# Professional development of mathematics teachers: Challenges from a national in-service teacher education program in Portugal

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#### The context for the in-service teacher education program

The initial training of elementary teachers in Portugal has been quite poor in what concerns mathematics. From the 80's till now, the majority of elementary teachers took his initial training in higher schools of education, designed to educate generalist teachers. The teacher education syllabus put a strong emphasis on pedagogy (general). Mathematics, didactics of mathematics and curricular development in mathematics are subjects with a brief presence. The situation becomes more critical if we take into account that most of elementary prospective teachers have a previous negative experience as learners of mathematics. In fact, most of them, studied humanities matters, without any work in mathematics along their last three years as secondary students. So, not only their mathematical content knowledge is poor but also they have a negative relation with everything concerning mathematics.

The situation is no better if we look to in-service education programs that have been developed for elementary teachers in the last years: the majority does not take mathematics or mathematics teaching as focus. In general, we can say that most elementary teachers are not well prepared to teach mathematics and to deal with the challenges of the new mathematics national curriculum. They teach from the textbook, in an essentially individualized practice. In general, teacher cooperation is not very common in Portuguese basic schools.

Aiming to overcome this situation, the government took the initiative of promoting a national inservice program for elementary teachers (PFCM). The final purpose of PFCM is to improve mathematical learning of the elementary school' pupils, recognizing that elementary teachers need to develop a positive attitude and a solid knowledge about mathematics and its teaching. A specialized group (including the authors of the paper), designed for Monitoring Commission (CA), was asked to conceive the program and to monitor its development by the higher schools of education and some universities all over the country.

## Principles, objectives and contents of PFCM

PFCM was oriented by the following principles: a) Teachers need to develop professionally – as any other professional, teachers develop continuously professional knowledge, a practical and situated knowledge that develops in relation with the context and experiences of teaching and allow them to deal with new challenges (Calderhead, 1987; Schön, 1983); b) Elementary teachers are mathematics teachers – they are not only arithmetic teachers but they promote fundamental experiences that shape from the beginning the relation of students with mathematics (NCTM, 2000); c) To teach is to develop curricular experiences and to reflect on them – and not only to reproduce the contents of textbooks in the classroom. It is essential to plan mathematical lessons

relating mathematics syllabus contents and purposes and the features of the students, and to analyze what they learn (or not) for improving teaching; d) Classroom practice is the starting point for professional development – the knowledge teachers need to teach mathematics (plan, conduct and assess the teaching activities) develops essentially trough the reflection-in-action, reflection-on-action and reflection on reflection-in-action (Schön,1987); e) Teachers need to learn to identify their weakness in mathematics and ways of overcoming it - recognizing that the quality of teachers mathematical knowledge is a factor of fundamental importance for an adequate planning and conduction of mathematical learning experiences of students. They must be able to work with mathematical content for students in its growing and not finished state and for doing so, they need to be able to deconstruct their mathematical knowledge in a way that the elemental components are accessible and visible (Ball & Bass, 2000); f) Teachers need to work with each others in schools, as a community - professional development is more effective within a group of colleagues of the same school or school organization that collectively participate on the planning and development of curricular experiences (Day, 1998; Hargreaves, 1994), giving support to each other in a relation of complicity; g) Teachers need to collaborate with different actors, including teacher educators from the teacher training institutions - teachers and teachers educators must work together (Jaworski, 2001) in a model called "co-learning partnerships" where they are both participants working together and both engaged in action and reflection and learning from the process of education.

Taking these principles into account, PFCM defined as main goals: a) To deepen mathematical content, didactical and curricular teachers' knowledge; b) To support the development of curricular experiences, including the planning of lessons (goals, content, tasks, resources, classroom organization, assessment,...), its conduction and the reflection about the action, about what students have learned and the factors that affected their learning of mathematics; c) To improve a more positive attitude of teachers about mathematics, its teaching and pupils mathematical capacities; d) To promote collaborative work among teachers in schools and with teachers educators.

PFCM choose four main areas of contents for the work with teachers, essential for an integrated vision and knowledge of mathematics for teaching and with a strong link to the Portuguese mathematical curricular demands: 1) Fundamental mathematics contents, related with the national curriculum (Numbers and operations, geometry and measure, data analysis and probability). The approach should focus on understanding of concepts and its relations with each others, procedures and mathematical processes (NCTM, 2000), and also develop teachers knowledge about ways of thinking in mathematics and its relations with the world around; 2) The nature of tasks for classroom, focusing on problem solving, investigations, projects and comprehensive practice of procedures, on its selection and adaptation considering students necessities; 3) Resources as context or support for the learning of mathematics, including concrete materials, calculators, computers and also textbooks, aiming the development of a critical perspective about its use; 4) The culture of mathematics classroom and assessment, stressing the relevance of the interactions between students and teacher for the learning environment and discourse of classroom (NCTM, 1991) and the importance of listen to the students to identify and understand their reasoning.

#### **PFCM main features**

We would like to stress the main features of this practice-based in-service program in what concerns its structure and organization.

Different but interrelated sessions, evolving actors in multiples dimensions, in a long period of time. PFCM is structured by two different but interrelated kind of sessions that take place in schools all over the scholar year: 1) Collaborative working sessions (two per month, 3 hours each one) with 8-10 teachers from the same school or school organization, aiming to work on the mathematics curriculum and related content and didactical knowledge needed for the planning of teachers lessons, to reflect about teachers' classes and to discuss the questions arising from supervision; 2) Supervision sessions of classroom work of individual teachers intended to put in practice selected tasks explored in the previous working session of the group.

A final one day session at the end of the scholar year is also required, joining all teachers and teachers educators, for sharing experiences identified by teachers of their professional development, illustrated by significant episodes of good practices of teaching that occurred in the context of PFCM.

*New and complex teaching experiences*. The collaborative working sessions include the collective planning of mathematical learning activities for classroom that are often complex for teachers, because they evolve new mathematical knowledge, new kind of tasks, different teaching strategies, new resources in the classroom. To support that planning, it is very important to consider: a) the discussion of mathematics contents and processes selected from the school mathematics curriculum, according to the group planning negotiated in the beginning of PFCM; b) planning of coherent sequences of lessons focused on the selected topic, including decisions about the tasks, ways of exploring them in classrooms of different levels, adequate resources, classroom organization. That planning is often finalized by individual teachers — and they can ask for feedback of teacher educator by e-mail.

*Reflective coaching in classroom.* In PFCM, coaching is considered as a form of professional collaboration and support between teacher and teacher educator. So, along the scholar year, each teacher has four/five supervision sessions, seen as an opportunity to get support from another teacher colleague (the teacher educator) to put in practice the lessons planned in the previous working session of the group. Each supervision session takes about two hours and a half, including two moments. The first one, in the classroom, in the course of the teacher lesson takes one hour and half; and the second one, after the lesson, takes about one hour and has the purpose of promote a initial reflection about the action, about what students have learned and the factors that affected their learning of mathematics.

*Collective reflection about teacher's classes*. The collaborative working sessions include also the reflection about what happened in the classroom of supervised teachers. They put their individual reflections in common, sometimes of classes about the same topics. Teacher educator plays a very important role in that discussion, promoting the sharing of the significant episodes of classrooms of different teachers and its analyses (the way tasks were presented by the teacher, how students react to them, the interactions of classroom, students' mathematical productions, their errors and difficulties, factors that affected them,...). Teacher educator has also a fundamental role in the summarizing of ideas of what teachers and him/herself have learned from experience to improve their future instructional practice.

*Individual and written reflection for promoting professional development.* Individual and written reflection is also considered important in PFCM as a way of get conscious and deepen the professional development of teachers. So, teachers are asked to develop a portfolio, that must include, at minimum, the description and reflection about two lessons selected by teacher considering its significance for his/her professional development. For each lesson, the portfolio must include: 1) the planning of the lesson, clarifying tasks' goals; 2) the implementation of the tasks, with references to the students' reactions, such as answers to teacher' questions, difficulties they express, written mathematical productions,... and also references to the teacher' role and performance, that must be illustrated with teaching episodes; 3) reflection about teacher' experience, including teacher' assessment about the students' mathematical learning and what factors affected students' learning, how would he/she change and why a future lesson with identical goals; 4) reflection about what teacher learned from experience and its meaning concerning his/her development as mathematics teacher. The individual portfolio is also the most important instrument to assess teachers' professional development in the context of PFCM.

*Continuity and promotion of autonomy.* The improvement of teachers mathematical content, didactical and curricular knowledge and the fostering of new perspectives about mathematics and school mathematics in relation with its teaching are ambitious purposes that require a continuous interplay between theory, practice and guided inquiry. Taking this into account, the program is being developed over one complete school year. Besides, the same teachers may be enrolled in the program over two school years, if they whish. In the second year, some of the collective working sessions run out without the presence of teacher educator (called autonomy working sessions). The main purpose of these sessions is to foster teachers autonomy in what concerns curricular development from discussion with their peers, expecting to promote a collective dynamics that will prevail after the ending of PFCM.

## **PFCM** in terrain

PFCM was developed by 18 institutions all over the country. In its first year (2005/2006), PFCM evolved only elementary teachers that participated in the program in a volunteer way. In 2006/2007 the program was extended for mathematics middle school teachers (grades 5 and 6). Taking all together, near 11000 teachers participated in PFCM in 2005/2008 (8924 elementary teachers, 1785 middle school teachers (grades 5 and 6)).

The institutions should respect the principles and objectives of the program, as well as its structure and organization and ways of teachers' professional development assessment. But the content of the program in each institution is of its responsibility – it must be selected by each teacher training team from the national program of PFCM. That option should take into account

the perceived necessities and interests of the teachers of the region and be adequate for the specificities and dynamics of the team.

It is important to note that teacher educators' work is very complex and exigent. Each teacher educator has to deal with 5 groups of teachers (40-50 teachers) of different schools in a region. He/She conducts the group sessions, trying to involve teachers actively in reflection about the action, in the work on the mathematical content and in lesson's planning. The teacher educator has also to conduct a considerable amount of supervision sessions of the teachers, collecting data and preparing the subsequent reflections. He/She has also to give feedback to individual planning of the supervision sessions, often by electronic mail after a long day of work. Another important component of its work is the support of the development of teachers portfolios. All these activities are supported by the collaborative work of the teacher educators team, in a regular one day working session by week.

# PFCM and its effects on teachers' development as mathematics teachers

The national Monitoring Commission (CA) asked periodic reports to the coordinator of each team (3 per year) focusing on the development and consecution of the objectives of PFCM by his/her institution and reflecting on the main achievements concerning teachers development as mathematics teachers. We collected and analysed all the reports and that allow us to have a broad view about the effects of PFCM at a national scale.

All institutions refer to a very positive balance of PFCM. The main gains reported are:

- Clarification and deepening of mathematical knowledge, including: a) concepts and procedures of several domains of mathematics, namely in numbers and operations, the most familiar topic to elementary teachers (for example, from the concept of number and algorithms to number sense and comprehensive approaches to calculation, stressing mental calculation); b) enlargement of the vision of mathematics and mathematical processes like problem solving, mathematical reasoning and communication, supported by several kind of representations.
- 2) Development of didactical knowledge to face mathematical curricular demands, resulting in an improvement of the quality of lesson's plans, including a critical selection of tasks and essential aspects that affect the learning of students, as important questions to promote mathematical reasoning from the students;
- 3) Development of a more confident relation with mathematics, with consequences for the fostering of the expectations about students mathematical capacities;
- 4) Recognition of the importance of the reflection about the action, about what students learned and the factors that affected their learning of mathematics, with particular emphasis on teachers options and decisions for the classroom, beginning on the preparation of the lesson;
- 5) Recognition of the importance of the collaborative work, either with teacher educator either with colleagues, with positive consequences for the development of an attitude of opening and sharing what happen in classroom to discuss student's mathematical learning and possible factors of success or failure, namely the ones concerning the teacher him/herself;

6) Development of a more inquiring professional attitude, with the acceptance of the importance of continuous investment and study by the teacher and development of an attitude of questioning teacher practice to better improve it.

These aspects were more visible for the teachers that participated in PFCM for two years. In general, their portfolios were more reflexive and expressed a more consolidated professional development.

#### Focus on teaching practice: Issues to reflect on

PFCM takes the teaching practice in mathematics as an essential key aspect for the promotion of in-service mathematics teachers' professional development as mathematics teachers. In fact, PFCM approach supports the professional development of teachers for practice, in practice and from practice. These three aspects are all important but can also raise some complex questions. Professional development for practice. Asking teachers to prepare math classes to their real and actual students is a powerful strategy to help teachers to give personal meaning to the in-service activities of PFCM, namely with the more theoretical group sessions (van der Berg, 2002). But the assistance by the teacher educator of the planning activity of teachers is not always easy. In the group sessions the time is not enough to discuss individually with teachers so the individual finalization of the preparation is mostly accompanied at distance, often with limitations. What are the consequences of the lack of support of teachers planning with new tasks, methodologies and materials? How do teachers deal with it? Are they able to adapt and prepare math classes according PFCM orientations when they do not have the support of teacher educator? Do they really integrate the mathematical lessons (tasks, materials,...) from PFCM in their regular classes or do they just put them in practice when they have their class observed by the teacher educator? The entrance of the in-service activities into the real math classes may also conflict with the organization of teachers schools (schedules, logistic conditions, math program control) and this is well perceived by middle school teachers. To what extent does the attitude of schools influence the possibility of teachers to develop professionally? To what extent is the school institution open to deal with the demands of PFCM when they do not fit with the institutionalized practices of schools in what concerns mathematics teaching? (for example, when schools do not use the calculator, when they do not value materials as fundamental resources for mathematics teaching, ...)

*Professional development in practice*. Classroom is an excellent context for teacher development, namely when the teacher educator is present. She/he can collect data from the development of the class (mathematical activity of students, teacher actions, ...) for further reflection but she/he can also assume a collaborative attitude in the classroom — can help the teacher to manage the class, to conduct the discourse, to put questions to students, to accompany slower students working individually, showing ways of teaching that teacher is not familiar with. But the responsibility of the class is of its teacher, and sometimes teachers do not feel comfortable with the presence/intervention of teacher educator in front of her/his students. What role must teacher educator assume in teacher's classroom? How can teacher educator construct a relation of complicity and partnership? (Day, 1998) How to deal with a prevalent teaching culture of individualism in classroom?

*Professional development from practice*. Considering the real teaching mathematical practice gives opportunity to the teacher to observe the reactions of its own students to the new tasks or approaches she/he tries in classroom, a decisive factor for considering its integration (Brown &

MacIntyre, 1993). Focusing the reflection on what students learned in the classroom and analyzing the factors of success is very important. In doing so teachers get conscious of the importance of its teaching options, namely of the importance of the nature of the tasks and questions they put to promote students mathematical reasoning. It is important that reflection takes place individually and also in the group, where teachers can share and confront what happened in different classes and why. But the majority of teachers tend just to report what happened. How to help teachers to deepen the reflection about their practices as mathematics teachers? How to assure the development of professional knowledge that goes beyond the context of PFCM? How to promote the development of a more inquiring professional attitude? Writing a portfolio is it an effective strategy to help teachers to think about their practices in a more reflective way?

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