Touchstone Document 2 The Language Spectrum

In Touchstone Document 1, we mentioned "communication context" (i.e., working in small groups, reporting out to the whole class, or writing up solutions) as a context that matters for how students communicate about mathematics. In the same way that a visible light spectrum distributes colors of different frequency ranges, we use the term *Language Spectrum* to emphasize the range of ways people communicate (or the characteristics of the texts[1] they produce) in relationship to their communication context. The Language Spectrum can help you consider how to strategically choose to have students work in various communication contexts in order to support their growing facility with disciplinary-based ways of communicating over time. For example, if students only listen to lectures or work independently, they are not producing language to generate ideas and solutions to problems. By mixing in some small-group work, students are able to use less formal language to talk about mathematical ideas. If students continue to use this less formal language when they are writing up solutions to turn in to you, however, then they may need further support to learn how to produce a more formal and mathematically explicit solution. Most students do not learn to do these things on their own. Rather, it is through your support in each of these communication contexts that they learn to make mathematical meaning and to express that meaning in appropriate ways. It is important to note that, across the range of texts students might produce, one way of communicating is *not better* than another, just as red light is not better than orange. The Language Spectrum illustrates how communication context affects the kind of language that students use. Thus, it helps us think about how important it is for us, as teachers, to use a range of communication contexts to support students' facility with mathematically explicit language.

To illustrate the *Language Spectrum*, we ask you to consider how language might change when:

a. a small group of students work at their desks after completing some examples to try to figure why $\frac{b^m}{b^n} = b^{m-n}$;

b. one student from that group is asked to describe the solution to other students in the whole-class discussion after the small groups worked on the problem;

[1] In following with one of the primary theories about discourse that we draw on, systemic functional linguistics, we use the word *text* to mean a stretch of spoken or written communication that is produced in a context.

c. a student writes up a formal explanation for the teacher (or someone evaluating them) of why the division rule works; and

d. the textbook explains the idea or offers tasks for students to work on.

We provide a mix of hypothetical transcripts and real student dialogue next to illustrate each of these communication contexts, along with a related example that appeared in a mathematics textbook. (See Table 1.1.) In order to highlight some of the important language shifts that take place as the communication context (CC) changes, we describe linguistic features of each text in the following sections.

Table 1.1

CC1: Working in a small group	**CC2: Reporting out to the whole class**	**CC3: Student writes a solution**	**CC4: Written description in a mathematics textbook**
Text 1: Language of interaction	**Text 2: Language of recounting experience**	**Text 3: Language of generalizing**	**Text 4: Mathematics register**
Student 1: OK, so I think you just take this away from this, and then you just have, like, something on the top, right? Like, here and here, [*points at examples*] there isn't anything left. They all just cancel out. I think that's why the rule works, doesn't it? You can cross out the numbers under here. [*points to the denominator*] Student 2: Couldn't you have, like, more on the bottom?	Student 3: Remember when we had that assignment where we had to write out what all the exponents meant, like three to the fifth power was three times itself five times? And when we did that with the division problems you could cancel out the same amount on the top and bottom? Like, if there are five on top and three on the bottom, you can cancel three of them and just have two left. But we just did that problem with *b* to the *m* on top and *b* to the *n* on bottom. So, just like we said five minus three is two, you do *m* minus *n* and that's what you have left. That's what we got.	When you divide exponents with the same base, like $\frac{b^m}{b^n}$, there are *m* copies of *b* in the numerator and *n* copies of *b* in the denominator. You can simplify this expression because copies of *b* in the numerator will cancel with copies of *b* in the denominator. Since $\frac{1}{b^n} = b^{-n}$, we know $\frac{b^m}{b^n} = b^m \cdot b^{-n}$. When you multiply exponents with the same base, we add the exponents, so $\frac{b^m}{b^n} = b^{m-n}$.	In the case of division where the bases of the exponential expressions that are divided are the same, such as $\frac{b^m}{b^n}$ where *b*, *m* and *n* are rational numbers, the result is b^{m-n}. This is a consequence of the multiplication rule for exponents with like bases. $\frac{b^m}{b^n} = b^m \bullet b^{-n}$ $= b^{m-n}$

The following are some differences among the four texts that help to see how language is shaped by the communication context:

Communication Context 1: Working in a small group   ***Text 1: Language of Interaction***
• The *references to mathematical terms and processes* may not be very precise (e.g., *on the top*, *cross out the numbers*, *under here*, *bottom*).
• The mathematical *density* is low; there is not a high ratio of mathematical vocabulary words to other words.
• The problem and possibly the work is in front of the students, so they are likely to point and use language that is *context dependent* (e.g., *here and here*, *this*, *it*).
• The meaning is co-constructed as students who share a common experience and comprise an immediate *audience* ask each other questions (e.g., . . ., *right?* . . ., *doesn't it?*) and tell each other to do things.
Communication Context 2: Reporting out to the whole class   ***Text 2: Language of recounting experience***
• The text is more mathematically *dense* with increased use of mathematical terms.
• The student's contribution needs to be more specific and explicit because the *audience* is more removed; that is, others in the room were not part of the small-group discussion.
• There is still an expectation that the *audience* will share certain experiences with the speaker. For example, the student references previous assignments that the rest of the class would be familiar with but that an outsider would not understand.
• Context cannot be used in the same ways as in Text 1. So, language becomes more explicit because the *audience* was not present during meaning making. The student reports specific locations and uses more precise mathematical language (e.g., *b to the m minus n*, *exponents*).
• The *actors* who worked on the problem are recognized (e.g., *we*, *I*) and the processes used become more explicit (e.g., *cancel*).
• The *verb tense* is often past tense, indicating that these events occurred previously and are not happening currently.
• Sometimes the description provides time references (e.g., *and then*) to *organize the flow of the text* because it is reported as a chronological description of events that occurred.
• There is also a logical connector (e.g., *because*) that provides the group's reason for deciding to write out b^m and b^n as products. The use of logical connectors adds *organization and flow* to the text.

Communication Context 3: Student writes a solution ***Text 3: Language of generalizing***
• More precise *mathematical terms* are used (e.g., *numerator*, *denominator*, *expression*) and specific *mathematical processes* are named (e.g., *divide*, *simplify*, *add*).
• Text 3 is more mathematically *dense* than either Texts 1 or 2. There are typically more mathematical terms (and possibly symbols) than Texts 1 or 2.
• The language needs to change so it makes sense to an *external audience* who did not participate in the activity. The writer explicitly recognizes that the activity might not be known to the reader by prefacing the solution with *When you divide exponents with the same base*. This type of framing shows that the writer understands that the audience may not know what she is describing, making the description less reliant on the actual context in which the activity took place.
• The *actor* in Text 3 is *you*, a general reference similar to *one*. This pronoun is often used in mathematics to generalize processes at a broader level than when a student describes what she did using the pronoun *I* (Rowland, 1999) like students often do in Texts 1 and 2.
• Text 3 is a general explanation of the process, so the *verb tense* is the timeless present.
• Text 3 uses terms like *when* to establish conditions, and *because*, *so*, and *since* to offer reasons and results, which *organize the flow of the text*.
Communication Context 4: Written description in a mathematics textbook ***Text 4: Mathematics register***
• Mathematical symbols replace words, creating *dense*, efficient and precise expressions of ideas. Conditions are stated as general laws and not as a result of "what *you* do."
• Unlike Texts 1 and 2, the formal explanation provided by the textbook does not reference specific examples because the *audience* may not have experience with those examples.
• The text has *no human actors*; it is not about people and what they *do* or *did* but instead about relationships between things, so the subjects are abstract entities like *the result* and *a consequence*, and passive voice is used (e.g., "expressions are divided").
• Related to this, the processes have changed from *verbs* like *add* to relational verbs like *are*, *is*, and equality expressed as a symbol rather than the word. The relationships expressed in the use of *are* and *is* are equivalency; that is, m and n are rational numbers, and the result is b^{m-n}.

These examples illustrate how communication context influences the language choice in each text. Yet, students can only make appropriate choices about language if they understand that there are various ways to express their understandings and can make conscious decisions about these choices. As Gibbons (2009) pointed out, these "four texts, taken together, represent a speaking-to-writing continuum" that characterizes the ways in which "the less shared knowledge there is between speaker and listener (or writer and reader), the more explicit language must become" (p. 48). Each text focuses on the same *content*, but the *grammatical choices* are quite different: the language (and symbols) becomes more mathematically technical, the feel becomes less personal, and the mode of communication becomes formal academic language.

The Language Spectrum traces the development of mathematical precision in the written and verbal language across these texts. The most precise use of mathematical discourse (similar to what is found in textbooks), however, is probably a rare occurrence in class discussions because of its formal, de-personalized feel. On the other hand, written work that looks like Text 1 may also be less common than having a range of types of communication in Text 2.

Although we have numbered these as Texts 1, 2, 3, and 4, we want to be clear that the use of such language is not as linear as it appears. In fact, students *must* engage in *multiple ways of talking and writing throughout the teaching-learning process* because each of these contexts allows students to express their understandings to themselves and others and helps them to develop more formal ways of talking and writing about mathematics.

The Language Spectrum is a lens for thinking about (a) how communication context shapes language, and (b) how students tend to use language in particular communication contexts. This lens is important because it helps us understand *how to support students to develop more mathematically precise ways of communicating over time*. That is, the Language Spectrum can help us think about whether the discourse is PRODUCTIVE for student learning or not. For example, if you notice that some students use the kind of language we might expect them to use in a small group (i.e., context-dependent references like "this" or "that") even when they are writing up solutions, it may be that these students need more support to use language in more appropriate ways in Context 3. You may, for instance, want to spend some time talking with students explicitly about your expectations for *what* their written solutions should look like and make clear *why* those ways of communicating are important when communicating about mathematics. Alternatively, the students may need to have more exposure to the other communication contexts. For example, if students only work through mathematics by working individually or in small groups, they may not have had enough opportunities to use language in less contextual ways by reporting out to the whole class. Or, they may not have had enough experience with stepping back another level to write solutions that would allow someone who did not have the same mathematical experience to understand what they did. Thus, you may need to provide more variation of communication contexts in order to help students develop appropriate language use.

It is through the consistent use of these different ways of talking and writing—being put in different situations to communicate—that students come to learn how to be fluent with construing meaning in appropriate ways. As teachers and students work in different situations, they should move back and forth in these ways of communicating as needed. Sometimes the formal written mode needs to be unpacked in less dense or less formal ways in order for students to make sense of the ideas. And sometimes the teacher needs to introduce formal mathematical language for ideas students talk about. The decisions about when to move back and forth in the Language Spectrum must be informed by what the teacher knows about the students with whom s/he works. Knowledge of students is paramount to supporting student learning.

References

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