

## **Doctoral Programs and Academic Research on Mathematics Education in the Spanish Universities**

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### **Introduction**

Within Educational Sciences, the Didactic of Mathematics has suffered in the last 50 years a sustained development both in extension and in depth. Such a development is the cause as well as the effect of the key role of mathematical knowledge within the society and modern culture. The relevance of mathematics in the compulsory education curricula has resulted in a great number of theoretical studies and a considerable effort for practical implementation, supported by a wide and systematic research corpus on Mathematics Education (Romberg, 1992; Popkewitz, 1994).

The specialists agree that the most relevant features of mathematical knowledge are its formative character and its practical usefulness both at an individual and social dimension (Romberg, 1991; Niss, 1996). Mathematics teaching involves millions of students; and as a field of professional action, there are thousands of teachers and educators working on the teaching and learning of mathematics (OCDE, 1995).

Because of the highly social character of mathematics teaching, together with the complexity and difficulties found within the learning of this subject, a wide scientific community has emerged on Mathematics Education and has been working on these questions as its main subject of interest. Such a community has been studying over the processes of mathematics communication, transmission, and comprehension and has been developing qualified research on this topic for more than a century (Kilpatrick, 1992).

The majority of the efforts of the community of mathematics educators has been focused on research, as well as on curricular innovation and teacher training (Rico and Sierra, 1991).

The recent development of research on Mathematics Education has been sustained by certain keys; such as its integration at the university (Long, Meltzer, and Hilton, 1970), the academic control and assessment of its results, the support of specialized journals with a high level of scientific accuracy and exigency, the meetings and periodical debates among specialists, the delimitation and implementation of research agendas, and the encouragement to the research groups on Mathematics Education by the organizations and agencies dealing with research promotion (Kilpatrick, Rico, and Sierra, 1994).

Within this frame Spanish research on Mathematics Education has developed in a specific way during the last 25 years.

### **Backgrounds: Spanish Research on the 70s**

In Spain, in the 70s, the Law of General Education was passed. Regarding research on Mathematics Education there are two interesting points in this law that need to be highlighted:

\* a new organization of the educational system that develops a curriculum based on New Mathematics for all the levels of compulsory education (6 to 14 years old) and

post-compulsory (15 to 18);

\* the creation within each university of an Institute for Educational Sciences (ICE) by means of which both educational research and teachers training become a part of university competencies.

As a result of these reforms, there is a need to provide straight answers to the teaching problems found within the educational system, and to justify the adjustment of the new programs to the formative needs of students. During these years, several initiatives arise to tackle such problems, and it is worth to mention two of them due to their research orientation: Granada-Mats Team created in 1971, and the innovation groups Cero and Zero whose first works appeared in 1975. For further details about the research activity of these groups, see Rico and Sierra (1997).

Within the frame of the reforms caused by the Law of General Education, a new subject arises in the Spanish University - Didactic of Mathematics. This takes place first, in the new curricula for the initial training of General Education Teachers, and then, within the curricula of the Degree in Mathematics of some universities (1975). In this context, there are specific researchers' groups in certain universities starting to work on Didactic of Mathematics; and, at the same time it is achieved the academic valuation of some of the works made on this area. This is the case of the University of Granada, where in 1975, for the first time in Spain, two master thesis on Didactic of Mathematics were defended.

Nevertheless, the opportunities and institutional conditions of this period were very limited, and that impeded the adequate development of the research on Mathematics Education.

### **The Law for the Reform of the University**

In 1984 the Law for the Reform of the University (LRU) is passed. From the new university structure derived from such a law, the traditional disciplines were diversified in a new range of Areas of Knowledge adapted to an updated development of sciences.

The law stated that Areas of Knowledge are "those fields of human knowledge characterized by the homogeneity of their matter, a common historical tradition, and the existence of national research communities, as well as international ones." Within this frame the Area of Knowledge Didactic of Mathematics arises as one of the fields of knowledge the university consists of, what means the recognition of the efforts made by the community of mathematics educators in the previous years.

The constitution of university Departments where the Didactic of Mathematics area is included, and specially, the constitution of Didactic of Mathematics Departments has meant a great advance for Mathematics Education in Spain. Since there are new personal and material resources available, and both teaching and research on such an area are encouraged.

However, the starting point involved many difficulties; the needs and lacks outnumbered the resources at hand, and the challenge faced seemed to be impossible to meet successfully. At the beginning, the Didactic of Mathematics area had to take up great challenges; one of the main ones was academic research and the assessment of its results by means of doctoral dissertations (Puig & Calderon, 1996).

At international level, the priorities of the research on Mathematics Education dur-

ing these years have been focused on the delimitation, clarification, and statement of the main problems this research must work on (Shumway, 1980; Freudenthal, 1981; Wheeler, 1984), as well as on the required connection between the results from research and school practice (Bell, Low, Kilpatrick 1985). At a national level, each research community must adapt this program to its own needs, determine its priorities, adjust means to aims, and start an accurate proposal of academic research. Within this frame, the first measures to start the doctoral programs on Didactic of Mathematics are taken in Spain.

### **Doctoral Programs**

The new university law stated that "within the university each Department is the responsible of the co-ordination and articulation of its own teaching tasks and research activities." One of the most important achievements caused by the new university regulation has been the organization and development of specific Doctoral Programs on Didactic of Mathematics, such as happened in the Autonomous University of Barcelona, the University of Valencia, and the University of Granada; later on, other universities as the ones from Sevilla and Extremadura developed these Doctoral Programs too.

The relevance of Doctoral Programs is shown by the Government Decree regulating postgraduate studies that reads:

"Postgraduate studies, as shown by compared experience, are an essential condition for scientific progress, and therefore, for the social and economic development of a community, since researcher's formation depends on the depth of their contents and the accuracy of their approach."

Because of this, the Law of University Reform poses four main goals within the field of the studies mentioned above:

- \* To have a suitable frame to attain and transmit the scientific performances;
- \* To train the new researchers and to prepare researching teams in order to confront successfully the challenge posed by the new sciences, techniques, and methodologies;
- \* To encourage the new teachers training;
- \* To improve professional, scientific, and artistic development of the upper level graduates.

There is no doubt that the evolution of an Area of Knowledge involves the maintaining of a Postgraduate Program by means of which the goals above can be achieved. Thus, the universities of Granada, Valencia and the Autonomous one of Barcelona started, in the academic year 88-89, the Doctoral Program on Didactic of Mathematics which has been working since then.

### **Doctoral Program in the University of Granada**

The Didactic of Mathematics Department of the University of Granada offers a bi-annual Doctoral Program for researchers training. So far, 4 biennium programs have been developed, and a new one for the 96-98 biennium is in progress. According to the rules on this issue, Doctoral Programs must comprise:

- a) Courses or seminars on methodology and research techniques.
- b) Courses or seminars on the main contents of the scientific, technical or artistic fields the Doctoral Program is devoted to.
- c) Courses or seminars on topics related to the program and interesting enough for the Doctoral dissertation project of the postgraduate student.

Following these guidelines, the Didactic of Mathematics Doctoral Program for the

96-98 biennium includes the subjects appearing below:

### **96-97 Course**

Research on Mathematics Education - Methodological Advances  
Theory of Mathematics Education  
Design, Development and Assessment of Mathematics Curriculum  
Seminar of Didactic of Mathematics I  
Epistemology of the Probability and Combinatorics  
Data Analysis I  
Numerical Thinking  
Research Models for Ethnomathematics, Teachers Training and Curriculum I

### **97-98 Course**

Seminar of Didactic of Mathematics II  
Research Models for Ethnomathematics, Teachers Training and Curriculum II  
An Introduction to Multivariate Data Analysis  
Design of Educational Research  
Research on Problem Solving  
Advanced Numerical Thinking  
Semiometry and Ecology of Mathematical Objects  
Teachers beliefs and conceptions; Research on Teachers Training  
Assessment in the Mathematics schoolroom  
Epistemology and Didactic of the Statistic

### **General Regulation of Doctoral Programs**

Each doctoral student must take and pass a whole of 32 credits (320 hours), in two years (period that can be extended up to three) by means either of the courses and seminars included in the program, or of a compulsory research work that can mean up to 9 credits. A minimum of 16 credits should be devoted to subjects of the area of knowledge or basic ones; the rest of the credits can be taken by means of related subjects.

The research work is a first approach to the doctoral thesis. The Department understands that the best way to learn to research is carrying out such a work. Thus, doctoral students are encouraged to present a Postgraduate Studies Dissertation showing the results obtained in that work. They need to present at the Department, before finishing the program, a proposal for their doctoral thesis supported by the Professor(s) who are going to be their director(s). The doctoral thesis must be ended five years after the beginning of the studies, period that might be extended up to seven. To date, 16 doctoral thesis within the Doctoral Program on Didactic of Mathematics of the University of Granada have been presented.

### **Research Development**

To the four general goals stated by the law regarding research, the Didactic of Mathematics area has added the following:

\* To establish and maintain a space for criticism, debate and communication about the current state and recent development of research on the Didactic of Mathematics area, as well as about its theoretical and methodological advances.

\* To impel the delimitation of relevant problems within mathematics teaching and learning, so that they can be studied systematically and thoroughly, and significant information can be obtained. By means of the assessment and treatment of such infor-

mation, suitable materials and resources for mathematics schoolroom can be achieved.

\* To set up solid research groups working methodically, orderly, and with continuity on specific research lines on Mathematics Education. Equally, these groups must be a reference for specialists and be in touch with the international research community.

\* To produce its own qualified research, making original and specific contributions to the main investigation issues within the area of knowledge; and to present regularly the results obtained in the forums and media of the research community.

The main achievement of Doctoral Programs on Didactic of Mathematics involves not only writing doctoral thesis, but also the attempt to constitute solid research groups, and to consolidate a research community on Mathematics Education at the Spanish university.

Such a statement is supported by several facts. The professors and lecturers of the Didactic of Mathematics area have reported their research to the evaluations on investigation activity made by the Spanish Ministry of Education; there is a significant group of these teachers whose work has received a positive assessment. Within the National Plan for Researchers Training, some scholarships have been awarded to works on Didactic of Mathematics.

In the annual General Knowledge Promotion Plans supported by the General Directorate for Scientific and Technical Research (DGICYT), several projects by groups of Didactic of Mathematics researchers have been presented and passed; as well as in the Educational Research National Plan supported by the General Directorate for Pedagogical Renewal. At a regional level, there are projects passed by the Andalusian Research Plan supported by the Education and Science Department of the Andalusian Government.

The Didactic of Mathematics Departments are organized by means of research lines. This is the case of the University of Granada, where the Department comprises five research groups, in order to arrange its research activity. Such lines are the following:

Didactic of Mathematics: Numerical Thinking

Didactic of Statistic and Probability

Design, Development, and Assessment of the Curriculum of Mathematics

Teachers of Mathematics Training

Theory and Research Methodologies in Mathematics Education

Each of these groups is having an important development that enables the placement of project researches and doctoral thesis within a more general and coordinate frame, which provide these specialized studies with continuity and depth.

Another feature of the current situation is international relationships. Apart from individual invitations to give courses and lectures, the Didactic of Mathematics Departments of the universities Autonomous of Barcelona, Valencia and Granada have agreements among them, with other Research Centers on Mathematics Education, as well as with university Departments from other countries mainly of the European Union (EU) and Latin America. These departments have taken part in EU projects, such as Erasmus, Tempus, Socrates and Alfa, co-ordinating and belonging to networks of Mathematics Education researchers. The contribution of the above mentioned universities to the initial training of Latin American researchers on

Mathematics Education is systematic and fruitful.

It is also important to point out the joining of Spanish researchers to international groups (PME, CIEAEM, ICOTS, ICMI-Studies, etc.) and the significant participation in lectures, research groups, books writing, research reports and abstracts.

### **Spanish Society of Research on Mathematics Education**

Within the frame shown, the relationships among the Spanish researchers on Mathematics Education have increased and each time are more focused on research works and tasks. All the activities and debates held have developed the perception of belonging to a single research community.

Thus, a professional research group on Mathematics Education is delimited. A group that can be recognized by its academic works, its involvement in international groups, and its orderly production of investigations in this field that is criticized and assessed by the community itself.

Such a group, not quite vast, requires its own space for meeting, debate and reflection. At this way, it is posed the need to formally set up a society which summons and organizes the professional researchers on Mathematics Education.

The Spanish Society of Research on Mathematics Education (SEIEM) was finally founded in March 1996. Their main goals are the following:

- \* To promote Mathematics Education in research institutions and educational agencies. To encourage the participation in the institutional and private schemes for supporting research.

- \* To contribute and to assume a leading role in the development, assessment and application of research in Didactic of Mathematics.

- \* To stress to the dissemination of research outcomes in the Mathematics Education forums, meetings and reviews.

- \* To establish relations and to promote collaborative work with other research groups in Mathematics Education.

- \* To actively foster the cooperation and exchange between research and practice throughout the whole educational system.

- \* To transmit and spread institutionally the activity of the Society.

The Society has started the debate on the research fields with priority in Mathematics Education in order to make easier the constitution of stable work groups within the community.

After a review and analysis of the topics and research fields the Spanish researchers have been working on, the Society decided to set up the groups below:

- 1 Didactic of Analysis. Advanced Numerical Thinking.
- 2 Geometry Learning, and New Technologies.
- 3 Didactic of Statistic, Probability and Combinatorics.
- 4 Numerical and Algebraical Thinking.
- 5 Mathematics Teachers Training.
- 6 Research Methodology on Didactic of Mathematics.

### **Future Development**

We have shown a description of the changes and innovations happened in Spain concerning the research on Mathematics Education during the last 25 years, highlighting specially the fast development of the last 10 years. Neither of these great and striking changes would have taken place if there was not been an evolution within the

Spanish society, and particularly, within its educational system. Thanks to this, we have found the appropriate conditions for research development.

Just to mention a few of these changes, we should point out the great cultural and social development happened in Spain, and the economic, political and educational innovations introduced during the last 25 years.

In order to achieve a stable research community on Mathematics Education, the previous consolidation of a solid community of researchers on the different mathematics disciplines has been essential. The fact that Mathematics is a field of research within the Spanish university gives sense to the problems that appear both at teaching and learning levels, due to the communication and transferring difficulties found. Another key fact for the achievement of stability is the consolidation of different research communities on the disciplines gathered within the so called Educational Sciences, since they provide suitable theoretical and methodological frames, and can be used to criticize and contrast the researches on Mathematics Education.

As we have previously mentioned, the set up of Mathematics Teachers Societies is also a contribution to research. These associations have developed a vigorous activity supporting the design and development of mathematics curriculum for school level, and the initial and continuous training of teachers. In Spain, the contribution of Teachers Societies to the Mathematics Education development, and specially to the reflection on the connections between theory and practice has been quite important. A great part of the research work done has been diffused from the meetings and conferences held by Societies, being the results from such meetings spread by means of the reviews and publications edited by Societies.

Despite the fact that, from a professional and academic point of view, the problems of research on Mathematics Education are very specific, we cannot forget the compromise and necessary link to the professional practice of mathematics educators. Equally, mathematics teachers should not see the researcher as an element which has nothing to do with their work; rather than this, they should ask them for accuracy, clarity and practical outcomes.

Researchers in Mathematics Education, for their own reasons, take part in the community of mathematics educators, nevertheless they have their professional competencies and must take care of them with priority. This situation requires a reflection on common problems that need to be solved by agreement. It is also necessary a systematic coordination with the teachers of mathematics in order to achieve a well-founded identity, and to consolidate both communities.

All the Spanish mathematics educators have the same aim: to improve the quality of the teaching and learning of mathematics in Spain, and everyone must assume this goal within their own competency. Researchers have a well-defined professional field which cannot be avoided. By ethical, civic and professional reasons they owe to carry on the necessary development of the Spanish research on Mathematics Education. That is a major duty whose accomplishment must be achieved and that cannot be eluded. The success or failure in this task will give in the future the authentic measure of their contribution to the Mathematics Education in Spain.

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