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Sources of meaning and meaning-making practices in a Canadian French-immersion mathematics classroom

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Research on the learning and teaching of mathematics in the context of language diversity has highlighted how students make use of many different features of language in mathematical meaning-making, such as gestures, code-switching, genres or narratives. I refer to these features as sources of meaning, to highlight their fluid, dialogic nature. Each student has a unique repertoire of sources of meaning, on which they draw in mathematical meaning-making. I argue that to understand the mathematical meaning-making process, we need to attend to the meaning-making practices they use as they draw on these repertoires during classroom interaction. I illustrate and reflect on these ideas with an episode from an elementary school French-immersion mathematics classroom in Canada.

Keywords: Language diversity, sources of meaning, French-immersion, Bakhtin, multilingual mathematics classrooms.

Introduction

In highly multilingual classrooms, an important feature of students' meaning-making is the use of code-switching. Setati (2005), for example, showed that students in four South African classrooms used their home languages for conceptual matters, and English for procedural matters. In many parts of the world, however, even where students are familiar with multiple languages, only one language is used in mathematics classes (e.g., Barwell, 2005). This observation implies a difference between what may be *available* to students for mathematical meaning-making, and what they *actually use*. Research has identified many other aspects of language which students may use in mathematical meaning-making, including graphs, gestures, genres, narratives, grammatical features and multiple meanings (e.g., Moschkovich, 2008; Barwell, 2005, 2014). These features of language are often referred to as *resources*, a term that implies a static view of language (as a fixed resource) and a monologic view of students (as users of the resource) (Barwell & Pimm, 2016). I refer instead to the *sources of meaning* students draw on in their mathematical meaning-making (Barwell, 2018), based on a Bakhtinian view of language use. Research on the sociolinguistics of multilingualism has adopted a similar approach, demonstrating the fluidity of language use in contexts of superdiversity (Blommaert & Rampton, 2011). Speakers are shown to use repertoires of languages, styles and genres, which they combine in particular situations to make various kinds of meaning, including the construction of identities, building relationships and identifying with particular groups or subcultures (see for example Blommaert, 2010). In this paper, I argue that to understand students' mathematical meaning-making in contexts of language diversity, it is necessary to examine their repertoires of sources of meaning *and* the meaning-making practices through which these repertoires are activated.

Sources of meaning

From a Bakhtinian perspective, language is a dynamic constantly changing system of shifting relations. Although it is convenient to talk about recognisable patterns of language, such as French

or Japanese, or mathematical discourse, such labels are at best approximate. Any recognisable feature of language is in constant evolution. This evolution is driven by two opposing forces, known as centripetal and centrifugal forces (Bakhtin, 1981). Centrifugal forces are apparent in the continually changing nature of language, and its constant diversity, known as heteroglossia. Centrifugal forces are necessary, since without the possibility of change, it would be impossible to ever saying anything new, and since every utterance is in some sense says something new, all communication would be impossible. Centripetal forces arise from widespread ideologies about language as a fixed, rule-based structure, apparent in every dictionary or every time a grammar rule is cited. Again, centripetal forces are necessary, since without some degree of standardisation, communication would become a tower of Babel: many different languages, but no mutual understanding. These two forces operate in every utterance, shaping how things are said, so that every utterance to some extent follows standard forms of language, while also being a unique instance of language-in-use (Bakhtin, 1981). In previous work, I have shown how the tension between these two forces can be seen in multilingual mathematics classrooms (Barwell, 2014, 2016). Students talk about mathematics using a variety of accents, pronunciations, languages, words, grammatical forms, gestures, generic fragments and so on. Their meaning-making is also shaped by centripetal forces that imply preferred forms of mathematical discourse, classroom language, pronunciation, accent, correct spelling and so on. Students' thinking and learning emerges through these interactions and is shaped by these two forces. The relations between a given feature of language influenced by this tension amounts to a source of meaning. For example, the relation between formal and informal geometric vocabulary results in a source of meaning, consisting of more formal and less formal terms and the various meanings that arise from the relations between these words (see Barwell, 2016).

Sources of meaning can be organised around three dimensions of heteroglossia: languages, discourses and voices (from Busch, 2014). Students can draw on a repertoire of languages, including the classroom language and any other languages they may know. Students can also draw on a repertoire of discourses, including multiple mathematical discourses, multiple educational discourses and multiple informal discourses. Mathematical discourses might include various versions of the language of algebra, statistics, geometry, etc., as well as various degrees of formality, and the language of different genres, such as textbooks, tests, classroom talk, etc. Multiple educational discourses include various institutional ways of interacting in classrooms, talking about the curriculum, discussion of assessment, etc. Multiple informal discourses refer to the many ways of talking students bring from outside of formal schooling, including discourses of the family, community, popular culture, etc. Students can draw on multiple voices, including the expressions of mathematical meaning of their teacher, their peers, their textbooks, members of their family, personalities in the media, and so on.

Although not previously organised in relation to these three sources of meaning, research has provided descriptions of language use that illustrate them. Much research, for example, has described the presence of multiple languages in mathematics classrooms. Setati's work (e.g., 2005) has documented the use of home languages in South African classrooms in which the language of instruction is English. Moschkovich (2008) has documented the patterns of use of Spanish and English in US mathematics classrooms. Planas (2014) has examined the use of Catalan and Spanish in mathematics classrooms in Barcelona. Equally, research has documented the use of only one language, even where students may be familiar with others (e.g. Barwell, 2005). Research has also documented the different discourses used by students in multilingual mathematics classrooms. For example, in a study of the engagement of elementary school learners of English with arithmetic word problems in the UK, I showed how they drew on features of the genre of word problems, as well as narrative accounts of everyday experience (Barwell, 2005). Genres and narratives were thus sources of meanings that were part of the students' discursive

repertoires. Similarly, in work conducted in Canada, I have shown how textbooks mediate second language learners' meaning making in mathematics (Barwell, 2017). This analysis implies that the discourse features of mathematics textbooks are sources of meaning that form part of students' discursive repertoires. Finally, the literature includes examples of multiple voices in mathematical meaning-making. A good example can be found in Moschkovich's (2008) analysis of what she terms 'multiple meanings' for features of a graph that were a source of meaning for two students as they worked to make sense of the graph. Students and the teacher "revoiced" each other's ideas, so that mathematical meaning arose from the interaction between their voices, even within a single utterance. In my own work, I have shown how students' take on the words of their teacher (and vice versa) and these voices become intermingled in their mathematical meaning-making (Barwell, 2016). This interaction between a repertoire of available voices creates a relationship between students and others, including their peers, teacher, and textbook (Barwell, 2017).

Sources of meaning in use: Meaning-making practices

The concept of sources of meaning, organised into languages, discourses and voices, is a useful way to understand what students draw on in mathematical meaning-making. Comparative studies, however, have shown that there may be significant variations in how students actually conduct meaning-making in multilingual classrooms, even when their repertoires appear to be similar. In one analysis, for example, students in a classroom in Canada, two classrooms in South Africa and a classroom in Malaysia, all appear to have repertoires of multiple languages, and yet in some settings, one language predominates, while in others a mixture of languages may be used (Barwell et al., 2016). To make sense of such situations, a description of students' repertoires of sources of meaning is not sufficient. We must also examine the *meaning-making practices* (what participants do) through which these sources of meaning are deployed. To illustrate this point, here are three examples of practices:

1. *Code-switching*. There is a fairly extensive literature that documents the use of code-switching in mathematics classrooms (e.g. Planas, 2014; Setati, 2005). Code-switching is a meaning-making practice that draws on multiple languages as a source of meaning. This source of meaning is available in many classrooms, but the practice of code-switching is not used in all of them (e.g., Barwell, 2005).
2. *Scale-jumping*. Although not widely reported, scale-jumping is likely to be common in mathematics classrooms: it involves indicating when mathematical formulations are too 'local' and prompting students to use more widely recognisable formulations. One example in Barwell (2014) is when a student is prompted to rewrite an explanation in a way that will make sense to his teacher, not just to himself. That is, he is prompted to align his writing with a more widespread discourse of explanation. Scale-jumping is thus a meaning-making practice that relates to multiple discourses as a source of meaning.
3. *Revoicing*. The revoicing of students' contributions by the teacher is common in many classrooms, including multilingual classrooms and students may also revoice and reformulate each other's utterances (e.g. Moschkovich, 2008; Barwell, 2016). Revoicing is a meaning-making practice that draws on multiple voices as a source of meaning.

In the following section, these ideas are illustrated with the example of a mathematics classroom in which two languages are regularly used.

An illustrative example: A French-immersion mathematics class

Canada has two official languages, English and French. Thus, schooling is available in each language throughout the country. In addition, many anglophone school boards offer French-

immersion programs, in which anglophone students follow some or all of the curriculum in French, with the goal of developing a high level of proficiency in that language. The classroom described in this paper is a Grade 3 French immersion class in Ottawa, Canada. In this immersion program, students study mathematics in French until the end of Grade 3. As part of a comparative ethnographic study (see Barwell 2014, 2016, 2017), classroom observations, fieldnotes, audio recordings and photos of classroom artefacts were collected on eleven occasions in the spring of 2012. I have selected one lesson with a focus on capacity, the second lesson in a unit on measurement that started the day before. The teacher first revises various units of measurement with the class, and also works with a poster depicting a container on which one litre is marked. The class discuss where to mark 250ml, 500ml and 750ml, as well as various connections between words for quarter, half, three-quarters, 25¢, 50¢, 75¢ and other related ideas. The students are then to complete a worksheet in pairs. The teacher introduces the worksheet in some detail, reading out each question and in some cases elaborating on what is expected. Students then work in pairs to solve the problems. In what follows, I summarise the sources of meaning and associated meaning-making practices used in the teacher-led portion of the lesson, as well as in the work of one pair of students, as identified through my analysis of the data.

Teacher-led presentation of the worksheet

The main sources of meaning relating to *languages* arise from a shared repertoire of English and French. The teacher also spoke Greek and several of the students spoke other languages at home. In the teacher-led portion of the lesson, the main meaning-making practice relating to multiple languages was a pattern in which students sometimes *inserted English partly or entirely in their responses* to the teacher's questions, and the teacher would respond in turn in French. That is, he would focus on the students' meaning rather than their language. On one occasion, another meaning-making practice was observed: the teacher *provided a direct translation* of a word arising in one of the problems:

d) ça vous demande « résous les problèmes » donc le premier problème c'est « un seau peut contenir » un seau en anglais c'est a bucket donc « un seau peut contenir trois litres de sable combien de litres de sable est-ce qu'il faut pour remplir cinq seaux? »

d) it says "solve the problems" so the first problem is "a bucket can hold" a bucket in English is a bucket so "a bucket can hold three litres of sand how many litres of sand are needed to fill five buckets?"

These meaning-making practices are similar to code-switching, although more fluid and less structured than formal code-switching.

Sources of meaning relating to *discourses* included the word problem genre, the main form of the problems on the worksheet. A key meaning-making practice related to this source involved several components *to support reading and interpreting the problems*: first the teacher would ask a student to read out one of the problems, which they would generally do quite disfluently; next, the teacher would read it out again himself; finally, some interpretation of the problem was usually conducted, either through direct comment from the teacher, or through interaction between the teacher and the class. In one case, the solution to the problem was actively discussed. Connections between explicitly rehearsed vocabulary relating to units of measurement, and specifically capacity, formed a second source of meaning. Several meaning-making practices involving *explicit attention to vocabulary* drew on this source: vocabulary was introduced in the previous lesson, reviewed at the start of the second lesson, and the teacher made explicit connections to this vocabulary when going through the worksheet. This rehearsal of mathematical vocabulary is related to scale-jumping, since it introduces more widely used forms of mathematical discourse. For example, after a student has read out the second problem, the teacher follows up:

Donc « Samuel demande chaque récipient a une capacité d'un litre utilise les mots donnés pour décrire le montant d'eau que chaque récipient contient » oh regardez ces trois moi je vois trois mots ici qui sont au tableau est-ce que tout le monde peut les voir?

So "Samuel asks each container has a capacity of one litre use the words provided to describe the amount of water each container holds" oh look these three I can see three words here that are on the board can everyone see them?

Thus, the teacher provides some interpretation of the problem and also highlights a connection with vocabulary discussed at the start of the class.

Sources of meaning relating to *voices* include the interactions between students' and teacher's voices, as well as voices carried by the word problem, both as an authored mathematics classroom text, and as texts that often feature fictional children. In the problem cited in the quotation above, for example, the problem refers to a fictional Samuel. Meaning-making practices relating to this source of meaning include the *teacher's revoicing of students'* more hesitant reading of the problem, as well as the *teacher's revoicing of his own earlier presentation of vocabulary*.

Students' work

In the interaction between Kyle and Sara, two students recorded during the work on the worksheet, the sources of meaning relating to *languages* were identical to those during the teacher-led part of the lesson. The meaning-making practices they used were, however, very different. The majority of the students' interaction was in English, while their use of French was when one of the students read out the problem or referred to some element of it in their discussion of their solutions. *French was generally used in direct quotation of the word problems*, while *English was used to interpret the meaning of the problems and discuss solutions*, as in the following extract (they are working on: "Joseph drinks a half litre of milk each day. How many days are needed to finish four litres of milk?"):

- Kyle : okay what the heck is this? « Joseph boit un demi-litre de lait par jour combien de jours » [*Joseph drinks a half-litre of milk each day how many days*]
 Sara : un deux trois [*one two three*]
 Kyle : aaahhh so four litres is like up to here (.) four litres is two sizes of this if he drinks that
 Sara : (...)
 Kyle : on my calcul[malations
 Sara : [but that's a half of it already (...) two
 Kyle : oh I know yeah (.) I know what this is it's um ah grrr (3.0) I know it's something around (.) to drink 'kay Joseph (3.0) oh demi-litre two c'est deux um litres [*oh half-litre two it's two um litres*] (*writing*) « deux litres » (2.0) just do two and a capital L

In this extract, the problem is read out in French, while aspects are interpreted in English, such as when Kyle says "it's something around (.) to drink". At the point at which Kyle seems to be moving towards a solution, he code-switches back to French, coincident with the act of writing his solution, which must also be in French.

In relation to *discourses*, the word problem genre is again a prominent part of the students' repertoire. Unlike with languages, however, the students adopt similar meaning-making practices to the teacher: *they often read out the problem and then interpreted it with subsequent discussion*, as the above extract illustrates. An additional meaning-making practice involved students making *reference to their own experience of the world* to interpret the word problem. For example, in the next turns following the above extract, the following exchange occurs:

- Sara: combien de jours (.) [oops (*how many days* (.) oops)]

- Kyle: [no no if it's if he does if how if he does a deux a half of a milk carton a day if he does one like you know how you have those you guys have you have mini
- Sara: [yeah
- Kyle: [milk cartons that's a half a demi-litre [half-litre] (.) if you drink four of those how much is it?

Kyle refers to a particular kind of 250ml milk carton as a point of reference to interpret “demi-litre”, although he seems to have proposed a non-standard interpretation of the problem. Finally, in relation to *voices*, the two students revoice parts of the word problem. In particular, Sara’s revoicing of “combien de jours” (how many days) indicates some doubt about Kyle’s proposed solution. Kyle certainly hears it in this way, since he revisits and expands his explanation.

Discussion

The brief example I have presented illustrates the value of the distinction between sources of meaning and meaning-making practices related to these sources of meaning. Most notably in the lesson in question, teachers and students have overlapping language repertoires of English and French, but they use quite different meaning-making practices in drawing on these sources of meaning. The teacher draws almost entirely on French, offers only occasional English glosses of key vocabulary, and generally does not comment on students’ use of English, simply focusing on the mathematical meaning of their utterance and responding in French. Kyle and Sara, in contrast, work largely in English, using French mostly to read out word problems or other instructions, or to formulate their written responses. In relation to discourses, on the other hand, and to some extent in relation to *voices*, teacher and students use similar meaning-making practices. For example, both teacher and students adopt the practice of reading out parts of the word problems and then interpreting them through subsequent discussion. As already noted, however, in the case of the teacher, all of these practices were conducted in French, while the students switched from French to English during this process.

The meaning-making practices observed in this class are shaped by the centripetal and centrifugal forces of language. Centripetal forces include the institutional preference for French and the broader societal dominance of English. The tussle between these languages results in a distinctive heteroglossia in which a shared repertoire of English and French is asymmetrically deployed according to the participants’ roles: French for the teacher, English for the students. This situation is relatively unusual, in that in many contexts described in the literature, English is the dominant language and is imposed in the classroom over students’ less valued local languages. The tension between the two language forces can also be seen in the realm of discourse, such as when students read out the word problems with hesitation and disfluency, while the teacher reads them clearly and offers interpretations reflecting the preferred or conventional meaning. Indeed, it is important to see the interaction between languages and discourses here: the institutional, centripetal imposition of French produces the students as disfluent. Had the problems been presented in English, it is likely that the students would be able to read them out loud with greater fluency. Sources of meaning, then, arise from the relations between various features of language. In this lesson, it is not simply the repertoire of English and French that provides a source of meaning; it is the constant interplay between utterances in these two languages. Students and the teacher make use of these relations to interpret the word problems (sometimes more successfully than others).

In conclusion, to develop a comprehensive understanding of how language is used in mathematics classrooms in contexts of language diversity, attention needs to be paid to the sources of meaning available to students and teachers, *and* to the meaning-making practices that bring these sources of meaning into play in different ways. This approach needs to examine languages, discourses

and voices, not least because these different dimensions interact in important ways in students' and teachers' repertoires and thus influence students' learning of mathematics.

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