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Oh Sheets!: A Tool for Online Collaboration in the Cloud

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Abstract

Higher education needs to bring students into the practice of cloud based online collaboration such as they will encounter after graduation. A useful introduction starts with data collecting and pooling with Google Forms followed by real time graphing and computations, easily accomplished in the Excel-like Google Sheets. We find students and in-service teachers are very positive about their experience. Here we review the limited literature and describe how instructors can get their students into cloud based online collaboration using spreadsheets and other powerful collaborative options available via Google Drive.

Keywords

spreadsheets, online collaboration, data pooling, cloud application

1.   Introduction

Online collaboration was ranked last of eight US undergraduate education technology skills in a recent Pearson-Microsoft-Gallup report [1] but is increasingly vital in the modern workplace. Thus it is important to bring this 21st-century cloud-based technology to into the STEM classroom in a way that engages students and prepares them for their careers. Laboratory classes are excellent places to introduce online collaboration, because the students generate data as part of their work. Google Drive has a phenomenal potential to enter data into the spreadsheet using Google Forms as a data entry vehicle for Google Sheets during online collaboration; Google Sheets operates very much like MS Excel for data analysis.

We have demonstrated this by pooling data gathered by lab partners in freshman level general chemistry classes. We used the Forms to Sheets in Google Drive and we added online discussion using Forms to Sheets with Chat [2, 3, 4, 5]. More recently, we added real-time graphing and computations to Sheets as data was pooled by groups of students who wrote collaborative reports [6, 7]. Readers may want to look at our papers [2, 4] especially to get details.

All of this ignites a competitive spirit in students while working in the laboratory. A useful side product is that it rapidly becomes clear if one of the groups presents suspect data, and the students can work together to find and correct the problem. Further increasing the amount of data generated makes a real positive difference for teaching statistical analysis of the results. When individual groups generate two or three data points, finding averages, fitting data to functions, etc. is intellectually problematic, but the online collaboration (pooling) allows for richer data sets on which statistical analysis has obvious advantages and applications.

All of our evaluations have shown very positive response from our students and from in-service high school math teachers in workshops as well. Further, feedback and assessment can be easily accomplished in Google Forms. Previous work in the CSUN science education program independently implemented pooling of data combined with formative assessment [8, 9]. This article shows how instructors can begin using this powerful online collaborative tool, all in the cloud and available free, and provide resources to get you started.

2.   Google Sheets Capabilities

In order to begin the novice should spend some time exploring the capabilities of Google Sheets. The reader will need a free account, and any Google related account such as for Gmail will work. Once having accessed Google Sheets you can start exploring.

If you click on Help on the menu bar in Google Sheets then select Function List from the dropdown menu, you can peruse the impressive list of functions and their syntax that are available. The computational capabilities of Sheets are comparable to MS Excel and OpenOffice. You can install add-ons (menu bar: Add-ons > Get add-ons…) such as Solver (from Frontline, the same as contained in Excel), Open Solver (from opensolver.org and can be installed in Excel as well), Risk Solver (from Frontline) to do Monte Carlo simulations, or XLMiner Analysis ToolPak, plus many others.

For mathematical modeling of data using Sheets, the regression types are limited to linear, exponential, and polynomial, and the graph insert process is slightly more involved than in Excel. Other regression types (sine, power, logistic) can be accomplished by setting up adjustable cells for the parameters and doing a manual fit (just get close) to minimize the sum of the squared errors. Then you can run the Solver add-on to get the best fit. This will need to be done by matching data points with points from your fit as you cannot connect points in Sheets on a scatter plot. Solver needs to be set up and run on each access as conditions are not saved as in Excel.

3.   The Collaborative Capabilities

Collecting a class data set can be as easy as setting up a Google Sheet by the instructor then sharing the link with editing allowed to students and other participants via email or posting on a web page. Instructors can also use a URL shortener tool, such as goo.gl, to shorten the URL addresses from Google Drive. Anyone with the link can add/edit data. This can be done in the anonymous mode. To set this up, students can have access to a Google Form requesting specific information, both quantitative and qualitative. We suggest selecting "allow edit" authority to give students the ability to correct errant forms after submission. Once the data is in Google Sheets, it can be analyzed and graphed, or exported in Excel format for further processing in Excel. This is a simple start to pooling data; and computing class statistics allows comparison of group data where analysis can be done by the students and/or instructor.

Figure 1 is an example of a spreadsheet set up to collect group data of multiple trials. In this example, the students would enter their group's data for five trials, and the mean and standard deviation are computed as well as the grand mean and standard deviation for the class. If students had calculated the mean and standard deviation by hand at first, they can use this as a check. Since the cloud stores all versions of any sheet the instructor can revert if a student introduces errors or deletes any data. An instructor comment can be inserted and a cell is marked where group C is about to enter their data. This is the concept used in whole class laboratories in physics by Kouh [10]. For a variety of other examples in a wide range of sciences, see Vandergon and others [9].

Figure 1: Multiple measurement sheet for student groups

Simple data set entry for student analysis in dry labs (given data for an experiment) can also be easily done. Data is placed in the sheet directly or collected using a Form in Google Sheets set to share with anyone possessing the link. The data can then be transferred to the student's account by selecting "Make a copy…" for saving as a Google Sheets file in Google Drive (the copied file can be edited) or downloaded in a variety of formats (MS Excel, OpenOffice, csv, or pdf).

As an introduction to mathematical modeling for students and in-service teachers, we have them develop a model by measuring the stack height of cookies such as Oreos [11]. After groups collect their data and develop their model, they pool their data using a Form (Figure 2) and develop a class model in Sheets as illustrated in the screenshot in Figure 3. We added plus/minus error points that are one standard deviation from the data point. The class model is usually better because it is based on multiple measurements of the various cookie stacks. The exercise can be extended to classes with multiple sections with either a single or combined set of worksheets.

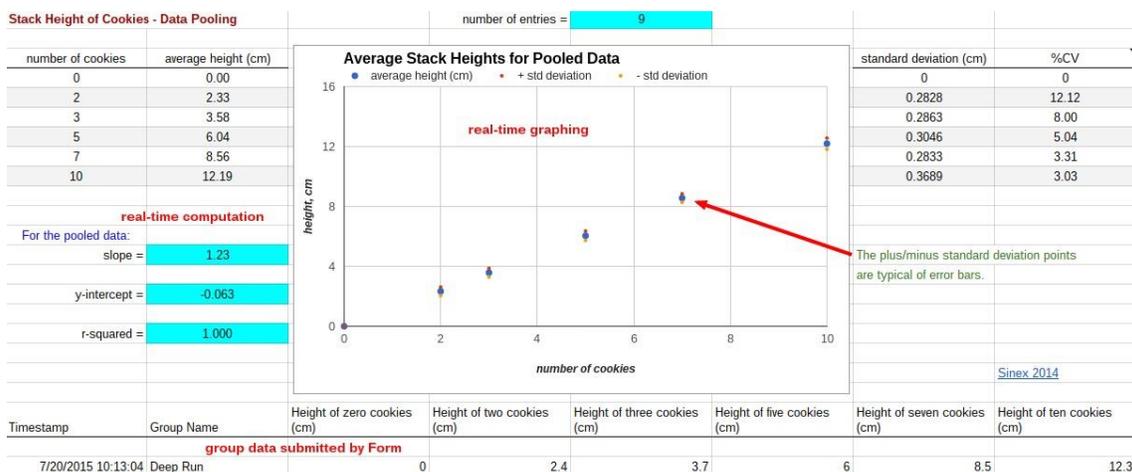Figure 2: Google Form for pooling of stack height data from groups.

Figure 3: Pooling data in Sheets with real-time graphing and computations including error points (± one standard deviation) for stacking cookies.

Pooling data where the pool size is larger, such as flipping pennies to demonstrate radioactive or exponential decay illustrates how a larger size can improve sampling statistics. Data pooling also allows instructors to have students look for consistency in collected data by comparison. Note that novice students interpret consistency as constancy (values must match each other). See discussion in next section on how to deal with this.

4.   More Advanced Collaborative Capabilities

When multiple students are logged into Google Drive, they can use the chat feature to communicate in real time. We did this with two data collecting laboratory activities [4, 5] where students signed in using lab groups accounts set up in Google. They communicated, questioned, and supported their laboratory data and their interpretations. This gives students a semi-anonymous approach as they discussed the data from our Nuts and Bolts of Extrapolation experiment [4] in first-semester general chemistry. To allow students to see consistency in data, we added a ringer bolt to one group's sample that was heavier than all the other groups. Below is a short excerpt of an instructor-moderated student chat for this activity.

instructor	How consistent are the mass of the bolt data?
pgcc lab group 3	Excluding group 2 the data is fairly consistent.
pgcc lab group 2	What is wrong with our data?
pgcc lab group 3	I'm not saying it's wrong, it just doesn't fit the pattern
pgcc lab group 2	What is wrong with group 2?
pgcc lab group 4	If you round the masses of the bolt, most of the bolts round up to 31 and 32 except for group 2, which rounds to 38. That is about 6-7 units greater.
pgcc lab group 2	How?
instructor	So could group 2 have a different bolt size?
pgcc lab group 3	That's a possibility.

Once students discover the chat feature, they use it in collaborative assignments to communicate with each other and their instructor as well. As an instructor, it is an excellent way to pose questions to drive students to find and correct errors and offer evidence or support to their arguments [12]. In a more asynchronous method, use of the comment feature works well and notifies that a comment was made by sending an email to authorized recipients. The comment feature is also very useful for returning feedback in Docs for collaborative group laboratory reports, and Sheets when grading.

We have started a series of collaborative-pair spreadsheet assignments [7] to be carried out in Google Sheets. Our results show that students need to enhance their computational skills and get past the symbolic barrier of spreadsheet formulas and mathematical models using "y and x" and scientific variables. We have found that some students use values calculated elsewhere and manually entered in sheet cells. Panko [13] has discussed how spreadsheet errors can be reduced by team collaboration, which includes the instructor, to provide help by posing questions to student pairs to get them to ponder corrections, and emphasize the idea of doing the computations using sheet formulas. The instructor provides formative assessment (by leaving comments or via chat) in their role in the team.

To perform real-time calculations in Sheets *in the columns beside data collected by a form*, the query function should be used to bring the original data into a second tab [14]. To add an additional tab, click on the "+" in the lower left corner, just to the left of the Form Response 1 tab. So in cell A1 of the new tab (click on tab name to edit name) place the following formula:

$$=query(`Form\ Response\ 1'A:D)$$

This will essentially copy any form data in columns A to D onto the new tab. Now computations can be performed in the columns from E and beyond. As form data is added the new tab will update as well. You can set up a real-time graph on the new tab too by either dragging formulas down a large range of the columns, or use (E:E) to read the complete column.

5.   Assessment and Feedback in Forms

Using Google Forms provides an instructor with a quick and easy method to collect feedback on activities (for example, include a link to the form at the end of a laboratory exercise). It makes a superior electronic post class response tool [15] for workshops or to reveal the unclear and confusing points [16] from a lecture. The instructor can then revisit issues that were not well understood in the next class. Likert scale or multiple choice questions can be constructed along with comments in textboxes. We have started to include some basic assessment questions to our activities. For instructions to set up Forms, see McMillan [16].

For an assessment such as a quiz, forms can have embedded graphics and videos plus the recent addition of gMath for forms (an add-on), allows function graphing,

histograms, etc. and embeds them directly into the form. In the future, maybe even an embedded interactive spreadsheet will be available! There are two Sheets add-ons that will grade form results in Sheets (multiple choice style questions) - Flubaroo and Super Quiz. Both return feedback to students via email.

6.   Google Sheets/Forms Resources

Below is a list of websites that provide instructions plus examples for the use of Google Sheets and Google Forms plus getting instructors into data pooling.

General spreadsheet use:

    The Guru (all things Google; now Bettercloud)

        Guru University Sheets Course (good starting place and compares to Excel) https://www.thegooru.com/university/spreadsheets/section-1/

        Google Sheets https://www.bettercloud.com/monitor/category/sheets/

        Google Forms https://www.bettercloud.com/monitor/category/google-forms/

    Spreadsheet Solving (instructions and videos) http://spreadsheetsolving.com/

Data pooling (Forms to Sheets):

    Data Pool in the Cloud (authors)

    https://sites.google.com/site/datapoolinthecloud

    Collaborative Data Analysis in the Science Classroom (CSUN)

    https://sites.google.com/site/hpcacscs/

7.   Some Final Thoughts

Google Sheets and Forms offers students a chance to become involved with online collaboration in a variety of ways. Our feeling is that higher education needs to take more advantage of Google Drive and other online tools to get students using online collaboration methods before they enter the workforce or other professional environments [1]. Students [2, 3, 6] and in-service teachers have very positive comments when introduced to and while using the Google Drive tools. A simple introductory density experiment that does this, is available in Sinex et al. [6], and for other examples from Vandergon et al. [9]. Our Data Pool in the Cloud website mentioned above includes all instructions plus our activities.

To demonstrate the capability of Google Forms and Sheets, we have included a survey link (https://goo.gl/tZG7Ea; URL's are case sensitive!). After the reader submits the

form, a thank you box appears (which also allows the editing of errors if there are any) and the reader can click the link to see the results summary that collated in Google. To see the raw results in Sheets plus our summary and question responses, go to this URL - https://goo.gl/oCio0S. Thanks for collaborating in the cloud!

8.   References

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