealth of knowledge on chemical concepts and teaching methodology has made it imperative that new programs of professional training be established in universities. Watson Jr. (1992) suggested that there is a need to provide graduate-level chemistry courses for secondary teachers that “would stress both the subject matter and strategies for teaching the various concepts”. As a result of such considerations, the qualifications of prospective teachers are being reconsidered, and new training programs are being developed (e.g. in Italy: Bargellini, 2000).

Some efforts in this direction have been going on for a number of years in some Greek chemistry departments, by including in their undergraduate programs elective courses on education (*pedagogics*) and chemistry education (*didactics of chemistry*). In addition, some members of these departments have also experience in educational research, as well as in the development of educational material such as chemistry books for the secondary schools and educational software.

Furthermore, each year the *Association of Greek Chemists* organizes a two-day seminar on secondary chemical education, which attracts over 400 participants who are chemistry teachers from all over Greece. From discussions with chemistry teachers during these seminars, the necessity of special educational programs has been well understood.

During the last three years, the Greek chemistry departments have started a discussion about the organization of a graduate program focusing on chemical education. At the same time, the *Ministry of Education* of Greece has put particular emphasis on the development of inter-university programs of graduate studies in an effort to fulfill the needs of the Greek society and market for well-educated and specialized human capital. In response to this general directive, the Departments of Chemistry of the Universities of Athens, Thessaloniki and Ioannina, and the Department of Chemical Engineering of the National Technical University of Athens have proposed a program for graduate studies entitled “*Chemical Education and new Educational Technologies*”. The Ministry of Education, after evaluation of this program, has approved it and financed its organization and the first two years of operation with the amount of 950,000 ECU, under the framework of the “Operational Program of Education and Initial Professional Training”. The program started in September 1998.

GOAL AND MAIN DIRECTIONS OF THE PROGRAM

The general goal of the program is to provide scientific and educational training at graduate level to actual and future secondary teachers in Greece. It is hoped that our students will be able to transfer the chemical knowledge in a more efficient way, taking advantage of:

- (a) the guidelines offered by research in chemistry and science education and
- (b) the vast development of new educational technologies.

The main directions of the program are:

- teaching of chemistry and chemical technology courses, with emphasis in their application to everyday life, society and the environment;
- familiarization with and clarification of conceptual difficulties encountered in teaching and learning chemistry;
- provision of general pedagogical theory and practice;
- contact with established theory and modern trends in science and chemistry educational research;
- training of the students on the structure, operation and usage of both conventional and new educational technologies, as well as on the principles, methods and authoring tools for the development of educational multimedia software focused on chemistry teaching.

The program runs in parallel in the Departments of Chemistry of Athens and Thessaloniki. The two-year study leads to the master's degree, after which the students can continue for the doctor's degree in any of the participating Departments.

STRUCTURE OF THE PROGRAM

At the master's degree level, the students have to take a series of courses during the first three semesters. In addition, every student has to carry out a small research project in chemistry education or in the development and educational evaluation of a multimedia software on a chemistry topic, under the supervision of a specialist from among the teaching staff.

The Table provides a list of the main courses taught during the first three semesters. The curriculum is divided in three branches: the first deals with special chemistry topics; the second includes courses in general educational theory and practice, as well as in science and chemistry education; the third branch deals with the new educational technologies. Particular emphasis is placed on the methodology of educational research.

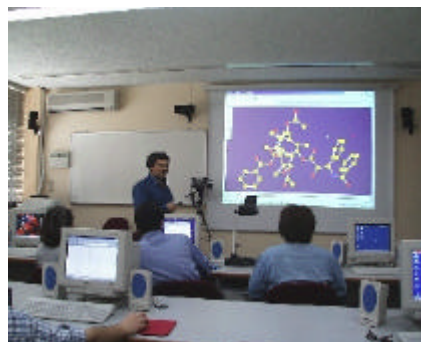
Furthermore, the library of the program provides the students with textbooks, educational multimedia packages, and general software and authoring tools needed for their study.

TABLE. *List of courses taught during the first three semesters.*

Chemistry courses	Educational courses	Courses on new educational technologies
<ul style="list-style-type: none"> • Topics in General and Inorganic Chemistry • Topics in Organic Chemistry and Biochemistry • Topics in Chemical Technology • Experiment in Chemistry Teaching • Aspects of Chemistry in every day life 	<ul style="list-style-type: none"> • Science Education • Chemistry Education • Planning, organization and evaluation of teaching • Cognitive Psychology • Environmental Education • History and epistemology of Chemistry • Methodology of educational research 	<ul style="list-style-type: none"> • Information technology and science education • Audio-visual educational tools • Authoring tools • Educational application of networks and data bases. • Computer simulation of chemical processes

Specialists having teaching and research experience in each discipline teach all the courses. They are members of the Departments of Chemistry and Chemical Engineering, of Education, of Methodology and History of Science, of Philosophy-Education-Psychology, and of Mathematics and Computer Science.

The needs of the program with respect to the infrastructure are fulfilled by the classrooms and laboratories of the Chemistry Departments, as well as by new special lecture and research halls arranged and equipped with all the necessary audio-visual technology and hardware.



THE STUDENTS

The program has found a considerable response by science graduates as well as active science teachers. In the first year there were 110 candidates from whom 35 students were selected and they attend the courses given in the Chemistry Departments of the Universities of Athens and Thessaloniki.

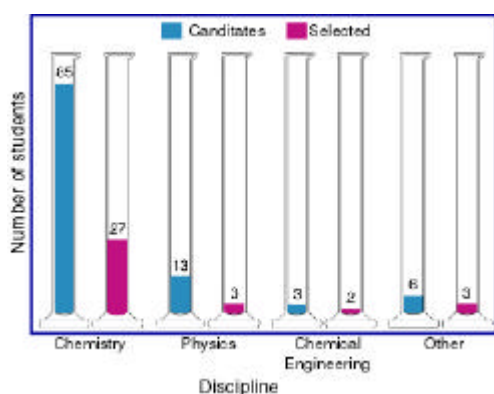


FIGURE 1. Distribution of 1998-99 applicants according to subject of specialization.

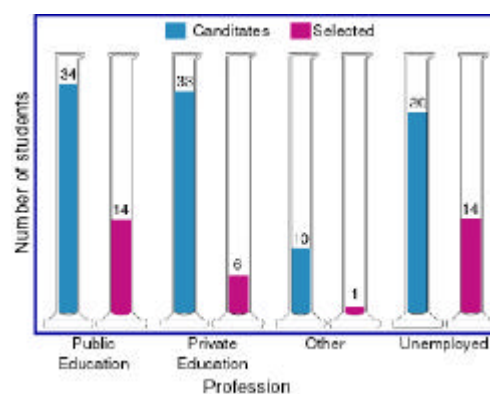


FIGURE 2. Distribution of 1998-99 applicants to professional status.

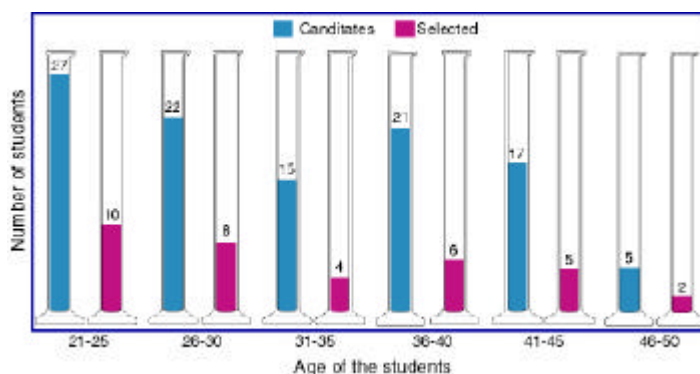


FIGURE 3. Distribution of 1998-99 applicants according to their age.

It is of interest to take a look at data concerning some characteristics of both the candidates and the selected students for the academic year 1998-1999. The majority of students were chemists, but we had also applications by physicists, chemical engineers, and primary teachers (Figure 1). Concerning the professional status, the great majority was equally divided between (i) those employed in public and private secondary education, and (ii) young graduates, as a rule unemployed (Figure 2). Finally, the majority of the students were between 20 and 30 years old, but there also were a significant number of candidates with age between 35-40, who were active teachers (Figure 3). For the academic year 1999-2000 year, the number of candidates was 115, from whom 37 were selected.

Although, the program runs for only three semesters and it is very early to talk about its success, some promising indications arise from the participation of the students and their activity. Thus, they have already participated in some presentations in the 5th ECRICE. They have produced some experimental educational CD-ROMs. They have taught chemistry lessons in school, and they have carried out all the activities of the Chemistry Departments for the “Year of Chemistry”.

CONCLUDING COMMENTS

A number of intensive activities has been initiated in the last few years in Greece for the in-service educational training of state teachers, as well as for graduates intending to enter the teaching profession. Four months in-service seminars for state chemistry teachers have been organized by the chemistry departments. In addition, discussions have started within the faculties of science of the Greek universities about the organization of a one-year preparation program for prospective secondary teachers that will lead to the award of the *diploma of educational training*. According to new legislation, this diploma is a prerequisite for the participation of new state teachers in the Competition for the Selection of Teachers from the year 2002 onward. In this framework, the graduate program presented here plays an important role in producing highly educated specialists, who are going to be involved in all these efforts.

Modern education can no longer afford to set as its goal the mere transfer of knowledge from expert (the teacher) to novice (the learner). Instead it must pursue the ‘construction of shared meaning’ (Mintzes & Wandersee, 1998). According to Novak (1998), the pursuit of the dream that education can be improved is a realistic one. We are optimistic that our program will contribute to the realization of such a dream!

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