

THE TEACHERS' TENSIONS IN THE PRACTICE OF MATHEMATICAL MODELLING

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Abstract - We present the result of an empirical study on which tensions the teachers has experienced when doing mathematical modelling. The context of this research was taken from the first experiences with mathematical modelling of three elementary school teachers from public schools. The data was collected through observation accomplished through filming of the classes, interviews after each class and narrative about the classes, with each teacher. The identified tensions in the teachers' practices were classified as: the tension of *the students' involvement*, the tension of the *students' comprehension of mathematical content*, the tension of the *understanding of the activity of modelling by students* and the tension of *deciding what to do* in the modelling practice. Thus, the analysis of the data suggests a discursive dimension for the tensions in the teachers' discourses in relation to unexpected situations that happen in the practice of mathematical modelling.

Introduction

The debate about the insertion of mathematical modelling in the school curriculum has been winning visibility in the last decades. For modelling, we understand a learning environment, in which the students are invited to investigate, through mathematics, situations coming from other disciplines or daily situations (Barbosa, 2003, 2006). One of the questions approached has been the teacher's role in this enterprise, just as, for example, it was approached in the ICMI Study 14 (Blum et al., 2007).

Niss, Blum e Galbraith (2007) have pointed out that the teachers need to have opportunities to use modelling during their pre-service education and through regular activities in their professional development. On light of this, the teachers need to develop several activities of modelling, so that they can experience a variety of situations and discuss the pedagogical implications of accomplishing modelling in the school.

Empirical studies have discussed the actions (Doerr, 2006), the strategies (Chapman, 2007), the interventions (Leiß, 2005), the content knowledge and pedagogical content knowledge (Doerr & English, 2006) and the dilemmas (Blomhoj & Kjeldsen, 2006) constituted in this practice by teachers when developing modelling in their classrooms. The aspects discussed in these studies point out that the modelling demands the configuration of situated actions in the school culture for the development of this environment and not just the knowledge of doing modelling. Thus, to understand these aspects, resultants of the insertion of an environment in the school that challenges the traditional practices, can support teachers in the accomplishment of modelling in school practice.

It is possible to identify in those studies that the notion of “tension” in the discourses gains visibility starting from the analysis of the insecurities, the difficulties, the concerns and the dilemmas in the development of modelling. In this proposal, we will present part of a wider research on teachers’ tensions in the practice of modelling. In particular, we delimited our focus with the following question: Which tensions in the teachers’ discourses are constituted when accomplishing activities of mathematical modelling in his/her practice?

Thus, we hope to generate theoretical understandings that can help us to understand the teacher’s role in developing activities of modelling. In addition, the found results could support programs of teachers’ professional development as well as other actions that focus on the insertion of modelling in the educational systems.

In the study carried out by Evans, Morgan and Tsatsaroni (2006), the authors worked with the category

"emotions" to understand the students' practice of mathematics of a classroom. The authors considered emotions as socially discursive phenomena, being formed by relationships of power and constitutive of the social identity. In a similar way, we can say that the tensions in the discourses are socially organized, because they have a more interpersonal origin than an individual one. Following this point, the tension in the discourses does not represent the manifestation of some inner psychological instance, but it is constituted through the contact among discourses that circulate and are legitimized (or not) in the social environment. However, the production of these discourses does not happen freely, being socially positioned and being part of their production conditions.

In the study conducted by Doerr and English (2006), the teacher manifested uncertainty in relation to which strategy the students could use to solve the problem during the modelling task. This uncertainty refers to the legitimacy of his/her action in this context, as discussed by the authors, constituting the tension between the implementation of the task and the uncertainty about which solutions the students could develop.

Thus, the tension in the discourses was constituted in the contact among them. Without discourse, we cannot talk about the tension among them, because it is discourse that gives meaning to the situation that the teacher experiences. The tensions can only be produced when the subject identifies – by using words, images, symbols – different possibilities of action. Therefore, we assume that the tension in the teacher's discourse is manifested through concerns, dilemmas and uncertainties, referring to the possibilities of actions, being identified as discursive phenomena.

Context and Methodology

The context of this research was taken from the first experiences with mathematical modelling of three elementary school teachers from public schools in the Northeast of Brazil. In the period in which the data was collected, these teachers were finishing a training program

for non-certified teachers at the State University of Feira de Santana. In this course, the teachers were involved in the situation-problem approach and in the development of modelling projects, as well as in the development of modelling activity in their classrooms. As the purpose of the research was to understand which tensions are manifested in the practice of modelling, the nature of the research follows a qualitative perspective (Denzin & Lincoln, 2005).

The data was collected through observation of the classes (accomplished through filming), interviews after each class and narrative about the classes, with each teacher. The analysis of the data was inspired by Grounded Theory (Charmaz, 2006), with the intention of producing theoretical understandings based on the collected data and orientated by the objective of the research. This analysis occurred in two phases: the first, involved the codification of the teachers' tensions in each class and the second consisted of classifying the codes into more general categories. After that, we were able to produce an understanding for the research problem by integrating the results in the literature.

The tensions in the teachers' discourses in the practice of Mathematical Modelling

In this section, we present the tensions experienced by teachers when developing modelling-based lessons. The teachers organized the modelling environment according to what Barbosa (2003) calls case 2; in other words, the teacher presents a problem and the students should collect data and investigate them. The modelling project of two teachers was on "Basic food for all" and of another teacher was on "Analyzing the water bill". The teachers organized the classes into groups for the development of projects.

The identified tensions in the teachers' practices were classified as following: the tension of *the students' involvement*; the tension of *the understanding of the activity of modelling by students*; the tension of *the students' comprehension of mathematical content* and the

tension of *deciding what to do* in the modelling practice. We are going to present each tension.

The tension of *the students' involvement* refers to the concern related to the students' participation in the activities.

Vitoria was the teacher who worked with the project "Basic food for all". She presented concerns regarding the theme to be focused in the modelling project, because she had doubts whether the students would have interest in the project. Thus, the tension of the students' involvement was constituted during the choice of a theme for the modelling project. Vitoria suggested that there would be some more difficult themes and other easier themes to work with the students:

"First, I thought a project about the construction of a sports facility. Then, I thought that it would be very difficult. My concern was whether the students would be able to develop the activity. After that, I thought a project about public transportation, but I found this too difficult. Next, I thought a project about a vegetable garden, but I didn't know if I would be able to manage it. However, my biggest concern was with the class. Then, I began to think about a theme that would be easy for them". (From the interview)

In this part of the interview, Vitoria voiced her concern in choosing a theme that would guarantee that the students would develop and participate in the project activities. Thus, the tension of the students' involvement was constituted in the concern involved in looking for a theme for a project so that the students would be interested in the modelling activity.

The tension of the *understanding of the activity of modelling by students* refers to the concern in relation to the students understanding the activity so that it guaranteed his/her accomplishment of it.

Maria was the teacher who worked with the project "Analyzing the water bill". She spoke to the researcher (first author) during one of the classes of the project that the groups were not able to do the calculations, because they did not understand the modelling activities. "Most of the students are not able to understand the written

instructions for the activity” (From the observation). In the narrative, she said what happened: “They asked me for explanations about the activity. Some students called me and they said that they did not have any idea how to do the calculations. One student asked her: ‘Which calculations should I do?’” As the students did not understand what they would have to do in the activities, it constituted a tension for Maria, because they were not able to know which mathematical content to use to solve them and this situation could cause the accomplishment of the modelling activity to be difficult.

The tension of the *students’ comprehension of mathematical content* refers to a concern about what the students knew about mathematical ideas and algorithms.

Boli was the teacher who worked with the project "Basic food for all". During the project’s classes, his concerns and dilemmas referred to the comprehension that the students would have about mathematical topics. Most of the time, the students demonstrated gaps in the expected mathematical knowledge for their grade level, frequently interrupting the development of the modelling project activities. During a class, when Boli followed the groups that were developing the percentage calculations for a family’s expenses, he was confronted with the fact that some students were not able to accomplish the activity. In view of that, he asked the students: “Did you study proportion and percentage in the 6th grade, didn’t you?” (From the observation). In the narrative of this class, he commented on what he observed: “I verified that almost all of the students did not have any notion of percentage or the rule of three”. This situation constituted a tension for Boli, because he did not expect that the students would not know the content. Thus, the activities could not be developed. Because of that, he used part of the classes destined for the modelling project to deal with the students’ difficulties in relation to previous contents.

The tension of *deciding what to do* in the modelling practice refers to the dilemmas of which decisions to be made in a certain moment of the class.

In the interview, Maria related that she had come across unexpected situations during the development of the modelling activities:

“Now, what am I going to do? Therefore, I have come to talk with you (first author). At first, I thought of water consumption, but the concept of parameters and treatment came up. Several new things appeared that were not in the original script. So I thought that to the students did not lose the enthusiasm, I had to give them attention. Really, at every moment that I had doubt, I had to ask: Now, where do I go next?” (From the interview)

In this part of the interview, Maria referred to the moment when she presented the activity to the students and she requested that they choose three items from the water bill to discuss with her. She did not imagine that the students would choose other items besides the consumption of water. So, then Maria had doubts about how to work with the various options presented by the students. These doubts generated the tension in how to decide what to do for conducting the process, because unexpected situations appeared and Maria had to accomplish actions. Due to these situations, Maria talked with the researcher (first author) after each class and she commented on the doubts and concerns that appeared during the class.

These tensions presented through the teachers' discourses were constituted by the difficulties, the concerns and the dilemmas involved in the development of the modelling activities. These aspects seem to refer to the legitimacy of the actions in the modelling practices of these teachers, constituting the following tensions:

- The tension of *the students' involvement*;
- The tension of the *understanding of the activity of modelling by students*;
- The tension of the *students' comprehension of mathematical content*;
- The tension of *deciding what to do* in the modelling practice.

As the teachers developed a different practice in their classes, they found new challenges to manage. The

identified tensions are likely found in other types of pedagogic innovations (and not only in math) as well. “Understanding of the activity of modeling by students” and “students’ comprehension of mathematical content” tensions describe the teachers’ concerns about the students’ interest in the task, mainly the comprehension about what is to do and the application of previous contents.

On the other hand, we noticed some concerns seemingly associated to Modelling such as the teacher choosing real subject for modeling and discussing the parameters for a situation. The data illustrated that as tensions of students’ involvement and deciding what to do, which addressed the presence of “real” situations in classroom.

Discussion and conclusion

Thus, the analysis of the data suggests a discursive dimension for the tensions in the teachers' discourses in relation to unexpected situations that happen in the practice of mathematical modelling. This discursive dimension manifests itself through the concerns, dilemmas and uncertainties referring to the possibilities of actions being socially organized and constituted through the contact between discourses that circulate and those that are legitimated in the social environment.

As in the study of Blomhoj and Kjeldsen (2006), the teachers from our study faced dilemmas that constituted specific tensions. Understanding the aspects that constitute tensions in the teachers' discourses in the modelling practice can provide indications about how the teacher develops the pedagogical knowledge to deal with them (Doerr, 2007) and the strategies used for the modelling practice in the classroom (Chapman, 2007). In our study, we observed that the teachers had to accomplish actions in order to work with the situations that arose during the modelling activity. In this way, the tensions can help the teachers in their professional development, since they can produce actions, strategies and pedagogic knowledge in the accomplishment of a new practice in their classrooms.

As implications for teacher education in modelling, it is important to approach the specific nature of the modelling and to bring the discussion on the possible difficulties, dilemmas and tensions that can happen when the teacher works with modeling by the first time.

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