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5. Cross-curricular Mathematics - A Case Study

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Abstract
A research was developed to explore how the process of inter-year and inter-cycle Cross Curricular Mathematics is interpreted, planned and experienced, as set out at a ministerial level, within a vertical grouping of schools. A qualitative and interpretative case study was chosen. The participants were 11 teachers, some with management positions. For data collection, a document analysis, observation and inquiry were included. The data show that teachers unanimously believed in the potentialities of collaborative work. And that, despite all efforts and measures introduced, there continues to be a difference between the scholar cycles. In fact, there are horizontal articulation regarding the several years of the same cycle but, in what concerns vertical articulation, there is a gap between the 1st and the others cycles.

Introduction

The "general crisis" system which has been repeatedly denounced by several sources lead, in the Portuguese political-educational panorama, to continuous reforms, which translated in legislative measures that intended to resolve problems resulting, namely, from the mass generalization of Education.

A school network structure was implemented, organized in School Groups and, more recently, in mega School Groups. School autonomy emerged, which allowed them to create their own development projects. This was made clear by the decision-making at a strategic, pedagogic, administrative, financial and organizational level. Such autonomy legitimizes the increase of autonomous participation of teachers, providing them and the management structures they belong to with the power and the means to define their own school policies and to establish their development plans. And is assumed specifically that the collegial spirit promotes efficient and innovative collaborative practices, based on a constant reflexive confront of ideas, experiences and knowledge among the teachers within the same or different school cycles and/or years.

Within this framework, it is pertinent to understand in particular the way different school structures are organized in order to accomplish the articulation, the mathematics, between school years and cycles, contributing thus for an effective learning of the subject.

Therefore, the defined main research question was: *How is the process of inter-year and inter-cycle Cross Curricular Mathematics interpreted, planned and experienced, as set out at a ministerial level, within a vertical grouping of schools?* From this starting point, seven research objectives were outlined:

- To identify the process of student characterization in the School Groupings in mathematics and to assess the impact on the teaching planning;
- To learn more about the organization of Curriculum Department and its influence on teachers' work;
- To understand the process of inter-years and inter-cycle Cross Curricular Mathematics;
- To identify the impact of the school Project – Mathematics Plan – in the teachers' work;

- To identify the difficulties and benefits of collaborative work among the Mathematics teachers, to characterize the type of teachers' culture;
- To obtain teachers' points of view on what it means to be a mathematics teacher today;
- To obtain teachers' points of view on what the work of a mathematics teacher entails - the link between cycles.

Theoretical framework

This study's theoretical framework is based on three main connected themes: vertical grouping of schools, curricular articulation and teachers' work.

The creation of the Vertical Grouping of Schools – which is the current privileged model of administration and management of the Basic Education in Portugal – was assumed as one of the responses by the Official Authority to the current demands, which requires a more integrated and inclusive school, that should not promote a compartmentalization of knowledge. In opposition, it should assure a comprehensive teaching of all Basic Education students. This was firstly legitimized through the Normative Resolution number 27/97, publish June 2nd, and by the Autonomy, Administration and School Management Regime (Decree-Law number 115-A/98) published May 4th. An autonomy perspective emerges and assumes a conception of *School* with its very own identity, where teachers interact and their participation is valued and promoted, which allows a better management of resources and, in consequence, a better educational public service performance, as stated by Nóvoa (1992), Alonso (1998), Roldão (1999), Canário (2001), Barroso (2001), Simões (2005), Dácio (2005), among others.

Therefore, all teachers should mobilize and assume themselves as co-creators of a more pertinent curriculum for their schools or school groupings, as they should take responsibility for the promotion and structuring of the learning process of their students. Such curricular management is essentially linked with the way teachers interpret and shape the curriculum in two levels: a macro level, which is related to the planning of the teaching practice, and a micro level, which corresponds to the class room and the execution of the teaching practice (Ponte, 2005; Roldão, 2005).

Taking into account a periodic evaluation and reflection of its professional practices, the curriculum is always subject to adjustments and should be based on a true curricular articulation, which, in a logical and sequential way, assures the continuity between the school years and cycles – "The Mathematics School Curriculum should provide a sort of map, which should help the teachers to lead their students towards increased levels of complexity of knowledge. This guidance requires a well-articulated curriculum allowing the teachers, in each level, to understand the mathematics learned by their students in the previous level, as well as contents in which they should focus in the following levels." (NCTM, 2007: 17).

In fact, the curricular articulation, either at a vertical level, between school cycles and years, or at a horizontal level, between subjects and non-subject curricular areas, seem to be the keyword in all the legal documents which regulate the Portuguese Educational System, as far as the mandatory basic education goes, regarding the 9 school years as whole. Such articulation is clear in the teachers' work, which should be based in collaborative behavior.

These behaviors are currently promoted and developed by the pedagogic structures, particularly the Curricular Departments, created by the Decree-Law number 115-A/98 and published May 4th. In its 35th article is defined that "in the 2nd and 3rd Cycles of the Basic and Secondary Education, the curricular articulation is ensured by the Curricular Departments, in which the Subject Groupings and Areas are represented according to the courses, the number of teachers by subjects and the dynamics which should be developed by the School" and "in the pre-school and 1st Cycle of the Basic Education, the articulation is ensured by the Teach-

ers Councils, which in each school integrate the pre-school teachers and 1st Cycle teachers (this competency was initially legislated by the Regulate-Decree number 10/99, 3rd article). According to Simões (2005: 78), "the advantages of School Grouping, however, are limited by its structure, which continues to contemplate the separation of the Cycles". Therefore, in the Decree-Law number 75/2008, published April 22nd emerges the designation of Curricular Department, embodied as an educational structure and pedagogic supervision structure. In its 43rd article, it can be read: "the curricular articulation and management are ensured by curricular departments, in which all the recruitment groups and subject areas are represented, according to the courses and the number of teachers" (43rd article, item 2). And, as stated in item 3, article 43rd, the 1st Cycle of the Basic Education can also be integrated.

The current Basic Education Mathematics Program aims to promote vertical and horizontal articulations, as stated previously (Ponte et al, 2007). Particularly, in what concerns vertical articulation in each school cycle, in the introduction of each mathematical theme and cross abilities, it is anticipated the articulation between a specific cycle program and the previous cycle relative to that theme or ability.

Teachers should assume the role of connecting the cycles, since their work is, with the most certainty, one of the elements which most influences the quality of education and learning, as underlined by Thurler (2001), Arends (1999), Bolivar (2000) Nóvoa (2007), Ponte et al (2007), Frota (2011) among others. Such demanding task will be certainly facilitated and fostered if developed in collaboration with their pears (Aston and Webb, 1986; Fullan and Hargreaves, 2001; Frota, 2011). In fact, team work promotes the resolution of common and specific problems and provides mutual support for their professional development, targeting innovation and education quality and efficiency (Hargreaves, 1998; Bolivar, 2000; Frota 2011). It is through participation that teachers can make decisions, together and actively, present, confront and share ideas and, in particular, develop curricular management interpreting and promoting the curriculum taking into account the specific characteristics of their students, existing resources, school conditions and social-economic and educational framework (Correia, 2007). By getting involved in reflection processes, this participation will allow the existence of a critical debate about their tasks, their problems and the way to resolve them, in short, to intervene fully in all the education activities e contribute actively for their professional development, as stated by Correia (2007) and Guerra (2002).

For the schools and, specifically, for the teachers to consider and develop what will be the new and great challenges in all plenitude, they will have to overcome constraints and obstacles, but also (re)invent other conditions and factors which promote and optimize the work of the teacher, of mathematics in particular, namely, within a framework of curricular articulation between school cycles and years.

Research methodology

In this item, we start to explain the methodology options and participants of this research work. We proceed with a brief presentation of the chosen information gathering tools and techniques for each research phase and a summary description of the case study. Finally, we explain the method used for data processing and its presentation.

Methodology options and participants

Taking into account the research objectives, it was decided to undertake a qualitative study, based on a constructivist paradigm, and to follow the single study strategy, micro ethnographic study form (Bogdan & Biklen, 1994; Stake, 1995; Gomez, Flores and Jimenez, 1996; Crosswell, 2003; Coutinho, 2011).

The study focused in a Vertical Grouping of Schools, selected due to the schools' accessibility, since it was geographically close to the researcher residence area, which allowed easier access, more frequent visits with lesser costs, as well as for the schools' voluntary participation to implement a project at the 1st Cycle level, suggested by a school inspector and which contemplated an actual vertical curricular articulation.

At the macro level, this study had the participation of the President of the Executive Council and the president of the Pedagogic Council. At the meso level, the study counted with the participation of the coordinator of the Curricular Department of the Basic Education 2nd and 3rd Cycles, which integrates the Mathematics subject, and the coordinator of the Curricular Department of the 1st Cycle. Finally, at the micro level participated three math teachers from the 3rd Cycle, three from the 2nd Cycle a one teacher from the 1st Cycle. Nine of the participants were females and two were males, ranging from 8 to 39 years of teaching experience.

Information gathering tools and techniques and study description

The information gathering techniques used in this study were the document analysis, which was based on formal records at an exo and macro level, the inquiry, using script-oriented semi-structured interviews, and the direct observation, supported by field note registration and logbook, which permitted a complete perspective of the studied phenomena.

This research occurred during the 2008/2009 school year in a Vertical Grouping of Schools of the Central Coastal Region, which assembles nine 1st Cycle schools (all geographically separated from each other and from the Head School) and one 2nd and 3rd Cycle school. The 1st Cycle schools are built according to traditional architecture models, although well preserved e globally well equipped. In the Head-School facility there is an exclusive classroom for the Mathematics subject.

The empiric study was organized in three distinct phases. The first phase consisted in the planning of the study in what concerned the theoretical framework, method definition of the research, question preparation, setting of research objectives, selection of School Grouping and participants. After the acceptance of all participants, a guided visit to the 2nd and 3rd Cycle School and some of the 2st Cycles Schools facilities was carried out. During this guided tour we were able to observe all areas and collect some field notes. At that same time, the School Grouping documents were gathered: School Grouping Curricular Project, School Grouping Education Project and Internal Regulation Documents. It was then created the interviews script, which were promptly individually carried out onsite. In the last phase, we proceeded to the sorting and analysis of the collected data.

Data analysis and presentation

The data was analyzed through content analysis and sorted by categories, which were created taking into account the research purposes. The data was then presented using a descriptive approach, transcribing some of the most relevant statements.

Data analysis and discussion

In a Vertical School Grouping, the students are considered 9 year residents – from the 1st to the 9th grade. Their Individual File gathers information such as their social-economic context, family background and their school path. However, these elements are not enough to have a general perspective of their development stage comprehensively and individually, as far as Mathematics is concerned. Therefore, to complete this characterization it was taken into account test results, exams and other records from previous school years, and also the question-

naires filled in the classrooms, which completed the information recorded in the Class Curricular Project and the diagnostic forms. A participant from the 1st Cycle further stated that Individual Student Files "are assembled throughout each school year. I have a chart composed of specific student evaluation items, which ranges from problem solving, to memorizing and communication skills in Mathematics, which I use to record the related values" (1st Cycle teacher).

Other source used to characterize the students was the meetings carried out at the beginning and at the end of the school year. These meetings' agenda included the execution of the curricular management and involved the three Basic Education Cycles – "In the first meetings we prepare and organize the entire school year and the final meetings are used to evaluate the execution of the programs and to improve some aspects of the work carried out during the year and to plan specific activities for the beginning of the following year" (2nd Cycle teacher). According to the interviewees, the collected information influenced, at a meso level, the management of the Subject Group activities and, at a micro level, it affected the planning and organization of the class tasks. The 1st Cycle coordinator stated that the student characterization influenced the work of the group of teachers who taught in the School Grouping.

In what concerns the curricular departments, we must single out the Mathematics and Experimental Sciences Departments, which are composed by 2nd and 3rd Cycle Mathematics, Nature Sciences, Natural Sciences and Physic-Chemistry Science teachers, as well as the 1st Cycle Curricular Department. These departments were responsible for the curricular development based on a collaborative culture, and together were responsible for the standardization of the work to be undertaken in the future, shared and crossed ideas and experiences, and searched for adequate activities for their students' needs, as stated a 3rd Cycle teacher: "This is the opportunity for us to act in a more or less uniform fashion, with mutual help and sharing collaborative work." The 1st Cycle Math teacher emphasized that the Curricular Department meetings, held in a mandatory monthly basis, were useful to outline new challenges and new projects. However, she expressed the number of participants was too high and the meeting duration too short. She also referred to the legislation changes, which altered the Department's composition, namely resultant of the association of more Subject Areas, which reveilles to be less productive. However, it was unanimously recognized that this is the only formal moment of group work, in what concerns the model of curricular management developed on a collaborative culture basis.

After analyzing the School Grouping Education Project, it has emerged the curricular articulation as an element to improve, as referred by all the Curricular Departments. In that Project a point was made about not attributing a single school level to each teacher. This measure was submitted to the Curricular Departments and is also included in other school documents, namely the Internal Regulation document and School Grouping Curricular Project. In the latter, the school defines the pedagogic organization guidelines, assuring the continuity between school levels and years, appealing to a participation of all teachers.

In what concerns the 2nd and 3rd Cycles, the Math teachers benefit from the School Project – Mathematics Plan. This sub-group of teachers held 90 minutes weekly meetings (these 90 minutes were included in the school timetable, in accordance to the deliberation of the Pedagogic Council) to develop their work, promoting horizontal and vertical articulations, intra and inter-years and school cycles. According to the general opinion, that Project brought many positive aspects for the teaching and learning of Math. These teachers underlined, on one hand:

- the possibility to work as a team and to obtain new (and more) materials, namely, computer and technological resources, and, in particular, interactive boards;

- the better teaching articulation and equity in the curricular development and in the evaluation moments;
- the assignment of more teaching time for the Math subject, making the most of curricular areas of non-related Math subjects, such as Guided Study and, in the 6th Grade, the School offer also oriented for its teaching.

None of the interviewed teachers mentioned any negative sides associated to the Mathematics Plan. They only denounced the lack of work among pears in the classrooms and, also, that the implementation of the project justified an increase of funding, as well as more physical resources, since they considered them to be scarce. As far as the 1st Cycle is concerned, the time destined for non-related teaching activities were all used with study support activities, supervision and meetings. Nonetheless, the teachers held regular meetings, although isolated from the other cycles, as it's stressed by a 3rd cycle teacher: "In this school, the 3rd cycle teachers work in articulation with the 2nd and 3rd cycles, whereas the 1st cycle is a bit distant. Nevertheless, it's possible that next year we will be able to improve the articulation between the cycles. We are thinking about it".

In what concerns factors which make vertical curricular articulation more difficult, the interviewed teachers underlined the incompatibility of schedules and the lack of culture for this kind of work, to which the great workload, beyond the scheduled school timetable, is no stranger. They also stressed that the number of teachers participating in the workgroup influenced the outcome of their work. Additional difficulties come from the lack of physical spaces, which has negative implications in the teachers' timetables, if they want to hold their group meetings beyond the weekly 90 minutes determined by their Management.

The system hiatus are starting to be resolved since the creation of weekly or daily periods and the appreciation for collaborative work praised by the interviewed teachers, as it's also perceived the Official Authority intends to implement a mechanism at an exo level, by conceding greater autonomy to School Groupings.

About the perception of what it means to be a mathematics teacher today, the interviewees admitted that it is a challenge, a difficult task, sometimes discouraging. In opposition, they understand it to be enriching when it comes to sharing the knowledge of science. These opinions are related to the students' attitudes towards the subject and their motivation; with the level of knowledge they are able to acquire throughout their school path; with the belief mathematics will influence their professional future. On the other hand, there have been new information emerging and new challenges introduced by the Official Authorities, namely concerning innovative methodologies to be implemented and assessment tests. With this regard, the 1st Cycle Curricular Department Coordinator stated: "I believe the first change happened with the assessment tests. This shook the class and teachers started to realize they had to change methods and teaching material and even their own training. I can add that, in our School Grouping, all teachers are currently in training". Even so, they recognized the importance of their role in the society, associated to an increase tendency for the subject. They argue that being a Math teacher today demands continuing training, a constant exchange of professional experiences gathered through many years of work, and value collective practices in opposition to individual and hallow actions in what concerns learning and final outcomes.

All interviewed teachers underlined the work developed by their math colleagues and placed the link between cycles at the level of curricular articulation and collaborative work. They admitted that the taste and motivation for mathematics is "born" in the 1st cycle and used terms such as "this is how we build a house" and "it's a snow ball" to justify the connection between cycles, in a perspective of continuity and sequential progress. Even though they understand the importance of their role as links between cycles, the teachers referred to the

existence of some obstacles in that articulation , namely between the 1st and 2nd cycles, starting from the fact of their physical separation.

In short, from the several collected statements, it has stood out a feeling of hope in a greater student involvement with mathematics. The teachers recognized unanimously that the Mathematics Plan opens new horizons for teaching, but also new and increased responsibilities in its interpretation and application. The changes introduced in the education system, mainly through the Mathematics Plan, were greatly emphasized by the teachers, now integrated in a new concept of school, where the involvement of parents, students and teachers is faced as increasingly important and decisive, now and in the future - in other words, an open and modern school, open to the community, free of barriers and obstacles of all sorts.

Conclusion

The study allowed us to understand better a certain reality and obtain several significant conclusions about the constraints faced by the mathematics teachers of the basic education while developing their work, in particular, in the creation of links inter-cycles and assess which measures should be taken to surpass the obstacles, and on the other hand, to identify which conditions and factors promote the desirable vertical articulation.

The work of teachers as a link between cycles is founded in the curricular articulation. Such articulation is obtained horizontally. However, vertical articulation is much more evident in the 2nd and 3rd cycles of basic education, being promoted by a collaborative culture.

The mathematics teachers of these cycles benefit from the Mathematics Plan proposed by the Official Authorities in 2005 and report positive outcomes from this project: the collaborative culture and the collegiality; the work among pears; equipped schools, namely, with computer technologies (pc and interactive boards); equity in the assessments; increased teaching time schedules for the subject; continuity between school years and cycles; a more ample and effective articulation of efforts and better outcomes. In what concerns the work dynamics of the mathematics teachers, it was applauded the 90 minutes weekly meetings. The teachers, thus, saw an old wish come to light: the setting of a weekly period for collaborative work, aiming at the sharing of acquired experiences, at the definition of methods and at the continuing group learning. All these aspects promote facilitating conditions and the settlement of some of the constrains many authors (Thurler, 2001; Little, 1990; Hargreaves, 1998; Fullan and Hargreaves, 2001) have been highlighting in what concerns the implementation of more regular practices of collaborative work, also revealed in a study by Pereira (2002). This Project meets another study "Mathematics 2001 – Diagnostic and Recommendations for the Teaching and Learning of Mathematics" undertaken by APM. "These collaborative activities may be related to the diagnosis of learning problems of students, to the definition of projects and intervention strategies or to the preparation of materials and class plans, with the correspondent reflection on the classroom activities and its outcomes" (APM, 1998). The 1st cycle teachers, even though not included in this project, also promoted regular work meetings for each school year.

Unanimously, the teachers who participated in this study admit that collaborative work promotes the creation of group methodologies, allowing in a more objective and secure way to analyze in a concerted fashion the objectives of teaching Mathematics, the study of the general objectives outlined for the school year or basic education cycle and the observation and discussion of the learning results of students from the previous year or cycle. In conclusion, the teachers admit, just like us, being the step to close the link between cycles. One may also conclude that the factor pointed out by Brites (2002), which represents an obstacle to vertical curricular articulation (schedule incompatibility and a lack of culture for this work), has started to be resolved, by creating a weekly or daily period and by valuing the collabora-

tive work, as stated by the interviewed teacher in this School Grouping. It's also perceived the Official Authority intends to implement a mechanism at an exo level, by conceding greater autonomy to School Groupings.

In this final footnote, we can infer by this study that, in the 2nd and 3rd cycles, the implementation of the Mathematics Action Plan was, next to the creation of Vertical School Groupings, the most important element, well succeeded and necessary to the mathematics teaching, creating conditions to promote continuity and support for the transition between school years and /or cycles, in a logic of sequential progress. All it remains is to improve curricular articulation between the 1st, 2nd and 3rd basic education cycles.

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