

The Professional Practice and Professional Development of Mathematics Teachers

Introduction by João Pedro da Ponte (Editor)

Didactics of mathematics has developed internationally as a scientific field of studies in the late 1960s in the wake of the modern mathematics movement. Particularly important landmarks in this development were the creation of the journal *Educational Studies in Mathematics* by Hans Freudenthal in 1968, and the establishment of the *Journal for Research in Mathematics Education* in 1970, with David Johnson as its first editor.

In Portugal, didactics of mathematics began as a research field between 1980 and 1990 when the first graduates had obtained their PhDs from foreign universities and when master's degree programs were set up at Portuguese universities. The national research journal *Quadrante* was established in 1992. Since then, the mathematics teacher has been one of the subjects to receive the most attention from local and international researchers studying teacher conceptions, knowledge and professional practices, as well as teacher education, development and identity. In the last ten years, the focus on the teacher has clearly been centred on the professional practices, together with institutional conditions and teacher education processes that may promote their transformation in order to further students' learning.

Any research perspective on the mathematics teacher presupposes a perspective on the school, the curriculum, and the role of mathematics as a subject on the curriculum. There is not only one canonical way of viewing the educational role of mathematics. There are many; and each one has its own

cultural legitimacy. Therefore, mathematics as a school subject can be viewed in a range of ways: from a winnowing out device that fosters segregation and social stigmatization through school failure, to a tool for the development of creativity, transversal capacities such as communication, reasoning and problem solving. There are examples of both views in many countries including Portugal where, over a few decades, mathematics education has gone from memorizing definitions and procedures to exploratory teaching, emphasizing discovery and student understanding, then back to basics once again in the last few years with an orientation that stresses memorization of terms and rules that are basically meaningless to students.

The important changes that took place in Portugal from 1990 to 2011 with a mathematics education that sought to develop the students' creative and transversal capacities – which is usually termed as exploratory or inquiry-based teaching – was largely based on studies done with and by mathematics teachers in collaborative and/or teacher education settings. The intention was not to improve teaching and learning by inventing solutions in laboratory contexts, but to contribute to student learning by conducting research with groups of teachers in natural settings in order to find solutions that work in such environments, function under usual teaching conditions, and effectively help to solve existing problems.

Any perspective of mathematics teaching subsumes we will have opinions about the teachers themselves. Teachers are at the core of the teaching and learning process and it is tempting to attribute the greatest blame to them for students' poor performance in mathematics. Ironically, it is also tempting to let teachers off the hook, by viewing them as the hapless victims of a top-heavy, inefficient educational system that, very often, blindly follows policies that are based more on subjective preferences than on research-based knowledge.

Yet, it is not easy to have mathematics teachers as the object of one's study. Research carried out in Portugal has sought to avoid the two extreme positions by changing focus: instead of studying the teacher himself, researchers work with teachers bearing in mind the conditions they teach under and how they can transform their practice. Research has also sought to take into account a number of different issues related to teaching practice and the teacher's role such as the institutional context, teacher education opportunities, and the surrounding social and political conditions in order to provide the most balanced, wide-ranging view possible of teachers and their professional milieu.

This has been done in tandem with international research, of which Portuguese research initiatives are clearly a part.

The connections between national and international research strands are clearly depicted in this issue of *Sisyphus*. In the first article, Tim Rowland presents the genesis and application of the Knowledge Quartet, one of the most influential frameworks for studying teaching practices and how teachers can develop their knowledge of mathematics teaching. This model includes features that broach knowledge, its transformation and organization for learning purposes, as well as the teachers' ability to make appropriate decisions when confronted with unforeseen classroom situations.

Also examining teaching practice, but from a much more focused point of view, a group of Portuguese researchers, Luís Menezes, António Guerreiro, Maria Helena Martinho, and Rosa Tomás Ferreira discuss the role of questioning in exploratory mathematics teaching. In their paper they explore the different moments in which this type of teaching usually develops in the mathematics classroom. In order to achieve this exploratory stance, they discuss the roles of verification, focusing and inquiry questions during the different stages of a classroom mathematics task.

Salvador Llinares addresses another aspect of mathematics teaching practice – professional noticing, which may be defined as the teacher's skill at identifying and interpreting important aspects of the students' oral and written output. This skill is fundamental if the teacher is to form hypotheses about the students' rationale, undertake new activities and make informed decisions in the classroom.

Three papers in this issue of *Sisyphus* discuss in-service teacher education. First, David Clarke, Hilary Hollingsworth and Radhika Gorur present a model for teacher development in which they closely interlink theory and practice with enaction and reflection as key processes that mediate change in teachers' beliefs, knowledge and practice. They use this model to discuss the contribution of video in facilitating teacher reflection and action.

Working with a group of elementary in-service teachers, Olive Chapman analyses their learning in an inquiry setting in which they are encouraged to take an investigative stance towards their own practice. Her main thesis is that this process may be described as an overarching inquiry cycle in which teachers begin with practice, pose a pedagogical problem, understand a key construct in the problem, hypothesize an inquiry-teaching model, test/apply it, and finally revise/apply the model.



Dario Fiorentini also looks at professional learning, but in a different setting – a mixed collaborative group of teachers and researchers. He argues that this is a formative and powerful environment for participating teachers, especially in terms of developing a research attitude and promoting changes in the way teachers relate to and work with their students. As the author indicates, this is also a powerful way of constructing research knowledge for academics.

Two other papers examine preservice teacher education. In the first, Neusa Branco and João Pedro da Ponte present an algebra course that also stresses the articulation of theory and practice. The framework for this innovative course (which was researched as a teaching experiment) is based on two main premises: the key role of analysing practical situations (represented in different ways) by prospective elementary school teachers and the close connection between content and pedagogy in their development. It also shows the advantages of introducing prospective teachers to the early educational application of algebra.

In another paper, Hélia Oliveira and Márcia Cyrino study prospective mathematics teachers' grasp of inquiry-based teaching. To illustrate their premise they discuss an experiment using multimedia materials. The results show that participants developed an understanding of different dimensions and a heightened awareness of the complexity of inquiry-based teaching.

Finally, Paola Sztajn once again takes up the issue of the relationship between researchers and teachers. At one end of the spectrum we have the prevalent view, among university researchers, that academic knowledge of the craft is superior to that of practitioners. This has often led to another extreme position which argues that, when it comes to the knowledge of these two kinds of professionals, never the twain shall meet. Teachers and researchers work in different institutions, have different practices, belong to different communities and have different kinds of knowledge, and therefore, as some assert, they are incapable of connecting with each other. However, if the knowledge generated in research settings aims to be useful in in-service or preservice education, a solution to this standoff must be found. As several papers in this special issue suggest, collaborative environments and university-school partnerships may be fruitful contexts to explore.

The articles by the international authors from Australia, Brazil, Canada, the United States and Spain in this issue of *Sisyphus*, which is devoted to the professional practice and professional development of mathematics teachers, reflect the research that has been done by renowned scholars. The articles

by our Portuguese contributors, on the other hand, emerge from a research project (Project P₃M) that I coordinated, whose objective was to study the mathematics teachers' practices and the conditions under which transformation takes place.

Two methodological approaches form the basis of many of the most fruitful studies on mathematics teachers, and we find traces of one or the other in the articles in this issue. One of the approaches is, as we have already discussed, collaborative studies. In these studies, the researcher becomes a member of a team that seeks to deal with a certain professional problem. The team pinpoints possibilities and constraints, and evaluates solutions. The researcher participates fully in the work of the group and shares in its successes, stalemates and failures. Thus, the researcher gains a profound awareness of the nature of the problems being tackled. Collaborative work also creates a collective dynamic, and generates vital energy and professional creativity that allow new educational realities and processes to emerge, enabling all the educational actors to view each other from a completely new angle.

In the other approach, the educational actors assume an inquiry stance with regard to their own teaching. This approach is often dubbed «practitioner research». It brings the logic of exploratory teaching or inquiry-based-teacher education into to the professional realm. However, since this approach is not explicitly required of the teaching professional, and since educational research is most often portrayed as formal and demanding, this perspective is hard to replicate on a large scale. But, if the proper context is provided for such activities and if suitable conditions are created, it can become a very promising framework, both in terms of practitioner development and new research insights. Unlike the other approaches, practitioner researcher studies have the great advantage of yielding immediate results and findings and – in the very least – can benefit the researcher's teaching. However, very often it produces results that impact the practices of the institution itself.

Studies centring on the mathematics teacher undertaken in Portugal are, to a great extent, linked to international research. These studies have had a significant impact, inspiring a number of educational policies regarding mathematics education, especially from 2005 to 2009. They have led to the development of new syllabuses, the production and dissemination of teaching and support materials, large scale national programs for teacher education (in the first and second cycle of basic education), field experimentation, and local support for the introduction of new syllabuses. The fruits of these policies



can be seen in the results Portuguese students have achieved in international evaluation programs (such as TIMSS and PISA) and also in the way concepts, practices and the results of mathematics teaching and learning have changed in many schools.

The international and local results discussed in this issue's articles show that the knowledge produced in academic settings may be put to work in in-service and future teacher training programs, in professional development initiatives, and in educational organizations and public policies. Society must ask researchers to make their findings available while forging ties with social actors, so that these findings will be put to efficient use. Researchers, on the other hand, should ask educational actors to reciprocate by finding how the research results, proposals, and materials can be used to improve educational results and processes.

João Pedro da Ponte



