A New Elementary Mathematics Curriculum: Practice, Learning and Assessment
Some Classroom Episodes

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Abstract

The aim of this paper is to present the new and innovative Mathematics Curriculum for elementary levels that is being implemented in the Portuguese basic education system (students from 1st to 9th grade) through an overview of an ongoing study of implementation/experimentation of this curriculum. A specific mechanism was implemented in the field to provide scientific and pedagogical support to the development of the new elementary mathematics curriculum (NPMEB) implementation at all grade levels and all over the country. In particular, the NPMEB is being experimented by a set of teachers that teach in their own classes and that have been trained and accompanied along the experience by the different authors of the program. We will focus on some classroom practices, sharing innovative and creative ideas of teachers and students, grounded on some of the tasks used by the teachers. The preliminary results suggest that some improvements are already visible, namely regarding students’ attitudes and mathematical competences and teachers’ practice.

Introduction

In the current Portuguese education system there is a new and innovative elementary mathematics curriculum (students from 1st to 9th grade), the NPMEB (ME, 2007) that includes a series of changes of the government’s responsibility to improve the conditions of the teaching and learning of that discipline. To this have contributed the discontent with the results obtained by students in national external (e.g. standardized tests, examinations) and international assessments (e.g. Program for International Student Assessment - PISA). This curriculum was designed to gather some disperse curricular documents and substitute the current syllabus/curriculum/program, published in the early 90s, but mainly to provide the sustained development of students’ mathematical learning focused on the more recent recommendations of mathematics teaching and learning.

A specific mechanism was implemented in the field to provide scientific and pedagogical support to the development of the NPMEB implementation through all the grade levels and all over the country. This approach was not generalized but applied to a sample of classrooms/teachers. In particular, the NPMEB is being experimented since 2008 by a set of teachers that teach in their own classes and whom have been trained and accompanied along the experience by the different authors of the program. At the same time the Ministry of Education named a team of mathematics educators for an evaluation study of the process of implementation/experimentation of the NPMEM for three years. The study was designed in three phases with the following purpose: to describe, analyze and interpret teaching practices and assessment developed by teachers of the experimentation and/or teachers to teach in the process of generalization; to describe, analyze and interpret the involvement and participation of students in developing their learning in the context of the classroom; and to evaluate such practices and other curricular materials applied. It was expected to have three
multiple case studies (one for each cycle of basic education), an evaluative global summary and some recommendations.

We propose to present an overview of some of the tasks used by the teachers and the work of the students in accordance with NPMEB, as well as the strategies used by the teachers. Data has suggested that some improvements are already visible, namely regarding students’ attitudes and competences and teachers’ practice. Before presenting the method of evaluation of the study and some classroom episodes, we began to identify the main ideas of the NPMEB.

**Main ideas of the NPMEB**

The NPMEB is no more than a readjustment of the existing program, with nearly twenty years, for grades 1-4 (1\textsuperscript{st} cycle of basic education), 5-6 (2\textsuperscript{nd} cycle of basic education), and 7-9 (3\textsuperscript{rd} cycle of basic education), (ME, 1990, 1991), which points to significant changes on mathematics teaching and learning, and to professional practices of teachers. In our opinion, the most innovative aspect of the NPMEB was to replace the three existing programs by a single one that involves all grades from 1 to 9 with the same structure and the same mathematical themes. On the other hand transversal skills are addressed in the same way that mathematical topics, i.e. to which were suggested methodological guidelines, resources and examples of tasks.

The aim of the new curriculum (ME, 2007) is to promote, in the students, the acquisition of information, knowledge and experience in mathematics. On the other hand intends to develop the capacity of integration and mobilization in different contexts and also indicate the development of positive attitudes towards mathematics and the ability to appreciate this science of all students. Thus three indissociable basic aspects are pointed out for mathematics education - the acquisition of knowledge, ability to use it appropriately and develop general relationship with the discipline. At a subsequent stage of the program is organized in each cycle, around four major mathematical themes (Numbers and Operations, Geometry, Algebra and Organization and Data Analysis) and three transversal fundamental capacities (Problem Solving, Reasoning and Communication).

The NPMEB also presents several general methodological guidelines, with emphasis on the need for diversification of tasks and giving particular attention to its nature, mainly to the challenge they promote, the role of situations in context, the importance of mathematical representations and the connections in mathematics and with extra-mathematical aspects, the educational value of group work and moments of collective discussion in the classroom, the importance of appropriate use of technology and other materials. It is an opportunity to: value certain features of mathematics that were forgotten or worked in a decontextualized way (e.g. mental computation, number sense, demonstration, visualization, geometric transformations, patterns, algebra, statistics); introduce some topics earlier (e.g. rational numbers, algebra); value mathematical processes (problem solving, reasoning and communication); and value the mathematical tasks and the roles of the teachers and students.

The program outlines a set of general principles for the evaluation and especially emphasizes the importance of curriculum management held at the school level. Such program involves a process of curriculum change and demand for an exploratory teaching-learning with a new kind of classroom culture, where students must be much more active and be part of the construction of new knowledge, where teacher must offer appropriate tasks within a challenging element. The tasks have a crucial importance in this change. It is the teacher who can start by giving a task that uses students’ knowledge, while allowing the development of new concepts or processes so that they effectively engage in work and interpret correctly the task proposed. This work can be done in different ways, discussing and arguing ideas, orchestrated by the teacher, in order to avoid repetition, and highlight what is mathematically essential. In this perspective the traditional classroom is replaced by
discovery and the development of higher-order capabilities such as testing, conjecturing, reasoning and proof, can be shared by students and teachers. To face these new challenges it is asked for a change of attitude towards mathematics and its teaching, for proper teacher training programs, appropriate educational materials, as well new organizations in schools.

NPMEB: The Evaluation Study
The Ministry of Education through the Department of Curriculum Development and Innovation (DGIDC) requested under the Process of Experimentation of the NMPEB a evaluation study, that it’s ultimate purpose is to produce a set of evaluative synthesis and recommendations that could contribute to regulate and/or enhance the development of NPMEB. The DGIDC devised a plan to implement the new program in basic schools. This plan provided five actions such as: a) experimentation, during 2008/2009, the NPMEB in 40 pilot classes of three cycles of basic education; b) the beginning of widespread NPMEB in the academic year 2009/2010; c) the production and distribution of curriculum materials of different nature (e.g. thematic booklets, assignments for use in classrooms; lesson plans); d) a support structure for the beginning of widespread NPMEB in 2009/2010 (e.g. new program coordinators in each group; set of accompanying teachers); and e) teachers’ training. In the training, all teachers experimenters participated in training throughout the school year (50 hours classroom and 50 hours of autonomous work) which, in essence, was of the responsibility of NPMEB’ authors. Yet developed a monitoring process (e.g. visits to classrooms and meetings with teachers experimenters) through a coordinator group for each cycle that met on average once a month and all groups three times per year. All teachers had reductions in their school hours and shared their classes with a pedagogical pair. The process of experimentation began in forty pilot classes equally distributed by the 3, 5 and 7th grades.

The First Phase
included the design of the conceptual framework of the process of the NPMEB’ experimentation. So it was taken into account: 1) the NPMEB framework; 2) the design of the implementation plan; 3) the structure of support for plan implementation; 4) the plan to support the process of experimentation; 5) the management system of the process; and 6) the teachers experimenters. The data was obtained through: interviews – to all the 40 teachers experimenters (EP) and 42 others intervenient (from coordination group, consultative council, authors program, and professional and scientific associations, mathematicians and mathematics educators, teachers of the three cycles of basic education, administration) translated into about 110 hours of material recorded and transcribed in full; document analysis; field notes and a questionnaire – to the teachers experimenters.

We can summarize the main results of this first phase of the evaluative study, in the following ideas: 1) An innovative process of implementation 2) A hard beginning of the process of implementation 3) a demanding program (the NPMEB) 4) A well achieved teachers education training. However there were some problems with the educational materials available, the follow-up of the teachers experimenters had some virtues and difficulties, it is expected a difficult generalization so some care will be need.

The Second Phase.
In this phase we were mainly concerned with classroom. Taking into account the objectives of the study we intended to describe, analyze and interpret the learning environments, students participation, teaching and assessment of the classrooms in the process of experimentation and generalization of NPMEB. The dynamics of the classroom and its complexity is always difficult to be categorized, because most times there are overlaps and interactions that can not be translated directly into an "instrument". However we designed a assessment matrix where considered three main objects of evaluation and fourteen dimensions, indicated in parentheses, to support the team in the data collection and systematization and also to organize and structure the first report: 1) Teaching practices (e.g. teaching planning, organization, resources, materials, tasks, classroom dynamics; role of teachers and students, time management); 2) Practice assessment (e.g. integrating, articulation with teaching, predominant assessment tasks; nature, frequency and
distribution of feedback; dynamics of assessment; predominant role of teachers and students); and 3) Participation of students (dynamics, frequency, nature).

This evaluation study is descriptive, analytical and interpretive in nature and therefore it was decided that the treatment data should follow closely the recommendations of Wolcott (1994). We used for data collecting lessons' observations, semi-structured interviews with teachers and students, and field notes for information from informal conversations with teachers and students. Were also consulted and analyzed various kinds of documents (eg, legislation, guidelines produced by ME; specific bibliography). This study took place over about ten months where participated six teachers, two for each cycle of basic education, that were interviewed and observed their classes and interviewed thirty-eight students. We decide to focus on description, analysis and reflection of what was listened from teachers and students and of what was observed in the classrooms of each cycle, producing just a narrative by cycle.

**Two Classroom Episodes**

Despite being quite difficult summarize in few words the work done, we selected two tasks during the observations in the 4th and 6th grades respectively.

**Example 1.** This example (part of a math class) intend to illustrate the role played by students and teachers in solving one task, designed under the NPMEB, where you want to develop students own learning. This task is a growing figurative pattern that allowed the exploration of various mathematical topics, with particular emphasis on algebraic thinking that is a new theme for this cycle and used manipulative materials.

In the third part of the lesson (20 minutes) the students organized themselves into groups of four to solve a pattern task in afigurative sequence context. As a support material the teacher gave each group square to realize the first terms of the sequence.

Emerged as usual in this class, several resolutions and different interpretations and strategies. We conducted a synthesis of all resolutions and each student had the opportunity to share their reasoning with the class.

This group was limited to making a statement very concise.

But there were groups that explained their thinking in more detail and clearer.

In the last question, which asked "to determine the number of squares needed to build a picture of any order, "there were many difficulties. A number of students appeared to have misunderstood the question.

One student, considered the best in the class, explained to colleagues that it was "another two times. " The teacher asked him to complete then he write: "Number figure x 2 + 1".

This, for these young students, it is not easy, it was made far generalization, using algebraic thinking and a representation near the formal algebraic expression. Here could have been using the term "double" but in the meantime, the class was nearing the end. (Notes from observation)

If it is true that one of the roles of students is undoubtedly be involved in discussions in small or large group, this is due in very large to the actions of the teachers in order to
encourage mathematical communication in classrooms. In fact, the teachers try to provide time and space so that students could present their own resolutions, ask questions and discuss with colleagues. Thus, it is never left to explore issues even in the preparation of the final synthesis.

Example 2. The communication that it was more often observed during classes, it was in the form of dialogue between teachers and students that were always invited to explain and verbalize their thoughts and reasoning. It was noted also that teachers were concerned with questioning on the work and on the arguments presented, providing clues and alternatives in order to supplement and enrich their work. Teacher seemed to have driven discussion of the strategies used in problem solving and presentation of the main findings. The following episode shows that students had opportunities to express themselves, share their thoughts, and present their questions or to submit alternative solutions which could be explored by the whole class.

One student, that usually has problems of being concentrated, read the task. Then the teacher asked to a student:

- How do you think we can find half of the perimeter of a circle?

The student answered at once

- Radius times pi.

The teacher asked to explain his answer

- What is the diameter of each?
- 2.
- Why?
- Because $2 \times 3 = 6$.
- Or because $6 \div 3 = 2$.
- So to know the length of the blue line what I have to do is:
  
  \[ P = d \times \pi \quad ; \quad P = 2 \times 3.14 \quad ; \quad P = 6.28 \]

- Anne, do you agree with what William said?
- No, I think it's worth here. (and makes a draw)

- Why?
- Humm ...
- I wanted to understand ...
- I also wanted to explain ...
- Look, if I took this line and put it here
- Ah! Yeah.
- And now what is missing?
- I think we have to divide 6,28 by 2.
- Let's do the calculation? We can do it but this relationship here (pointing to the calculation $2 \times 3.14$) ...

Students painted each line of the drawing with the color of the calculation.
- And now?
- Now we add the two parts.
- Come on. Use another color.

At the end, another student intervened:

- If we make the radius times pi gave half and then we multiple by 3.
- Excellent! Let's register.

Then, the students respond to the other questions by themselves, in pairs. A pair of students presented its solution as shown in the next picture.

This description illustrates the dynamics of work and communication, used often by participating teachers, to help students learn to work in solving problems raised by the tasks presented. However, as mentioned by one of the teachers is not always possible to explore
every task or topic with the desired attention and depth, because of the time to carry out all the themes of the program.

Conclusions
The main main conclusions and reflections in this second phase of the evaluative study, can be summarized in the following ideas. 1) A successful stake - despite some difficulties it was possible to establish a support system and monitoring which contributed decisively to the creation of new and innovative dynamics in areas such as teacher training and the participation of students; 2) A well interpretation of the program - contrary to what appears to be usual, the participating teachers seem to have a well understood on basic content areas of the program, the fact of textbooks are no available may have contributed to the teachers need to study in detail the program; 3) The planning and collaborative work of teachers - the planning of lessons, their analysis and discussion led to dynamic collaborative work that contributed to teachers felt more confident of their performance; 4) The presence of transversal capabilities - the transversal capacities constant in the program were deliberate and systematic part of the daily concerns of the participating teachers, which eventually settle as a routine in the classroom observed; 5) Structure of classes and pedagogical routines - The practices of the teachers were generally well articulated with the methodological guidelines set in the program. Typically, the classes, focusing on tasks followed from in accordance with the next four phases: a) Presentation and appropriation of the task, b) Resolution of the task, c) Discussion of solutions and results, and d) Reflection systematization and synthesis; 6) Teachers well aware of his role - all teachers, even with styles and very different experiences and attitudes, seemed to have well-established routines. Perhaps one could say that in general, the teachers participating in this study appear have learned to listen more carefully to a greater number of students; 7) The problem of time management - teachers have great difficulty in managing time and when they could, they used the time away from other curricular areas; 8) The problem of students assessment - the concepts and practices of teacher assessment participants seemed to be articulated with their teaching practices. For most participating teachers there are issues that are not resolved, such as the very concept of assessment, its purposes, functions, modalities and their nature; and 9) Student oriented, cooperative and aware of your paper - students participated with relative ease in the dynamics established in the classroom, were well-oriented by teachers to the tasks to which they were proposed and participated, not all equally, in developing their own learning.

In short, the preliminary results suggest that some improvements for school mathematics are already visible, namely regarding students’ attitudes and mathematical competences and teachers’ practice.

References