Josh's questions and imperatives (or commands) positioned the textbook both as something that determined the purpose of classroom activity and as something in which students could find answers to his questions. Interestingly enough, there were instances in the larger set of classroom data that indicated that students came to understand that the textbook was a place in which they were to find answers to Josh's questions. In some instances, when Josh asked students a question and then asked "How do you know?", students said, "It's in the book", as a form of explanation or justification.

I contend that the words spoken in relation to the textbook matter when supporting students' learning. When teachers, textbooks and students come into contact with one another, there is the potential for each of these "participants" in the classroom to take on responsibility for the introduction and development of mathematical knowledge. A teacher's language choice when using and referring to textbooks encodes how teachers, textbooks and students are positioned as being responsible for learning mathematical terms, definitions and concepts.

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Science or mathematics?

ELLICE FORMAN

The kind of inquiry reflected in the transcript could easily have been part of a science class: collecting, representing, analyzing and comparing data with other data sets is a frequent occurrence in science classrooms. Modeling is also an important activity in science education (Stewart *et al.*, 2005). However, the instructional approach to modeling in science is different from the approach used by this teacher.

In the transcript, the sequence of activities seemed to be:

- collect data;
- represent the data;
- examine the data pattern on the graph;
- predict.

In addition, the students were asked to *compare* the represented data patterns from their class with those from a (presumably) fictional class to evaluate the goodness of fit of the graph model for the two different data sets. Some of these activities (*e.g.,* comparing the graph models and predictions) occurred during public discussions among the teacher and members of the class.

Stewart and his colleagues have outlined how science classrooms should sequence inquiry activities when they ask students to evaluate models. First, students need to collect or review someone else's data to look for patterns using a variety of data representations (tables, graphs, physical objects, *etc.*). Second, they must use these data representations to derive causal models. Third, they are to use the representations and models to make predictions. Fourth, they should present representations and models in a public forum to evaluate their validity in light of critiques by peers. Many of the activities described by Stewart and his colleagues seem very similar to those employed in the transcript from Josh's mathematics class. What differs is the range of data representations employed and their use in deriving causal models.

One important difference between mathematics and science is the nature of the models. In science, models often provide a metaphorical explanation for the properties of matter and/or energy. Scientific models are always evaluated in terms of what they can tell us about objects of scientific inquiry. In contrast, mathematical models need to be evaluated on their own terms: internal consistency, precision, logical coherence. A mathematical model (*e.g.*, the graph of a linear function) can help us to predict what is likely to happen when the values of the variables in the model increase or decrease. If a linear model fails to predict the phenomena it was supposed to predict, then a different model is proposed (curvilinear). The first model is replaced but not rejected as a valid model for a different phenomenon (*e.g.*, density). Mathematical models are not solely evaluated in terms of what they can tell us about objects in the world: they can also be valued for their ability to tell us about the nature of mathematical objects that may or may not have real-world applications.

Turning now to the transcript, there are several instances when the data representations could have been interpreted in either a scientific or a mathematical fashion. Nevertheless, teacher–student transactions co-construct this lesson as occurring within the "mathematics world" and not within the "science world" [1]. The first example occurs before the line numbering begins, when the teacher asks the class to compare the two data tables and Cory responds that the fictional classroom in Maryland may have used heavier paper, because their bridges held more pennies. The teacher responds by expanding on Cory's statement ("Theirs is like heavier or something"): "Looks like on every single layer, there's noticeably more pennies than ours." This exchange continues with another student and then the teacher proposing that the paper may have been thicker in Maryland. It ends with the teacher admitting that he did not know whether they had used construction paper and asks Cory to continue reading the problem.

Thus, the students and teacher could have pursued this idea: that differences in the paper used were causally related to the outcomes observed. This point could have led to a discussion of the forces acting on the paper bridges that made them collapse as weight was added or one about the nature of the paper itself that can resist breaking under weight in some conditions and not in others. Although the teacher seemed initially interested in engaging students in the topic of the scientific properties of paper bridges, when two of them mentioned their interest in those differences, he redirected their attention to the rest of the written problem that focused on the graph of those data and not on the nature of the material objects that were used to generate the data.

A second example appears in the text of the data from the fictional class in Maryland: only average breaking weights are displayed, not standard deviations (*i.e.*, a measure of central tendency, but no measure of variation). Later in the transcript (line 9), the teacher says, "Now, their data was a little bit scattered, a little more scattered than ours was." It was not clear to me whether he was referring to the distribution of data points around each average for a given number of pennies (*i.e.*, variation) or whether their average data points fell further from the line on the graph than those of the current class. Within the science world, variation due to measurement error would be an important topic, since all inquiry activities are subject to measurement error that can mislead or distort findings. So, scientists and science students must try to differentiate signal from noise in their data and in their data representations. There may be different models to explain the signal and the noise. In addition, some scientific models (*e.g.*, Darwin's theory of evolution) propose that variation is actually an important causal agent. Thus, a focus on variation is important in science education, but is de-emphasized in this transcript.

A third example appears in the transcript from line 14 through to the end and illustrates these different approaches to modeling. In the mathematics world, models need to be internally consistent. Thus, definitions play an important role in outlining the nature, purpose and limits of a model. Both linear and curvilinear functions enable predictions to be made about observable relationships between variables in a data set that should be valid for data already collected, data that could be collected in the future and for data that would be impossible to collect (*e.g.*, data with negative values for mass). Abram's answer (line 27), which refers to a mathematical object (a linear relationship), is consistent with modeling in the mathematics world. In contrast, Christy's answer (line 31), which refers to the information from the data being modeled, seems more aligned with models in the science world, where models are evaluated in terms of what they can tell us about the objects of scientific inquiry.

Note

[1] These imaginary worlds are often evoked in mathematics and science classrooms to motivate students or help them understand that disciplinary practices influence classroom practices. Nevertheless, it is probably more accurate to refer to them as a mathematics education world versus a science education world, since the world of classroom instruction in these two fields is more similar than either instructional world is to its disciplinary base (see Ford & Forman, 2006).

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Purposeful grammar

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I am interested in that last question from the teacher, "…what's the purpose here? Why do we even bother doing this?" and the problem the students have answering that question. My framework for analysis comes from systemic functional linguistics (*e.g.*, Halliday & Matthiessen, 2004), a theory of language that recognizes meaning in language choices and enables systematic analysis of the choices that speakers and writers make. In this transcript, an analysis of some linguistic patterns in the data shows that the answer to the question about *purpose*, while presented in the text that the class read, was not foregrounded, repeated or brought to students' attention in the discussion. The students remain focused on the particular cases of the Maryland class and their own experiment, and do not make the move to generalization about the utility of the construction of the graph and line of best fit that the teacher wants them to make and understand. In addition, the analysis demonstrates that the teacher was non-authoritative in responding to students, leaving it unclear in what ways the students' contributions were missing the larger point. The transcript reveals the difficulty of helping students develop technical language, as progress in learning requires that the technical language be understood and used to go beyond individual cases in order to generalize about the knowledge being developed.

In doing this analysis, I focus on two types of grammatical processes presented in the text read aloud from the textbook: processes of *doing* and processes of *being*. The *doing* processes construe the actions of students; the *being* processes construe the definitions of concepts. The focus changes from the particular case to a generalization about the possibilities that the use of a graph model offers.

Here is the relevant part of the text read aloud by Josh, with clauses containing *doing* processes underlined and clauses with *being* processes marked in **bold**:

> The class then made a graph of the data. They thought **the pattern looked somewhat linear**, so they drew a line to show this trend. **This line is a good *model* for the relationship** because, for the thicknesses the class tested, **the points on the line are close to points from the experiment**. […]
>
> **The line that the Maryland class drew is a graph model for their data. A graph model is a straight line or a curve that shows a trend in a set of data**. Once you fit a graph model to a set of data, you can use it to make predictions about values in between and beyond the values in your data.

The "doers" in this text are the Maryland class who "made a graph" and "drew a line", as well as the generalized "you"