Mathematics teacher education and professional development

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Abstract. This paper addresses fundamental notions in the development of mathematics teacher education in Portugal. First, it reviews concepts that have framed mathematics teacher education in this country, such as conceptions, professional knowledge, reflection, collaboration, project, and practices. It also discusses the relationships between two very close but distinct notions: teacher education and professional development. I bring together these notions giving two examples of teacher education processes, both based on inquiring practice, but situated at rather different levels. Finally, I note the role of institutional and political factors in teacher education processes and I underline the importance that they center on practices and on the transformation of the school reality.

Key words. Teacher education, Professional development, Conceptions, Professional knowledge, Reflection, Project, Collaboration, Professional practices

There is a growing consensus that the mathematics teacher plays a fundamental role in the process of education and that, to be successful, any change or curriculum innovation needs to be accepted and put into practice by teachers. As a consequence, everyone agrees on the need for teacher education. In fact, our knowledge about mathematics teacher education processes made important progress in the last decades. However, teacher education is not just a technical problem concerning what models or activities provide the "best results". It is mostly a conceptual and political problem that involves knowing how one regards the teacher and his/her role, both at the school and on the teacher education process. Put in another way, teacher education involves a discussion about the goals, the potential and the conditioning factors that encompass it and mathematics teaching. In this paper, I consider some concepts that emerged in recent years in Portugal about teacher education and I present two cases where they play an important role but that, nevertheless, face critical challenges.

Emerging notions in 20 years of research in teacher education

1. *Mathematics education has a crucial role to play in teacher education*. This may seem trivial for all of us, but that was not the case at the beginning of the 1980s, at least in Portugal. It is still not the case in some countries where the preparation of secondary school mathematics teachers is seen as only including mathematics courses. Therefore, a first step was considering mathematics education as an "essential component in teacher education", regarding it as a simultaneously theoretical and practical activity (Abrantes & Ponte, 1982).

2. *Teachers' practices are influenced by teachers' conceptions.* An important step was made when teachers' cognitions become a central focus of research. Beliefs and conceptions are important notions on the grounds that conceptions mark in a central way the perspective that the teacher has about the realities of teaching as well as his/her practices (Thompson, 1982). Assuming that all mathematics teaching practice stands on a philosophy of mathematics leads to the notion that to change practices it is necessary to begin by changing teachers' conceptions.

3. *Professional knowledge as a combination of theory and practice*. Another important step was the notion of teachers' professional knowledge. As other professional groups, such as medical doctors, lawyers, and architects, teachers have a specific kind

of knowledge that is characteristic of the profession and is taught at professional schools. An important author in establishing this notion was Shulman (1986) who underlined the importance of a special blend of content and pedagogy that he labelled as *pedagogical content knowledge* (PCK).

1.4 *Reflection as the teachers' way of dealing with professional problems.* Reflection may be regarded as a possible "quality" of some teachers – the "reflexive teachers". Others prefer to speak of "reflexive practices", that is, they see reflection not as an attribute of people but as a characteristic of some professional practices. The influence of the notion of reflection is due to the work of Schön (1983) who distinguished among reflection on action, reflection about action, and reflection about reflection on action.

1.5. *Collaboration as critical element of teachers' professional culture*. Collaboration is a strategy that groups of people adopt to deal with particularly difficult problems that are beyond the capacity of a single individual to solve. In some cases it is a spontaneous and natural practice of teachers, notably when they face a new situation (such as a new curriculum). In other cases it is a challenge posed by someone (a researcher, a leader of a project), and may include actors with different levels and kinds of expertise. Some authors indicate several varieties of collaboration (Hargreaves, 1998), whereas others make a special point of establishing a difference to weaker forms of working together such as cooperation or networking.

1.6 *Projects as a strategy to bring about change.* The notion of project is pervasive in contemporary society. A project represents assuming a goal and a working program to achieve it from the current conditions (Boutinet, 1990). Much more than a simple "methodology" to follow, the notion of project underlines the need to construct and regulate the activity according to the needs, actors, conditions, resources, and the evolution of the process.

1.7 *Practices are at the center of the teacher education process*. Teachers' practices are the activities that they carry out regularly, in the framework of their working conditions, meanings, and intentions. This includes the social structure of the context and its multiple levels – classroom, school, community, professional structure, educational and educational system. It became clear that if the goal is to influence teachers' practices, such practices must be addressed in a direct way. The idea that the student learns mathematics from his/her experiences in mathematics and reflecting about such experience is now well established. Its natural extension is that the teacher learns from his/her experiences as a teacher and reflecting about such experiences.

1.8 *Teacher education and professional development as two complementary processes*. The teacher may participate in many discrete teacher education experiences. But the teacher is not just the sum of all such experiences. The teacher is not the object of teacher education but the subject of the process of professional development. Such process involves necessarily a combination of formal and informal activities. Teacher education may be designed in such a way that it reduces the creativity, the self-confidence, the autonomy and the sense of professional responsibility of teachers. But it may also enhance their power, identity, and resourcefulness. Professional development requires time, experimentation, and flexibility and does not conform to narrow agendas, external to the teacher, that often inform the teacher education process.

1.9 *A dilemma*. On one hand, mathematics education has much to contribute to the professional activity of the teacher. It provides curriculum guidelines, reflects on the educational implications of the epistemology of mathematics, analyses students' processes of construction of knowledge, and suggests central notions to construct and observe teaching/learning situations. There is much to teach the teacher. On the other hand, teacher education cannot ignore the natural processes of professional development

of the teacher that are framed by his/her practical problems and institutional situation. Teacher education that seeks to transmit concepts, practices and theories that the teacher does not feel any need are ineffective and counterproductive. In such situations, how to use the growing body of knowledge of mathematics education to assist teachers in developing professionally?

There may be many solutions to this problem depending on the particular situation one is involved. In all of them, practice is central, as well as theory. A collective stance of working with others is necessary, but it is also required that individual teachers assume their own personal projects. At the very end, the success of a teacher education process depends very much on its adjustment to the professional development needs of the teacher in his/her specific context.

Two cases

Researching our own practice in a collaborative context. Reflection, collaboration and working in projects find a particularly powerful combination in researching our own professional practice. Research is an important way of constructing knowledge about mathematics education, if developed in a collaborative context and oriented towards the problems of professional practice. It may help to identify strategies to solve such problems and to reach formative effect on the participants (Ponte, 2002). Since the very beginning of mathematics education in Portugal that teachers and teacher educators are developing research projects closely related to their own professional practice. Several studies that represent researching their professional practice were carried out by teachers of different school levels, engaged in putting into practice new curriculum orientations (e.g., Segurado, 1998; Pires, 2001).

However, the work by far most significant carried out in this perspective is that of the GTI Study Group of APM. This work is carried on a team involving about fifteen teachers and teacher educators of several school levels, most of them with research experience, that undertake in a collaborative way reflection and external presentation about their investigation experiences, all related to their own professional practice. In a first working cycle, this group decided to reflect on the notion of researching practice and summarized the issues related in this kind of investigation (GTI, 2002). In a second cycle, the group, renewed, decided to center specifically in the problems related to the role of the teacher in curriculum development (GTI, 2005). It was possible to verify that to carry investigation projects about our own professional practice, reflecting together with other group members about such investigations and the ways of making them available to the professional community, collaborating with each other in undertaking specific investigations and in the elaboration of a global account of the work of the group, is a powerful setting of constructing knowledge and promoting its members' professional development (Ponte, 2004; Ponte & Serrazina, 2003). What is still not clear is the role of such projects in the professional culture of teaching.

Mathematics and mathematics teacher education of 1st cycle teachers. Another teacher education process currently going on in Portugal is a national program for 1st cycle of basic education teachers (teaching students aged 6-9), promoted by the Minister of Education. Assuming that most teachers of this school level have a fragile mathematical preparation and that this affects in an important way students' learning, the Minister decided to take an intervention at this level as a priority, challenging mathematics educators to present a project to do so. This project decided that such program should involve in an integrated way mathematics and mathematics education and begin with the analysis and reflection about teachers' practices (Serrazina et al., 2005).

Therefore, the emphasis of this teacher education process is at the schools. Teacher educators meet with groups of teachers, discuss with them curriculum orienta-

tions and present proposals of tasks. They also speak of the problems that teachers feel in their classes, observe classes, teach segments of classes to be observed by teachers and reflect together about episodes and problems detected. This is a large scale teacher education process and, therefore, reflects all difficulties related to the setting up and monitoring of such processes. Case studies carried out at the field show that teachers refer that they made important professional learning and report the existence of real changes in their practice (Magina, Ponte & Veloso, in press). As one teacher who participates in this program refers, one year of work is not enough to solve all the problems. But this year already helped to introduce clear changes in her teaching practice and that is something that few formative processes ever manage to achieve.

Conclusion

The two cases that were just presented illustrate two rather diverse situations. The work of GTI has ambitious goals that involve teachers constructing knowledge regarding problems of their own professional practice and involves using rather sophisticated working and inquiry methodologies. The work involves a restricted number of teachers who already have a remarkable journey of professional development. The National 1st Cycle Teacher Education Program is a work in extension, involving several thousands of teachers. In both cases the notions of professional development and professional practice assume a leading role. It is on the demands of such practice and of the need of its transformation that these teacher education programs are designed respecting the natural processes of teacher professional development.

The studies undertook and the theoretical perspectives that gained acceptance among mathematics educators enabled significant advances in teacher education practices in Portugal. However, what happens in the field of teacher education (preservice, inservice or specialized) does not depend exclusively on the new perspectives and understandings reached by research. Research is not the instance that most influences teacher education practices, but the system established at a political level (by the government and by educational administration) and the conceptions and values of educational actors. The opportunities and constrains that emerge at the system level are analyzed and interpreted by those who prepare and carry out teacher education, beginning with teacher educators that seek to design viable ways of making it happen. Also in preservice teacher education there is a great distance between practices based on observing real practice, on reflection and research by trainees, and what really takes place in many programs. The scarcity of reports of experiences and analysis of innovative preservice teacher education projects - involving programs or single courses - suggests that teacher education current practice follows in many cases a “transmissive model”.

The quality and the scope of teacher education depend on the determinations of the system and of the quality of teacher educator. But it depends, equally, of the personal investment and attitude of participants. An effective change in the effects of inservice teacher education must be based in a change of conceptions, leading this to be no longer seen as attending detached courses but rather as supporting long term processes of professional development, in individual terms and at the school level. One must note that, in Portuguese mathematics education, the relative absence of the school as an arena for teacher education and for intervention is a recurrent problem. Teacher education supports teachers in the evolution of their careers and in solving the urgent problems of their professional practice (such as the introduction of new curricula). But it needs to be increasingly put at the support of school level projects, centrered on mathematics education issues and oriented towards students’ needs.

Therefore, in Portugal, mathematics education has generated concepts that help to understand the formative processes and conceive promising teacher education settings. However, its mobilization in the field of teacher education real practices requires the conception of adequate settings from teacher educators and an orientation towards learning based on their practices from participants. All this requires a serious transformation of the professional culture of teacher educators and of teachers of different school levels. Such transformation involves emphasize the concept of teacher professional knowledge, to value his/her practice as the center of the formative process, and to stimulate processes of collaboration, reflection and projects, often framed as research on teachers' professional practice.

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