

Expanding the power of data analysis with Google Sheets

BY RAJA RIDGWAY

What does data analysis look like in your classroom? What are students doing to gain insights into those temperature readings or density calculations? According to Appendix F of the *Next Generation Science Standards* (NGSS Lead States 2013), such analysis aligns

to the *Common Core State Standards, Mathematics*, as calculating measures of central tendency are part of the standards for sixth grade (NGAC and CCSSO 2010; see below for Standards alignment). This is a notable shift from the elementary grades, where students focus on qualitative ob-

servations with limited or no statistical analysis involved.

The NGSS also note that middle school students should be, when possible, using technology to enhance their data analysis processes. Although students should certainly learn how to conduct statistics calculations

Connecting to the Standards

Next Generation Science Standards [NGSS Lead States 2013]

Science and Engineering Practice 4: Analyzing and Interpreting Data

Apply concepts of statistics and probability (including mean, median, mode, and variability) to analyze and characterize data, using digital tools when feasible.

Common Core State Standards [NGAC and CCSSO 2010]

CCSS.MATH.CONTENT.6.SP.B.5.C

Giving quantitative measures of center (median and/or mean) and variability (interquartile range and/or mean absolute deviation), as well as describing any overall pattern and any striking deviations from the overall pattern with reference to the context in which the data were gathered.

K-12 Computer Science Framework [K-12 Computer Science 2018]

Algorithms and Programming: Modularity (by the end of eighth grade)

A procedure is a module (a group of instructions within a program) that performs a particular task. In this framework, *procedure* is used as a general term that may refer to an actual procedure or a method, function, or similar concept in other programming languages. Procedures are invoked to repeat groups of instructions. For example, a procedure, such as one to draw a circle, involves many instructions, but all of them can be invoked with one instruction, such as “drawCircle.” Procedures that are defined with parameters are generalizable to many situations and will produce different outputs based on a wide range of inputs (arguments).

by hand, they should also learn how technology, such as computer spreadsheets, can help them analyze larger data sets faster and with greater accuracy. Google Sheets is one way to expose students to the power of technology in the context of your middle school science classroom.

Google Sheets

Google Sheets is a free spreadsheet software that can be accessed with a free Google login. While an internet connection is required, Google Sheets can be used on computers, laptops, and smartphones. As access to web-enabled devices continues to increase (National Center for Education Statistics 2017), Google Sheets could be a way to expand the way students conduct quantitative data analysis, such as calculating the mean, median, and mode of a data set, in your classroom while helping them understand basic computing concepts.

Built-in functions

If you or your students are new to using Google Sheets, consider starting with built-in functions to calculate the measures of central tendency and variability. One way to introduce the use of built-in functions is by using a model-debrief-practice method, which allows the teacher to model his or her thinking and help students make connections (Saphier, Haley-Speca, and Gower

Accommodation tip

If you are presenting the Google Sheet for all students via projector, zoom in on just the data set to maximize the size of the text.

Essential definitions

- **Function:** a repeated set of instructions for a specific action, such as “AVERAGE[value1,value2,...]” which returns the mean of a provided data set.
- **Parameter:** the input for a function generally, such as “[value1,value2,...]” in the function for calculating the average.
- **Argument:** the input for a function in a specific situation, such as 24.5°C, 23.2°C, 24.7°C, 24°C, and 25.1°C for calculating the average of a set of temperature values.

Management tips

- If only the teacher has a device that can access Google Sheets, display the data set for all students to see. If students have access to their own devices, use a shared Google Sheet that students can view on their own computers [see Resources for how to share Google documents].
- Use paired programming for both built-in and custom functions. One student is the “driver” and takes on the role of interacting with the computer or smart device. The other student is the “navigator” who asks and answers questions as the team works together. See the Resources for a Code.org video to use when introducing paired programming to students.

Assessment suggestions

1. To provide students with more opportunities to practice using the predefined functions in Google Sheets, have them calculate the mean, median, and mode of multiple groups’ data sets after they complete their own.
2. If using GAS, assess students not only on their scripts, but also on the efficiency of those scripts. Consider using a generic rubric for scoring custom functions:
 - Exemplary [4]: The function works as intended with efficient code.
 - Proficient [3]: The function works as intended.
 - Foundational [2]: The function contains minor errors.
 - Attempting [1]: The function contains major errors.
 - Lacking [0]: A function is not provided.

2008) before students practice the techniques themselves.

Model finding the mean

Start by inputting data collected from a lab or experiment and setting up cells for the measures of central tendency and variability. Once the data are entered, model a clear set of steps for how students will determine the mean of the data set (note that Google Sheets uses “average” instead of “mean”). Consider using chart paper, a whiteboard, or a student handout to detail the steps. Here is an example set of steps:

- Click into the cell to the right of “Mean.”
- Start with an equal sign (=) to indicate a function is being used.
- Type in “AVERAGE.”
- Type an open parenthesis.

- Choose each data point that should be included (individually or as a set).
- Type a closed parenthesis.
- Press Return/Enter (see Figure 1).

Debrief the model

To ensure that students are able to use Google Sheets and understand the process the computer is using, a debrief of the model is necessary. One way to debrief the model is through guided questioning to illustrate the key concepts (Figure 2).

Facilitate student practice

Have students practice calculating the median and the mode of the data set using the “MEDIAN ()” and “MODE ()” functions following the same steps as shown for finding the average. In addition to finding the values,

students should provide an explanation of the steps the computer took when the functions were called. Students can also practice calculating the standard deviation “(STDEV())” and range “(MAX() – MIN())” of the data set.

Writing custom functions

If you and your students are more experienced with Google Sheets, consider teaching them how to build their own functions using Google App Scripts (GAS). GAS allows users to customize their experiences with a variety of Google products, including creating functions in Google Sheets. Middle school science students can create custom functions to expand the types of data analysis they conduct, such as determining percent change, all the while learning more about the concept of modularity. The process to create a custom function is straightforward and does not require any additional software or add-ons. The process to find and open the script editor can be found on the guide page provided by Google (see Resources).

In addition to providing more options for data analysis, custom functions are perfect for introducing students to basic programming concepts such as variables and loops. Although JavaScript is the programming language using by GAS, neither you nor your students need to be coding experts to develop and run custom functions. The model-debrief-practice

FIGURE 1: Average function

	A	B	C
1		Initial Temperature (C)	Final Temperature (C)
2	Group 1	24.5	17.7
3	Group 2	23.2	17.2
4	Group 3	24.7	17.2
5	Group 4	24	18
6	Group 5	25.1	19.2
7		24.3 ×	
8	Mean	=AVERAGE(B2:B6)	
9	Median		
10	Mode		
11			
12	Standard Deviation		
13	Range		

process can be used to introduce writing simple scripts, such as a function for calculating percent change based on initial and final value inputs (see Figures 3 and 4). The use-modify-create process (Lee et al. 2011) can also be used to support students in progress-

ing from using custom functions to developing their own functions for other types of data analysis. Although an explanation for how to write scripts using GAS is beyond the scope of this article, a great variety of tutorials are available (see Resources).

A common pitfall

As with any tool for analysis, it is important to teach students how to analyze data using Google Sheets within the context of a lab or investigation. Rivet and Ingber (2016) note that students should analyze and interpret data to pro-

FIGURE 2: Guided questioning

Key concepts	Questions
<p>The function is called by typing the equal sign, the function name, and providing a specific input argument.</p> <p>[Note: “Calling” functions is the terminology used to describe actually using the function that has been defined. With predefined functions, such as “AVERAGE,” the code for the function is already written. The computer just needs to be prompted to access the right code, and thus the user needs to “call” the function by typing in the name of the function.]</p>	<p>How did the computer know that we wanted the mean of the data set? <i>We used an equal sign followed by the name of the function, AVERAGE.</i></p> <p>How did the computer know which numbers we wanted to include in the data set? <i>We put the specific data set in the parentheses.</i></p> <p>What do you think would happen if we didn’t include the equal sign? The data set? <i>The function wouldn’t be called without the equal sign. The computer wouldn’t know which data set to analyze.</i></p>
<p>Each function has a predetermined set of steps to execute once it is called. The function then returns the output value.</p>	<p>What steps did the computer take once we pressed Return/Enter? <i>The computer added up all the numbers in the data set. It also found the total number of data points. It then divided the sum by the total number of data points to calculate the average.</i></p> <p>How did the computer know to take these specific steps? <i>The computer was programmed to take these steps. It didn’t come up with them by itself!</i></p>
<p>Functions allow for faster analysis with greater accuracy. This is especially useful when large data sets are being analyzed.</p>	<p>Why is using a computer to find the mean better than doing it by hand? <i>The computer can find the mean of the data set faster than we can find it by hand.</i></p> <p>Say we had 1,000 data points rather than just five data points. Why might using a computer be beneficial, besides speed? <i>The computer will not make mistakes because it follows the same procedure each time. We, as humans, are likely to make mistakes if we had to calculate the mean of 1,000 numbers by hand!</i></p>

FIGURE 3: Custom function for percent change

```

Custom Function.gs x
1 function percentChange(initial, final) {
2
3   perChange = (final-initial)/(initial)*100;
4   return perChange;
5
6 }
7
  
```

FIGURE 4: Calling the percent change function

	A	B	C	D
1		Initial Temperature (C)	Final Temperature (C)	Percent Change (%)
2	Group 1	24.5	17.7	=percentChange(B2,C2)
3	Group 2	23.2	17.2	
4	Group 3	24.7	17.2	
5	Group 4	24	18	
6	Group 5	25.1	19.2	
7				
8	Mean	24.3		
9	Median			
10	Mode			
11				
12	Standard Deviation			
13	Range			

vide meaning for relationships and patterns found in the data, and answer a question or provide a solution to a problem. Google Sheets is an excellent tool for expanding the types of data analysis students conduct in the science classroom, but a lesson using Google Sheets should not come in isolation from science labs or investigations.

Conclusion

Research has shown that one way to support interest in high school computing classes and careers in computing is through experiencing computing concepts in middle school (Friend 2015). This has been shown to be true for female students, an underrepresented

population in computing fields (Hur, Andrzejewski, and Marghitu 2017). Using Google Sheets to analyze data can help you meet the expectations of the NGSS and introduce students to basic programming concepts. Help your students gain insights into their data while building fluency with spreadsheets!

How else are you integrating computer science into your middle school science classroom? Do you have a great resource or experience to share? Let me know via e-mail! ●

REFERENCES

Hur, J.W., C.E. Andrzejewski, and D. Marghitu. 2017. Girls and computer science: experiences, perceptions, and career aspirations. *Computer Science Education* 27 (2): 100–20. <https://doi.org/10.1080/08993408.2017.1376385>.

Friend, M. 2015. Middle school girls' envisioned future in computing. *Computer Science Education* 25 (2): 152–73. <https://doi.org/10.1080/08993408.2015.1033128>.

K–12 Computer Science. 2018. Framework statements by grade band. <https://k12cs.org/framework-statements-by-grade-band>.

National Center for Education Statistics. 2017. Children's access to and use of the internet. https://nces.ed.gov/programs/coe/indicator_cch.asp.

National Governors Association Center for Best Practices and Council of Chief State School Officers [NGAC

Raja Ridgway [rridgway@relay.edu] is the director of computer science education and an assistant professor of practice of secondary science education at the Relay Graduate School of Education in Denver, Colorado. He is a former middle and high school science teacher who now supports teachers with integrating computer science into their classrooms.

and CCSSO]. 2010. *Common core state standards*. Washington, DC: NGAC and CCSSO.

NGSS Lead States. 2013. *Next Generation Science Standards: For states, by states*. Washington, DC: National Academies Press. www.nextgenscience.org/next-generation-science-standards.

Rivet, A.E., and J. Ingber. 2016.

Analyzing and interpreting data. In *Helping students make sense of the world using next generation science and engineering practices*, ed. C.V. Schwarz, C. Passmore, and B.J. Reiser, pp. 159–80]. Arlington, VA: NSTA Press.

Saphier, J., M. Haley-Speca, and R. Gower. 2008. *The skillful teacher*. Acton, MA: Research for Better Teaching.

RESOURCES

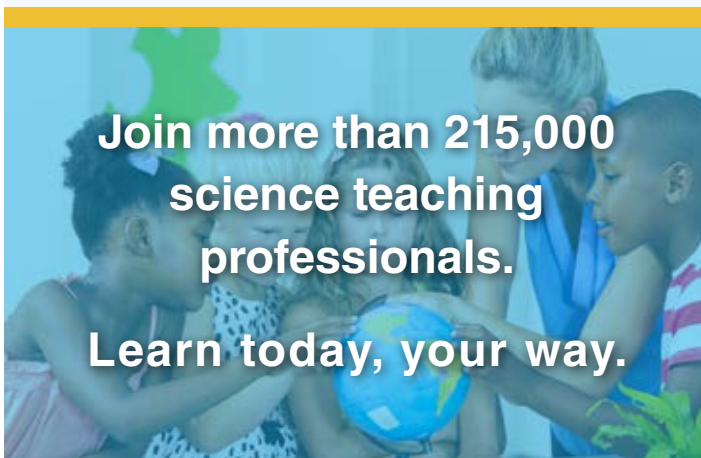
- Built-in functions available in Google Sheets—<https://tinyurl.com/nqyj7xu>
- Code.org video for paired programming—<https://tinyurl.com/kuwoond>
- Find and open scripts—<https://tinyurl.com/n2fyo9g>
- How to share Google Sheets—<https://tinyurl.com/jhcgyn3>
- Tutorials for Google Apps Script—<https://tinyurl.com/ybumyfvt>

Read NSTA’s free online journal, *Connected Science Learning*



CSL explores programs codeveloped by schools and out-of-school organizations, including museums, science centers, afterschool providers, zoos, and aquaria. If you’re involved in program development or want to start STEM partnerships in your community, this is the journal for you. You can view the articles and subscribe at <http://csl.nsta.org>.

The NSTA Learning Center



Join more than 215,000 science teaching professionals.
Learn today, your way.

“The Professional Development Indexer helps you diagnose your needs in specific science content areas and provides suggestions of NSTA resources and opportunities to consider as you plan your professional learning experience. The Indexer saves your resources list so you can keep coming back to accomplish more!”

– Marguerite Sognier
T-STEM Center Executive Director

- Gauge your knowledge in 25 content areas
- Explore thousands of resources: lesson plans, articles, book chapters, and more
- Attend events, online and in-person
- Track your professional learning goals and activities
- Connect with others through 14 topical forums or via private messaging

<http://learningcenter.nsta.org>



Reproduced with permission of copyright owner. Further reproduction prohibited without permission.