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Strategies that promote the mathematical activity of students with language disorders: an analysis of language interactions

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This article outlines the methods of a teacher of mathematics who works with a class of students with language disorders related to autism. By adopting the theoretical framework of the Dual Approach (ergonomics and didactics) and Maturanian epistemology, we show how an analysis of language interactions allows for a better understanding of teaching practices and their influence on the mathematical activity of students. We explore the nature of the language interactions, both verbal and non-verbal, within a specific learning project, when it comes to reinvesting, in a non-explicit way, basic mathematical objects. Our analysis highlights the richness of a practice in which the teacher proposes different types of help to trigger the mathematical activity of her students.

Keywords: Language interactions, mathematical activity, teaching practice, language difficulties.

Problematic

In Quebec, approximately 15 000 students have an autism spectrum disorder. In general, these students present difficulties related to language, communication and social interaction with their peers (MSSS, 2017). Moreover, since language interactions are an integral part of the teaching practice, finding ways to carry out a project represents a significant challenge in the context of a special class for students with autism (Odier-Guedj & Gombert, 2014). For the teaching of mathematics, this phenomenon is particularly problematic given the difference in the meaning of words in everyday language and those used in mathematical language. Although the Ministry of Education prescribes guidelines encouraging teachers in Quebec to adapt their practice according to their students' characteristics (MELS, 1999), operational means are not proposed. Thus, teachers are required to determine and implement their own means of adaptation. In this context, research in psychology of ergonomics and didactics (Robert & Rogalski, 2002) has led us to question the way that teachers adapt their practice in order to meet the specific needs of their students, and to inquire whether these adaptations and this help contributes to the mathematical activity of their students.

This paper focuses on the richness of the language interactions and the types of help offered by a teacher to trigger the mathematical activity of her students. In this article, we present a part of our analysis of the practices of a teacher within the context of a project requiring students with autism spectrum disorder to build a birdhouse to reinvest basic mathematical notions. We begin by outlining our epistemological stance, our conceptions of language and mathematical activity, as well as the types of help offered by the teacher to trigger the students' activity. After highlighting our framework for the analysis of teaching practices, we reveal an overview of our results.

Epistemological foundation and theoretical context

What is mathematical activity

Mathematical activity accounts for the process of appropriation and reasoning required to answer or mathematize a given problem or situation (e.g. Freudenthal, 2012; Proulx, 2015). Within the framework of our research, mathematical activity exists as a process of “coordinations of coordinations of doings” (Maturana & Verden-Zöller, 2008). In this process, teacher and student actions take place within an ethical space where their legitimacy is mutually recognized. Their immediate actions and their respective historical and cultural experiences (Radford, 2010) are interrelated to their representation of mathematics and shared by and through different forms of language (Barrera-Curin, Bergeron, & Perreault, in press). According to Maturana and Verden-Zöller (2008), interactions emerge within and through language as a way of coexisting in the coordination of coordinations of actions. Language, in all its forms, becomes a fundamental element to consider when studying interactions within an educational context.

Language and the specificity of teaching practices

Many recent studies in the fields of didactics of mathematics and mathematical education have focused on the link between language interactions, language and mathematics (e.g. Bulf, Mithalal, & Mathé, 2015; Morgan, 2013; Moschkovich, 2010; Sfard, 2008). Within the framework of our research (Barrera-Curin, Bulf, & Venant, 2016), the language of mathematical activity is considered as a dialogical and situated activity involving not only language with its written and verbal codes, but also the diversity of its manifestations. The appropriation of mathematical objects, “does not necessarily result in the same consequences for all persons, because it is a historical, situated and individual process” (Bauersfeld, 1995). As Bauersfeld (1995) raises it: “only across social interaction and permanent negotiations of meaning can “consensual domains” emerge” (p. 275).

In order to study language interactions where students’ language difficulties are added to the already existing constraints influencing teaching practices, it is necessary to observe these practices in a localized way. In studies that articulate didactic, psychological and ergonomic concepts (Robert & Rogalski, 2002; Roditi, 2013) the teacher’s task is viewed as the management of a diverse, dynamic and complex environment where interventions focus on knowledge acquisition and on students, while considering that students progress according to their participation and interactions in the classroom. The mediating and cognitive components of a teacher’s practice are central to the didactical organization of the mathematical tasks proposed by the teacher and adapted through interactions with the students. Thus, a teacher’s practice includes the targeted mathematical content, the choice of tasks and their organization, the types of help offered, classroom management, the language forms chosen by the teacher, and the different forms of student work. As we enrich the dual approach with Maturana and Varela’s framework as seen below in Figure 1, the teacher’s activity is viewed as a process of adaptation resulting from the coordination of the coordinations of actions between a teacher, their students and the environment.

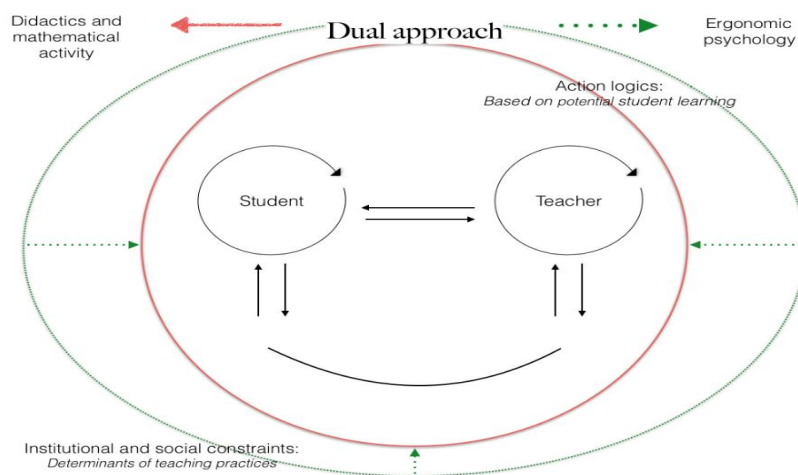


Figure 1: Modeling teaching activity (Barrera-Curin, Bergeron, & Perreault, 2018)

The teaching activity can be grasped by analysing beyond the immediate observation of interactions in the classroom: institutional constraints, historical background, action logics of the teacher and personal beliefs, didactical implication and interaction in context. Therefore, analysing this activity must take into account different components of the action *in situ*. To identify those components, the Dual Approach (Robert & Rogalski, 2002) propose the observables concept, which take place within the language interactions between the students and their teacher. The observable categories consist in types of helps, task enrollment attempts and interaction surrounding mathematical objects (Barrera-Curin et al., in press). Procedural helps act directly on the initial task by dividing it in a series of simpler ones. Constructive helps focuses on questioning the student in order to serve his knowledge construction. Compensatory helps aim to compensate a disorder of the student that could slow down or prevent his mathematical activity.

In the present work, we focus on the articulation of these types of help with the mathematical tasks proposed to the students in order to observe in which ways mathematical actions are brought forth. In other words, we study how different types of help within language interactions carried on by the teacher trigger the mathematical activity of the students in the context of a specialized class.

Analyzing the articulation of language and mathematics

Five teaching sessions were observed and videotaped with focus on language and interactions surrounding mathematical objects. Interviews were conducted with the teacher before and after each observations and focused on the teacher's choices (before) and her explanations about the progress of the session (after). In this paper, we focus on the first session and the corresponding interviews.

First, we analyzed the interviews to conduct a didactical analysis of the mathematical tasks and objects (Robert & Rogalski, 2002) planned for the session as well as the teacher's chosen form of teaching (action logics and constraints). Secondly, we identified episodes in the first session according to the richness of language and social situated interactions surrounding a mathematical object. Those episodes were then described according to the observable categories (types of help). Finally, we analyzed how those interactions trigger the mathematical activity of the students.

Hélène's Project

Hélène teaches in a class for students with autism spectrum disorder designed to prepare them with skills for the workforce. The students are between 16 and 20 years of age and their mathematical knowledge varies from sixth grade of primary school to the second year of high school.

The project to build a birdhouse

The teacher's focus was for students to reinvest geometrical concepts through a project of constructing birdhouses. Project based teaching of mathematics is not the usual approach within the context of special education. In special needs classes, teachers seek to respond to institutional expectations by conventional methods, in particular the evidence based model. In this case, Hélène plans to focus her sessions on dialogue and on the problematization of her students' questions. She proposes to her students to design their own birdhouse. During the session, she brings sheets of white paper and milk cartons. She wants each student to make a 2D model of their birdhouse using a set of 3D objects. She anticipates that the students would use these objects as points of reference for measuring the faces of the birdhouse. She plans 4 sessions to allow time for students to: design the paper plan, reproduce the plan with drawing software, perform laser cutting, and assemble a wooden birdhouse. To carry out this project, students must understand the relationship between the faces of the solid (incidence relations) and anticipate the operationalization of the solid as it passes from 2D to 3D. In this paper, we focus on the first session, particularly on some interactions that has led Hélène to add an unexpected session in order to work on the incidence relations.

Creating conditions that trigger language interactions: help that becomes constructive

During her interactions with students, Hélène realized that she had not anticipated certain difficulties related to the 2D modeling of a 3D object. In fact, during the first session, she noticed that several students had designed a plan that did not include incidence relations. Up until that point, her questioning of students regarding the feasibility of their respective plans had not led to adjustments desired. Therefore, printing on wood without anticipating results was not possible. She decided to add a session in which students would cut out the development of their solid in paper form, build it and modify it as needed. At the end of the first session, the teacher decided to involve her students in a process of reflection regarding their final product. In the following excerpt, the questions raised by Hélène help to build her students' knowledge collectively as they are focusing on the students and the task at hand (constructive help).

Hélène: If we ever cut it in the wood and it doesn't work? What happens (pointing the plan), once cut, it will make a birdhouse?

Student 1: We'll make a simulation.

Hélène: We'll make a simulation with what?

Student 2: With the computer?

Hélène: We will have to ask the technician, but what if we don't have a computer, a bit like what we did with Phil and his roof?

Student 1: We make the sketch and we will cut out?

By analyzing language interactions, we notice that the teacher allows her students to reflect on a real issue related to the construction of the birdhouses. She does not present herself to the students as having the solution to their problem, but instead, she offers them a space to reflect where the end product of the task remains their responsibility, because “at any stage the child is an informant child as the teacher is an informed expert” (Bauersfeld, 1995, p. 278). When the teacher speaks, she considers the student’s proposal repeating the words that they used, while guiding them by reframing her questioning towards the more precise elaboration of a solution. In doing so, she creates an ethical space where her students’ legitimacy is recognized and where classmates listen to each other. H  l  ne’s place in the interaction remains central, but the context of the project and the way that she engages her students by raising questions promotes the expression of their ideas and encourages their participation in the collective reflection. Through a superficial analysis of this session, we could attribute to H  l  ne the status of a teacher who puts into place compensatory and procedural helps, but a more in-depth analysis of language interactions reveals that the help is constructive because of the importance given to dialogue as well as the activity it triggered.

Another moment during the first session reveals students seeking to validate their product by their teacher before continuing their work. But the teacher does not respond by answering or refusing her students’ request. Instead, she questions them. This management of the process is particularly important in terms of its mediating and cognitive components (Figure 2) because the task remains the responsibility of the students while H  l  ne presents herself as a trigger of their mathematical activity. At that particular moment in the session, the mathematical task at hand required identifying the appropriate measurements in order to optimize the production of the pieces of the birdhouse.

Student 3: So far, my floor is done.

H  l  ne: Yes, what's missing after the floor ... we said?

Student 3: Ummm... The sides!

H  l  ne: What measurements are they going to have? [...]

Student 3: Ummm, the height of my side ... Wait! If that ..., if we counted 25 cm, that's it?

H  l  ne: Hum, hum. (she agrees)

Student 3: Maybe 25 too?

H  l  ne: 25 ... how much is your floor?

Student 3: Ummm ... 20 cm!

H  l  ne: So ... does it ... have to be wider or more narrow than your floor... your side? Your wall is going to go like this. (She takes a pint of milk to show it to the student on his sheet.) Here I will ... We'll go up like this. You want the wall to come to where?

Student 3: Maybe equal?

H  l  ne: Equal? So how much would it be?

Student 3: Uh 20 ...?

Hélène: 20. With a height of how much?

Student 3: ... ummm ...

Hélène: There will be the floor like that 20, and... a height of?

Student 3: 25. (hesitates a little)

Hélène: So, two walls of?

Student 3: 25 cm! [...]

Hélène: And with a width of?

Student 3: ... 20 ...

Hélène: Two times 20 by 25. (She mimes two times the width and then the height.)

Student 3: Wait, kind of like... 20 here, 25, 20? (He shows the sides with his hands.)

The teacher addresses the student's questions, but procedural help is suggested by the new questions that she raises - she helps the student to organize the steps for developing his plan without giving him the answers. The student, in turn, adapts in a flow of interactions by trying to answer her questions. When he experiences difficulty formulating his answers, the teacher proposes compensatory help, in this case, modeling the incidence relation between the floor and the wall with the help of material. At the language level, the teacher models the measurements with the help of gestures that the student will repeat afterwards in order to appropriate them (Figure 2).



Figure 2: Teacher and student's gestures to model and appropriate measurement

However, the help that the teacher puts into place does not change the mathematical objectives of the task. She triggers mathematical activity by putting in place different types of help (procedural and compensatory) in the form of questions that promote explanations from the student. Therefore, Hélène's help becomes constructive regarding the mathematical activity of this student.

Discussion

To sum up, the proposed approach for making meaning of teaching practices allows us to reveal the influence of language interactions in a classroom where a teacher offers space for dialogue with students and questions them in order to trigger their mathematical activity. Through the preceding examples, we have the opportunity to see in a new light how different types of help, that may modify the task or the mathematical object, can become a powerful drivers of student activity in a classroom context when the teacher offers a space where all voices are legitimized. The Dual Approach combined with the Maturanian foundation allows us to investigate the teachers practice at a macrostructural level as well as microstructural. Those two dimensions help us understand some

reasons for the action of the teacher but also to analyze how those action logics (in reference to the teacher beliefs about his practice and his students) and institutional constraints come to act. If H  l  ne can promote language interactions that enable students to socially build their knowledge, it's because, among others, few institutional constraints represent obstacles in terms of planning the delivery of her courses and her choices in terms of content and form of teaching. This teacher shares with researchers that she appreciates that a rigid educational program is not imposed on her. This greater professional freedom allows H  l  ne to consider broader possibilities for the mathematical activity of her students by seeking to maximize the usage of the tasks proposed and to be in sync with her conception of teaching. According to our analysis, H  l  ne prioritizes open and authentic questioning that encourages her students to engage in a process of reflection regarding the tasks at hand. Thus, it is both the supple institutional framework and the teacher's conception of the importance of student dialogue that promote the emergence of the language interactions observed.

As a final reflection, we want to underscore that the interactions we witnessed in this classroom diverge from the usual expectations for the behavior of students on the autism spectrum. Hence, we hypothesize that the importance that H  l  ne places on the collective dimension of her classroom promotes the emergence of language interactions, which may not be possible in a special class with a more prescriptive environment. Those results lead us to reconsider dominant teaching practices in Qu  bec and to place in the foreground the richness of mathematical reflections possible among all students, even those with a language disorder, when the classroom environment encourages authentic language interactions. What we witnessed in this class of students with language disorders related to autism, in terms of interactions around a mathematical object, is not so different of what we can observe in an "ordinary class". Unfortunately, H  l  ne's case is an isolated one. What we observed in other "special classes" within this research is merely comparable. In fact, other teachers tend to reduce learning opportunities within mathematical tasks (see Buro & Prediger, 2019, in this volume) by focusing on their cognitive characteristics and behavior. Thus, our analysis leads us to question the learning environment provided for students with language disorder. Therefore, we must reconsider the teachers' formation in an institution that promotes differentiated instruction and the impact of this instruction model on the inclusion of students with a language disorder.

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