Several years ago, I overheard two students speaking of the “math in Miss Jones’s class.” At the time, I was teaching several levels of mathematics and Miss Jones was a science teacher whom I had known for some time. In science class, students perceived that the mathematical shortcuts and formulas manipulated for efficiency produced something new, not related to the step-by-step strategies they were seeing in mathematics classes. Over the following years, I have encountered some of the examples of what our students perceived as “different” mathematics in science classes like Miss Jones’s. Other researchers have experienced the same situation. Porter (2002) asks “Do teachers know enough about the content of each other’s instruction to ensure that students experience a reasonable progression of content as they advance from grade to grade and course to course?” (p. 3). Mason et al. (2004) suggest that “when the science program at a school is coordinated with the mathematics program, then students’ use and understanding of both mathematics and science are improved” (p. 14).

The powerful influence of the textbook as a representation of the discipline in all areas (Herbel-Eisenmann 2007) warrants an investigation of the dissonance between mathematics and science textbooks as a source of confusion.

Often the differences students see in science and mathematics classrooms are in perspective, approach, or application. Understanding those differences can help teachers to present a unified picture of mathematics and science to their students. In this article, I have attempted to give the science teacher a glimpse of the treatment of topics shared by both disciplines as they are represented in mathematics texts, with suggestions for better transfer between disciplines.

To investigate the connections and disconnects between classroom mathematics and science, I reviewed student editions of 12 middle school textbooks currently adopted for use in my state (8 mathematics and 4 science texts) for the quantity and quality of references to the other discipline. The dates of the science and mathematics texts were not as close as
would be ideal because the adoption schedules for the two disciplines are not aligned. Mathematics adoptions occurred quite recently and new science texts have not been adopted in several years. I used only standard texts, not the digitally based materials also available in mathematics. Still, there were more texts in mathematics than in science. The conclusions were all drawn using percentages rather than frequencies so as to compensate for the unequal number of texts under review.

I analyzed each instance of mention or use of science in the mathematics texts and mathematics in the science texts, recording the language, problem types, strategies, units, and symbols used. If one of the goals of science and mathematics educators is the presentation of mathematical and scientific knowledge and processes as part of a cohesive whole, teachers in both disciplines need to be aware of what is contained in the other discipline’s curriculum. Then careful adaptation of language and strategies in both disciplines can strengthen the connections between the two and increase understanding in both.

Points of intersection

In a review of the textbooks, it is clear that mathematics and science share many strategies, tools, and topics. However, they are approached and used in a variety of distinct ways.

Data gathering and analysis

Although called for by the Principles and Standards for School Mathematics (NCTM 2000), students are still rarely asked to gather their own data in the mathematics texts reviewed for this study. Students are asked in math class to organize data contrived to illustrate the tool or strategy under discussion. Sampling is discussed in the context of random samples and avoidance of bias with examples often taken from measurements, opinion polls, sports events, and such. But students in math class are seldom asked to do the sampling themselves.

In contrast, data used in science class are often the result of an experiment or observation of natural phenomena conducted by the student in class as encouraged in the National Science Education Standards (NRC 1996). The science texts include examples of how to gather data, organize it into tables, construct appropriate graphs from the data, and draw conclusions from the data involving several levels of critical thinking. The clean, simple, and usually artificial data in mathematics look quite different from what students see in science class. Students may be concerned about the messiness of their real data gathered in science class caused by the inability to control all variables or inaccuracy of measure or count. Sharing science examples with mathematics teachers in your school can help your students see stronger connections between the two subjects and validate the strategies used in both disciplines. For example, students could collect data in science...
class and then use them for math class. The data could be used to draw conclusions and report/communicate results in both disciplines.

**Probability**

Math class explores probability as it evolves from experiments with collections of objects differing in one or more characteristics. Theoretical probability is the main focus of the conversation. The data presented in math books are also rather artificial and not authentic. Most activities and examples involve marbles, spinners, dice, and other humanmade objects of different colors or decoration. In the mathematics text reviewed, no scientific examples were used in the discussions or presentation of probability.

One example of the science texts’ use of probability is in the sampling strategies often referred to as catch-and-release, where animals are tagged and distributed throughout a population. When a random resampling of the population contains a percentage of tagged animals, inferences are made about the total population. These are, of course, based on experimental probabilities that do not look anything like the permutations and combinations seen in math class. If the strategy is presented only as a procedure to be followed, without the mathematical background of probability theory, students are likely to miss the connection and the reasoning behind the strategy. This is a great opportunity for a math teacher to find better, more realistic science-related examples of probability to use with students.

**Graphs and graphing**

The modern study of secondary mathematics is built from the perspective of mathematical function. Graphs are most frequently representations of two-variable functions with ranges including zero and including relatively small maximum values. Independent and dependent variables are carefully identified and represented accordingly on the graph. Dependent variables are represented on the vertical axis, almost without exception.

Graphical representation of scientific phenomena often looks quite different from the graphs considered to be properly constructed in a mathematics class. Ranges may not include zero. Science texts do not necessarily arrange the axes so that a (0,0) is possible, as when representing data where all the important changes occur far from 0 (e.g., the changes in height of an elephant as it grows).

Labels of the axes can sometimes be misleading. Choices for placement of a dependent variable may be made to emphasize some other concept besides mathematical function, as when height is indicated on a vertical axis, but labeled instead as distance. For example, in graphing the movement of an object sliding down a ramp, time is usually represented on the horizontal axis (see Figure 1). If the distance the object has traveled is indicated on the vertical axis, the slant of the ramp is illustrated for clarity, but the measures must range from 0 at the top of the graph to a positive value at the bottom of the graph. (These would need to be negative values in the fourth quadrant on a mathematical graph.)

If height of the object is indicated on the vertical axis, measures range from 0 at the bottom of the graph to a positive value at the top of the graph, a standard graph in the first quadrant.

<table>
<thead>
<tr>
<th>FIGURE 2</th>
<th>Change in height sliding down a ramp</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image.png" alt="Graph" /></td>
<td>Time in seconds</td>
</tr>
<tr>
<td>90</td>
<td>0.5</td>
</tr>
<tr>
<td>80</td>
<td>1</td>
</tr>
<tr>
<td>70</td>
<td>1.5</td>
</tr>
<tr>
<td>60</td>
<td>2</td>
</tr>
<tr>
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</tr>
<tr>
<td>10</td>
<td>4.5</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Height in cm**

**Time in seconds**
The emphasis on independent and dependent variables in mathematics class without the same emphasis in science application can cause confusion. However, one result may not be dependent upon another even though the relationship between the two variables is important for study. In the ramp example in Figure 2, height changes as time goes on. In mathematics, height is said to be “dependent upon time,” and time is placed on the horizontal axis in a mathematics class. However, in showing the relationship between the life span and mass of a species, for example, both may be dependent on other factors. Although there may be a relationship between life span and mass, one does not cause the other. Either variable may be placed on the horizontal axis. Single-variable graphs in mathematics may include stem and leaf, histograms, and dot plots. However, their application is rare in science texts, which most often use circle graphs, line graphs, scatter plots, and bar charts. Single-variable graphs are as common as two-variable graphs in science textbooks. Sharing the data that students collect in class with mathematics teachers can help students see the value of using a variety of strategies for mathematical and scientific representation and communication.

**Measurement**

Measurement most certainly looks different in science class than it does in mathematics. The most obvious difference is the use of customary and metric systems. As long as our culture continues to use both systems, our teachers will strive toward building student fluency in both. Most science texts, in deference to the system used in most scientific inquiry outside of the school setting, contain little or no reference to the customary system. Only one science textbook I reviewed incorporated a mixture of customary and metric measures. Mathematics textbooks, in contrast, include customary measure in the majority of measurement activities and discussion, with metric measure as a unit of study in one chapter and then often neglected in other sections. Metric measures are used as examples of decimal notation and the customary measurement system produces a myriad of examples of fractions.

One of the most common uses of *average* in science is taking the average of repeated measures as part of an experiment, using the median of three measures, or the arithmetic mean of two or more measures. Mathematics teachers rarely require a measure be performed more than once. Most uses of arithmetic mean in math texts are applied to significantly more than three items. Familiarity with science texts would help to remedy this issue.

Accuracy and precision in measurement and percentage of error are covered in most mathematics texts. However, the topic is most often positioned toward the end of the text where it gets little attention. The finer points such as why 1.0 g is not the same as 1.0000 g in science class are not well covered and the differences encountered may leave students in a quandary.

Mathematics curricula pay careful attention to rounding values to a nearest decimal place. Science texts also include the need to round measures to the nearest unit. Regrettably, the consideration of significant digits in calculation, taken as essential in science fields, is not as well represented in mathematics texts. Again, the use of the same data in both classes could help students get a better picture of what is important about measurement in both.

**Unit analysis (dimensional analysis)**

Concentrating on the mathematical process in many calculations, it is easy for mathematics students and teachers to neglect the unit of measure. By using units along with the numerical values, students are able to see a familiar technique from mathematics and use the analysis as a check for reasonableness of answers. Here is an example (from Holt and Holt 2002, p. 147):

Calculate the heat added to a mass of 0.2 kg of water to change the temperature of the water from 25°C to 80°C. (The specific heat capacity of water is 4,184 J/kg°C.)

\[
heat = \frac{4,184 \text{ J}}{\text{kg} \cdot \text{°C}} \times 0.2 \text{ kg} \times (80 \text{ °C} - 25 \text{ °C})
\]

\[
heat = \frac{4,184 \text{ J}}{\text{kg} \cdot \text{°C}} \times 0.2 \text{ kg} \times 55 \text{ °C}
\]

\[
heat = 46,024 \text{ J}
\]

In math class, students have seen the same structure, but might not have recognized them as equivalent.

\[
y = \frac{4,184 a}{b} \times 0.2 b \times 55 = 46,024 a
\]

**Conclusion**

This article has addressed a few of the places where the unique use of concepts in mathematics and science may cause confusion. As a science teacher, it is
important to be aware of what is happening in your students’ mathematics class so that you can point out distinctions between the way terms and procedures are used in each setting and strengthen students’ understanding in both disciplines. The same suggestion is made for mathematics teachers who work with texts that often fall short in adequately considering the science students are studying. With better communication between the two disciplines, students will benefit from more consistency between the two classes.

What you can do:

- Work with the mathematics teacher in your school to minimize the conflicting presentation of related topics.
- Build a joint vocabulary list that includes terms used in both classes.
- Review one another’s curriculum materials to identify and correct points of confusion. Share and discuss textbooks and other resources.
- Use data gathered in science class for work in math class.
- Explore the possibilities of collaboration and coordination with the mathematics teachers in your school.
- Consider joint projects, math/science fairs, and thematic units.

Every way that you can enhance the translation of knowledge between disciplines helps your students to know and understand their world better and builds their respect for the value of both disciplines.

References

Textbooks reviewed

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