Desmos' Penny Circle Activity: Enhanced Analysis and Data Pooling

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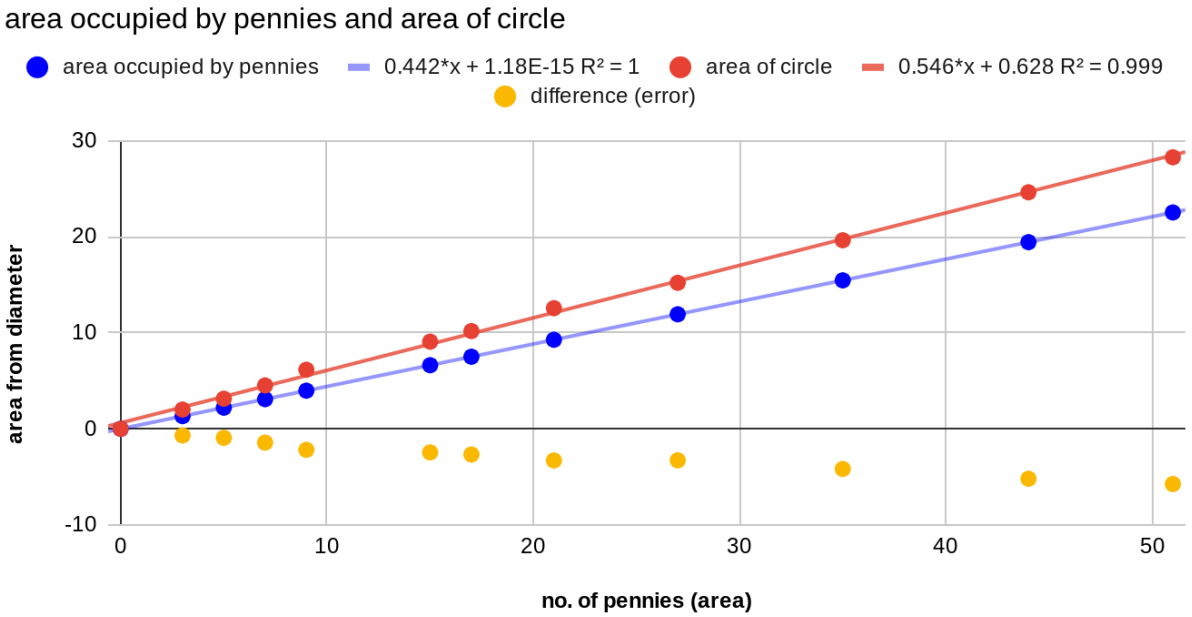
Two interactive Google Sheets spreadsheets were developed to expand the data analysis of the Desmos' Penny Circle Activity. This interactive web-based activity was developed by Dan Meyer at Desmos, see Meyer (2014).

Desmos' Penny Circle Activity: Enhanced Analysis Spreadsheet

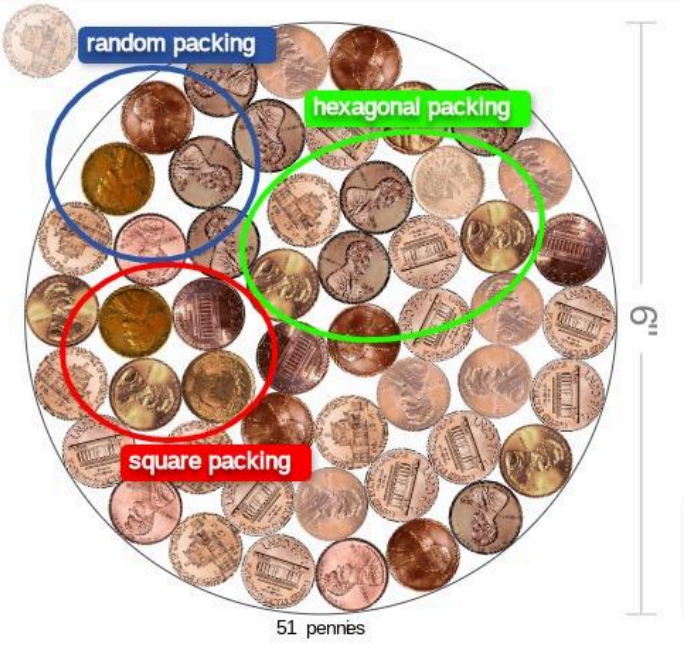
The activity assumes that the number of pennies are a function of the diameter of the circle. Students explore fitting their collected data with linear, quadratic, and exponential models, which the spreadsheet revisits.

Next the spreadsheet examines the area computed from the number of pennies (area occupied by pennies = number of pennies x area of a penny) and the area computer from the circle diameter ($A = \pi d$). The difference (area occupied by pennies - area of circle) is determined and this is the absolute error. Then the percent error is calculated by %error = (area of pennies - area of circle)*100/ area of circle. These are illustrated on the graph taken from the spreadsheet. How does the error behave and what is the cause of the error are good discussion points! The slope of the blue line is the area (0.442 sq-inch) occupied by a US Mint penny!



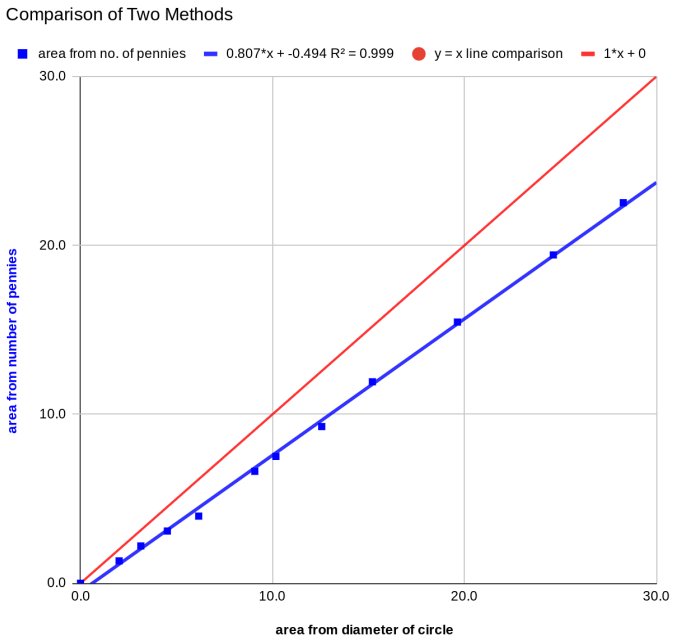
Examining the penny packing tab might help students with addressing the error. The error is a negative proportional systematic error and is caused by increasing empty space not occupied by the pennies as the circle diameter increases. Students discover the cause of the error or bias!

Here is a screenshot of the Desmos app pointing out the types of packing as shown on the penny packing tab. This is a very useful lead-in for packing of atoms in crystal structures, especially metals. Starting with 2D helps to transition to 3D.



Another type of comparison plot where a new method can be compared to an old method or two different analysts doing the same analysis. If the two methods or the two analysts agree, the data will lie on the y = x line (for perfect agreement: slope = 1, y-intercept = 0, and r-square = 1).

Getting error analysis into activities is an important element that needs attention to develop the mindset.



The use of the spreadsheets range from class discussion to having students completely set-up the computations and graphs. They could be made to be "just-add-data" spreadsheets as well. A "just-add-data" spreadsheet has computations, graphs including regressions (or simply the line of best-fit) all set up, plus any simulations, and all students do is add their data to get results and explore.

If you want to examine types of errors, see Rulers and Measurement Error (interactive Excel spreadsheet or Excelet). If you want further discussion, see Sinex (2005) and for some simple, easy experiments with readily available manipulatives (Sinex 2013, 2017, 2018).

Desmos' Penny Circle Activity II: Data Pooling Spreadsheet

Students working in groups can enter their number of pennies to fill a prescribed set of specified diameters. This spreadsheet addresses variability in data (see Hunter-Thomson (2022) for more) and can stand alone (no need to do the Extended Analysis). The two tabs on this spreadsheet allow for the "just-add-data" by up to eight groups and then calculate the mean, maximum, and minimum, plot the three quantities, and fit it with a linear regression, while the second tab does the mean plus/minus the standard deviation (standard error bars) for more advanced students. By displaying the spreadsheet, a class discussion would ensue. For more on data pooling and online collaboration, see Data Pool in the Cloud.

For the Just Getting Started Crowd

If you are just getting ready to introduce modeling of data, here is a really good first activity (possibly some author bias here) with a "just-add-data" spreadsheet and simulations.

Investigating the Height of a Stack of Cookies Excelet Activity (pdf)

…and yes students can eat the cookies after all is completed!

References

Kristin Hunter-Thomson (2022) Why is Variability Worth the Teaching Challenge? (Data Literacy 101) Science Scope 45 (3) 8-13.

Dan Meyer (2014), Penny Circle Task at https://achievethecore.org/content/upload/Grade%20HS%20Dan%20Meyer%20task%20-%20penny%20circle%20final06.26.14.pdf.

S.A. Sinex (2005) Investigating Types of Errors, Spreadsheets in Education 2 (1) 115-124.

S.A. Sinex (2013) Investigating and Visualizing Measurement Error for Novice "STEM" Learners in Proceedings of the Spring 2013 Mid-Atlantic Section Conference of the American Society of Engineering Education, pp. 222-234.

S.A. Sinex (2017) Multivariable Spreadsheet Modeling and Scientific Thinking via Stacking Bricks in Electronic Proceedings of the ICTCM Conference, Vol. 28, pp. 381-390.

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Link to Gdoc: https://bit.ly/3Z7djQB