We are able to make meaning from data when we work with clear and relevant visualizations or representations of data (see Evergreen’s article in Resources; Few 2012; Fontichiaro, Oehrli, and Lennex 2017). Although many students know how to make different graphs, they lack the critical-thinking skills required to select the best graph for their data and the question they are trying to answer (Webber et al. 2014). Therefore, helping our students gain a better understanding of how to best display their data to answer their question is paramount for our students to be successful in interpreting and analyzing data (Bowen and Bartle 2014).

This does not have to be time-consuming. Working on this data skill should be scaffolded and revisited throughout the year. Let’s explore some strategies we can integrate into our teaching to help students learn this important data skill.

First, to purposefully address our students’ gap in this data skill, we can help them make connections between the words they say when talking about their question or data and the graph types they should consider based on their question type (Hunter-Thomson 2018). For example:

- If students are talking about the range of earthquake magnitudes along the Pacific Rim to get a sense of the spatial scale and extent of this geoscience process, then they are looking at the distribution of their data (a Common Core State Standard, Mathematics [CCSS Mathematics], sixth-grade concept, 6.SP.A.2; see NGAC and CCSSO 2010). Thus, they should use a distribution graph (i.e., a histogram or boxplot).
- If students are talking about the proportional differences among land usage categories when exploring examples of human impacts on the environment, then they are looking at the composition of parts to the whole of their data (a CCSS Mathematics seventh-grade concept, 7.RP.A.2; see NGAC and CCSSO 2010). Therefore, they should use a composition graph (i.e., a pie chart).
- If students are talking about the height of a plant before and after they add fertilizer as they investigate the influence of local environmental conditions on the growth of organisms, then they are making a comparison with their data for one variable (a CCSS Mathematics seventh-grade concept, 7.SP.B.3; see NGAC and CCSSO 2010). They should use a comparison graph (i.e., a bar chart).
- If students are talking about the relationship between the mass and change in motion caused by different amounts of force when exploring Newton’s second law, then they are making a comparison with their data for more than one variable (a CCSS Mathematics eighth-grade concept, 8.SP.A.1). In this case, they should use a comparison graph (i.e., a scatterplot).
Because this may seem like a lot to remember, as it may be a different way of thinking about making a graph type choice, I created a Graph Type Matrix as a resource to provide support for users (Figure 1; also see Resources). Through numerous professional development sessions with teachers, I evolved this resource to be as concise, effective, and age-appropriate as possible. The Graph Type Matrix is a way for users to think about what kinds of graph types they have to choose from, based on the kind of question they are asking or the words they are using to talk about their data. The eight graph types included in the Graph Type Matrix are those most often used in K–12 science classrooms, appear in the math standards and science assessments, and are often used in news media (e.g., USA Today, The New York Times). The intention of this resource is to help our students become familiar with all of these graph types in general. By the end of middle school, students are not expected to be able to execute making all of these graph types themselves (i.e., bubble chart).

This is a great resource to have students put in the backs of their notebooks to refer to all year, as well as to post in the classroom. The resource can be used from multiple entry points; for example:

- If they know what kind of question they are asking (distribution, composition, or comparison), students can follow the corresponding row in the Graph Type Matrix to find graph options that match their question type.
- If they know what kind of data they have, students can look for the words they (or a partner) are using to describe their data, and then they can follow the row in the Graph Type Matrix to find graph options based on how they are talking about their data.
- If they know what kind of graph they want to make, students can follow the row in the Graph Type Matrix to see whether the kind of question for that graph type matches their own question (as a way to check whether they are making a smart graph type choice).

### FIGURE 1: Graph type matrix

<table>
<thead>
<tr>
<th>Type of Question</th>
<th>Describing Words of Data</th>
<th>Common Figure Types to Choose from</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Comparisons:</strong></td>
<td>among items</td>
<td>Among items</td>
</tr>
<tr>
<td>Comparison</td>
<td>between items</td>
<td>Among items</td>
</tr>
<tr>
<td>Difference</td>
<td></td>
<td>Among items</td>
</tr>
<tr>
<td>Similarity</td>
<td></td>
<td>Among items</td>
</tr>
<tr>
<td>Trend</td>
<td></td>
<td>Among items</td>
</tr>
<tr>
<td>Change</td>
<td></td>
<td>Among items</td>
</tr>
<tr>
<td><strong>Distributions:</strong></td>
<td>within variables</td>
<td>Within variables</td>
</tr>
<tr>
<td>Distribution</td>
<td></td>
<td>Within variables</td>
</tr>
<tr>
<td><strong>Compositions:</strong></td>
<td>within proportions</td>
<td>Within proportions</td>
</tr>
<tr>
<td>Composition</td>
<td></td>
<td>Within proportions</td>
</tr>
</tbody>
</table>

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### FIGURE 2: Creating a data visualization key

Data Visualization Key

- **Comparison**
  - Among items
  - Between variables
- **Distribution**
  - Within variables
  - Between variables
- **Composition**
  - Static in time
  - Changing over time

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The Graph Type Matrix helps students independently choose an appropriate type of graph, explain why they made that choice, and understand why an activity might have required a specific type of graph. The key is that a graph type is chosen for a reason (not just by chance), and the goal is to provide a resource to help students practice this skill over time. Another resource that can be helpful and provides similar information in a different setup is the Graph Choice Chart from Participatory Science (see Resources).

If you are looking to more deeply help your students make the connections between the mechanics of making a specific graph (e.g., as they would in graphing or spreadsheet software programs) and when they should consider using that graph, try using the Creating Graph Type Key activity in your class (see Resources). During this activity (about 20 minutes, depending on students’ prior knowledge of graph types), students work to match the different graph type options (that have been cut into individual cards) to the corresponding questions that can be answered from the graph type (composition, distribution, or comparison; see Figure 2). After they build out their completed key of graph types and you debrief the activity as a group, students can then fill in the right-hand column of the Graph Type Matrix themselves. Thus, they are driving their own knowledge generation of when to use different graph types.

Once your students are thinking about graphs more critically, integrate this data skill throughout your other content lessons. If you are providing students with the data sets, consider purposely plotting the data on a graph type that does not match your question or data. For example, if you are looking at air temperature over time to help students see annual patterns in
temperate climates, plot the data as a pie chart (Figure 3) as well as a line graph (Figure 4). Have students talk about why the pie chart (composition graph type) does not help them answer their question of how air temperature changes over time (comparison question).

Another approach to reinforce this data skill in lessons you are already teaching is to plot data for your students, or have them plot the data, in more than one graph type. For example, rather than just plotting the air temperature data in a line graph (Figure 4), also plot it in a bar chart (another comparison graph type, Figure 5). Then have students talk about how each particular graph type makes it harder or easier to interpret and analyze the data to investigate their question about changes in temperature over time. In this example, both are comparison graph types and thus could be used to plot the data. However, each graph type enables a user to make meaning of different parts of the data. A bar chart helps you easily make meaning of differences from month-to-month to determine which months had the largest or smallest changes in temperature. However, a line chart helps you easily make meaning of the trend across the year and thus get a sense of the annual weather pattern. This helps highlight that there is no one answer for which graph students should use based on the question type alone; they must determine graph type based on the specifics of their actual question. What are they actually trying to ask with the data? The answer will direct them as to which graph to use.

The important thing to remember with this data skill is that students need to practice it often. So, take the opportunity to teach the skill at the start of the year, but also reinforce it each time your students look at a graph or make a graph in class. Have your students take one or two minutes with each graph and talk about which graph type to use, which not to use, and why. This reinforces the data skill and critical thinking about how a graph helps in our interpretation and analysis of data for a specific question.

Conclusion
For students to be successful at interpreting and analyzing data, they need to look at visualizations that are set up to help them make sense of the data. We need to teach our students how to make the decision of which graph to use. This will help students more deeply understand their data, enable them to more authentically practice the process of science, and, most importantly, increase their data literacy inside the classroom and beyond. Let’s give our students the tools they need to understand the growing world of data around them in the 21st century!

REFERENCES
Hunter-Thomson, K. 2018. Interdisciplinary Ideas: Data literacy
High quality interactive content for K–12 science teachers

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RESOURCES
Creating Graph Type Key—https://wp.me/p8doHt-fY
Graph Type Matrix—http://bit.ly/2pZAzM
Participatory Science: Graph Choice Chart—http://bit.ly/2J3TEmg
Stephanie Evergreen: The Most Important Question in Data Visualization—http://stephanieevergreen.com/most-important-question

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