

# THE TRAINING AND PERFORMANCE OF PRIMARY TEACHERS IN MATHEMATICS EDUCATION. THE CASE OF SPAIN

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## **1. INITIAL PRIMARY TEACHERS' TRAINING IN SPAIN.**

### **1.1. PRIMARY EDUCATION WITHIN THE SPANISH EDUCATION SYSTEM**

The regulation of the Spanish Education System is stated by the General Organization of the Education System Act (*Ley de Organización del Sistema Educativo*, LOGSE) published in 1990. This law provides the following educational levels: Nursery Education; Primary Education; Secondary Education (that consists of Compulsory Secondary Education, Baccalaureate (16-18 years) and Primary Professional Training); Higher Professional Training, and University Education. Compulsory levels are those of Primary Education for children aged 6 to 12 and Compulsory Secondary Education for those aged 12 to 16.

Primary Education is made up of six academic years. The aim of this educational level is to provide all the Spanish children with a common background that enables them to acquire the basic cultural items, and those skills related to oral expression, reading, writing and arithmetic calculus, as well as to act progressively in an autonomous way within their environment.

Primary Education must develop among children these skills:

- a) To use appropriately Castilian language and the official language of the Autonomous Region.
- b) To apply simple calculus operations and basic logical procedures to their everyday life.
- c) To acquire those abilities needed to act on their own within their familiar environment as well as within the social groups they are related to.

d) To use the different media for artistic expression and representation.

e) To know the main features of their cultural, social and physical environment, as well as the possibilities to interact with it.

Primary Education consists of three stages, which involve two academic years each. It is divided on compulsory areas, which have a global and agglutinative character, being mathematics one of those areas.

In Spain, during the academic year 1997-1998, 2.610.041 students were enrolled in Primary Education. They were divided into 117.284 units and groups within 14.289 educational centers and attended by 97.760 teachers (Spanish Ministry of Education and Culture, 1999). Primary Education, regardless other consideration, is an activity that affects directly to a 6,8 % of the Spanish population including teachers and students.

Among the cultural tools that almost all the citizens acquire and share through this training period, we can find basic mathematical notions, with which scientific ideas can be set up and systematic procedures for problem-solving can be organized.

## **1.2. PRIMARY EDUCATION TEACHERS**

Nowadays, those teachers responsible for Primary Education have been trained following four different curricula:

\* The 1950 Curriculum. According to it, in order to follow teacher-training studies it was required a basic baccalaureate degree (secondary studies for four years finishing at 14 years). They were trained in the old Escuelas Normales (traditional teacher-training colleges), focused on a rural and a very low industrialized society.

\* The 1967 Curriculum. In order to follow teacher-training studies it was required an advanced baccalaureate degree (secondary studies for six years finishing at 16 years). They were trained in the updated Escuelas Normales, focused on a developing society both at an economic and industrial level.

\* The 1971 Curriculum. In order to follow teacher-training studies it was required a degree suitable for University studies (secondary studies for six years and another pre-University course, finishing at 17). They were trained in Escuelas Universitarias (Colleges) and they were supposed to begin a discipline specialization within the third cycles of the General Basic Education for a developed society.

\* The 1991 Curriculum. According to it, it was required to pass a test to enter the University (being 18 the average age to start the University studies). Students are trained in Faculties or Escuelas Universitarias which are fully integrated. Their training is focused on the teaching of general Primary Education with some rather instrumental specialization within a society with a high degree of self-government and decentralization, and that is included in the European Union.

The changes undergone by Primary teacher training in Spain in the last 50 years have been so great and radical as those experienced by the Spanish society. Such changes can be seen in the educational institutions involved, in the previous training required to follow teacher-training studies, in the goals and aims of the training curriculum, in the expectations on the kind of professionals resulting from such training curricula and in the social needs taken into account.

Primary Education is taught by maestros (school teachers) who are responsible for all the areas at this level and who work with children aged 6 to 12. The teaching of music, physical education, foreign languages or those other subjects that can be determined will be developed by maestros with the appropriate specialization.

### **1.3. HISTORICAL BACKGROUND.**

Those authors devoted to the study of the history of Primary teacher training in Spain usually point out that there are five great stages within this activity. Such periods show the different aims and social needs considered for this job (Sierra y Rico, 1996).

The first stage includes from the foundation of the first Escuela Normal in 1839 to the Restoration of 1875; here, the Moyano Act of 1857 is outstanding. During this period it is worth mentioning the important development of the number of children attending the schools, the consolidation of state monopoly on teaching, the shortage of pedagogical and didactic elements within those curricula in force, the continuous search of a professional model for teacher training, the lack of interest in female teacher-training and the permanent attempts by those political parties in the government to interfere and control the ideology of the Escuelas Normales.

At that time, Primary Education is divided in two stages: Elementary (compulsory period for children aged 6 to 9), and Higher (non compulsory period for children aged 9 to 12). As a consequence there were two different degrees for teachers, that is, Elementary Teachers (Maestro Elemental) whose training lasted for two years, and Higher Teachers (Maestro Superior) with a three year training.

The second stage is referred to the Bourbon Restoration (1875-1931). The main feature of this period is the initial decline and the later recovering. The last quarter of the XIX century means the lack of interest in public education, and the abandonment of the Escuelas Normales as an evidence of the decadence of the country. After some attempts to eliminate such centers, from 1903 there is a new regulation that recovers the teacher-training studies. In 1914 a new curriculum is set up, establishing a four-year course, starting at 12 years. Other feature of this curriculum is that it determined the access to public teaching through competitive exams. It had an encyclopaedist and cultural slant, what was to the detriment of the professional aspects. The prevailing social origin of the students was that of middle-lower classes. From 1903 Primary Education is still divided in two stages, Elementary and Higher, but both stages become compulsory.

The third stage is that of the Second Republic (1931-1936) one of whose main political aims is to address the problem of public education. This period is characterized by the dignifying and development of the teacher profession. The 1931 Curriculum known as Professional Plan meant the consideration of Primary teacher training as University studies, giving them a clear professional slant. Two of the main features of this stage are the specific methodology of each subject (curricular Didactic of Mathematics) and practical training. Primary Education continues to be compulsory and cover children from 6 to 12.

The fourth stage takes place between 1939 and 1970, almost during the whole Franco's dictatorship. Along these years there was first, a backward movement and then a stagnation regarding educational and pedagogical advances. The Primary teacher becomes again a professional whose qualification is not very high, focused on supplying basic levels of literacy with a low degree of professional training and a shortage of resources. The great majority of these professionals have a middle-low class social origin.

Although Primary Education is compulsory and involves children from 6 to 12, the Institutos Nacionales de Bachillerato (Baccalaureate Institutes) are in charge of the training of those students with the highest qualifications from the moment they pass their entrance exams.

In the period 1970-1990, during the last years of Franco's Dictatorship and the

beginning of Democracy there was a marked change in the training of Primary teachers. The Escuelas Normales are introduced within the University. The compulsory education period is expanded to address the social, economic and cultural development needs. The Ley General de Educación (General Education Act) of 1970 states Basic General Education (E.G.B) as a compulsory education period for children aged 6 to 14, being Primary teachers in charge of education at this level. During these years, almost a 100% of population is schooled and educational facilities are improved and expanded. The professional qualification of teachers is better and a high degree of specialization is achieved. On the other hand, the studies on special didactic are recovered.

Between 1970 and 1990, Primary teachers assume the training of all the citizens between 6 and 14 years. In order to tackle with the needs of those students in the higher courses of compulsory education, teacher-training studies are organized in three different specialties, that is, Human Sciences; Physical-Natural Sciences and Mathematics; and Spanish and Foreign Language. The professional training within each one of these specialties intends to combine an academic training at a first University cycle, with a didactic training focused on each of the above disciplines. It is within this setting, that the development of Didactic of Mathematics takes place in the University.

Thus, in the E.G.B. Schools during these years there are generalist teachers devoted to the first five courses, and specialist teachers who work on the subjects related to their specialties in the last three courses (Rico and Sierra, 1992).

#### **1.4. BALANCE OF THE TRAINING CURRICULA REVIEWED.**

Next, we offer a summary of the invariant we have detected through the analysis of the different Primary teacher training curricula:

- \* Contradiction among the aims stated for the Escuelas Normales, the attention paid by the Administration and the real possibilities to achieve such aims.
- \* Modification of the status of teachers and changes in the investments and aids for Primary Education depending of the political orientation of the Government in power.
- \* Shortage of investments in those institutions devoted to training and low level of qualification required to enter such institutions.
- \* Lack of acknowledgment of the professional distinctiveness of Primary teachers in the training curricula.
- \* Dichotomy and contra position between culture and professionalization within the teacher-training curricula, being considered as alternatives not as a model to be integrated.
- \* Lack of links between training curricula and school practice.
- \* Lack of connection with educational research and insufficient interest in its results.
- \* Common features of the population usually attending the Escuelas Normales: they are from low/middle-low social classes, mainly women, with a poor cultural level and who initially are not very stimulated by this profession.

#### **1.5 TEACHER TRAINING ON MATHEMATICS AND ITS DIDACTIC.**

In the different Primary teacher training curricula reviewed, mathematics appears to be an essential discipline (Sierra and Rico, 1996). In the oldest curricula, mathematics is addressed with a culturalist approach, that is, the focus is on the exclusive command of its contents. In the more recent curricula, starting from the Professional Curriculum of the II Republic, mathematics knowledge is focused on a practical and didactical reflection. These curricula are also known as professional; thus, the 1931 and 1967 curricula followed the professional approach; whereas the 1971 curriculum tried to combine both cultural and professional dimensions, restricting it to a single specialty.

The table below shows the mathematics subjects included in the different Primary

teacher training curricula from the one of 1871.

Curriculum Academic Year	1871	1903	1914	1931	1942	1950	1967	1971
1°	Arithmetic and Geometry	Arithm. and Geom.	Arithm. and Geom.	Maths Methodology	Mathematics	Arithm. & Method. Algebra	Didactic of Maths.	Mathematics
2°	Arithmetic and Geometry	==	Arithm. and Geom.	Maths Methodology	Mathematics	Geom. & Trigonometry	Didactic of Maths.	Maths. & Didactic of Maths.
3°	Arithmetic and Geometry	Arithm. & Algebra. Geom.	Algebra	==	Arithm. & Algebra.	==	Practice Seminar	Mathematics
4°	Arithmetic and Geometry	Arithm. & Algebra.	==	xx	==	xx	xx	xx

Comparative Table of Mathematics Subjects in the Different Curricula.  
(Sierra and Rico, 1996)

### 1.6 NEW MODEL FOR PRIMARY TEACHER TRAINING.

The LOGSE, General Organization of the Education System Act, meant a deep modification of the education system structure, becoming Primary Education again a training period with its own entity and needs. As a result, the teacher-training curricula must undergo a thorough revision. Since teachers were no longer in charge of the first courses of Secondary Education (students of 13 and 14 years), the specialties of the 1971 Curriculum disappeared. On the contrary, there arose new specialties for Primary teachers, such as those of Physical Education, Music and Foreign Language.

The changes in progress seem to attempt to recover a certain Spanish tradition on the Primary teacher training and his/her social roles. As can be seen from the following factors:

Primary Education is a compulsory period which covers children from 6 to 12. The teacher to be trained is a generalist professional who must withdraw the interest in academic specialization.

Professional slant must prevail against the cultural one within Primary teacher training. Pedagogical training is the feature that makes these teachers different.

Classical formative disciplines, as language and mathematics, seem to lose strength against a more diversified education which is open to new interests. This is very noticeable in the case of mathematics, subject that is taught three hours a week in Primary Education.

The new specialties provide important training complements for the student, but the teacher continues to be a professional with general competence in all the disciplines.

These changes have been reflected in the training curricula in force. The current Degrees on teacher-training, that we review next, show the way the new needs are addressed.

## 2. INSTITUTIONAL FRAMEWORK OF INITIAL TRAINING.

### 2.1. INSTITUTIONS IN CHARGE OF TRAINING.

Within the current education organization, it is the University the institution in charge of the initial teacher training. The initial Primary teacher training is done through the curricula developed by the different degrees on teacher-training of each university. Such studies are taught in the Faculties of Education Sciences and the so-called Escuelas Universitarias, that is, teacher-training colleges. The specialty of Primary teacher-training is offered by almost all the Spanish public universities. Such studies can be also followed in private institutions that work in agreement with public universities (confessional or secular teacher-training colleges or Escuelas de Magisterio) and in some private universities.

The degrees on teacher-training are called Diplomaturas, that is, three-year courses of University studies of first-cycle which can amount up to 200 training credits. The legal regulation on this degree establishes 120 compulsory credits, within the total of 200, that are common for all the Spanish universities (each credit corresponds to 10 teaching hours).

## **2.2. SPECIALTIES OF THE DEGREE ON TEACHER-TRAINING.**

The Government Decree 1444/1991 of August 30th 1991 (BOE 11-X-91) regulates the Degree on Teacher-training and its different specialties, and provides the general guidelines in order to achieve it.

The Degree on Teacher-training in the specialties mentioned below qualify a student to become a Primary teacher. Those professionals working on public centers access to public teaching through competitive exams. In other words, in Spain, the teaching staff of public schools is made up by civil servants selected by educational authorities by means of public exams called by the Spanish Education Ministry, or by the Educational Departments of those Autonomous Regions with powers on this matter. On the other hand, those teachers working in private institutions are appointed without any kind of exam, but they do need to have one of the Degrees on Teacher-training.

Nowadays, there are four degrees that enable to work as a Primary Teacher:

Teacher (Maestro) - Primary Education Specialty.

Teacher- Physical Education Specialty.

Teacher- Foreign language Specialty.

Teacher- Musical Education Specialty.

There are also other three qualifications for the specialties of Nursery Education, Special Education, Audition and Language.

The 1991 teacher-training curriculum and the teacher responsibilities resulting from the LOGSE meant a transformation for this group of professionals. The keys underlying this new curriculum are a professional slant, a practical training and the tuning up of new specialties.

## **2.3 TRAINING IN MATHEMATICS EDUCATION. STRUCTURAL FAILURES.**

The curricula of the different universities for each of the Degrees on teacher-training have an average of 200 credits. The subjects are organized in core subjects (established at a national level), compulsory subjects (established by each university), electives (offered by University Departments) and optional credits (offered by each university). The credits allocated to the core subjects (120) amount for a 60% of the total teaching hours. Within these subjects there are 9 credits devoted to Mathematics and its didactic for the specialty of Primary Education, and 4,5 credits for that subject in those specialties of Physical Education, Music and Foreign Language. Those subjects related to Pedagogy and Psychology included in the core subjects cover 45 credits. This allocation permits to see where the priorities of those experts in charge of the design of the curriculum were.

In some universities the number of credits devoted to mathematics and its didactic is increased, in order to do it, they offer a compulsory subject for the specialty of Primary Education which amounts for 6 to 9 credits. There are also some electives, which generally amount for 6 credits.

These facts provide a reference to establish the percentages related to Primary teacher training on mathematics and its didactic. According to law, the minimum percentage is a 4%, which happens in a very few universities. Usually, the teaching on mathematics and its didactic represents an 8% of the total of teaching hours included in the curricula of a great number of universities. If we bear in mind those students who also take an elective on this area, the percentage in the Primary teacher training can become up to an 11%. Very often, what happens is that a great number of Primary teachers in training cannot complete a 10% of their education in mathematics and its didactic, whereas psycho pedagogic training surpasses a 25% of the total teaching hours.

If we turn now to the specialties of Physical Education, Music and Foreign Language, we can say that only a 2% of the training of those students enrolled in such areas is devoted to mathematics and its didactic. These students have no other subjects related to this discipline available to widen the core subject, and they hardly ever choose electives in this field. Nevertheless, they are supposed to be qualified to teach any course of Primary Education.

#### **2.4 INITIAL TRAINING PURPOSES.**

The Degrees on Teacher-training have a number of general training goals. The specialists in general pedagogy have established a wide range of responsibilities for the Primary teacher training.

"Initial training must be useful to teach all the basic elements of the teaching job (...) At any education stage, the teacher should be acquainted with the principles of the education system, its general goals, the cultural sense of his/her job, the moral dimension of his/her activity, the technical resources needed to teach and to make his/her assessments in a more effective way, and at the same time he/she must know the environment of the institution he/she is involved in and the projects that there are in progress." (Ibáñez, 1999)

In order to tackle with these and other training needs, it is determined the establishment of 45 psycho pedagogical credits as well as 32 credits devoted to the teaching practice.

Within the area of knowledge of Didactic of Mathematics there have also been reflections on the Primary teacher training priorities. Thus, the University of Granada has established a set of general aims for the subject of Mathematics and its didactic, that, to a great extent, are shared by many other universities:

1. To consolidate the training needed to deal with the basic mathematical contents that make up Primary Education curriculum.

2. To know and illustrate the inter discipline and constructive character of mathematics and the usefulness of its knowledge.

3. To qualify students to put queries and develop documented work on mathematics curriculum in Primary Education and general aspects of Didactic of Mathematics.

4. To encourage a critical and researching attitude and the ability to achieve a clear, accurate and strict expression, and the development of self-training competencies as well as collaborative work.

5. To know the usual medium, materials and resources used in the teaching and learning of

mathematics.

6. To acquire the skills needed to use the tools, techniques and didactic material used in the area of mathematics.

7. To qualify the future teacher so that he/she can make didactic proposals from the basic mathematics curriculum for Primary Education."

In order to achieve these goals and to gain the didactic knowledge of the contents of the mathematics curriculum, those teachers in training only have available a 8% of their learning hours, in an advantageous situation, and in other cases this available percentage falls to a 2%.

## **2.5 CRITICAL BALANCE ON INITIAL PRIMARY TEACHER TRAINING.**

Along the transformation happened in the 90's, Primary teachers have considered a great number of the changes arising from the LOGSE to be a backward step, due to the loss of specific professional competencies and bearing in mind the consequences for their initial training curricula. After having contributed to the enlargement of compulsory education within the country and the improvement of the cultural level of Spanish citizens, supported by the Basic General Education, once again teachers find restricted only to a certain area of their former field of work. According to the teachers currently in service, other signs of their professional backward might be the conversion of schools in lower level centers, the attention paid on generalities, the loss of discipline specialization and the lack of intellectual motivation, among others.

These changes are reflected in the training curricula in force, and the view regarding these changes is shared by that outside education activity.

"Although the initial training included in former curricula in mathematics for Primary teachers was not ideal, current situation was untenable. We need teacher with a solid general culture; the type of training in mathematics and its didactic need to be delimited more accurately. There is a contradiction between the educational needs of the Primary teacher and his/her real training; the goals established for Primary Education within the area of mathematics are not covered with the current Primary teacher training; it can be said that such training is virtually non existent.

Mathematics in Primary Education cannot be limited to the learning of algorithms, it is necessary to encourage a positive attitude among students, that must be transmitted by their teachers; the lack of training of these teachers is having negative consequences for education system. It seems that the training importance of disciplines such as language and mathematics have been forgotten. School mathematics must be learned and taught within a context; it is essential to encourage a favorable attitude among Primary Education students towards mathematics, there are other important things apart from routines." (Guzmán et. Al., 1999).

Initial teacher training is one of the main educational indicators on the environments and school process provided by the OECD. Initial teacher training has been and nowadays is a relevant and controversial issue within education: the type and duration of studies, its academic level, its contents, and the different consideration of teachers according to the several educational stages are some of the criteria used to asses initial training (Gil, 1999).

Any of the above criteria support the alleged benefits of the new Primary Teacher training curriculum, on the contrary, they marks important failures.

Thus, it has been highlighted the professional character of the current curriculum, as a way of contrast with the academic and cultural slant of the former. This can be considered as a fallacy, since it is intended to identify professional knowledge and pedagogic culture.



The curriculum in force nowadays is mainly academic with a very well-determined orientation- that focused on pedagogical and psychological academic knowledge.

Didactic knowledge within the contents of mathematics curriculum is hardly addressed and the future teachers in training face their school practice provided only with theories and generic principles.

Another issue whose review is pending is the duration of teacher-training studies. A considerable increasing in didactic training within the different curriculum disciplines, Didactic of Mathematics, among them, would mean an improvement of professional knowledge and a greater supply of working tools for the future teacher. Equally, if the practice time increased, with specific work on each of the areas included in the curriculum, professional training would be more qualified.

A year increase and the development towards the category of Licenciaturas (four/five year Degrees) are needs expressed by Primary teachers who require greater and better support by the different didactic disciplines.

In order to deal with these and other issues a thorough review on the contents and training process of Primary teachers is needed. Didactic knowledge within Mathematics curriculum is one of the pillars of this reflection.

In the next sections we introduce our considerations about the knowledge Didactic of Mathematics can provide to Primary teacher training.

### **3. CONTENTS, OBJECTIVES, METHODOLOGY AND ASSESSMENT IN INITIAL TRAINING.**

#### *A general overview of our teaching*

The discussion on contents, characteristics of the subjects and desirable profiles of the pre-service teachers have been present since many years ago, as Llinares says in the Introduction of the Proceedings of the 2<sup>nd</sup> Symposium on Pre-service Training of Primary and Secondary Teachers in Mathematics Education (Llinares, 1998a). He speaks about the 1<sup>st</sup> Symposium on Contributions to the Curriculum in the Pre-service Training of Primary Teachers in Mathematics Education (Blanco & Cruz, 1997) and about other meetings, in particular the Andalusian Symposia of the university teachers working on the area of mathematics education. He concludes that the main questions are still in the air, although the professional status of the university teachers in mathematics education has changed, and it implies a clear frontier between the mathematical traditional areas (like Algebra or Analysis) and the educational one (in Spain called Didactics of Mathematics).

We agree with Llinares' previous consideration, but, at the same time, one can see that, although many important questions remain unresolved, more and more university teachers are trying to approach them. It is a change in attitude that, on occasion, is linked to personal and spontaneous initiatives and reflections, and other times is based on research results. In addition to that, the university teachers' professional questions have changed, as Chamorro (1998) reminds us:

"Many teachers in our field asked themselves fifteen years ago whether it was necessary to dedicate themselves to mathematics training only or also to didactical training. Today the questions concern what we expect from this training and its content, as well as what the richest strategies are, leaving aside their appropriateness and necessity." (p. 97)

As Ruiz (1998) says, there is a wide consensus about the necessity to include some themes in the pre-service training:

"1. Generalities about Mathematics and its Didactics. Mathematics Education. Fundamental Didactics of Mathematics.

2. Mathematics and Curriculum in Primary Education.

3. Natural number. Numbering. Calculus.

4. Rational number. Decimal number.

5. Geometry. Spatial knowledge. Spatial structuring.

6. Magnitudes and its measure.

7. Organisation, representation and treatment of information. Initiation to Statistics." (p. 45)

Ruiz goes on to tell us that a very different thing happens when we try to interpret the specific themes of the different universities which have to do with didactical aspects. We observe less unanimity and many possible interpretations of the same sentence (e.g. "didactical strategies, didactical resources,... didactical resources and materials for the development of the logical and numerical thinking", p. 49). But even though, from our point of view, the main challenge lies outside of the particular mathematical topics and the variety of interpretations of the didactical ones; the main challenge lies on the coherence between the pre-service training and the further professional demands, because, unlike the mathematics degree (for example), pre-service training is a professional degree. In other words: it is a professional training at the university level; it should be not culturally, but professionally driven.

Such before mentioned coherence has been the object of many investigations and has inspired the work of many teachers and researchers. From the conception of the pre-service training based on mathematical contents, one can go to other based on the meaning of professional knowledge. In between one can distinguish subjects oriented to the acquisition of mathematical knowledge, or didactical one, or mathematics didactical knowledge, or professional one. Among others, Blanco (1998), Bromme (1994), Brown and Borko (1992), Carrillo, Coriat and Oliveira (1999), Elstgeest, Goffree and Harlen (1993), Llinares (1994b), Shulman (1986, 1987), and Wilson, Shulman and Richter (1987) have approached the problem of identification of types of knowledge and components of professional knowledge.

Of course, the results of investigations and reflections have different interpretations when the university teachers try to apply them or, at least, organise their subjects inspired on them. Apart from the above mentioned symposia, this has been the central issue of a congress which has been held in Huelva in May, 1999 (Carrillo and Climent, 1999). Azc-rate (1999), Flores (1999) and Contreras (1999) made explicit different conceptions of training strategies and goals: the debates dealt with the focus on curricular design (didactical units), on mathematical knowledge and on the use of cases as an appropriate methodology, depending on the talkers.

There is, of course, no unanimity with respect to the spirit every university teacher gives to the maths education subjects. One can distinguish several ways of dealing with these subjects according to different goals:

- a) focusing on contents,
- b) focusing on methodologies,
- c) focusing on attitudes and beliefs,
- d) focusing on the design of curricular materials,
- e) focusing on professional practice.

As a reaction to the old syllabus, in which the mathematical contents (including derivatives and integrals for example) were the focus, some current subjects focus on fundamental aspects of Didactics of Mathematics from the perspective of its status as a

scientific discipline. In general, they focus on the psychological or on the pedagogical aspects, or on the didactical aspects as a whole, but, like the former, they focus on the theoretical training. With regard to a teacher whose main concern is mathematics, one perceives the idea that proficiency as a mathematics primary teacher might be achieved through time: what is important is to understand mathematics and transmit that understanding to their pupils; experience leads to the rest. Some university teachers drive their subjects to the repetition of the mathematical issues considered at the primary levels. The results are usually discouraging, because their students build neither an appropriate mathematical knowledge nor a pedagogical one. Moreover, they reach the conclusion that initial training is not relevant to their future practice as teachers. Whilst, regarding a teacher concerned about Didactics of Mathematics as a scientific discipline, one finds the idea that the teacher must know the theories which support their practice from the point of view of the researcher, not only from the point of view of the practitioner: what is important is to have got a strong rationale for the theories; the didactical transposition will derive from that.

On a very different level we can consider those subjects organised through the design or/and analysis of materials. Their philosophy consists of considering such design as one of the most important professional tasks and thinking that this is more important than the acquisition of specific mathematical knowledge. In fact, this perspective shares the ideas of the perspective of the focus on professional practice and those of the perspective of the focus on attitudes and beliefs. The supporters of this perspective think that the students must have concrete tasks in front of them, in order to achieve reliability and self-confidence when they must take their own decisions in the future. They do not usually consider the pupils as elements who might distort the initial task, and they usually focus on the mathematical content when they plan a task, leaving aside the learning obstacles. On the one hand, these university teachers provoke a positive attitude from the students, because they deal with educational tasks, but, on the other hand, the danger of some beliefs appear (they might believe that the job of the teacher consists basically of making general didactical transpositions).

Other teachers deal basically with the relevance of the methodologies. The mathematical contents are mere excuses for the explanation of a particular methodology. In such a way, they show a variety of methodologies (e.g. oriented research, projects, resources, problem solving,...). They consider the methodology as the most important curricular element. Some of them think that the students, when they become teachers, if they know several methodologies, can organise the subject, because they know the mathematical content, as it is rather elemental. These teachers pay more attention to the presentation of methodologies than to the adequacy of a particular methodology to a particular mathematical content, or to a particular pupil or group. What is important is to move on from a methodology to another; it would imply the pupils' motivation.

Some teachers apply the curricular organisers as subjects' organisers: objectives, contents, methodology and assessment. They see the new curricula as a focus on their teaching. While those who focus on fundamental didactics try to provide the students with *theories for ever*, the latter pay more attention to the current primary syllabus<sup>1</sup>. The dilemma didactical rationale versus curricular rationale is currently being aired.

Focusing on the professional practice, one can see those subjects which take the students' teaching practice as problematic. The classes are organised depending on the

questions that arise from the current or simultaneous experience of the students as primary teachers. Blanco and Borralho (1999) say that university teachers must give the students the opportunity to analyse their knowledge and conceptions on mathematics and its teaching and learning. Then they state that such opportunities should be organised

through specific contexts... coming from the primary... classrooms, with activities that allow... to discuss the meanings that the prospective teachers are building owing to the fact that they are immersed in those classrooms." (p. 160-161)

Some times, when the students are very concerned with their practices, they become highly motivated, at least initially, because their problems constitute the subject's focus, but it is dangerous to reduce their professional training to that specific teaching experience: what may occur is that they will lack a theoretical framework to approach different, future teaching experiences.

Other teachers focus on the reflection on students' previous errors, analysing their causes. They pay attention essentially to the learning part of the teaching-learning process, but they deal with the teaching part after making the causes explicit. Some of them combine this focus with that of reflecting on the students' conception of mathematics, often linking them with the before mentioned errors.

According to the before mentioned (let us call) tendencies, many assessment models exist. One classification criteria for them might be the explicit consideration of the students' previous levels (previous knowledge and/or beliefs).

Coriat and Contreras (1999) propose an assessment model composed of three phases: a) previous knowledge; b) following; c) final knowledge. This model starts from the group in a formative manner and pays progressively more attention to every student, until it gives a mark. The authors distance themselves from the metaphors of the teacher as mistakes hunter, pupils tamer, doctor giving a treatment, judge who sanctions offences, and hangman who punishes a fault.

Then they propose a change in attitude from the teacher. But, what are the criteria to pass? There is no unanimity amongst university teachers. One can take into account the progress of the students, their motivation and interest, the way they work in groups, their level of discussion in the debates; one can use their work in groups, their individual tasks at home and in the classroom, the exams,... And all of these criteria and instruments might refer to: only mathematical knowledge, only mathematics didactical knowledge,... The question is now how the election of some of these or other criteria and assessment instruments fits in the curriculum as a whole, and to what extent they are reliable.

Assessment has to do also with the size of the group. Contreras (1999) proposes the use of cases, but this is a teaching task which can be applied (like others) in several different ways as an assessment task, ranging from a closed to an open task.

However, it is not very easy to match a particular teacher with one of these tendencies. In general, we find features of several tendencies in every teacher, although each one emphasises some of them.

#### **4. TEACHERS' DESIRABLE PROFILE: THE BALANCE.**

##### **A point to move towards**

We were asked to answer several questions, among them two which concern a certain degree of balance:

- How is an adequate balance between knowledge of mathematical content and

pedagogical abilities to teach mathematics obtained?

- What is the correct proportion of didactical theory and practice in the training of primary teachers?

These are very relevant questions, which, in fact, refer to a great concern amongst teacher trainers and researchers. Such questions might be approached from two points:

- a) from the perspective of the current and ideal achievement by our prospective teachers; and
- b) from the characteristics of an ideal situation.

Starting from the perspective a), the horizon is quite dark, owing to the fact that, in general, the novice teachers feel that their training is not appropriate to manage school situations. They lack, not only pedagogical abilities to manage it, but mathematical knowledge to approach the pupils' challenges and difficulties to learn. Their mathematical knowledge is rather useless and, above all, inappropriate.

Coming to the second perspective, we propose, in order to analyse the before mentioned questions, to adopt the perspective that considers the prospective teacher as a learner, and focuses on the decisions s/he must take in the future. In this way, pedagogical reasoning (Brown and Borko, 1992) and the process of learning to teach (Llinares, 1994a) provide us with a competent theoretical framework.

Within this framework, the different components of student teacher's knowledge are understood as parts of their professional knowledge. At the same time, the goal is not just to acquire these parts, but the elements which help integrate them and build their own (professional) knowledge. Cooney (1994) summarises in four the main aspects in a training program:

- a) to allow teachers to develop a mathematical knowledge ready to teach under a constructivistic perspective;
- b) to give them opportunities to reflect on their own experience as learners;
- c) to provide them with contexts related to practical problems and help them to tackle those problems; and
- d) to give them opportunities to value the pupils' mathematical knowledge.

Given that the focus is on learning to teach, the problem emerges with the questions about how we can promote such learning. Llinares (1994a) proposes case analysis as a method that leads prospective teachers to explain their conceptions and knowledge. In this way,

"The cases create opportunities... to develop... pedagogical reasoning process, and are a good instrument to evaluate both such processes and factors that influence it." (p. 168)

The use of cases is proposed by several authors (Shulman, 1986, 1992; Llinares, 1994a, 1998b) as a very appropriate methodology to promote the construction of professional knowledge, focusing on elements of pedagogical reasoning. Nevertheless, Llinares (1998b) gives a clear warning: in order to avoid that the cases become mere anecdotes, it is necessary provide the student teachers with

"theoretical instruments to see what these situations are paradigmatic examples of" (p. 60).

In other words: we are speaking of the transparency of the cases, using the notion of transparency from cognitive psychology, applied by Lave and Wenger (1991) in the context of the community of practice.

We may take this advice as general: one needs moments to institutionalise the inbuilt learning.

Coming back to the use of cases, Coriat (1999) has some doubts about teaching methods. Indeed, he proposes:

- to start from his knowledge of the 'situation' (he defines as the pair contents-group), instead of the effectiveness of a method,
- to put into practice a variety of teaching methods, instead of reducing the methodology to only one,
- to think that the variety of issues to reflect (coming from a method) do not entail a better training,
- to go back on the labels we link with some methods (their effectiveness depends on the teacher's use).

These aspects are a step towards realisation with respect to our main concern as teachers. Ruiz and Rodríguez (1998) remind us of it with the following words:

"The main goal for all of us responsible for the training of teachers is to provide them with specific tools in order for them to identify, in their future teaching task, the most relevant didactical phenomena concerning the mathematical teaching-learning processes. Thus, we try to provide the student teacher with knowledge about Didactics of Mathematics useful to understand, design, manage and assess the mathematical teaching and learning processes." (p. 55)

The goal of training, from the perspective of professional knowledge, is to learn to manage a primary class: to learn to teach. It is neither to learn mathematics nor to learn didactics of mathematics. This perspective entails a different professional epistemology: teaching practice emerges as a crucial point (it generates problems and solutions), and therefore professional knowledge has got a dynamic component. The teaching practices make possible that the static component of knowledge (Blanco, 1998) is transformed in strategies and schemes for the action. In order to do that it is necessary that our intervention in the practices increases, and that we invest an adequate amount of time in the subjects organising and analysing those practices. The practices themselves are not enough to promote reflection and development: it is necessary to analyse them with the students; they need a conceptual framework to interpret what they are experiencing during the practices. Unfortunately, it is very common to find that the students, after the practice period, hold more traditional conceptions than before. A double explanation appears. On the one hand, sometimes they meet traditional teachers in primary education. On the other hand, when reflection is lacking, the students' knowledge is not reliable for them yet: they do not feel that anything they have studied can help them to manage the class; then they organise the class in a traditional way, normally similar to that experienced by them when young.

The following sentence from Blanco (1998) deals with methodological implications of this perspective:

"Base knowledge for the future teachers is knowledge for teaching practice, and therefore reflection in and on the teaching practices has to be in the beginning and development of their learning. This should condition the tasks we propose in the classroom." (p. 94)

This perspective leads us also to a conception of in-service training rather linked to a pre-service one. The initial training, although administratively considered as a finished

phase, must be understood as part of a whole, in which the in-service training takes part. The question is, thus, teacher's training (maybe distinguishing two or more important periods, but they are all professionally driven).

We would add another implication derived from this perspective: the idea of an open teacher education (or training) curriculum (Carrillo, Coriat and Oliveira, 1999):

- \* Primary mathematics curricula change from time to time. If we suppose a professional life of 30 years, each teacher should work at least in the context of two curricula.

- \* School cultures evolve, often following with certain slowness the changes of the society.

- \* Mathematics curricula change slowly at the university level.

- \* In recent years people have gone into teaching due to two main reasons: vocation and unemployment.

- \* Each person is unique. So, students interact with different teaching conceptions.

All this leads to conceiving teacher education as an open process; for that reason we need to speak of open curriculum. Open, because:

- \* The diversity of teaching styles constitutes a value.

- \* Teachers should be able to adapt themselves to different changes (curriculum, social and of school culture).

- \* Each teacher should teach new groups of people.

- \* Not everything can be learned through pre- and in-service education courses.

- \* There are always unpredictable questions that experience sets down.

Combining the idea of the above mentioned elements, within our framework, and Cooney's aspects, we can point out, among others, the following elements:

- \* ability to reflect,

- \* capability for self-criticism,

- \* capability to share ideas,

- \* capability to respect the ideas of the others,

- \* capability to take decisions and to be responsible for them,

- \* ability to work in groups,

- \* understanding the main features of mathematical thinking,

- \* ability to distinguish the idiosyncratic way of each pupil's thinking,

- \* understanding the relationships between the concepts and its various representations,

- \* skill at designing materials in accordance with some previously determined goals,

- \* skill organising the syllabus,

- \* skill at differentiating the tasks depending on the pupils' levels,

- \* ability to analyse published materials critically,

- \* skill approaching problems (mathematical and pedagogical),

- \* ability to guide the pupils,

- \* capability to communicate their own mathematical ideas.

These elements perform as:

- motive force of their future professional autonomy,

- motive force of their current autonomy,

- repairers of possible (mathematical or pedagogical) shortcomings,

- learning metatools (being probable that they last longer than specific knowledge),

- builders of solid conceptions (they prevent their own conceptions of the change coming from an non-reflective enculturation).

Accordingly, one can not easily answer the above questions. There is no rule to be applied by all the university teachers in their classrooms. In fact, if it had been possible, we would already have reached the solution. Nevertheless, it is quite common to think that, even though Mathematics Education as a scientific discipline defines and deals with didactical problems, only such problems and its linked approaches are interesting for the teachers, not the inherent processes of researching on them. The answer must be brave, but sensible; general, but clear.

At the moment, when the specific training in mathematics deserves, more or less, 12 credits, it seems to us rather difficult to promote adequately the before mentioned elements. Time invested in mathematics education (like in other didactical specific areas) is scarce. Mathematical knowledge is also very important, but also how it has been learned by the students, and often it is not appropriate to become a teacher.

Primary teachers are not specialists and they should teach in a global or integrated manner; nevertheless, pupils must learn specific contents. Thus, primary teachers have to cope with specific knowledge. In order to achieve a good balance between general pedagogical knowledge and mathematical and mathematics educational one, a fourth year is needed, dedicated exclusively to teaching practice and subjects related to the specific didactics.

Apart from that, we would like to say that there is no allusion to the students in the posed questions. We have spoken of the (university) teacher, of the subject (including questions about the balance between theory and practice, and mathematical and pedagogical knowledge), and of the context (institutions taking charge of initial training: educational faculties). But we have not directly spoken of the students. They will shape our ideal balance definitively. According to the balance metaphor, the shop is the context, we are the clerks, the goods placed on the balance trays stand for the initial training content, and the customers are the students: they buy what they want, like or need, and handle it to their own profit, interests or advantage.

We do not recommend an ingenuous position, which entails a favourable homogeneous consideration of the students, thinking that they all are very interested in the challenges of education at the primary levels, in particular in those related to mathematics. On the one hand, we know that most of our students would have chosen a different degree if they had been able to do it; and on the other hand, our students, instead of being prospective primary teachers, they are rather prospective unemployed, at least as primary teachers. We should take them into account, but does it mean that we should accommodate some features of our desirable teacher profile to their interests as non-learners?

Experience says to us that, although the general panorama is discouraging, in every course one discovers some students who are aware of their role as learners and decide to face it. They are, above all, the ones who should be taken into account when putting into practice our balances. For them we must interpret their capacities as individual differences to learn.

## **5. OUR CHALLENGE: THE CHALLENGE OF INTEGRATION.**

### **Aspects to be taken into account as teachers and researchers**

The concept of integration offers another perspective from which one can conceptualise many questions related to prospective teachers' training.

Integration is a wide concept that refers, for example, to:

- a) the relationship between theory and practice,
- b) the balance between mathematical knowledge and pedagogical one,



- tc) the assimilation of new knowledge on the basis of previous one,
- d) the connection between the mathematical themes and the mathematics didactical ones,
- e) the relationship between research on mathematics education and teaching prospective primary teachers in mathematics education,
- f) the role that expert teachers have got in the training of prospective and novice teachers,
- g) the relationship between research on mathematics education and primary education (relationship between researchers and primary teachers),
- h) the connection between the assessment and methodology we implement and those we recommend to be implemented in primary education,
- i) the relationship between initial and in-service training.

The later example (i) is related to the concept of training (or education) as a whole, and with idea that the training processes are endless<sup>2</sup>. We would like to highlight the problem of the new teachers, who feel abandoned by their university trainers when they finish their degree and get their first job as teachers. There is no connection after the degree. The university teachers train the students as cakes, which are packed and prepared to buy and eat.

Although the distinction between pre and in-service training is usually useful to make explicit both the context in which research is carried out and the constraints the subjects have got, we propose a different way forward. We should make up a theoretical framework including pre-service training as a step before in-service training: it would imply, for example, a higher weight of teaching practices in pre-service training. In addition, in-service training should avoid considering pre-service training as an ended phase from a theoretical point of view, but only from an institutional perspective: it would imply that in-service training should deal with some pre-service contents (Carrillo and Coriat, 1998).

The integration between theory and practice (a) is also a hot issue in pre-service education. The subjects are usually theoretically biased and one expects that the prospective teachers shall make the integration in the future, when they become teachers. And this perspective goes on in the in-service education.

Mellado, Ruiz and Blanco (1997) point out some features of the prospective primary teachers; for example:

- they teach as they were taught,
- they prefer the methods they liked as pupils,
- they have got a piece-to-piece organisation of mathematical content.

We think that these features are applicable not only to this group, but to different students populations. Nevertheless, they acquire a main role amongst prospective teachers. In addition to these undesirable attitudes and conceptions, initial training reinforces traditional methods and the isolation of the different components of knowledge. Indeed, even in the case that the subjects concerning mathematics education are given in an integrated manner, related knowledge is just a little part of professional knowledge, which is promoted through several and disconnected subjects by disconnected teachers.

We would add a feature that, from our experience, is applicable to many people: the unrealistic feeling with respect to bad situations, which consists of believing that bad things happen only to the others. The projection of this feeling to the prospective teachers

is as follows: although they scared from managing a class, they believe that they will not make the same mistakes that other teachers.

Our point of view (Carrillo, Coriat and Oliveira, 1999) consists of proposing, to prospective teachers, the different structured combinations and specialised knowledge and allows stimulate the student to generate integration, e.g. by creating rich learning environments. This is very costly in terms of time in academic training and does not allow for the possibility that the in this way educated teacher will organise this knowledge hierarchically and in a definitive way. Lappan and Theule-Lubienski (1992, p. 253), quoting Feiman-Nemser (1983), point out a limitation in the initial education: the theorisation of the material, which gives the "professional life" the responsibility for the integration between theory and practice, between traditional academic knowledge and professional knowledge.

The relationships between theory and practice and the understanding of the processes entailed by the practices are not simple at all. The student needs to build his/her theoretical framework to make sense of his/her educational experience. In the words of Russell (1994, p. 205): "Learning from experience is neither simple nor straightforward and certainly not automatic."

Sánchez (1994), under the question of teacher socialisation, remind us of the three transitions by Elbaz et al. (1985), referred to student teaching: from the university to the school, from student to teacher and from theory to practice. She warns us:

"In some cases, these changes can generate *conflicts*, which may imply that the expectations and behaviour of the potential teacher are not fully coherent." (p. 183)

She goes on highlighting the importance that the perception of having enough knowledge has in order for the prospective teacher to be confident as developer of curriculum. Indeed, it becomes very relevant owing to the fact that school culture influences strongly in the process of socialisation.

With respect to methodology (h), a general complain from the part of the students is that university teachers recommend a variety of methods, driven by the orientations of the new curricula, but, at the same time, they teach and they assess traditionally. Thus, the students learn more from the teachers' real performance than from their discourse.

Concerning researchers and primary teachers (g), these are convinced that their problems have nothing to do with those researchers are dealing with.

We must face one of the real obstacles that students teacher have: they are asked to drive the primary subjects in a global or interdisciplinary way, but, at the same time, they are trained by university teachers who do not have such a preparation (these are specialist in something; in Mathematics or Didactics of Mathematics in our case)<sup>3</sup>. This reflection leads to consider the importance of teaching practices and of the role that expert primary teachers have to play (f).

The role that expert teachers might play in the training of prospective and novice teachers can go beyond the observation and reflection about the questions they asked. In fact, expert teachers' perception of the elements which play in the teaching-learning process is different from prospective one. Some elements are not considered by them to be relevant or are not understood. Therefore, expert teachers can play the same role that expert researchers in a research group. The constructive perspective does not imply that every person must start helpless, but that they will start from their own knowledge and

from the knowledge accessible for them. In this point, the concept of community of practice and legitimate peripheral participation, characteristic of the situated learning focus (Lave and Wenger, 1991), is rather useful.

Finally, with respect to our challenge to connect research and teaching at university (e), we would like to say that currently several teachers from different universities are carrying out a research project, trying to define common goals and objectives of the pre-service training, in order to improve the quality of our teaching and also to have elements for the assessment of teaching and learning at the universities.

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<sup>1</sup> See the debate between Lacasta and Rico in Abraira and de Francisco (1998, pp. 141-163).

<sup>2</sup> See the contribution of Estepa in Abraira and de Francisco (1998, pp. 162).

<sup>3</sup> In some cases, there is a lack of pedagogical training of university teachers, because there is no training for them and they get their sit on the basis of their degree.