A LARGE SCALE CASCADE MODEL IN THE CONTEXT OF MATHEMATICS CURRICULUM REFORM: INTERACTIVE FACTORS OF INFLUENCE OF MULTIPLIERS' WORK

Ana Paula Canavarro[1,2] and Leonor Santos[2]

[1]Universidade de Évora, [2]UIDEF, Instituto de Educação, Universidade de Lisboa

This study aims to know the influences identified by the multipliers on their work with schools, in order to understand the development of the cascade model implemented in the context of a Portuguese national large-scale programme for support mathematics teachers in mathematics curriculum change. 80 multipliers were surveyed with an open-ended questionnaire and the data were analysed with an inductive approach. Multipliers revealed they were affected by interrelated factors from different contexts: their colleagues, the scientific commission, the mathematics teachers and their schools and the Minister of Education. This suggests that the cascade model do not develop in a top down way, neither it is bottom up defined. Instead, it accommodates contrasting influences and its dynamics evolves as conditions change.

INTRODUCTION

In 2006, the Portuguese Ministry of Education (ME) invited public schools to propose school projects aiming the improvement of the results of their students' mathematics achievement (grades 7-9). More than 1000 schools, involving 12500 mathematics teachers, corresponded to this invitation. A national large-scale programme — the Mathematics Plan (MP) — was created to provide resources, human and logistics, for teachers and schools' support (Ferreira et al., 2010).

In 2007, a new mathematics curriculum (NMC) for the basic education (grades 1 to 9) was approved, proposing new contents (topics and mathematical process) and an inquiry-based approach to mathematics teaching (Maaß & Artigue, 2013). It was to be progressively implemented by the schools. So, from 2007/2008, the MP oriented its action for providing professional development focused on the new mathematics curriculum guidelines, concerning mathematical contents and classroom practices, recognizing the importance of having well-prepared teachers for the success of students mathematical learning (Sowder, 2007). In 2009/10, 37% of the schools voluntary implemented the NMC in some classes, without having textbooks. In 2010/11 begun the compulsory generalization of NMC. In 2011, a new government was elected and radical changes in educational policy were announced. The Mathematics Plan ended at the end of 2011/2012.

The Steering Committee (SC) responsible for MP development, a group of eight teacher educators and mathematics teachers (including this paper authors), adopted a cascade model (Maaß & Artigue, 2013) to implement at national scale. This cascade

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counted with multipliers (Krainer, 2015), who provided professional development to teachers in schools, based on the education they received from the SC.

This is a possible approach to scaling up professional development (Maaß et al., 2015) that remains of interest for the research on mathematics teacher education, namely for learning "how fruitful initiatives can be sustained" (Lerman & Zehetmeier, 2008, p. 17). One of the major concerns of this model is the question of how much can actually be handed down the cascade (OCDE, 1998).

Hearing from the voices of key players in the scaling up process as the multipliers can be worthwhile for the development of a more complete scenario of what counts as important in a large scale and time extended cascade model for its effectiveness and sustainability (Krainer, 2015).

In this study, we aim to know the influences identified by the multipliers for the development of their work in PM cascade model, in order to understand how the different contexts of the cascade interact and affect the development of PM programme. For so, we formulated the following research questions:

- What were the fostering factors most valued by the multipliers for the development of their work with schools?
- What were the hindering factors perceived by the multipliers for the development of their work with schools?

THEORETICAL FRAMEWORK

One of the well-known strategies for scaling-up professional development (PD) it is the so-called "cascade model. Here, multipliers are trained, who in turn train other teachers. This model can range from being top-down and also bottom up in parts initiatives" (Maab & Artigue, 2013, p. 785).

Decisive elements are the multipliers. They usually are supported by specialist and their education requires intensive efforts so they can acquire the knowledge they are expected to deliver to the teachers, in which they need to trust in order to transfer it to the continuous professional development courses they are responsible for (Roesken-Winter, Schüler, Stahnke, & Blömeke, 2015). This is of particular concern in times of curricular change, when usually exists a potential contrast between the current practice (at schools) and the reform practice intended by those financing PD. Multipliers' education must also discuss the role assumed by the multiplier. It can range from the outsider "transmitter of knowledge" to the "autonomous facilitator" of the teaching practice that helps teachers to critically reflect on their practice and to establish connections and compromises between the current practice and the intended reform practice (Krainer, 2015, p. 144). The exchange of experiences with colleagues and the meetings focused on themes recognized as relevant for day-to-day teaching are two factors of effectiveness for professional development initiatives (Maaß & Artigue, 2013) and the multipliers should be prepared to deal with them.

One important issue for the development of multipliers' work is the dynamics of schools social support in what concerns collaboration. Raising the likelihood and sustainability of success of a PD programme involves more than the teachers in an individualized way. "Scaling up PD is to reach all teachers, designing adequate school development processes are necessary—a good school is more than the sum of single good mathematics teachers" (Krainer, 2015, p.144). Colleagues need to share their knowledge and their teaching experiences and to reflect on their practice and how they can innovate in the context of a reform context. Supporting teachers' work in communities and networks is a strategy with a great potential: "Community building and networking represent the core factors fostering sustainable impact of professional development programmes" (Lerman & Zehetmeier, 2008, p. 17). Teacher networks can be seen as groups of colleagues providing social support in the development of demanding instructional practices. "This affords time built into the school schedule for collaboration among mathematics teachers and access to colleagues who have already developed relatively accomplished instructional practices" (Zehetmeier, 2015, p. 119). So, the organizational level concerning the institutions enrolled in the scaling up process (e.g. schools or ministries) need to be considered for support the individuals and their communities in their efforts to learn and bring about change. "A reform project needs several channels of networking between the autonomous triangle's domains practice, research and policy" (Krainer & Zehetmeier, 2013, p. 884). A final remark goes to the importance of the contexts, that must provide high level and good balance of internal and external resources and support: "internal and external resources and support are needed, but there is no direct and time continuous interconnection between internal and external interests" (Krainer & Zehetmeier, 2013, p. 884).

METHODOLOGY

The participants of this study are the group of 80 multipliers responsible for delivering professional development concerning new mathematics guidelines in schools. They were selected from the 450 responding to a national call and they were chosen by their experience and curriculum relevance concerning mathematics education, mathematics teacher training and development of projects. They were organized in teams covering all the regions of the country. Each one of the teams was monitored by one or two members of the SC, depending on its dimension.

The multipliers got support from the SC along all the PM development. SC provided annually intensive courses of two weeks focused on curricular, mathematical and didactical knowledge concerning the new mathematics curriculum, including both mathematical contents (e.g., mathematical reasoning, statistical literacy …) and methodological ones (e.g., inquiry-based learning, tasks design, digital resources, …). Besides, SC also provided extensive support to multipliers by a monthly regular one-day meetings aiming both to update and deepen their knowledge concerning the new guidelines and to support them in dealing with the specific problems they faced in their regular work with the schools. These meetings focused on specific strategies of

involving teachers in terrain in reflection about their mathematics teaching practice, like discussing students' mathematical productions, appreciating the potentialities of different mathematical tasks, exchanging experiences from classroom, etc. Each multiplier could choose, from the topics of these meetings, the agenda of the follow up meetings he/she would deliver to the schools under his/her responsibility.

Each multiplier was responsible for a group of schools (up to 17), organized by four or five subgroups according to geographical proximity in order to facilitate the schools interactions and collaboration. A multiplier should spend one day (Tuesday) per month with which subgroup, promoting meetings with the teachers responsible for the mathematics curricular development in the schools of the corresponding subgroup. These meetings took part in different schools, aiming to foster the participation of the mathematics teachers of the school "receiving" the meeting. In order to allow the participation of the teachers in the meetings organized by the multiplier, school directors were expected to respect the Ministry of Education' recommendation of releasing the Tuesday afternoon from classes to the involved teachers. This recommendation lasted to 2011 but was not assumed by the Ministry of Education in 2011/12 and some of the schools maintained the Tuesday free but others did not.

We followed an interpretative methodological approach, capturing the meanings of the multipliers from their responses to four selected open questions of an open-ended questionnaire. This questionnaire was elaborated by the SC and was used from 2007 to 2012, maintaining the same questions along the six years. The 80 multipliers completed the questionnaire at the end of each scholar year. The principles of confidentiality and informed consent were guaranteed to all (AERA, 2011).

The open questions considered for this study required the multipliers' reflection about the influences for the development of their work and asked for: Appreciation of the support by SC; Appreciation of the conditions of the schools; Strategies they used for preparing for work with schools; Difficulties faced in their work in schools.

The data were analyzed and classified with an inductive approach. Inspired by theory, we considered three a priori broad domains. These are the influences that the multipliers identified to their work concerning (1) the education assured by SC, (2) the dynamics of the schools contexts, and (3) the conditions provided by the Ministry of Education. In the course of the analysis, we added a new domain that has come up with a strong expression: the influences of collective work among the multipliers themselves. From the analysis of these influences, we obtained the fostering factors and the hindering factors of the multipliers' work.

Quotations from the multipliers were selected from the questionnaires for illustration of the interpretation of data and its categorization. The reference (M "year") means a quotation extracted from a response of a multiplier on the questionnaire of the scholar year ending in "year" (eg, M 2010 is a quotation from 2009/10).

RESULTS

Fostering factors valued by the multipliers

The multipliers revealed a positive opinion about the support they get from SC every year. In particular, the regional regular meetings were perceived by them as fundamental for their development of self-confidence required to act as multiplier in schools. They valued the contents focused and also the way they were approached. They also appreciated the materials provided by the SC, namely the theoretical references concerning the knowledge they needed to deliver to the schools:

> The topics I discussed at the follow-up meetings (with my schools) were mainly proposed following the guidelines and work of the meetings of the SC, which were extremely useful and adequate and had theoretical support, which gave me self-confidence to work in the follow-up meetings. (M 2012)

An aspect valued by the multipliers of the SC support concerned strategies for approaching the new curricular topics with the teachers without assuming the role of "transmitter of knowledge" but more like a facilitator of curricular development. The SC suggestion of beginning the school meetings with the sharing of experiences from teachers' classrooms was perceived as a positive influence for fostering reflection about mathematics teaching practice and collaboration among teachers:

> One of the strategies that has been very effective in the past few years is to promote the sharing of ideas, materials and reflections both within each group of schools and between schools belonging to different groups — (as we do with the committee). (M 2012)

Another fostering factor of multipliers work was the support they get from each others. In fact, this was not planned in advance and was an initiative of the multipliers themselves. Taking profit of the internet, they develop regional forums for change experiences and materials and for joint preparation of their meetings with the schools:

> This group of multipliers meets once or twice a month in a rotating way between Braga, Esposende and Famalicão. We prepare the agenda, the subjects to be worked, the materials to be presented. We carry out a continuous work of sharing, reflecting before and after the meetings, expanding this work with the exchange of emails. (M 2012)

This happened in all the country, being intensified along the years, and was valued as a fundamental contribution for a good adequacy of the meetings with schools:

> The collaborative work carried out by the multipliers of the region (...) was fundamental because it helped to make more sensible decisions and to make fewer mistakes. (M 2009)

Other fostering factors that multipliers identified come from the schools and their teachers. Two different aspects can be acknowledged. One was their consideration of the schools' suggestions about topics to be focused on the school meetings:

> Colleagues suggested some topics to be explored at follow-up meetings, such as: assessment, isometries, dynamic geometry (Geogebra), quadratic functions, data analysis, and tasks (elaboration and sharing). (M 2012)

It allowed the multipliers to better meet schools interests and needs:

> It is very important that the mathematics topics meet teachers' expectations. (M 2010).

Other aspect considered by the multipliers as a contribution for their work was the interest and enthusiasm they perceived in schools, particularly at the PM starting, due to the satisfaction with the collective dynamics of teachers and to their disposition to improve mathematics teaching practice:

> It was encouraging to see a large number of teachers interested in listening to what others wanted to share and also decided to embark on a gradual change in their teaching practice. (M 2007)

Hindering factors valued by the multipliers

Multipliers referred to same factors that constituted difficulties of the effective development of their work with schools, which varied along the time. One has to do with the pervasive curricular school culture. In many schools, multipliers had to deal with a sentiment of resistance that arouse significantly in the phase of progressive generalization of the new mathematics curriculum, namely when the teachers were expected to concretize the new guidelines with the respective students:

> I feel that teachers have difficulties in taking over the New Program, there is a certain resistance and distrust in the students' learning with some tasks, and a little critical about some aspects of the program. This change of mentalities takes time. (M 2010)

At that time, PM was extended to the grades 1 to 9 and some of the teachers were teaching from the old program and other with the new one. This diversity added complexity to multipliers work, namely because some of the teachers did not recognized relevance to the topics approached in the meetings at schools:

> The fact is that the meetings are jointed: schools with the new program and schools without it. The colleagues from schools who do not have the new program felt that it made no sense to be working on a topic they do not need yet to teach in their school. (M 2010)

Another hinder that multipliers felt in the last year of PM has to do with the decreasing of conditions (time and budget) provided by the Minister of Education, due to economic restrictions, affecting the work that multipliers could do in schools:

> During this school year, the greatest difficulty was the lack of availability of teachers on Tuesday afternoon to participate in the meetings. Also the lack of free time in common of the teachers of each school was a constraint mentioned by some coordinators for the collaborative work in their schools. (M 2012)

The new Ministry discourse about the mathematics program being implemented was very critical and he announced severe changes in the guidelines that teachers were experiencing and beginning to become comfortable with. All these changes contributed to a pervasive general feeling of disappointment and accommodation by many teachers, with consequences for the decreasing of the participation of teachers in the follow-up meetings and required an increased effort of the multipliers:

> This situation (reduction of time for collaborative work), along with others (reduction of time for consultancies, supports, etc.), contributed a lot to the demotivation and demobilization of the teachers that I felt this year in the follow-up meetings. It became a factor of resistance to the proposed work and was not easy to overcome. (M 2012)

CONCLUSIONS

The MP multipliers identified several influences for the development of their work. These influences aroused in different contexts. From SC, multipliers valued the direct support for the development of the meetings with the teachers in schools, consisting in opportunities for the acquisition and deepening of knowledge and strategies for PD development. From their colleagues, multipliers valued the support for the preparation of the follow-up meetings with teachers, taking profit of the collaboration with pears, not planned in the MP structure. From the schools, multipliers received incentive for the development of their work but also met difficulties to achieve their objectives concerning curricular changes. From the educational policies, multipliers found both fostering and hindering factors concerning, respectively, the provision or the withdrawing of logistic conditions and the promotion of a positive climate of investment in schools or the disruptive interruption of teachers' work for the improvement of mathematics teaching.

So, the multipliers were affected not only by the SC (as could be supposed in a top-down cascade model) but also by the other interacting actors. This suggests that the development of a cascade model depends of the consideration and articulation of all involved contexts. As Krainer (2015) points out, key players interact in the context of scaling up PD and it is important to understand how they can take profit of each others. The SC was perceived by the multipliers of a major importance, what suggests that a cascade programme benefits from a strong support of the entity that is scientifically responsible for it, which is expected to deliver knowledge and orientations for the PD' processes. But the multipliers also considered themselves as a relevant resource for the development of their work and this suggests the need of assuring conditions for the multipliers collaboration in a cascade model.

A remarks goes to the perceived effects of the changes in political conditions along the years. This suggests that cascades that develop in long time period need to acknowledge its dynamic nature. "Large-scale and long-term projects need both flexible plans and the use of windows of opportunity" (Krainer & Zehetmeier, 2013, p. 884).

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