WHAT IS AN EXPERT MATHEMATICS TEACHER?

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In Portugal, the introduction of new mathematics curriculum for basic education [1] (ME, 2007) generated new images about the activity of the mathematics classroom and about the role of the teacher, based on the notions of "explorations" and "discussion". This had strong implications to the perspective on teacher expertise accepted by teachers and also by researchers in this country. This paper provides a brief overview of the national context, in terms of curriculum and teacher education, and describes this perspective of mathematics teachers' expertise.

THE CURRICULUM AND TEACHER EDUCATION CONTEXT

In Portugal, in 2007, the mathematics curriculum for basic education (grades 1-9) was approved, replacing the 1991 curriculum and reflecting current curriculum guidelines, emphasizing ideas such as development of number sense, the development of algebraic thinking since primary school, the development of spatial sense and statistical literacy. It also emphasizes three main "transversal capacities", problem solving, mathematical reasoning and communication, the need of diversifying tasks and representations and of making appropriate use of technology.

The Portuguese educational system establishes the general profile of the teacher, for all subjects and school levels that includes four dimensions (Decree-Law no. 240/2001of 30 August): (i) developing teaching and learning, (ii) participating in school activities and relating to the community, (iii) lifelong professional development, and (iii) handling professional, social, and ethical issues. In this country, since the adoption of the Bologna process (in 2006), the preparation of prospective mathematics teachers involves two stages: first, a 3-years degree provides training in mathematics; second, a 2-years master degree provides professional preparation to teach mathematics in grades 7-12.

PERSPECTIVES ON EXPERT TEACHING

There is no systematic research on expert teaching in the frame of the former basic education curriculum. However, an important document from the Association of Teachers of Mathematics (APM, 1997) stresses that teachers' practice should include elements of "diversification": in the nature of tasks, in the kinds of classroom interaction, in the use of supporting materials, and in the forms of assessment. This emphasis in diversification was well attuned with the general perspective that to

[1] "Basic education" spans for grades 1-9, that is students who are 6 to 14 years old. In some countries the equivalent expression would be "primary and lower secondary school".

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address students with different cultural origins and learning needs, teachers had to introduce many elements of differentiation in their teaching.

Two methodological ideas stand outin the new curriculum for basic education (ME, 2007): The importance of the mathematical tasks that constitute the point of departure for the activity of the students and the communication processes take place in the classroom. The curriculum suggests that the teacher must use a variety of tasks, including problems, exercises, explorations and investigations. Since exercises are used since a long time in Portuguese schools and problems were emphasized in the 1991 curriculum, the novelty here are explorations (open tasks, quite accessible to most students) and investigations (also open tasks but more demanding, see Ponte, 2011). Regarding communication, the curriculum values the development of the students'capacity for oral and written communication, and emphasized the value of moments of collective discussion, creating opportunities for mathematical argumentation, in which teachers asked students to present and explain their solutions to the tasks undertaken, giving the opportunity to the other students to accept or disagree and to present their own claims and justifications.

The supporting documents of this new curriculum indicate that such guidelines may be put into practice using a classroom organization in four main segments: (i) presentation of the task by the teacher, collective interpretation and appropriation of the task by the students; (ii) autonomous work of the students on the tasks, usually in pairs or small groups, with the teacher monitoring the work and providing some support in a careful way, that is, without solving the task for the students; (iii) collective discussion, in which some students presenting their work and all the class discussing it; and (iv) a final synthesis, summarizing the main points of the lesson, that could be done ideally with the participation from the students. It must be noted that, at the time, classes in Portugal lasted for 90 minutes, providing an extended time both for the students' autonomous work, as well as for the collective discussion.

The three key words of this approach are: (i) task, (ii) collective discussion, and (iii) exploratory work. For teachers, before the new curriculum, "task" was not a term much used in daily practice. Whereas technically this term refers to a wide range of situations (including exercises, problems, explorations, investigations, projects, mathematical games, etc.), most teachers tend it to mean some extended piece of work that is more complex than just routine exercises. "Collective discussions" point to classroom interactions in which there is room for students' participation supporting different points of view. And "exploratory work" became the most encompassing designation for this approach, given the prominence of exploratory tasks.

This curriculum change and the extensive production of supporting documents and provision of teacher education and other support processes created a new perspective about what is an expert teacher in Portugal, at least in basic education. It is a teacher who (i) is able to select and perhaps adjust suitable tasks, especially exploratory tasks, involving students actively in mathematical work, stimulating them to develop their own strategies, concepts, and representations and (ii) to conduct classroom discussions

that create opportunities for negotiation of meaning, development of mathematical reasoning, and institutionalization of new knowledge.

DISCUSSION

This perspective on expert teaching has been (partially) validated in two ways. First, an in depth independent evaluation of the process of experimentation of the new basic education curriculum, was very supportive of classes that were observed in all different grade levels, from 1 to 9, using exploratory tasks and including highly productive moments of classroom discussion (Fernandes et al., 2011). A second element of validation has been the research studies undertaken at master degree and doctoral level based on teaching experiments that follow this perspective on expert teaching and that have been widely reported in research meetings and professional meetings (e.g., Branco, 2008; Henriques, 2011; Quaresma, 2011; Silvestre, 2006).

This perspective on expert teaching is a variety of deliberate practice (Li & Kaiser, 2012) and is aligned with international views. For example, presentingthe essential features of mathematicsteaching, the NCTM (1991), indicates the key role of worthwhile mathematical tasks (Standard 1) andclassroom communication (Standards 2-3-4, the teacher's and students' role in discourse and tools for enhancing discourse).In their study of the practice of mathematics teachers of the early years, McDonough and Clarke (2003) indicate 25 "practices" that they organize in ten major themes. The first three are strongly related to mathematics and tasks, including mathematical focus,features of tasks and materials, tools and representations. The next four themes include several aspects related to classroom communication and discourse: adaptions/connections/links, organizational style, teaching approaches, learning community and classroom interaction, and expectations. The importance of tasks with a high level of cognitive demand is underlined by Stein, Remillard, and Smith (2007). The value of situations involvingnegotiation of meanings is referred to by Bishop and Goffree (1986). The handling of classroom discussions involving the ability of the teacher in conducting classroom discussions, using a variety of questioning styles (with emphasis in inquiry questions), is currently an active field of research (Ruthven, Hofmann, & Mercer, 2011, Stein et al., 2007).

CONCLUSION

Curriculum documents provide statements about the mathematics to teach and learn and how to conduct and evaluate such teaching and learning. Such documents become important elements in framing new visions of what is expert teaching in teachers and also in researchers. Research and evaluation studies, such as those undertaken in our country provide additional strength to such visions and show that they are viable in practice, at least in small scale. However, a different thing is what happens in large scale. Visions of "expert practice" supported by these documents are supported by researchers and of teachers highly involved in curriculum reform processes. In fact, many of them already suppor5ted such view before the curriculum was approved. But

these visions are quite distant from the visions of most practicing mathematics teachers. The fact that within one country different visions coexist at the same time creates an interesting agenda for mathematics education researchers.

CREATIVITY IN TEACHING MATHEMATICS AS AN INDICATION OF TEACHERS' EXPERTISE

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Following the observation that "teaching has often been thought as a creative performance" (Sawyer 2004, p. 12), this paper argues that creativity is an integral component of mathematics teachers' expertise.

CREATIVITY AND EXPERTISE

A basic operational definition of creativity widely used nowadays, as suggested by Torrance (1974), is based on four main components: fluency, flexibility, originality and elaboration. *Fluency*relates to the continuity of ideas, flow of associations, and use of basic and universal knowledge. *Flexibility* is associated with changing ideas, approaching a problem in various ways and producing a variety of solutions. *Originality* is characterized by a unique way of thinking and unique products of a mental or an artistic activity. *Elaboration* relates to the ability to describe, illuminate and generalize the ideas. The four components are mutually interrelated, however not all of them are present at the same time. The four components naturally characterize activity of expert teachers: Teachers' expertise is evaluated in terms of fluency in lesson management including fluency in explanation of mathematical ideas that they provide to their students (e.g., Leinhardt 1993). Expert teachers are flexible when reacting to students' unpredicted responses (Simon1997; Leikin and Dinur 2007). Teachers' expertise is associated with their mathematical or pedagogical originality, insofar as it tends to surprise students and, consequently, to raise their motivation. Elaboration of students' mathematical ideas is the main mechanism of moving with students "to a new mathematical territory" (Lampert, 2001). At the same time expert teachers aim to develop students' flexible mathematical reasoning, knowledge and skills that promote fluent problem solving, raising their own novel ideas and elaborating other students' mathematical thoughts (Polya 1963, Even, Karasenty and Friedlander 2009).

I will discuss and illustrate these ideas with Problem 1, which Tami presented to her 11th graders who study mathematics at a high level.