

# Basic Components of the Scientific-Didactical Training of the Secondary School Mathematics Teacher<sup>1</sup>

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**Abstract** *Secondary mathematics teacher training in Spain is currently the subject of a heated revision debate. The speed of social, cultural, scientific and economic changes have left a hundred years old teacher training model well behind. However, academical inertia and professional interests are impeding a real new training of the mathematics teacher as an autonomous mathematical educator. Teachers of Didactic of Mathematics and the Spanish Associations of mathematics teachers have recently been discussing the issue. Their conclusions are included here.*

## Introduction

The training of the teacher of mathematics in Spain uses in real terms the same philosophy followed in many European countries, which is that Primary and Secondary School Teachers belong to two different and detached cultures.

In most cases, secondary school teachers have a five year degree in Mathematics. Since 1970, psychopedagogical training compulsory in state-run schools has been a short post-graduate course, the *Curso de Aptitud Pedagógica* (Pedagogic Aptitude Course) considered to be in nearly all cases a mere formality, which does not develop the necessary training and skills required in a qualified teacher. Most teachers at Secondary Schools have been trained since the introduction of the "New Mathematics", an approach that has had in Spain a clear Bourbakist bias. Consequently, teacher training in Spain is a formalist one which stresses structures, correction of procedures, and conceptual control through definitions and the comprehensive development of symbolic operations. In addition, there has been a shortage of trained secondary mathematics teachers for the past few years, which has steadily led to some Biologists and Chemists obtaining teaching jobs for which they are not fully qualified (Rico and Sierra; 1991).

Primary school teachers have a *Diplomatura de Educación General Básica* (a three year university degree), the requirement to get a teaching job in a primary school. At University, the teacher receives the basic mathematical training required to teach up to 14 year old, but this is obviously less than 5 year course provides. However, although the psychopedagogical training primary teachers receive is better, they are not always able to establish a connection between their training and the role of a teacher of mathematics, except in the more general aspects which apply to any other subject.

This two way training of the mathematics teacher has recently been challenged by the structural change of the Spanish School System deriving from the recent *Ley de Organización General del Sistema Educativo*, LOGSE, (General Education Law). This Act provides for compulsory education up to the age of 16, thus bringing present secondary teachers to this stage in education. New challenges in the teaching of mathematics are thus already under way.

For the time being, though, teachers do not have the adequate training to meet these challenges. In some cases, educational ideas amply surpass specific mathematical competence, where in other cases the reverse is true.

In a time of changes, the chance of getting rid of old concepts in the training of the teacher of mathematics should be taken advantage of, in order to create a new model of what a teacher should be; a **mathematical educator** who blends and integrates scientific competence, with a solid psychopedagogical knowledge and the methodological skills acquired through an adequately designed school practice period.

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### Some Historical Aspects

The Spanish system assumes that either there are teachers who happen to be teaching a subject whose complexities and difficulties they are not very well aware of; or that some other teachers are quite happy to carry on teaching mathematical trivialities of whose cultural value, cognitive difficulties or learning processes are fully ignorant. Mathematics education is not considered to be an aspect of education deserving its own rightful field. This inconsistency has been a fact for the past one hundred years.

The 1857 *Ley General de Instrucción Pública*, better known as the *Moyano Act*, is the basis of present day teacher training. The Act clearly established the competences of the *Escuelas Normales*, the primary teachers training schools, while designing a new curriculum; the Act also set up the Science Faculties which were to be organized in three sections: physical and mathematical sciences, chemistry and natural sciences. It was up to the Faculties of Sciences to develop their own identity and clearly differentiate them from the *Escuelas de Ingeniería de Caminos*, the Engineering Schools. These Faculties specifically devoted their work to research and the command of different mathematical theory fields, while giving training to future secondary school teachers.

There have been two methods in the making of the teacher of mathematics right from the beginning: the training at the *Escuelas Normales*, exclusively limited to Arithmetics and Geometry; and the training at the Science Faculties, where the emphasis is on reaching certain quality levels and learning techniques, significantly disregarding pedagogy and teaching methodology. *Maestros* and *Licenciados*, primary versus secondary teachers have been fighting their way to create their identity in which the weaknesses of their teaching has not been duly acknowledged. The fracture between these two groups accounts for the global devaluation of the teaching of the subject in recent Spanish history.

Efforts have been made to overcome this state of affairs, although meagre in number. Here we highlight some of the most significant ones.

Two major changes occurred at the beginning of the century. The *Plan de Formación de Maestros* in 1914, under the influence of the so-called *Movimiento Normalista*, which was promoted by teachers of mathematics at the *Escuelas Normales*. This scheme stressed the need for primary teachers to have a didactic as well as a methodological training. A second initiative was the opening of the *Instituto-Escuela* in Madrid in 1918, which drew up an innovative project for secondary teachers.

The *Revista de la Sociedad Matemática Española* closely followed the meetings of the *Comission Internationale de L'Enseignement Mathématique* (C.I.E.M). In 1914, the Commission was to have had another meeting in Munich with the "theoretical and practical mathematics teacher training for all the levels of education" high on the agenda but the onset of First World War frustrated the meeting. Despite this cancellation, the Mathematical Spanish Society strongly maintained the idea of having discussion on the matter concerning the Spanish system.

In 1915, the *Revista* published a translation of the questionnaire elaborated by the C.I.E.M., which dealt with the theoretical and practical training of teachers at secondary level. The questionnaire consists of seven sections, each one having several questions. There is no documentary proof that the Spanish subcommision drew up a report summing up the information gathered.

The *Revista Matemática Hispano-Americana*, founded by Rey Pastor in 1919, published in 1927 a significant article in the field of the mathematics teacher training written by Fernández Diéguez. The article, entitled "*Some aspects about the training of the teacher of mathematics in Public Education*", diagnosed the different elements occurring in Education, teachers, learners, methodology and subject. It also considered the necessary steps to improve the teaching of the subject. About teacher training, the article reads:

"A thoughtful and profound knowledge of the Science to be taught is not enough; nor is the mastering of the word and the clear explanation of the matter. To be useful, these two qualities need in addition Didactics and Pedagogy, the Methodology applying in Mathematics,

Psychopedagogy, the knowledge of the psychology of the teacher. They will be nothing without the will and urge to become a teacher (...) The teacher of mathematics must know how to teach the subject first. The mastering of the discipline will come afterwards. Pedagogy, History and the Philosophy of Mathematics, along with Experimental Psychology are paramount" (1927).

During the fifties, the negative effects of the Spanish Civil War progressively faded away. Profesor Puig Adam epitomizes the commitment of the mathematician with mathematics education. He gave a new impulse to mathematical teaching, and published numerous textbooks and articles. He also organized seminars for mathematics teachers. In his writings he expressed a great concern for the lack of qualified teachers.

In *Teacher training*, an appendix found in his book *Mathematics and present day teaching*, he points out four basic components in training:

i) Scientific training; ii) Historical, epistemological and humanistic training; iii) Psychological training; iv) methodological training.

Puig Adam managed to give a theoretical and practical training to his students of education at the Instituto San Isidro, where he was Head of the Mathematics Department. Regretfully, his activities came to a halt when he died in 1960.

The New Mathematics curriculum came up during the sixties and forced teachers in service to participate in seminars officially called *Formación Didáctica* (methodology training). The *Centro de Orientación Didáctica* (C.O.D.), an agency of the Ministry of Education, promoted meetings for the Heads of the Departments at state level to discuss content and the adequacy of the New Mathematics. Seminars were also held for unqualified teachers "to make them acknowledge to new curriculum and the latest methodological trends". The activities carried out during these years clearly expresses the urge teachers felt to update their training. The changes taking place are duly measured and time and efforts are devoted to grasping the changes. However, the efforts made by Puig Adam remained unparalleled.

In the year 64 the monopoly of Barcelona, Madrid and Zaragoza was challenged. A new plan of studies for degrees in mathematics was approved for Granada University, including a special course of studies on Methodology. Soon after, Santiago de Compostela, Sevilla, Valencia, Valladolid, Salamanca and La Laguna followed the trend. During the present decade, an even greater number of students have taken a degree course in mathematics, and teaching is one their professional options, and thus they choose their subjects accordingly.

A new plan of studies for the *Escuelas Normales* was approved in 1967 which extinguished the former 1950 plan. University applicants were required to have completed a six year course of studies at secondary education. Then, there was a period of time when these improvements were clearly seen and led to a greatly reduced gap between the *Escuelas Normales* and Faculties. The 1970 *Ley General de Educación* legally regulated specific methodological training for secondary teachers. This is the beginning of the C.A.P Course. Universities were to be responsible for teacher training. Although this course is nowadays considered to be a model worn out and without prestige, some interesting didactic activities resulted from it.

### **Present day situation**

Two features characterize current pre-service and in-service teacher training. Firstly, it is perceived that there is a need for a demanding, systematic and thorough training to match new professional teacher profiles and needs which LOGSE requires. Secondly, all course of studies leading to University degrees are being transformed with a view to bring more dynamism to them while widening the opportunities of up-to-date careers. These new degree courses will be offered by individual Universities. Likewise, Universities will have to update both their teaching and research staff.

This is the general framework in which the LOGSE Act (1990) is establishing that anyone wishing to become a secondary school teacher (either at *Centros de Enseñanza Secundaria*, *Bachillerato* or *Formación Profesional*) will be required to hold a five year degree:

"In addition, a degree course in Methodology will be required to teach in all state run Secondary Schools. It will be no less than a year course and will equally offer a school practice period. *Bachillerato* teachers will be required to hold the same degrees and have the same methodological qualifications as required for compulsory secondary education."(LOGSE)

Although both the methodology course and the practice period have been welcomed as positive, there are still some clear inconsistencies in the law. There is no definition of a common teaching corpus. No credit system has been regulated, not even the number of hours required is stipulated. The Authorities do not name the institution to monitor the courses. Finally, there is no mention of any organizational model nor any resolution on curriculum, assessment or promotion mechanisms.

As far as in-service training is concerned, educational authorities have created a network of teacher centres with the declared purpose of offering specific training to teachers on the reforms that are being enforced. Authorities at state as well as at regional level have accordingly been carrying out in-service schemes making use of human resources available at Teacher Centres, and setting up joint projects with Universities to monitor the reforms. These courses are varied in the number of hours: a teacher trainer course is an average of 300 hours long, while an in -service course is between 30, 150 hours. Objectives in both types are reckoned to be different, although they actually share some common features.

### **Basic Components Mathematics Teacher In-Service Seminars**

In the mathematics field, these seminars have devoted one or more sessions to deal with Epistemology, the History of Mathematics, and the Epistemology of Mathematical Education. Some other sessions have considered Cognitive Psychology, child and adolescent's evolution and Learning Theories, specially those applying to Maths. In most seminars, there have been several sessions on the subject of Educational Sociology, Anthropology and the cultural dimensions of Education, and especially Mathematical Education. Curricular Theory, design, development and assessment of the mathematics taught at school, materials and innovations in methodology have likewise been worked upon. At the central core of the curricular courses were specific instructional theories designed to handle mathematics teaching learning problems, and the didactical analysis of school mathematics contents. Finally, all courses offered detailed studies on classroom materials and resources, as well as laboratory and workshop management and the use of calculators and computers.

These have been the actual content of the training seminars carried out until now. There seems to be an agreement on what theory resources are necessary to draw up an adequate mathematics teacher training programme. However, differences between these seminars come up as priorities and selections of items may also vary a great deal.

This is the background in which the Spanish Federation of Mathematics Teacher Associations called a meeting in the city of Granada on 24th, 25th, 26th and 27th of March in 1993. A discussion followed on the training needs of secondary school mathematics teachers so that a technical and professional commitment could be reached.

### **Working schedule and conclusions**

#### **GOALS**

\* Clearly establish what training secondary mathematics teachers require to meet on-coming changes in the Education system and curricular design.

\* Define the boundaries of the theoretical corpus and practical classroom activities teachers need.

\* Discussion on the goals a mathematics teacher training program have to accomplish.

\* Criteria on design such a program; as well as the organizational and academic conditions to arrange contents, tasks, materials, methodology, and physical infrastructure.

\* A definition on the assessment of the scientific and methodological competence of in-service teachers, and the conditions to diagnose specific training needs.

CONTENTS. Discussions took place under the following headings:

First Session: Epistemology and Mathematics Education.

Second Session: Didactical analysis on Mathematical contents.

Third Session: Cognitive Psychology, learning theories and Mathematics Education.

Fourth Session: Curricular Theory and Mathematics Education.

Fifth Session: Curricular materials. Resource selection criteria, material aids in the mathematics classroom.

Sixth Session: Conclusions. Discussion on alternatives for a mathematics teacher training scheme.

### CONCLUSIONS

\* The complexities involving the scientific and methodological training of the mathematics teacher need thoughtful considerations beyond mere mathematical competence. These considerations rightfully have their own scientific groundings and play a significant role in all learning situations the mathematics teacher administers in the class. They must be at the core of all initial and in-service mathematics teacher training programmes, that is, at the planning, development and assessment stages.

\* During the sessions, there was a general agreement in that the scientific and methodological competences dealt with involved a wide range of conceptual fields relevant to the matter. Sociology, Antropology, Linguistics and Research Methodology were thought to be fully valid when clearly linked to specific teaching and learning problems.

\* It was not the aim of the seminar to draw together these conceptual fields in an specific program. However, it was clear that the first step had been taken and that the discussions held were a good starting point in that direction. The proceedings of the Seminar were but a first contribution.

\* Discussions also led to deep disagreement on the institutions and specialist to be responsible for developing research and training on these matters. The central issue was to decide whether specialist in the field of mathematics education should be leading the implementation of such programs, or whether that task should be in the hands of scholars of different fields who would naturally approach it from their individual fields.

\* This controversy gave rise to a heated debate on the role of Didactics of Mathematics at pre and in-service mathematical teacher training, a controversy that is summed in two leading questions: Should a teacher use a multi disciplinary bases to design his own curriculum, or should he simply implement ideas from different fields through his own epistemological status as a scientist? What is exactly the scope of mathematics education in teacher training?

\* Profesional responsibilities of the mathematics educator deserved long discussions too. The choice the teacher had here was either to find shelter under a specific theory on maths teaching; or to be the protagonists of their own decisions, to build up a theory frame from their own conceptions, believes, professional experiences and training needs. In other words, should this theory frame consider everyday teaching as an open phenomenon, or should it be a highly technified set of strategies design by researchers?

\* The mathematical learning of the teacher was not under discussion, although it was suggested that a specific seminar be organized on the issue: type and amount of mathematics a teacher should know; and what degree and training should the teacher have.

\* Theory versus practice: the discussions left the subject unresolved: should scientific and methodological training come through practical experience, in connection with it or should it come afterwards? A seminar on the matter was also thought to be required.

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