Enhancing Lessons Through Technology

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This paper will describe and analyze the integration of technology into a secondary school statistics lesson. The lesson will be described in sufficient detail so that a secondary mathematics or middle school integrated STEM specialist could implement the lesson in their own classroom. The benefits and potential disadvantages of the approach will be discussed, along with suggestions for how elements of the technology integration could be transferred to lessons in other STEM subjects and grade levels.

Lesson Selection

The example lesson selected is from a Grade 10 statistics unit; the topic is standard deviation. The specific learning outcome for the lesson is that students will be able to not only calculate standard deviation but also understand what it tells us about a data set and how it is related to the shape of a data set's histogram. This sequence of learning experiences was chosen as an example of one that is already benefitting from technology integration, but with scope for improvement. Moreover, the topic was chosen because of its importance in analyzing and interpreting large data sets, which is one of the Science and Engineering Practices in the Next Generation Science Standards (National Science Teaching Association, 2014).

Detailed lesson description

Prior to the lesson, students should be familiar with histograms and boxplots, and how to construct them in Google Sheets. They should also be familiar with basic spreadsheet features such as entering and filling down formulas, calculating averages, and so on. It is recommended that students work on this task in pairs. Students are given a large data set that is deliberately (but randomly) generated to be symmetrical about a chosen mean. There are a number of online tools that can do this, for example the Normal Distribution Generator on the Social Science Statistics website (Stangroom, 2021). One thousand data points should allow for the symmetry in the data to be apparent, without making the spreadsheet work too cumbersome. Share the data set with students in Google Sheets and ask them to make a copy of it.

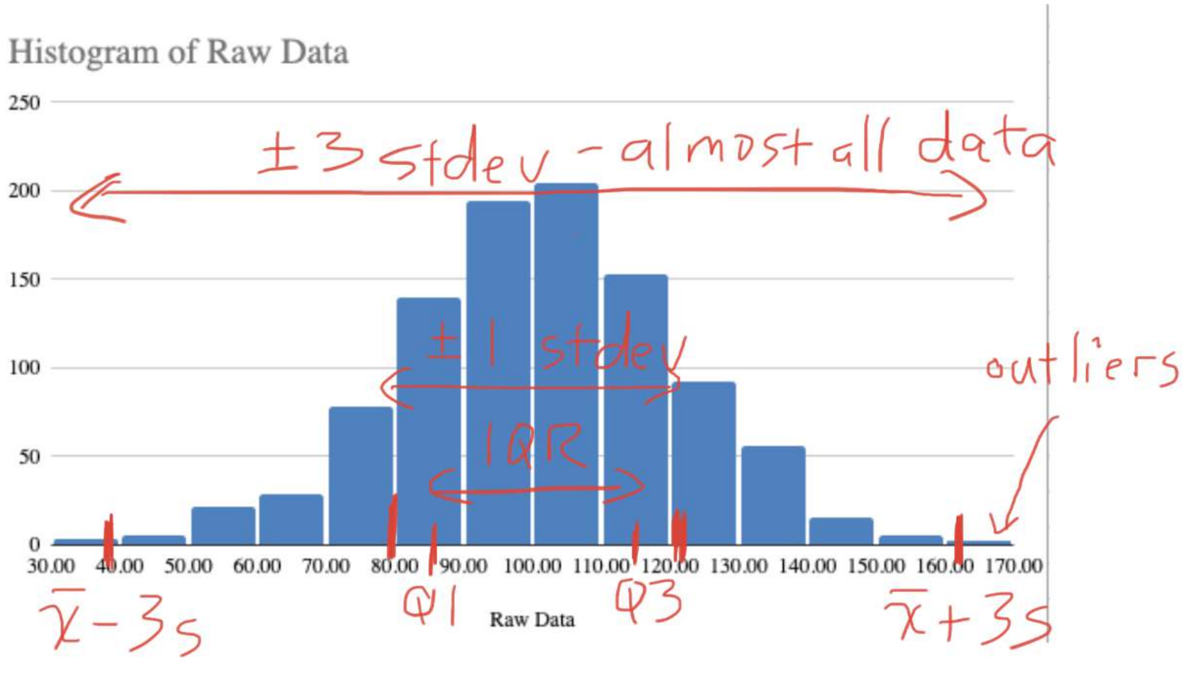
After calculating the mean (which should be relatively straightforward for most), students are challenged to find a way of calculating the average distance of each data point from the mean. If the data set is large enough, this should be approximately zero. Then, ask students how they could find the average *absolute* distance from the mean and allow them some time to think about ways of doing this before presenting them with the standard deviation formula. Stronger students can investigate what happens to the standard deviation when the data set is transformed by adding or subtracting a constant from each value or multiplying each value by a constant.

In the second part of the activity, students find the interquartile range and range of the same data set and compare these with the range of values represented by one and three standard deviations from the mean, respectively. Capable students might like to try calculating the percentage of data values that lie within one standard deviation of the mean. Finally, ask students to create a histogram of the dataset (again, in Google sheets) and mark these ranges on the histogram. Students may choose to do this using screen annotation tools (see example in Figure 1 below), or simply sketch the histogram in their notebooks first.

In the final part of the lesson, students are asked to apply their knowledge and understanding of standard deviation to a real-world situation. Students are presented with a sample of data taken from a nationwide survey of Australian high school students. The data includes information about students' favorite takeaway food and their scores on a game designed to test memory and concentration ability, as well as demographic data such as age, gender and grade level. Students are then asked to process the data in order to answer questions such as

Figure 1

Example Student Product for the Standard Deviation Activity



Note. Produced by the author using Google Sheets and Google Jamboard.

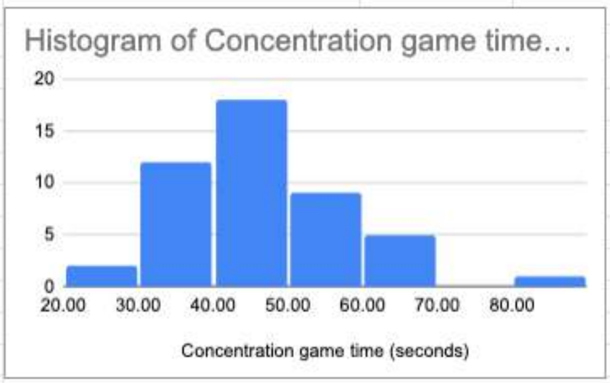
"which students have better concentration – males or females?" and "does eating healthy food improve concentration?". The data sample was taken from an Australian Bureau of Statistics initiative called CensusAtSchool, as introduced by Wong (2006) in the Australian Mathematics Teacher journal. Unfortunately, the original Australian data is no longer available online; however, equivalent sample data for both U.S. and international students can be easily obtained from the U.S. Census at School project website (American Statistical Association, n.d.).

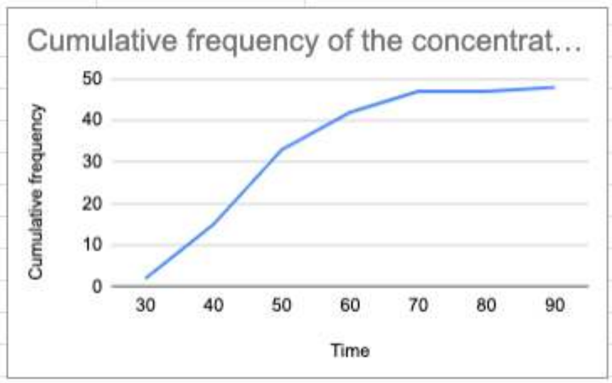
Alternatively, the activity could be turned into an ongoing class project. Students can collect their own concentration game score data from online versions such as the "Concentration Memory Game" available at MathisFun.com (2020) and design a survey to collect appropriate healthy eating data. If the class data would result in a small sample size, consider extending the survey to the entire grade level or even school wide. Students should be prompted to compare histograms of appropriately selected data sets and use both mean and standard deviation to support their conclusions. An example student response is shown in Figure 2 below.

Figure 2

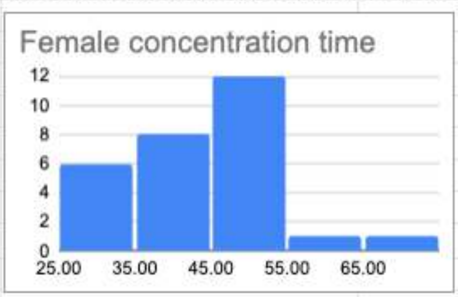
Example Student Processing of the Australian Bureau of Statistics Survey Data

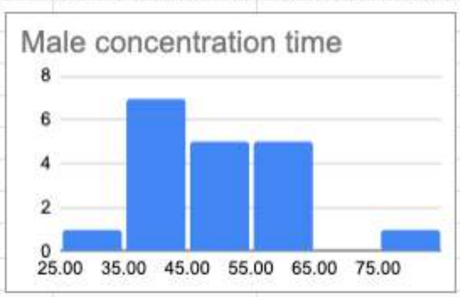
Concentration game time (seconds)				
Time	Time	Frequency	Cumulative frequency	Percentage cumulative frequency
20-30	30	2	2	4.17%
30-40	40	13	15	31.25%
40-50	50	18	33	68.75%
50-60	60	9	42	87.50%
60-70	70	5	47	97.92%
70-80	80	0	47	97.92%
80-90	90	1	48	100.00%





The outlier is the one has the value of in between of 80 and 90 seconds because it is located every far apart from other variables





Female did better in the test because the mean and median time they required to complete the test is lower. Furthermore, since their result's standard of deviation is lower than the male's, results are closer to the mean, so most of their results will be lower then the male's

Note. The student is supporting their answer to the question “which students have better concentration – males or females?”. Adapted by the author from student work produced in Google Sheets.

Analysis

Students in this cohort (and the author) had already used Google Sheets in several learning engagements that formed part of a sequences and series and financial mathematics unit. Moreover, they were familiar with general features of Google's office applications, such as commenting on and sharing work, both of which are used extensively throughout the school. To use terminology from Puentedura's 2013 SAMR model of classroom technology integration, the use of Google Sheets can be considered as "augmenting" the learning engagements described above, when compared with a similar lesson that might be conducted using textbooks, handouts and handwritten calculations and graphs. This is because it allows calculations to be performed on large data sets relatively quickly. This, in turn, allows students to visualize the symmetries that emerge from such large data sets, and thus conceptualize standard deviation as a measure of how closely data is grouped about a mean in a way that they would not otherwise be able to by performing calculations with the small data sets usually presented in textbooks. If the class were to collect their own data for the real-world application part of the lesson and then collaborate to compile aggregate data in Google Sheets, this could even be considered a "modification" on the SAMR model spectrum, as it moves the lesson outcomes beyond simply helping students to understand standard deviation more efficiently.

Another benefit of using technology in the lesson described above is that is allows students to engage in activities that more closely resemble what they might need to do in workplace teams as adults, which helps them develop key 21st century skills (Greenhill, 2010). Consider how the lesson contains all the workplace skills listed in Table 1 of Ruder et al. (2018, p. 30). Teamwork can be seen both in their working with a partner to solve a problem, and also their collaboration with the teacher via comments in Google Sheets. Information processing skills are required in deciding how to process the data, and in the real-world application part of the lesson, deciding what data is needed to answer the question. Critical thinking is demonstrated when justifying their conclusions with the available data, and problem solving is occurring because students are not given direct instructions on what calculations to perform in order to support their answer to the question.

As with any lesson that involves students spending extended amounts of time on laptops, there are always potential barriers to learning that need to be managed and anticipated. Apart from technological infrastructure issues such as unstable internet connections or limited battery life De Freitas and Spangenberg also mention “the need for teachers to micromanage learners” and “technology (being) a distraction to learners” as impacting the learning process (2019, p. 7). In their 2017 study of factors that influence technology-based distractions in Bring Your Own Device (BYOD) classrooms, Kay et al. found that students “will engage in distracting behaviors if lessons are not well planned, organized, challenging, and engaging.” (p. 990). This finding is certainly consistent with the author’s own experiences with technology integration, and although we are not a BYOD school, the overarching principle here is that adding technology to lessons does not remove the need for good lesson planning.

Google Sheets can be used to augment and modify almost any data handling lesson from upper elementary through to upper high school. For example, a lower middle school or upper elementary age-appropriate example can be found in McLaughlin’s 2013 article “Engaging middle school students in the analysis and interpretation of real-world data”. Similar to the example described in this paper, students use real-world data to create charts and draw conclusions, but the mathematics content involves bar charts rather than histograms and standard deviation. Although the lesson is actually designed for the Next Generation Science Standards, it could just as easily be used as a middle school mathematics lesson, and McLaughlin notes the relevant common core mathematics standards that the lesson aligns with. In the lesson, the students construct bar graphs on grid paper, but the lesson could easily be adapted so that the charts are constructed in Google sheets, if appropriate scaffolding is provided.

Conclusion

Visualizing large data sets is an important 21st century skill that can be effectively developed in a range of age groups by teaching statistics concepts through Google Sheets. Providing opportunities for students to collect and share real-world data and then use it to answer a meaningful question can further enhance the development of 21st century skills, as long as the potential barriers to learning that technology use presents are effectively managed. Future improvements to the lesson described in this paper could include the addition of more explicit and authentic teamwork role expectations that promote student interdependency and developing the project into an integrated curriculum unit that could include topics from biology, physical education and social studies.

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