

“Quaderni di Ricerca in Didattica (Matematica)”, Supplemento n.4 al n. 19, 2009.
G.R.I.M. (Department of Mathematics, University of Palermo, Italy)

COMMUNICATION IN THE CLASSROOM: PRACTICE AND REFLECTION OF A MATHEMATICS TEACHER

Maria Helena Martinho

Centro de Investigação em Educação, Universidade do Minho, Portugal
mhm@iep.uminho.pt

João Pedro da Ponte

Instituto de Educação, Universidade de Lisboa, Portugal
jponte@fc.ul.pt

Abstract

This paper discusses the conceptions, practices and reflections about practices of a mathematics teacher, Maria, with respect to classroom communication and their change during the activity of a collaborative project involving a researcher and two other mathematics teachers. The case study of this teacher, who teaches at grades 5-6, draws on interviews and participant observation of the collaborative project meetings. The results show the relevance of the project to develop the teacher's understanding of communication issues in her classroom, putting her practices under scrutiny, and developing richer communication processes between her and her students.

Keywords: Mathematics communication; Teaching practices; Reflection; Collaboration.

1. Introduction

Communication in the mathematics classroom is an element of especial interest in most recent curriculum reform movements. Particular attention is being paid to the nature of classroom interactions and to the negotiation of meanings between teachers and students. The analysis of communication processes and their development in the classroom was the theme of a collaborative project involving three teachers from the same basic school (with students at grades 5-9). Three case studies were made, one of each teacher. These teachers were all very different and very interesting. In this paper, given the space constrains, we choose to present just the case of a teacher, Maria, who experienced the most noticeable change (The reader is referred to Martinho (2007), for a complete account of the whole project and the case studies of the other two teachers). This paper addresses the work of this teacher, discussing her conceptions, practices and reflections on her own practices with respect to classroom communication and how they changed through this collaborative project.

We begin providing a brief characterisation of communication phenomena in the specific context of the mathematics classroom and then we describe the case of the teacher involved in the project. In particular we analyze her conceptions and practices with respect to communication, her reflections on her own practices, and the influences of the collaborative work. Finally, we suggest some issues for future research.

2. The teacher and classroom communication

Communication in the mathematics classroom. Several authors underline the relevance of communication in the mathematics classroom (e.g., Bishop & Goffree, 1986; Ponte & Santos, 1998; Sierpinska, 1998; Voigt, 1995; Yackel & Cobb, 1998). Communication may be regarded as a social process along which participants interact, sharing information and mutually constraining their evolution. It concerns not only the heterogeneous set of interactive processes evolving in a classroom but also their contexts, underlying denotations, and expressive resources. Such a perspective regarding mathematics classroom communication includes the study of two main issues identified in the literature (Ponte, Boavida, Graça & Abrantes, 1997): (i) the nature of the *continuous interaction* between the classroom participants, and (ii) the *negotiation of meanings*, understood as the processes such participants set to share and adjust their own ways of making sense of the mathematics concepts and procedures, and their evolution and relation to the formal curriculum contents. Mathematical learning requires a stepwise construction of a framework of reference through which students construct their own personal account of mathematics in a dynamic tension between old and newly acquired knowledge. Managing such tension is a fundamental part of the role of the teacher who needs to take into account that the negotiation of meanings tends to decrease with the increase in the control of the teacher over the classroom dynamics (Bishop & Goffree, 1986).

There are countless interaction processes happening in a classroom. Of especial import are the interactions between the teacher and the students, which simultaneously constrain and are constrained by the kind of lesson. For example, in a teaching-learning context stressing exposition and solving exercises, the teacher tends to assume a high level of control. In other contexts, instead, the teacher may assume the role of a coordinator. The way the teacher regulates the classroom discourse, the nature of questions asked, and the opportunities afforded for student participation may sustain in various degrees the development of communication and reasoning skills (Barrody, 1993). On the other hand, the role of classroom interactions among students cannot be underestimated. Many interactions, with rather smaller formal content, become essential to stimulate students' discovery and critical reasoning, as well as to foster personal appropriation of common meanings.

Research provides evidence that student-student interaction in lessons involving projects, investigations and problem solving tasks, carried out in groups, provide deeper experiences than interactions that take place while students do exercises (Alrø & Skovsmose, 2002; Ponte et al., 1997; Yackel & Cobb, 1998). Students feel more comfortable talking in small groups (Lester, 1996), in “non-threatening” environments (Buschman, 1995), where they progressively master the mathematical way of expressing themselves. Inversely, when interactions only take place in whole class, students become more reserved, removing themselves out of the discussions if they are unsure about how their voice is considered by the teacher and their colleagues (Alrø & Skovsmose, 2002).

The role of the teacher. The fundamental role that the teacher plays either in enabling or in limiting communicative processes within the classroom is widely recognised (Barrody, 1993; Lappan & Schram, 1989; Pimm, 1987). Such a role makes itself explicit from the outset, for example, when selecting challenging tasks or encouraging students to express and sustain their own views (Lampert & Cobb, 2003; Ponte & Santos, 1998), or else when resorting to tasks and educational materials that put the focus of the lessons on mathematical ideas, conjectures and intuitions, instead of on calculations and procedures.

“Quaderni di Ricerca in Didattica (Matematica)”, *Supplemento n.4 al n. 19, 2009.*
G.R.I.M. (Department of Mathematics, University of Palermo, Italy)

Teachers are also responsible for creating an atmosphere of self-esteem and mutual respect, so that students feel comfortable to participate in the classroom activity. They have an important role in structuring the classroom discourse, namely through the questions that they pose. Love and Mason (1995) distinguish three main kinds of questions: *focussing*, *confirmation* and *inquiry*. The first kind of question aims at focussing students' attention into a specific issue. Confirmation questions test students' knowledge of facts and procedures. Finally, inquiry questions are the “real” questions, as the teacher asks what he/she does not know. Asking questions in the classroom often falls into what is called the IRA (*initiate, respond, assess*) or ‘triadic sequence’ (Lemke, 1990). Such an interaction scheme is quite common, and is usually regarded as a convenient way not only to “keep speech control”, but also to “go around or ignore a number of answers” (Pimm, 1987, p. 64). The IRA sequence may involve several students in the class (Lemke, 1990), but their participation is limited to short, reactive answers. As Alrø and Skovsmose (2002) remark, it emphasises the role of the authority of the teacher in the classroom.

To promote the communication dynamics in the classroom, the teacher is expected to stimulate students' interest and to have the ability to enrich their mutual interactions. Steffe and Tzur (1996) underline the teacher's role in bringing to the fore the independent activity of each student. Therefore, the authority must be decentralised and the students must have the power to assess what is correct or fake in an argument (Alrø & Skovsmose, 2002). This entails the need for ways and opportunities for students to question themselves, even if the opposite attitude is still rather common (Ponte & Santos, 1998).

3. Methodology

As mentioned in the introduction, this paper is based on a collaborative project involving a researcher (the first author of this paper) and three mathematics teachers, one at grades 5-6 and the other two at grades 7-9. The project lasted for one year and a half and had weekly to bimonthly meetings. It was based on the theme of communication in the mathematics classroom and had the two main objectives: (i) to characterize factors that constrain or facilitate communication in the mathematics classroom and practices that may correct or foster them; and (ii) to find out in ways through which tasks and the overall organization of the mathematics classroom may improve the mathematical communication and support the students in developing appropriate communication skills. The project meetings were devoted to a variety of tasks, including the analysis of documents, lesson planning, reflection of lessons carried out, free debates on communication issues, and further planning and evaluation.

The conceptions, practices, and reflections of the teachers in the project were studied using a qualitative and interpretative approach (Erickson, 1986) based on a case-study design (Ponte, 2006; Yin, 1989). Data gathering was based on two semi-structured interviews and on the observation of group meetings. A number of lessons were selected by the teachers themselves to be observed and recorded by the researcher and these lessons were later discussed in a group meeting. Records included audio taping meetings and writing researcher's field notes. Maria was interviewed when she joined the group (I1 - Interview 1) and again by the end of the academic year (I2 – Interview 2). The researcher made verbatim transcripts of all interviews and all meetings of the collaborative project (M1 to M25, Meeting 1 to meeting 25).

4. Maria

Introduction. Maria is 52 years old and has 31 years of experience as a basic education teacher (most of these years teaching grade 5-6 students). She is married and has two children, already grown up. She assumes her work with professionalism and commitment. For six years she served as a school director and she is quite active in a trade union. She concluded a bachelor's degree in chemical engineering in 1974. Becoming a teacher was not her first professional option. But she got a teaching job, liked it and later completed another degree on teaching natural sciences. This background may explain her main concern as a mathematics teacher: to provide evidence of the usefulness of this subject. Her lessons, as she says, follow a traditional format: she writes down the summary of the previous lesson and recalls its subject, reviews the homework, moves to a new topic, proposes a few exercises, and, finally, assigns new homework.

Conceptions and practices about communication. Maria finds it fundamental that the classroom has a pleasant atmosphere. As she puts it: “I always try to avoid giving orders, but I say instead ‘I’ve asked you to do...’” (I2). Her interest on group work increased with her participation in the project. In the first interview she stated that using group work in class was not her priority. Later on she expresses a different concern: “To plan [for the following year] a lot of group work (...) discovery tasks, with manipulatives (...) with little guidance”. Moreover, she considers that if a more active role is assigned to the students, then the lessons become more interesting. She prizes students’ participation in the classroom and always tries to get all of them involved, resorting either to direct questions or open sentences that they must complete.

Maria tries to get everybody involved, even if sometimes the participation of some students is minimal: “I do not restrict myself to above average students. Often I confront students with difficulties even if I know they will limit themselves to a humble ‘I don’t know’” (I2). Usually, the students ask a lot of questions during lessons: “Normally it is like this: ‘I didn’t understand’. (...) But a few of them would ask ‘Can’t this be made like this?’ I answer: ‘Come to the blackboard and show us’” (I2). She also values the emergence of different strategies for a given problem. Maria compares and discusses these strategies, because she thinks that the students tend to be more involved when their way of solving problems is under scrutiny: “I say: ‘Please come here to compare our work’. And that’s it: there are no unique or best approaches to a problem” (I1).

In the first interview Maria explained her strategy to foster everybody’s participation: “I say: ‘Write it in the air!’ They find it funny. Some of them try to simulate writing carefully so that I can understand their input” (I1). This shows her commitment to make confirmation questions in a systematic way, trying to help students that have more difficulty in participating, and providing clarification as soon as she sees that they are confused. Her concern in identifying, discussing, and correcting errors or misunderstandings tells a lot about her perception of the teacher’s role – to signal the correct response, like the route in the map: “My reaction is to fix it straight away (...) ‘Look! Are you following me?’” (...) They say ‘Yes’, but I often wonder if the lesson is learnt” (I1).

Maria also values students’ autonomy, but she is aware of their difficulties: “Certainly all of these small steps help students to construct mathematics. My question is: Is there enough time? Which percentage of a lesson can be used for discovery, for building insight?” (M18). She

“Quaderni di Ricerca in Didattica (Matematica)”, *Supplemento n.4 al n. 19, 2009.*
 G.R.I.M. (Department of Mathematics, University of Palermo, Italy)

is also aware that the students prefer to work on open tasks and that excessive control from the teacher makes the lessons rather dull: “They like this sort of tasks, in which they do not have to guess. The way they follow to solve the problem is what they see as fundamental” (M17).

Reflection on practices. We now discuss Maria’s communication practices and her reflections on them starting with a set of episodes from the statistics unit taught in a grade 5 class. Such unit was largely planned at the project meetings. In all classes the students worked in seven groups, with four students each and balanced in gender. The work always started with a brief discussion of what had been achieved in the previous lesson and the definition of the task to be done. By the end of the class, the teacher discussed with each group the work done and the plan for the following lesson. Each group chose a leader to report the conclusions.

Table 1: Lessons schedule

Lessons	Topics
1	Introduction to statistics. Reading and interpreting newspaper fragments, in group. Discussion in the classroom of the emerging (different) interpretations. Introduction to the working theme: water consumption. Each group prepares two to three questions on water consumption (as homework students gathered relevant information to answer them).
2	Each group analyses answers to the part of the questionnaire assigned to it.
3	Data organisation is concluded. Each group prepares a slide with its conclusions.
4	Slide preparation is concluded. Results from the first three groups are presented and discussed.
5	Results from the remaining four groups are presented and discussed.

As the collaborative project developed, Maria’s critical sense and ability to question herself became more and more visible. Facing a discussion, a text or an episode, she always tries to provide illustrations from her own practice, to make comparisons, and even to place herself in the role of a student. For example, when discussing the sort of questions proposed to the class, she recognises that, in group work, inquiry questions emerge more naturally than in a conventional lesson: “Sometimes I have to ask further, because it is myself the one who doesn’t understand what they want to achieve and how” (M22). She reflects on the increased students’ commitment to the class and suggests that lessons with a focus on inquiry questions are intellectually more attractive for the students than the lessons based on other kind of tasks. She comments: “We have to recognise this task was intellectually more demanding. They had to listen the work of others, to interpret tables and graphics, to discuss what others have concluded often in a confusing way. But also much more motivating” (M22).

Maria is concerned about her own language in the class. She says, for example: “Some of my sentences are incomplete... How can they understand what I said if I do not complete my

“Quaderni di Ricerca in Didattica (Matematica)”, *Supplemento n.4 al n. 19, 2009.*
G.R.I.M. (Department of Mathematics, University of Palermo, Italy)

own reasoning?” (M22). She recognises that the IRA pattern is dominant in the first lesson of this sequence as well as in the group presentation in the end. And she wonders: “I ask myself: Is this unavoidable? Or is it difficult to do otherwise?” (M22). An episode of lesson 1 in which this way of questioning is quite visible is the following:

Maria: (...) And this group? What did you conclude?
Ricardo: Natural gas, energy and coal.
Maria: Just this: Gas, energy and coal? Any more information? (...) Yes, André?
André: The first page is on employment and unemployment.
Maria: Where? In China? In Guinea-Bissau?
André: Portugal.
Maria: Anything to add?
André: The second [page] is on a loan.
Maria: Of what?
André: Money.
Maria: More...
André: The third one is the rise of oil...
Maria: Did it go upstairs? [they laugh] Do you think this information is enough for us to understand? Oil rise... If it is not a change in position, what is it?
André: Price...

Again, Maria points out that, although this discussion emerged from the interpretation of the work that the students carried out in small groups, her questions were rather traditional: She knew all the answers. She recognizes that the discussion was focussed on herself and was “quite brief”. But, on the other hand, she comments the following episode, from lesson 4, during the presentation of group work, saying: “Here the IRA pattern was not overwhelming” (M22).

Maria: (...) My question is: If I show such a result to another class, without showing them the question (...), just saying “most frequent answer is 10 minutes”, would it be possible for them to understand the issue?
Ana: I do not think so.
José: Yes, it is.
Maria: Do you think nothing more is required?
Marta: They need the question!
Maria: If, for some reason, this is unavailable, will there be a second way...?
André: We explain better.
Maria: ... So that whoever looks at the results of your work, could say: Ah! This result is about that! If they fail to ask... What to do?
Ricardo: I think the number of people and minutes involved should not be given at the end but at the beginning.
Maria: Would that be better?
Ana: It's the same.
Maria: Agree? (silence) I think there is another alternative.

Actually, it is easy to note the difference between the kind of questions present in the two episodes. In the former all the questions were intended to guide the dialogue. In the latter, how-

“Quaderni di Ricerca in Didattica (Matematica)”, Supplemento n.4 al n. 19, 2009.
G.R.I.M. (Department of Mathematics, University of Palermo, Italy)

ever, questions are rather open: Maria invites her students to regard themselves as in the place of other colleagues, from another class, and simply tries to facilitate that experience.

With respect to *negotiation of meanings* Maria acknowledges that the collaborative project made her more attentive to this process. She mentions this in relation to the following episode, also from lesson 4, recorded in a group work when the presentation was being prepared:

Paula: (Writing in the slide) 4% have a proper bath.
Pedro: This is not a percentage!
Paula: But 4 students make 4%.
Pedro: In the whole they are 28... (Maria approaches the group).
Paula: (Addressing Maria) 4%, isn't it?
Maria: Why do you think it is 4%?
Pedro: Can't be! I've already told her.
Maria: Can you explain, Pedro.
Pedro: 4 out of 28 does not make 4%.
Maria: Why?
Pedro: It has to be 100.
(Paula, realizing her misunderstanding, corrected the slide)

In the group meeting she comments this episode as follows: “If we hadn't discussed this here in the group, I would, most probably, go ahead, just mentioning that percentages would be taught in the coming year and asking them [the pupils] to accepted my correction for the moment” (M22).

Actually, Maria understood the way Paula and Pedro were thinking and induced a process of negotiation of what percentage means. This dialogue was rather useful for both students and later shared with the whole class. In particular, Maria became aware this was a much more effective learning experience for Paula than what could be achieved through formal teaching Maria feels this moment illustrates an evolution in her practice: the ability to seize the opportunity whenever it comes. She says: “That's it! All this concern is the net result of our work [in the project]” (M22).

Influences. Maria recognizes that the experience of the collaborative project was a source of professional “added value”. The project made it easier to plan, implement and assess new teaching experiences. As she says: “This forces us to think”. And later she adds: “I love this work! But did I learn anything really new? No. Most of it we already knew... But we were unable to put it into practice. (...) This work questions myself” (M23). She goes on: “Our lessons are planned the way we get used to from our earlier experiences. (...) Without a possibility to share, review, criticise, the years go on and we stay close to the starting point” (M25). How relevant the project was with respect to the development of her own classroom communication skills is witnessed by her words in the analysis of this lesson: “Now I pay more attention to what students say. My own comments became more succinct and crisp” (M22).

On a number of occasions Maria provided evidence that this collaborative project meant a lot to her in several regards: (i) By becoming aware of communication difficulties – “The starting point to think about communication is to recognize that problems exist” (M25); (ii) By experiencing new communication strategies, namely in conducting group work – “I discovered the relevance of students taking notes and reporting their group work for improving communica-

“Quaderni di Ricerca in Didattica (Matematica)”, Supplemento n.4 al n. 19, 2009.
G.R.I.M. (Department of Mathematics, University of Palermo, Italy)

tion” (I2); and (iii) By discovering the relevance of sharing with other teachers – “To change things we cannot be alone, we need to share” (I2).

5. Conclusions

The case of Maria provides evidence on how important this collaborative project was for the practice of this teacher. Having the possibility to plan, review and assess new teaching experiences made her understand the relevance of seeking new forms of work in the classroom. Before the project, she was likely to speak most of the time in a lesson, controlling its dynamics in a rather strict way. Her concern to keep students interested and to cover all the official curriculum, explains the sort of direct confirmation questions that she used. In the collaborative project, she learnt how to carry out more flexible teaching strategies, promoting pupils’ autonomous without compromising the curriculum. With the development of the project, she brought to the classroom a more accurate perception of her role in the communication dynamics of a classroom, in particular her concern to listen carefully to each student. She became an enthusiastic of group work and got convinced that in this way her own communication with students became more natural and effective.

Future investigations must study how this sort of collaborative work can be integrated in the daily routine of a school, reducing, or even dispensing, the structuring role of an external researcher as happened in this case. Another question concerns the identification of the elements that may constrain or favour the evolution of a teacher in such projects, at different grade levels, with different kinds of students, and in different social and curricular constrains.

REFERENCES

- Alrø, H., & Skovsmose, O. (2002). *Dialogue and learning in mathematics education: Intention, reflection, critique*. Dordrecht: Kluwer.
- Barrody, A. (1993). *Problem solving, reasoning, and communicating, K-8: Helping children think mathematically*. New York, NY: Macmillan.
- Bishop, A. J., & Goffree, F. (1986). Classroom organization and dynamics. In B. Christiansen, A. G. Howson & M. Otte (Eds.) *Perspectives on mathematics education* (pp. 309-365). Dordrecht: Reidel.
- Buschman, L. (1995). Communicating in the language of mathematics. *Teaching Children Mathematics*, 1(6), 324-329.
- Erickson, F. (1986). Qualitative methods in research on teaching. In M. C. Wittrock (Ed.), *Handbook of Research on Teaching* (pp. 119-161). New York: Macmillan.
- Lampert, M., & Cobb, P. (2003). Communication and language. In J. Kilpatrick, W. G. Martin, & D. Shifter (Eds.), *A research companion to principles and standards for school mathematics* (pp. 237-249). Reston, VA: NCTM.
- Lappan, G., & Schram, P. (1989). Communication and reasoning: Critical dimensions of sense making in mathematics. In P. R. Trafton & A. P. Shulte (Eds.), *New directions for elementary school mathematics* (pp. 14-30). Reston, VA: NCTM.
- Lemke, J. L. (1990). *Alking science: Language, learning, and values*. Norwood, NJ: Ablex.
- Lester, J. B. (1996). Establishing a community of mathematics learners. In D. Schifter (Ed.), *What's happening in math class? The mathematics classroom: A community of inquiry* (pp. 88-102). New York, NY: Teachers College Press
- Love, E., & Mason, J. (1995). Telling and asking. In *Subject learning in primary curriculum*. London: Routledge.
- Martinho, M. H. (2007). *A comunicação na sala de aula de Matemática* (PhD Thesis. University of Lisbon).
- Pimm, D. (1987). *Speaking mathematically: Communication in mathematics classrooms*. London: Routledge.
- Ponte, J. P. (2006). Estudos de caso em educação matemática. *BOLEMA*, 25, 105-132.
- Ponte, J. P., Boavida, A. M., Graça, M., & Abrantes, P. (1997). *Didáctica da Matemática: Ensino secundário*. Lisboa: Ministério da Educação.
- Ponte, J. P., & Santos, L. (1998). Práticas lectivas num contexto de reforma curricular. *Quadrante*, 7(1), 3-32.
- Sierpinska, A. (1998). Three epistemologies, three views of classroom communication: Constructivism, sociocultural approaches, interactionism. In H. Steinbring, M. G. B. Bussi & A. Sierpinska (Eds.), *Language and communication in the mathematics classroom* (pp. 30-62). Reston, VA: NCTM.
- Steffe, L., & Tzur, R. (1996). Interactions and children's mathematics. In P. Ernest (Ed.) *Constructing mathematical knowledge: Epistemology and mathematical education* (pp. 8-32). London: Falmer.
- Voigt, J. (1995). Thematic patterns of interaction and sociomathematical norms. In P. Cobb & H. Bauersfeld (Eds.), *The emergence of mathematical meaning: Interaction in classroom cultures* (pp. 163-202). Hillsdale, NJ: Lawrence Erlbaum.
- Yackel, E., & Cobb, P. (1998). Sociomathematical norms, argumentation, and autonomy in mathematics. *Journal for Research in Mathematics Education*, 27(4), 458-477.
- Yin, R. (1989). *Case study research: Design and methods*. Newbury Park, CA: Sage.