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Supporting Mathematics Teachers' Learning with Educative Curricular Materials

Jonei Cerqueira Barbosa
Federal University of Bahia, Brazil
Andreia Maria Pereira de Oliveira
State University of Feira de Santana, Brazil

This paper presents a teacher development project that produces educative curricular materials and shares them in a virtual environment called COMMa (in English, Online Collaboration in Mathematical Modelling). Educative curricular materials are designed to promote students' and teachers' learning. Mathematical modelling tasks were planned and used in teachers' classrooms, where they were recorded. The project group was composed of scholars and teachers in charge of producing such educative curricular materials. They Teachers were able to interact with our project team by engaging in discussions and adding new files to the materials. Based on insights from our investigation of the educative curricular materials and teachers, we suggest three possible transformations that teachers may perform: transformations to engaging students, transformations to teaching the mathematical content and transformations to addressing the specifics of the school context.

Keywords: *Teachers, collaboration, educative curricular materials*

The focus on mathematics teachers' pedagogic practices has a long scientific tradition in the field of mathematics education (Remillard, Herbel-Eisenmann, & Lloyd, 2009). In many countries, despite official recommendations that highlight changes in the teaching of mathematics oriented towards a pedagogy that emphasizes the exploration and investigation of mathematical ideas, there is evidence that teachers experience difficulties in moving towards this model (Remillard et al., 2009). One way to support changes to teachers' pedagogical practices is the use of educative curricular materials. The expression "curricular material" refers to any type of instructional resouces (Schneider & Krajcik, 2002) including textbooks, handout, game, software program, etc. There is evidence that teachers adopt curricular material with respect to their beliefs and the context in which they teach (Sullivan & Wood, 2008). This finding underlines teachers' key role in the processes of curricular transformation and highlights the understanding that providing teachers with instructional resources is not sufficient to transform their practice. We have coined the construct *educative curricular*

materials, to distinguish the type of materials that are geared towards advancing both students' and teachers' learning (Schneider & Krajcik, 2002; Remillard, 2005). In other words, in addition to the materials designed for students, there must be complementary supporting materials for teachers to use these materials. Of particular concern to the community is understanding the nature of of such support.

We understand that educative curricular materials must promote teachers' learning. We equate learning with changes in the patterns of participation in pedagogic practice (Borko, 2004). This notion allows us to view teachers' learning as transformations in the actions they develop to teach mathematics. According to Schneider and Krajcik (2002), educative curricular materials may be composed of descriptions of the use of the curricular materials in the classroom, for example, narratives, reports of student-teacher interactions, analyses of videos, etc. The teacher is expected to reflect on the material in terms of how the task was used in a certain context and thereby gain inspiration regarding how it could be used in his or her own pedagogic practice. In addition, the curricular material may raise comments and questions that potentially promote teachers' learning.

As may be inferred from the definition of teachers' professional knowledge (Shulman, 1987), teachers' learning is related to know-how and has a practical dimension. Educative curricular materials should express teachers' learning during the use of these materials. We perceive this to mean that the design of educative curricular materials must happen through the collaboration of researchers and teachers so that teachers' practical knowledge may be incorporated. Based on this theoretical understanding, we are members of a collaborative research and development group consisting of teachers and scholars who design educative curricular materials on mathematical modelling.

A Collaborative Group

Since 2007, in the city of Feira de Santana in the Brazilian countryside, a collaborative group – the Collaborative Group in Mathematical Modelling (GCMM, in Brazilian Portuguese) – composed of scholars, future teachers and schoolteachers was formed. The team embers meet once a week to discuss and develop mathematical modeling tasks for classroom use. Initially, this group elaborated, planned and implemented mathematical modeling tasks, and implemented them in the classes of the teachers who participated in this group. The initial purpose was to promote the professional development of the group members so to gain insight on the implementation of mathematical modeling in the classrooms.

In 2009, the members of the CGMM began to consider socializing their pedagogic experiences and establishing dialogues with other teachers. We thought it would be appropriate to turn our experiences into educative

curricular materials (ECM) in order to stimulate outcomes in the classes of teachers not affiliated with the group. This point was based on the systematic evidence in the literature, as discussed above (Schneider & Krajcik, 2002; Remillard, 2005).

The group decided that the type of socialization of the ECM would be Internet-based. The rise of Web 2.0 has provided users with the chance to alter the published materials (Greenhow, Robelia, & Hughes, 2009), which permits dialogue with other teachers. The ECMs that had been designed by the group were made available in a virtual environment that the group named Colaboração Online em Modelagem Matemática (COMMa) (in English, Online Collaboration in Mathematical Modelling), which is now available at http://colaboracaoprofessores.blogspot.com.br/.

The Production of Educative Curricular Materials

The GCMM's first step was to define the appropriate characteristics for educative curricular materials. Based on the understanding that these materials could be built on teachers' "know how to do", each ECM should have a task handout for the students and some support that expresses a teacher's pedagogic practice using the task. Thus, each ECM comprised of the following parts:

(1) Introduction: the task's theme, its justification, the people who were responsible for designing it and the teacher who participated in the lesson;
(2) Task: the situation-problem on the theme, extracted from the science or from everyday life and to be solved by the students;
(3) Planning: the way the teacher planned the lesson regarding sequencing and mathematical contents;
(4) Narrative: a description of the modeling-based lesson as it happened that has been written by the teacher;
(5) Teacher's solutions: a solution for the situation problem that has been produced by the teacher;
(6) Students' records: students' different solutions;
(7) Video: interaction episodes that the students considered to be relevant;
(8) Forum: open questions for discussion.

In each part, the user has the opportunity to comment on the proposed material and to add further materials. For example, it is possible for a teacher who uses the proposed task to upload his/her own narrative.

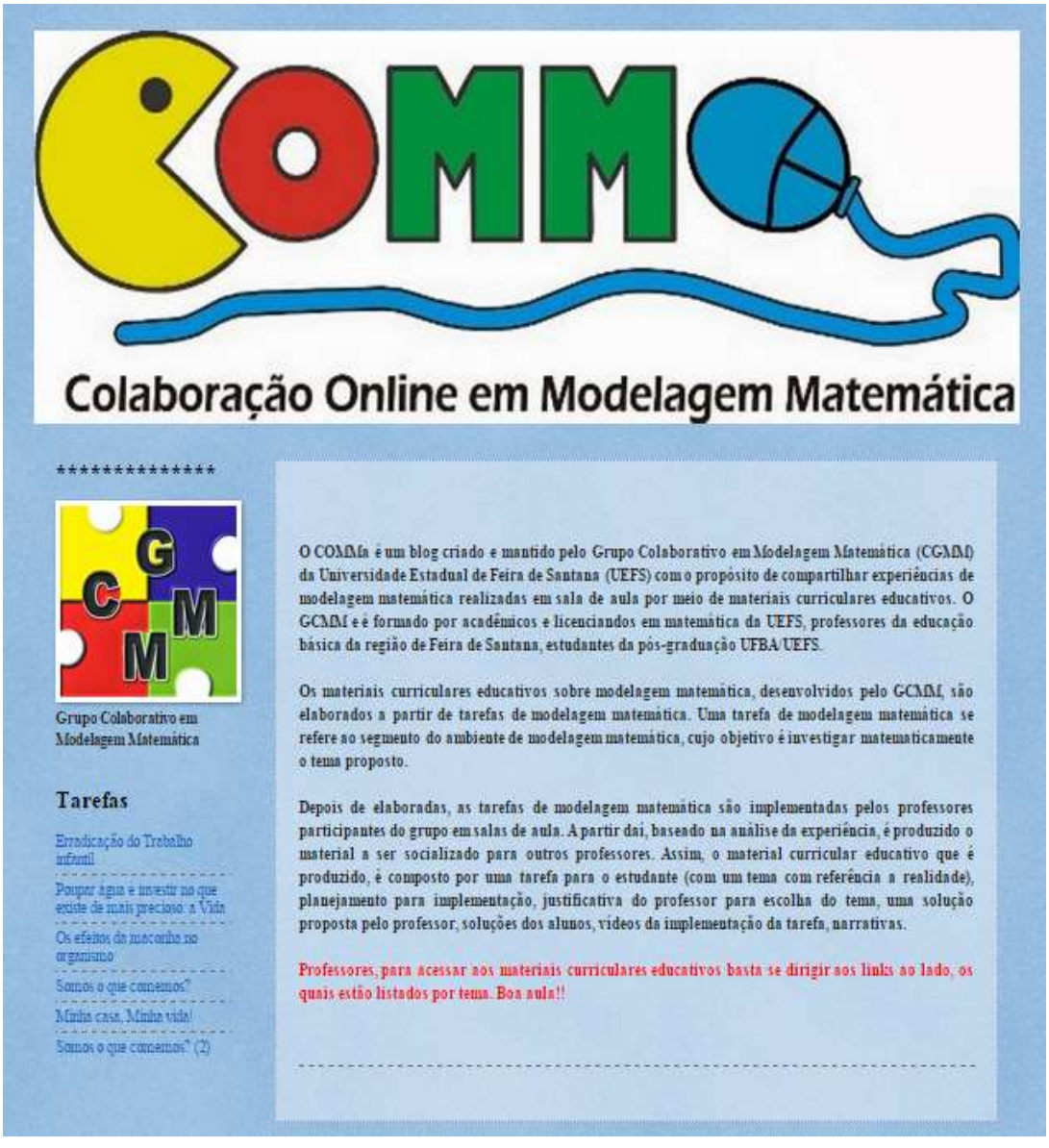

Figure 1. *The virtual environment COMMa*

Subgroups of the team were formed to produce EMC materials. Each subgroup included a classroom teacher. The design of the ECMs originated in the subgroups, which were then submitted to the group as a whole for critical analysis. This process involved in the development is described below.

Phase 1 – Elaboration of the task and planning for the classroom

In this phase, the mathematical modeling situation-problems were formulated. The subgroups chose certain themes (for example, nutrition,

water, children's work, marijuana and housing program). These modeling tasks were to be used in primary, secondary and adult education classrooms. During GCMM meetings, each subgroup offered ideas for implementing the modeling tasks in the classroom. All team members then offered suggestions for refinement of the materials.

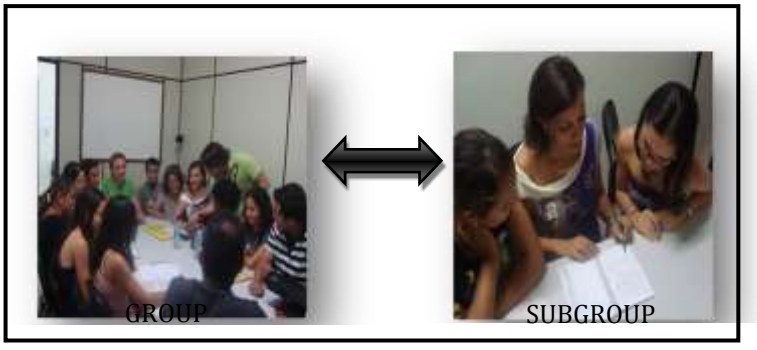

Figure 2. *Preparation of the task and planning*

Phase 2 – Implementation of the tasks in the classroom and documentation

This phase involved the classroom implementation of the tasks elaborated by the subgroups. The teachers participating in the GCMM used the tasks in their classrooms, and the other members of the subgroup video-recorded the lessons. Teachers sent a consent form to students' parents, reporting the filming of the classes and seeking their permission. Afterwards, during GCMM meetings, teachers noted important moments that arose, including: students' engagement with the task, mathematical questions and contents that were explored, difficulties the teachers experienced during the task implementation, etc. The moments that were discussed in GCMM meetings formed the basis for the design of the educative curricular materials.

Phase 3 – Analysis of the experience

In this phase, the group began organizing the parts of the educative curricular materials, such as the teachers' narratives, students' registers, videos of the classes, etc., with the purpose of making the ECMs available to other teachers once analysis phase was completed.

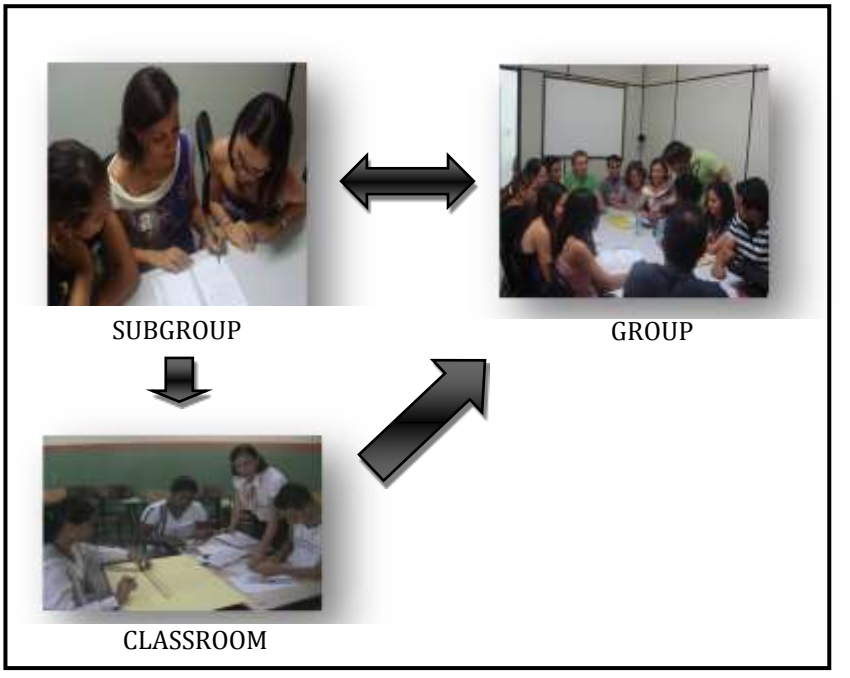

Figure 3. *Process of reviewing materials*

Phase 4 – Production of educative curricular materials

As noted at the beginning of this section, ECMs are comprised of a task designed for students and a group of materials related to the implementation of this task by a teacher who is member of the GCMM. The structure of the ECM consists of the following parts: Introduction; Task; Planning; Narrative; Teachers' solutions; Students' registers; Videos and Forums. The process of socializing the educative curricular materials for other teachers occurs in a *virtual environment* that is specifically intended for sharing the educative curricular materials. This website is expected to be a *collaborative virtual environment*. Beyond making the materials that had been made available to other teachers, it also offers a window for discussion, a forum, so users may comment on the tasks, propose questions and/or report their own experiences when using the materials.

Possible Repercussions of COMMa

In this paper, we reported on a teacher professional development project based on the concept of educative curricular materials (Remillard, 2005). Our expectation is to establish dialogue with other teachers who are interested in the materials available at COMMa and who want to come into contact with the collaborative group. Because of the on-line sharing, we have had the chance to dialogue with teachers throughout Brazil and the

Portuguese-speaking world. Yet, this contact does not mean that we dictate to teachers how to conduct modeling tasks. As noted by Bernstein (2000), we know that teachers change discourses once they bring them into the classroom. As noted by Brown (2009) and Remillard (2009), the task of the educative curriculum material is not always implemented in accordance with the original intention of its designers. Surely, any teacher who comes into contact with an ECM available at COMMa chooses what to take into their classroom and how to use the tasks. This fact raises an important research question: how do we understand how teachers change the educative curricular materials? We have reported our findings on this question in the study by Silva, Oliveira, and Barbosa (2013) as we considered what transformations teachers make as they use the on-line materials.

Using Bernsteinian an analytical lens, we suggest three possible transformations enacted by teachers: *transformations to engaging students*, *transformations to teaching the mathematical content* and *transformations to addressing the specifics of the school context*.

The *transformations to engage students* refer to the moments in which teachers changed the educative curricular materials to enable the interest and involvement of students in the mathematical modelling environment. For example, teachers may show the theme of the problem situation differently in the modelling environment to engage students in the development of the task. In our study (Silva et al., 2013), the teacher Hugo used a video to introduce the theme of the task. This strategy was used to foster a higher level of student involvement in the discussion of the theme of the task. Teachers, therefore, seem to take into account possible reactions from students. This result suggests the regulative role of students in the transformations performed by teachers.

The *transformations to teaching the mathematical content* refer to teachers' pedagogic practice for predicting the possible mathematical contents mobilized by students in solving the task. In the case of the teacher Hugo (Silva et al., 2013), in selecting content a primary consideration was continuity in the use of tasks. He selected those problems which students had studied in previous lessons. Moreover, it is possible for teachers to develop a mathematical modeling environment with the purpose of introducing mathematical content that students have not yet studied. This involves the selection of what (which) mathematical content that students should work on.

The *transformations to addressing the specifics of the school context* refer to modifications made in the educative curricular materials to address the specifics of the context of school. In the case of the teacher Erik (Silva et al., 2013), he modified an open question, which the students could exploit to potentially generate different solutions, into a closed question, for which all students found a single solution. In this case, the difficulty that the students experienced in solving the open questions led the teacher Erik to modify the structure of the task.

The transformations of the educative curriculum materials suggest that when teachers adapt them, they seek to address different principles that are already present and consolidated in their pedagogical practice. As Bernstein (2000) articulated when the teacher moves the curriculum materials for teaching practice, there are principles that control this process, and such principles change according to the context. The identification of the principles that control the transformations of the educative curriculum materials by teachers offers clues to designers for making explicit strategies that can support teachers in the transformations in their specific contexts.

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Authors:

Jonei Cerqueira Barbosa
Federal University of Bahia, Brazil
E-mail: jonei.cerqueira@ufba.br

Andreia Maria Pereira de Oliveira
State University of Feira de Santana, Brazil
E-mail: ampodeinha@gmail.com