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Developing Online Collaboration Skills in the General Chemistry Laboratory

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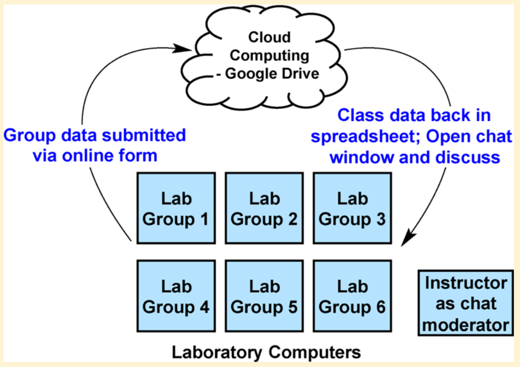
ABSTRACT: Online collaboration is a vital 21st-century technology skill. So how can online collaboration be incorporated into general chemistry? We are using Google Drive spreadsheets and forms to develop online collaboration skills in students. The forms capability allows easy collection of data for class comparison and student feedback. The information collected in a spreadsheet can be projected for class discussion, or can easily be downloaded and analyzed in Excel. This is an effective way to gather class statistics on experimental data. We have started to use the Google chat feature to promote discussion in the laboratory of class data, such as looking for uniformity in data or analyzing errors across groups. This is done by posting a link to the form to enter data for student groups and then the link to the spreadsheet of data (which only instructors can edit) and having students open it in the lab. With multiple openings the chat feature is enabled. Any discussion is anonymous unless students or lab groups identify themselves (students are not signed into Google Drive). These mock online collaborations are a valuable start and demonstrate the ease and power of the technology. Collaborative group projects or reports are a logical next step, which would require students to have a Google account.



KEYWORDS: *First-Year Undergraduate/General, Curriculum, Collaborative/Cooperative Learning, Inquiry-Based/Discovery Learning, Internet/Web-Based Learning*

Developing students' online collaboration skills is an important 21st-century technology goal, according to ISTE's NETS Student standards for K−12,[1] and a recommendation for higher education from a recent *Educause* survey of undergraduate students.[2] The recent release of the NRC Framework for K−12 Science Education suggests that engaging students in argument and debate from evidence early in the education process would be of great value.[3]

Google Drive[4] has been used in the higher education classroom. Pence and Pence[5] suggest the spreadsheet for collecting data in undergraduate research projects, and Spaeth and Black[6] recommend it for collecting and calculation of laboratory data. Bonham[7] incorporates the use of the Google Drive form for class laboratories, and Wood[8] uses Google Drive for collaborative laboratory reports. Silverstein[9] tasks engineering students with doing a collaborative spreadsheet project, including the chat feature.

A no-cost, easy method for instructors to engage students in an emulated online collaboration of experimental data using Google Drive[4] in first- and second-semester general chemistry is presented. The collaboration process involves collecting group laboratory data via an online form as input to a spreadsheet using cloud computing; then an online forum allows instructors to structure discussion of the data using the chat feature. Data can be presented to students in view-only mode; using a second form facilitates gathering feedback from the students. We recommend having no-cost Google accounts for each laboratory group to ensure the chat function operates as desired and the browser functions as expected. This process was introduced in our general chemistry program using the four experiments that are summarized in Table 1.

Here we discuss experience gained using the Nuts and Bolts of Extrapolation experiment,[10] which engaged students in measurement and provided an introduction to mathematical modeling. More information on the Nuts and Bolts of Let Us Make an Error experiment mentioned, including a chat excerpt, is available elsewhere.[11]

EXAMPLE EXPERIMENT: THE NUTS AND BOLTS OF EXTRAPOLATION

Students determined the mass of a bolt with increasing numbers of nuts from one to five.[10] From a plot of mass as a function of number of nuts generated on graph paper, students determined the equation of the mathematical model where the slope was the average nut mass and the extrapolated *y*-intercept the mass of the bolt. The mass of the bolt alone was then determined on a balance, and the percentage error was calculated and the model validity tested using a prebuilt Excel spreadsheet. The data entered into Google Drive were displayed by an LCD projector for class discussion. Figure 1 shows a sample spreadsheet (column headings from online form developed) and the chat feature button, which appears only when two or more students open the spreadsheet: chat will open when clicked on as indicated.

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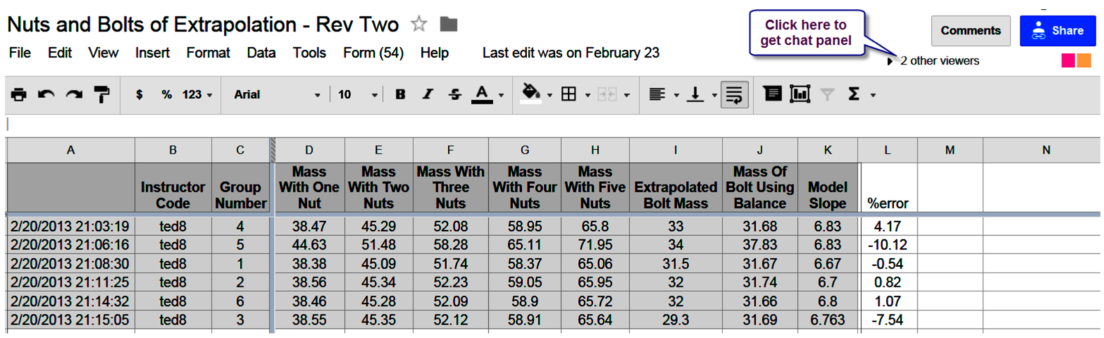
Table 1. Summary of Experiments Using Google Drive

Class	Laboratory Activity	Collaboration Effort
First-Semester General Chemistry	Nuts and Bolts of Extrapolation: Massing bolt with 1 to 5 nuts; determine bolt mass by extrapolating to zero nuts	Masses, slope, *y*-intercept, r^2; compare via chat
	Lights, Color, Absorption (Beer's Law): Calibration curve and analysis of a common unknown	Standards, unknowns, slope, r^2; compare via chat as postlab follow-up activity
Second-Semester General Chemistry	Nuts and Bolts of Let Us Make an Error: Introducing systematic error; Al nut in place of stainless steel nuts	Errant nut location in sequence, slope, *y*-intercept, r^2; compare via chat
	$Fe(SCN)^{+2}$ Equilibrium Constant: Multiple values derived by serial dilution	Examine error as a function of serial dilution; form submission and then class results posted



A	B	C	D	E	F	G	H	I	J	K	L	M	N
	Instructor Code	Group Number	Mass With One Nut	Mass With Two Nuts	Mass With Three Nuts	Mass With Four Nuts	Mass With Five Nuts	Extrapolated Bolt Mass	Mass Of Bolt Using Balance	Model Slope	%error		
2/20/2013 21:03:19	ted8	4	38.47	45.29	52.08	58.95	65.8	33	31.68	6.83	4.17		
2/20/2013 21:06:16	ted8	5	44.63	51.48	58.28	65.11	71.95	34	37.83	6.83	-10.12		
2/20/2013 21:08:30	ted8	1	38.38	45.09	51.74	58.37	65.06	31.5	31.67	6.67	-0.54		
2/20/2013 21:11:25	ted8	2	38.56	45.34	52.23	59.05	65.95	32	31.74	6.7	0.82		
2/20/2013 21:14:32	ted8	6	38.46	45.28	52.09	58.9	65.72	32	31.66	6.8	1.07		
2/20/2013 21:15:05	ted8	3	38.55	45.35	52.12	58.91	65.64	29.3	31.69	6.763	-7.54		

Figure 1. Screenshot of the spreadsheet in Google Drive.

Table 2. Chat Session Characteristics

Chat Types	Results	Comments
Open (no or very little guidance)	Open chat can bomb or be very wordy and nonproductive.	Might work better with experience or upper level classes
Questions posed in activity	This is about the same as open chat.	Students ignored questions in activity.[11]
Moderated on the fly by instructor	Instructor poses questions and guides students if they go off track. This keeps chat very productive and on target.	Moderator could be a peer, especially as students gain experience.

Table 3. Results from Summer/Fall 2012 Student Survey

	Distribution of Responses from Students					
Statement or Question for Response	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree	Average Score, 1−5; Agreement % (N = 63)
Using Google chat is straightforward and easy.	35	24	3	0	1	4.46; 94
Google chat enhanced each group's ability to analyze the data.	31	28	2	1	1	4.38; 94
Using Google chat was more efficient than using hard copy and the telephone or email to discuss ideas and exchange results.	39	20	2	0	2	4.49; 94
What is your overall rating of using Google chat during collaboration?	Very good: 32	Good: 21	Average: 7	Poor: 2	Very poor: 2	4.27; 84 (above average)

Six lab groups opened the Google Drive spreadsheet on their lab station computers and engaged in discussion using chat. Results and commentary are included in Table 2. Conducting moderated chat appeared to work best in both the first- and second-semester general chemistry classes.

■ RESULTS

Because the manufacturing process produces minimal variation in the bolt mass, students should get relatively consistent data. All groups should get quite similar data and a correct mathematical model with a high degree of goodness-of-fit (very high r^2); the student data obtained supported this assumption.

To introduce online collaboration simulating real-world scenarios described in the introduction, various ways to incorporate the chat function in our general chemistry courses were explored. Geographically disperse collaboration was simulated by having each group emulate a different university in distant geographical locations, with the stipulation that they could only communicate between groups using the chat function.

In the spring of 2012, an open chat session was tried with limited success owing to the lack of student focus and inexperience analyzing data. In the summer of 2012 and thereafter, a chat moderated by the instructor was used with more success. In the moderated discussion with the instructor posing questions, student groups were able to better analyze the data, focus on possible discrepancies, and formulate hypotheses.

To enhance variation in the data and encourage discussion, one higher mass bolt was intentionally added, which facilitated student focus to spot the consistent data of the other groups.

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STUDENT FEEDBACK

In the spring of 2012 open chat was tried with very little moderation of the discussion. Students liked the concept and use of the technology but felt the online discussion lacked focus and was not as productive as it could be, so a moderated chat session was conducted in subsequent classes. Table 3 contains student feedback data, while Box 1 contains student comments for moderated chat sessions.

Box 1. Selected Representative Student Comments

Positive Comments

- Exchange of real-time data and rapid communication regardless of location. Awesome!
- Allows students to interact and think logically with available information.
- Quick and straightforward and don't have to carry on a long conversation; quick and to the point.
- Everyone can get points across without someone being intimidated since you are somewhat anonymous.
- Very useful, you were able to cross reference data and collaborate with others forming ideas and giving solutions.

Constructive Comments

- Typing in chat is time-consuming and people may fall behind in the conversation. (Mentioned multiple times with suggestion for video chat.)
- Confusion when one's data doesn't match others' data.
- Some information in chat can be missed with many responses.
- If there is not a moderator, the conversation could get off track.

CONCLUSION

The method we present is easy for instructors to implement in their classes and can be applied at the high school through college levels. To keep the chat productive, the instructor must be involved and ready to respond, as every class is different. It is a great example of cloud computing and could work for multiple student-based research projects by just setting a particular time to chat.

In a recent review article in *Science*, Osborne[12] noted the lack of argumentation and debate in science education. Our approach gets students into discourse about their experimental data in a semianonymous way by laboratory groups. As instructors, we had to prompt many times to get evidence, but we elicited it from students. Students used 21st-century technology, which enhanced engagement and thinking as they debated in the chat. This activity was successful in meeting some of the goals put forth in the new NRC Framework for K–12 Science Education.[3]

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Notes

The authors declare no competing financial interest.

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