COMMUNICATION AND COLLABORATION IN SUPPORT OF A SIGNIFICANT MATHEMATICAL LEARNING

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Recurrently we observe that the practice of teaching probability prioritizes the use of rules and formulas. In other words, teachers develop the concept of probability by repetitive exercises, reproducibility, like a mechanical process. In this way the teacher is an enunciator while the students become listeners, reproducing the information. However, we believe in a more collaborative and communicative process to teach the topic. This article is a result of two research projects. Although they had different purposes, themes and subjects, they were developed concomitantly, using the same tools and with mutual cooperation between the two researchers. In this paper we discuss the process of developing problem solving ability in the students, where they act as the protagonists of their own process of conceptual development, and how cooperation between teacher and researcher can help in this process.

INTRODUCTION

The lack of experience in the early part of our careers led to some inquiries and concerns, which motivated us to seek answers in order to improve our methodology and our teaching practice inside the classroom.

We always believed in a shared character of work, since we worked that way in our school, and that made us seek and find the GRUCOMAT - Collaborative Group of Mathematics – from the São Francisco University, in Itatiba - SP, under the guidance of university professors Adair Mendes Nacarato and Regina Celia Grando.

In this group, our focus turned to the improvement of our practices in math classes and, thus, the collaborative actions that were already being made by us initiated the two research studies, from the teacher-researcher authors of this article, which had as central themes: "The development of probabilistic meanings in students from a grade 10 classroom" and "The analysis of evaluation processes, from a formative perspective in the context of problem solving by students of a grade 9 classroom".

Through this study group (GRUCOMAT), we were able to become familiar with the methodology of problem solving, from the perspective of NCTM (1991), Shaughnessy (1992), Sáenz (1999), Batanero (2001), Van de Walle (2009), and other authors.

The differential in our research was the fact that the same sequence of tasks that related to the concepts of probability was performed concomitantly in the two teachers' classrooms, who then became teachers-researchers-collaborators, each having an eye to the other's classrooms and each under her own research focus.

In our research, we were able to investigate that, although we had different foci, the results showed many intersections, such as the importance of communication, interaction and negotiation of meanings for developing probability concepts. Thus, the fragment that we will bring to this article takes into account a common axis between the two research studies: the potential of the processes of communication and interaction among students, through the negotiation of meanings for the building of concepts when participating in a sequence of tasks of probability; and how the discussion and analysis of the students' outputs are extremely significant when performed collaboratively between teachers who share the same methodological approach.

METHODOLOGICAL PROCEDURES OF THE RESEARCH

The research from Marocci (2011), which investigated the development of probabilistic meaning, was based on the assumptions of Vigotski (2000; 2007), which highlights the circulation of meanings among the students. Vigotski suggests that concepts are constructed by the student through his or her experiences in the subject, which lays the foundation for generalization. Furthermore, this research relied on the theoretical framework of cultural-historical perspective that

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provides rich support for the organization of the classroom as a space for conceptual development of probability through problem solving.

Furlan (2011) investigated the processes of evaluation, which had as theoretical foundation the studies of Santos (2008) in defense of the importance of a sequence of tasks in a methodological perspective of problem solving, based on communication and the negotiation of meanings to promote reflection on mathematical concepts. “The reflection is for the student, in the questioning of his or her schemes of thoughts and his or her routines, the ability to distance themselves from their ideas to acknowledge the interest and importance of a new reconstruction” (Santos, 2008, p. 15).

The selected and adapted tasks for the sequence had as characteristics the exploitation of probabilistic language and involved estimations, predictions, the raising of hypotheses, experiments and calculations of measures of chance.

Several instruments were used in the production of the data, such as: the production of an oral newspaper, the use of games with the production of oral and written records on the analysis of games, the production of a comic strip and also the exchange of letters between the two research participating classrooms.

Although the events in both classrooms were different every day, and in each of the classrooms of the teachers, in general, the classroom dynamics occurred so that students, always working in groups, drafted resolutions to the problems presented, organized records on these resolutions and, finally, interacted with colleagues in the room. These discussions for socialization of problem solving were recorded on video and constituted the data for this study, together with audio recordings of discussions in small groups, the researchers’ field diaries, records written by the students, and audio and written records of discussions among the teachers-researchers.

Some Significations that Circulated Through Discursive Practices in our Classrooms

We selected one of the tasks from the sequence applied in both classrooms: the game “Crossing the River”, taken from the website of the Association of Math Teachers of Portugal (APM). The game comprises a board simulating a river and its banks, two sets of twelve chips, each of a different color, and two cubical dice numbered one to six.

Rio	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**

Board of the game “Crossing the river”

The game rules ask that each player put their chips on one of the river banks, however they want, and they can put more than one in the same square, leaving others empty. The players alternately roll the dice and calculate the sum obtained. If the sum corresponds to a square where there are chips wagered, the player can move one of the chips across to the other side of the river. The winner is the player who can get all their chips to the other side.

In Furlan’s (2011) research, the discussion with all the students in the class was very rich due to the significant mediation from the teacher, in the case, Lia. The potential of communication is evident in both the construction of concepts of probability, as the formative potential of the environment of negotiation of meanings. For this purpose, we bring in the following excerpt from the socialization of the game “Crossing the river”.

In the episode in question, the student Raf.A. goes to the front of the class to defend why he bet on the numbers 5, 6, 7 and 8, arguing that these numbers were more likely to be rolled than 12, for example, which was wagered by his opponents.

Lia: *So 12, Raf.A.?*
Raf.A.: *A 12 is rolled only with two 6.*
Lia: *So what?*
Raf.A.: *So it’s only one possibility.*

Fer.: *So how do I write this?*
May.: *Put "a 12 is rolled only with 6+6".*
Lia: *So Raf.A., do you think 12 wasn't easy to be rolled?*
Raf.A.: *No.*
Lia: *And the other numbers?*
Raf.A.: *There's only 2 possibilities for 11 because 11 is rolled only with 5+6 and 6+5.*

The socialization continues until the teacher intervenes once more.

Lia: Ok, so let's think. Why, then, was Raf.A's strategy better? Let's think of the numbers 7 and 6. What are the possibilities of rolling a 7 and a 6?
Jo.L.: *10%.*
Lia: *No! Not the probability. For example, in what ways can we roll a 7?*
Sar.: *It could be 3+4 or 4+3.*
May: *5+2 or 2+5.*
Raf. A.: *There's 6 with 1 and 1 with 6.*
Lia: Right, so how many possibilities are there?
Adr.: *Too many!*
Raf.A.: *There are 6.*

We realized that, through interaction between students mediated by interventions from the teacher, they participated in a process of reflection together. Many misconceptions surfaced and new understandings emerged throughout the discussions. The most important factor is that the concept was built by the students; it was not exposed or imposed by the teacher. We note that in the formative evaluation processes in learning environments that value communication, the hypothesis are considered and (re)considered, discussed and (re)analyzed. Thus, the assessment becomes "a process of dialogue between actors, from different points of view, which is able, through the explanation of their differences, to build common and shared understandings" (Santos, 2008, p.14).

From these reflections, we highlight the development of probabilistic thinking as a process of negotiation of meanings mediated by language and actions organized by teachers. We were careful with the preparation of the tasks so that they allow the problem-related contexts and situations that would allow students to develop argumentation skills, strategizing, communicating ideas, data interpretation. We understand, therefore, that "the development of probabilistic and statistical thinking, no doubt, can bring about the formative potential of the discipline of Mathematics" (Lopes, 2008, p.63).

SOME CONSIDERATIONS ABOUT THE COMMUNICATION IN OUR RESEARCHES

In our reflections and (un)certainties, we could verify that when students are faced with supported tasks in contexts in which communication, dialogue, interaction, reflection and mediation prevail, we can get a formative assessment of the students' learning.

We conjecture that the context of problem solving favors the development of this formative environment by giving students confidence in their own abilities.

We understand that to be a conducive learning environment for the development of probabilistic thinking in students, it was necessary to seek support on theoretical concepts, such as problem solving, a cultural-historical perspective, processes of formative assessment and probability. All these concepts together helped to create the classroom environment for the production and analysis of data from both researchers.

We observed a common point in our research: the interaction between the students promoted the movement of meanings and, consequently, of learning. We observed that a pedagogical action is needed in order to set in motion the thinking processes of the students. It needs to occur both when the task is being chosen, as well as during the discussion. We found that this pedagogical action is strengthened when there is a partnership between teachers. In our research, this partnership was built little by little, in a relationship that involved mainly sincerity and mutual respect, which is the result of some years as colleagues, sharing ideas, practices and questions with regards to the teaching practice.

The dialogue between us opened space for a reformulation and a redefinition of ideas, which made possible a joint reflection and, thus, the development and enhancement of the

knowledge inherent in teaching practices. The dialogical process established during our conversations led to personal and professional development, made us dependent on the collective practice of sharing ideas, and provided the potential that collaboration provides for the professional development of teachers. Our job as teachers was conducted jointly, "not in a hierarchical relationship, but on an equal basis to enable mutual help and to achieve goals that benefit everyone" (Boavida & Ponte, 2002, p.45).

Finally, we found that communication was critical to our research both inside and outside the classroom. Communication among students and teachers was necessary to develop student ideas so that they could build concepts related to probability. Outside the classroom, the teachers communicated and analyzed the productions of the students to decide the next strategies that would contribute to the development and construction of probability concepts by the students.

We believe that our research has become a two-way street, because it is a work of sharing ideas between two teachers-researchers-collaborators. Would it be two research studies in one, or rather, one research study in two parts? You cannot define this because even we, teachers-researchers, were confused.

However, this confusion has enabled many moments of relaxation, learning and professional development and it enabled the construction of an environment of production of significative probabilistic knowledge through the communication of ideas, which was the main goal of the researchers, while teachers.

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