Using Classroom-Based Research to Explore Mathematics and Language in Secondary French Immersion

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This classroom-based doctoral study aims to better understand how bilingual mathematics students use and attend to both language and mathematics while they interact to solve various mathematical problems. Drawing from sociocultural theory, I focus on the interactive nature of language learning (Vygotsky, 1978) and view mathematics as a situated, social activity (Moschkovich, 2007). This paper presents the research context, selected literature, and study, and offers a discussion of preliminary results stemming from discourse analysis (Gee, 2014). To conclude, I reflect on the data collection process and outline future directions for the study.

Context

This research explores high school French immersion mathematics classrooms in urban New Brunswick. French immersion is an optional, school-based language learning program available to New Brunswick students beginning either at Grade 3 (earlier entry) or Grade 6 (later entry). The program is intended for non-Francophone students who wish to learn French not only as a school subject but also through the medium of content classes such as science, social studies, and mathematics (Day & Shapson, 1996; Swain & Johnson, 1997). The latest figures report that 25.2% of eligible New Brunswick students are enrolled in the French immersion program (Canadian Parents for French, 2013).

In New Brunswick French immersion programs, mathematics may or may not be delivered in French at the high school level (although mathematics is always or nearly always delivered in French at the elementary and middle school levels). The availability of mathematics in French for immersion students depends on the size of the individual schools and the availability of teachers who are qualified to teach, in French, the specialized mathematics content of high school courses. At the school in this study, for example, mathematics was offered in French to French immersion students in Grades 9 through 11. Student achievement in French immersion mathematics has been studied quite closely since the program's beginnings in the 1960s. In general, large-scale and smaller-scale studies of student performance in mathematics indicate that French immersion students achieve results that are comparable to, or sometimes exceed, those of their English program peers (e.g., Bournot-Trites & Reeder, 2001; Cummins & Swain, 1986, Turnbull, Hart, & Lapkin, 2003; Turnbull, Lapkin, & Hart, 2001). Despite what this valuable work can tell researchers and educators about student achievement, more research, particularly of a qualitative nature, is needed that examines how students engage with mathematics in their second language in the classroom. Understanding this phenomenon has implications for teaching, learning, and policy decision making within bilingual mathematics programs in New Brunswick and in broader national and international contexts.

Theoretical Framework and Selected Literature

In order to explore in an in-depth way the linguistic and mathematical nature of students' interactions while they communicate about mathematics problems in their second language, I adopted a sociocultural approach and reviewed selected literature, both theoretical and empirical, that was key to

understanding it. Sociocultural theory has its roots in Vygotsky's (1962, 1978; see also Wertsch, 1985, 1993) work and emphasizes the social nature of learning and the key role of language as a cognitive tool with regard to the development of higher-level cognitive processes and second language learning (e.g., Donato, 1994; Lantolf, 2000; Lantolf & Appel, 1994; Swain, 2000, 2008, 2010; Swain & Lapkin, 1998).

A sociocultural lens is also effective in viewing mathematics in terms of a mathematics learning register, or the specialized symbols, words and structures, and meanings, that are appropriate to the language of the mathematics classroom (Halliday, 1978; Pimm, 1987, 2007). Mathematics education scholars who have adopted a social, situated view of mathematics to explore bilingual mathematics classrooms (e.g., Barwell, 2005; Moschkovich, 2002; Wagner, Kristmanson, & Herbel-Eisenmann, 2011) have underscored the key role played by language in these learning contexts. Far from considering mathematics to be "language free", viewing mathematics in this way requires a shift in thinking to envisioning mathematics as inherently intertwined with language and literacy.

The Study

Participants

This study is situated in high school French immersion mathematics classes in a large, urban school in New Brunswick. The participants are 22 students from two Grade 9 French immersion mathematics classes, as well as their classroom teacher. In each class students come from the earlier entry (i.e., Grade 1, as these students had enrolled prior to 2008, the year in which the entry grade for early immersion was changed to Grade 3 in New Brunswick) and the later entry (i.e., Grade 6) programs. Sixteen girls and six boys participated in the study. Their classroom

teacher is a woman and has just over 15 years of teaching experience, the majority of which has been spent in the French immersion program.

The Mathematics Activity: Planning a Playground

The teacher and I came together to plan an activity that we both felt would be valuable (linguistically and mathematically) and motivating for the students. The activity we chose required students to work in pairs or groups of three in order to plan for and construct a new playground for a fictional daycare facility (NCTM, n.d.). Students were given 200 feet of fencing in 1-foot panels and were asked to construct the fence so that they would maximize the area within it. Students were then given several pieces of playground equipment that they needed to fit within the fenced area, according to each piece's particular area. In order to solve the problem, students had to first come to the realization that the figure with a maximum area for 200 feet of fencing is a square (50 ft x 50 ft). However, not all of the playground equipment will fit into a square. Students were required to problem solve to discover the next greatest maximum area (a rectangle of 52 ft x 48 ft) that would accommodate all of the playground equipment. Students were given hands-on models (paperclips and paper) to construct their playgrounds, and then were asked to draw their playground design to scale using graph paper. Students also had to respond to a series of questions relating to the activity. Two of these questions are featured in the results section of this paper.

Data Collection and Analysis

Data were collected via several methods: audio recordings of student interactions, researcher observations, field notes, student artefacts (written work, drawings), and follow-up interviews. Preliminary analysis suggests that the varied sources of data and my

engagement with the participants have enabled me to elicit rich material for analysis. The primary methodology is a discourse analysis inspired by scholars such as Gee (2011, 2014) and Schiffrin (1994) that focuses on three interrelated facets of communication: (a) language in use and interaction, (b) the situatedness of language, and (c) context and meaning.

Preliminary Results

In this section I highlight preliminary results of analysis of data collected from one pair of participants. L.S. and L.L. are both girls who have been in French immersion since Grade 1. In the following excerpt, transcribed from the audio recordings collected during their interactions about the playground activity, L.S. and L.L. discuss the following two questions from the activity worksheet: (a) "How and why did you choose the final dimensions for your playground?" and (b) "Why is your playground plan the best choice?" (These questions appeared in French on the students' worksheet.)

Original Transcript	My Translation
L.L. Je pense que c'est le seul façon que tout les choses fait, mais.	L.L. I think it's the only way that all the things do, but.
L.S. Je ne sais pas. Parce qu'il y a des enfants.	L.S. I don't know. Because there are children.
L.L. Oui. Je ne sais pas qu'est-ce qu'on est supposé de mettre.	L.L. Yes. I don't know what we're supposed to put.

L.S. Je pense que tout le monde a fait ça. ... Parce que tous les objets vont dans la cour. Parce qu'il n'y a pas un qui **fit** pas.	L.S. I think that everyone did that. ... Because all the objects go in the playground. Because there isn't one that doesn't fit.
L.L. Je pense que ça c'est la seule raison.	L.L. I think that that is the only reason.
L.S. Et il y a de la place pour d'autres tables de piquenique si tu as besoin.	L.S. And there is place for other picnic tables if you need.

In this exchange, the students engage in mathematical communication in order to explain and/or justify their particular mathematical choices (e.g., dimensions, area, equipment placement). Furthermore, they must relate these choices to the "real life" context of the playground itself. The exercise requires use of linguistic structures such as *je pense que* (*I think that*) and *parce que* (*because*), which are inherently tied into the mathematical discourse of explaining or justifying. These structures are repeated several times.

Another linguistic feature also related to the mathematical context of the problem, is the word *fit*, bolded and underlined in the original French version to indicate that it was given in English. This term reappears as *vont* (*to go*) in the written portion of the students' work, along with the explanation they were discussing:

Original Written Response	My Translation
Je pense que c'est un des seules emplacements qui fonctionne. Tu devrais choisir notre plan de cour parce que toutes les objets vont dans le cour avec assez	I think it's one of the only placements that work. You should choose our playground plan because all the objects go in the playground with enough

d'espace et il y a de l'espace pour un autre table de piqunique, si tu as besoin.	space and there is space for another picnic table, if you need.

It is clear that the students' written response is largely based on their oral discussion, since the two are almost identical.

Finally, follow-up interviews conducted with the student pairs provide insights into their meaning making processes. While the limitations of stimulated recall interviews are acknowledged even under ideal conditions, this type of data can nonetheless provide another source of information related to students' work (see, e.g., Gass & Mackey, 2000):

Original Interview Transcript	My Translation
L.L. On n'a pas fait quelque chose de spécial.	L.L. We didn't do anything special.
L.S. Oui, il n'y a pas d'autres façons que tout ça peut aller. Donc je pense que tous les autres groupes avaient à peu près la même chose. Donc ce serait presque tout le même, mais.	L.S. Yes, there aren't any other ways that all of that can go. So I think that all the other groups had pretty much the same thing. So it would all be almost all the same, but.

The students provided additional information in the interview, relating to their discussion and written answers. They described how their belief that their playground design was essentially the same as everyone else's made it difficult to justify or explain what was special about their choices. Whether justified not, the students' perceptions affected their discussion of the questions at hand.

Discussion and Implications

The preliminary results of this study demonstrate the intertwined and intersecting nature of language and mathematics in the bilingual classroom. Students' need for linguistic resources (e.g., structures such as *parce que* and *je pense que*) in order to express themselves mathematically (e.g., justifying, explaining) is apparent. The repetition of the same structures suggests a need for teachers to move beyond the teaching of mathematical terminology in the traditional sense (e.g., *area*, *perimeter*) and to focus on the linguistic structures needed for mathematical communication. Furthermore, other so-called nonmathematical vocabulary (e.g., *to fit*) is also an important part of the mathematics in the classroom, particularly if students are expected to work with mathematics problems set in real life contexts.

The strong connection between students' oral production and their written production suggests a need to support opportunities for student interaction in the bilingual mathematics classroom. The link between oral and written language has been highlighted in writing research (e.g., Shanahan, 2006) and seems to be supported by these results.

Conducting my research in schools and classrooms presented its own particular challenges related to ethics, timelines, workload, schedules, people, and so on. It was, at times, unpredictable. That said, my classroom-based approach enabled me to collect rich data from diverse sources (e.g., spoken interaction, written work, interviews), which in turn is helping to provide a contextualized and deeper understanding of bilingual mathematics teaching and learning. Moreover, I was able to contribute time and resources to the classroom, the teacher, and the students.

Future Directions

The next step in this doctoral study is to further analyze my first round of data, which means coding and interpreting the remainder of the interactions, written work, and interviews. Following that, I will move on to analyzing the second round of data collected during a different mathematics activity done with the participants. I look forward to writing a complete report of these analyses and discussing further implications of the findings in my doctoral dissertation.

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