

Fostering Small Group Discussion in an Online Instrumental Analysis Course using Google Docs

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Abstract: In recent years there has been a strong case made for the improved learning outcomes that come with the use of active learning environments such as those involving flipped or POGIL models within in-person classrooms. A cornerstone of these classrooms lies in the use of small group discussion facilitated by the instructor or teaching assistants. These discussions allow students to explore material using critical reasoning and scaffolded questions to build to high order thinking. Due to the COVID-19 pandemic, many classrooms were forced to immediately move to remote learning models in Spring 2020. Many of these courses were further reimagined into fully online designs for Fall 2020 and beyond. While there are many technological tools available, this activity presents a method for leveraging the collaborative nature of the Google Doc platform for fostering discussions among students. This method is presented in the context of a largely asynchronous Instrumental Analysis course for chemistry and forensic science students. The advantages and disadvantages of this method are presented specifically in the realms of student engagement and soft skill development. The robustness of this method in how it could be utilized in other teaching environments such as synchronous or hybrid courses is also discussed.

Keywords: Active learning; instrumental analysis; remote learning; POGIL

Introduction

An Instrumental Analysis course and lab are required as part of the Forensic Science (Chemistry option) and Chemistry undergraduate curriculum at the authors' University. Students from both programs are enrolled in the same lecture course (cross-listed) with differing lab experiences. The Chemistry major students perform a small synthesis as part of the lab to prepare them for their Synthetic and Analytical course plus lab (capstone experience) while the Forensic Science major students concentrate on learning more instrumentation that they may need for their future courses such as Trace Evidence, Drugs and Toxicology, and their Senior capstone experience (1). This article will focus on the Instrumental Analysis lecture. To build active engagement between students and the course material, a Process Oriented Guided Inquiry Learning (POGIL) model (2) for lecture instruction was introduced during the Fall 2018. While the course was based on POGIL, the material utilized was not reviewed by POGIL. This classroom model emphasizes exploration of course material and critical consideration of the information provided through small-group discussion, image interpretation, and application of concepts to new situations. This model type has been successfully implemented within in-person Chemistry classrooms (3–7) including in instrumental analysis courses (8–9) and analytical chemistry courses (9). In the Fall 2018 and 2019

offerings, student-led discussion groups were the cornerstone with the instructor serving a facilitator to help further student conversations into higher level thinking. Class time was balanced between small group discussions and interactive short lectures to summarize concepts while introducing new topics. The worksheets developed supplemented the class information and guided the discussion.

Due to the COVID-19 pandemic, many university courses for the Fall 2020 semester transitioned to on-line learning environments to reduce students' exposure to the virus and accommodate the reduction in classroom seating for social distancing purposes (for example a classroom usually containing 70 students sits 30 students due to social distancing) (10). This course was no exception. With on-line education, a variety of ways have been utilized to engage students with course material and discussion including using video conference breakout rooms (10), discussion boards, wikis (11), and blogs in Learning management systems. Breakout rooms allow small group discussion but require students to be synchronously meeting at the time designated by the instructor. This does not always accommodate asynchronous offerings and can be difficult to coordinate for a student population spread across several time zones. In addition, the instructor is unable to be in all of the Breakout rooms at once. Discussion boards for POGIL activities can be useful, but do not foster real-time interaction and refinement of

answers as editing posts or tracking edit histories is not easily accomplished. Also, given the overall number of questions posed for discussion and how many of these questions are scaffolded toward an overall goal, separating questions into individual discussion boards seems impractical. Trevathan and Myers (11) developed an option for on-line POGIL activities using wikis, individual student blogs and a Facebook group. While the ease of recording a grade is an advantage with wikis and blogs, students have to learn the tools/gadgets associated with this technology. Utilizing pre-loaded figures and questions for each group's discussion is not easily accomplished using these platforms. With improvements among technology platforms abounding, other options can be utilized for small group discussions. In this case, the instructor utilized Google docs. The advantage of a Google doc over a Learning Management System wiki is that students are already familiar with Google drive and the associated programs shareability. At the authors' university, students have their own Google drive associated with their university account. Additionally, the edit history features and ability to control editing permissions were advantageous. The purpose of this article is to outline the strategies employed utilizing Google docs for facilitating small group discussions with an online course.

Methods

Course Organization

While the online Instrumental Analysis course in Fall 2020 was designed to operate in an asynchronous format, the instructor utilized an option provided by the University to maintain the scheduled normal meeting time (8-9:15 am, T/Th). This set time provided students a time where they could reasonably be expected to be available and collaborate with their small groups, though meeting at the designated class time was not required. This time block also allowed students real-time contact with the instructor to answer questions about the course.

This course utilized Blackboard as the Learning Management system. Topics were covered in modules usually lasting 2 weeks (TABLE 1). Each module in Blackboard included an overall checklist of expectations, instructor videos produced using recorded PowerPoints or illustrations filmed utilizing a document camera, small group discussion worksheets utilizing Google Docs (see example in Appendix), homework sets (True/False, multiple choice, matching and short answer questions), and a self-reflection journal (~300 words) about students' learning or locating research utilizing the module's topic. In addition to the module work, an 8 to 10 minute small group presentation about an instrumentation type not otherwise covered in the course was assigned and a comprehensive final complete the course assignments.

Small Group Assignment

The student population of the course consisted of junior and senior-level students majoring in Forensic Science (Chemistry option) or Chemistry with an approximately 2:1 ratio between the majors. Prior to the start of term, an optional survey was distributed to students to gather information about their anticipated availability for group work during the week outside of the designated class time. Groups were primarily selected based on common times of availability. Secondary criteria for group selection was student major. Groups were selected to include a mixture of the two majors to maximize the diversity of backgrounds and foundational knowledge for discussion. Group size was limited to 4-5 students, with one group dropping to 3 students mid-semester. Students completed a Group Contract at the start of term to outline expectations for participation, communication, and completion timelines. Group Contracts were revisited throughout the semester and revised to reflect changes in group dynamics or reinforce group expectations.

TABLE 1 *Topic Schedule*

Week	Topic
1	Review of Quantitative Analysis Concepts
2-3	Ultraviolet-Visible (UV-Vis) Spectroscopy
4-5	Fourier Transform Infrared (FTIR) Spectroscopy
6-7	Atomic Spectroscopy, including Atomic Absorption (AA), Inductively Coupled Plasma Optical Emission (ICP-OES), and X-ray Fluorescence (XRF)
8-10	Chromatography Introduction: Basics and Gas Chromatography (GC)
11-12	Liquid Separations: High Pressure Liquid Chromatography (HPLC), Ion Exchange (IC), and Capillary Electrophoresis (CE)
13-14	Mass Spectrometry (MS)
15	Group Presentations and Review (Thanksgiving Week)
16	Comprehensive Written Final

Google Doc Group Folders

The instructor created a folder in the Google Drive for each group and granted editing privileges to the group members. This ensured the integrity of the group's work and privacy from being viewed/edited by other groups. All worksheets for each module were placed in the group folder prior to the start of each 2-week module. One worksheet was due at the end of each week of the module, giving ample time for completion and the opportunity to work ahead within a module. Students were instructed to log in using their University accounts each time they edited the document and to ensure that all group members made

meaningful contributions to the document. Student progress was monitored through instructor checks each weekday morning. Daily feedback was provided through written notes in the worksheet text (highlighted in an alternate color from the student work to distinguish from other text) as well as using the comment feature in Google Docs. Students were encouraged to leave comments on the worksheet if they had specific questions and required more immediate feedback. Student participation was tracked using the edit history. As a formative activity, the worksheet grade was assigned based on participation and completion only with correct answers provided after the worksheet due date.

Group Worksheets

The first author attended a week-long Analytical Chemistry POGIL workshop during the Summer 2018. This experience inspired the class organization and worksheets developed for Fall 2018 and Fall 2019 Instrumental Analysis sections. These worksheets were then modified for the on-line Fall 2020 section. Utilizing knowledge about the different POGIL question types, the first author constructed directed (answered using textbooks or course videos), convergent (answered via group agreement), and divergent (range of possible answers) questions for the worksheets (10). Not every worksheet contained all three question types, though each type was utilized within each module. The worksheets served as an aid for the students to answer their homework in conjunction with the instructor-provided videos and assigned textbook readings.

Each worksheet consisted of 6-10 questions, similar to the worksheet provided in supplementary material. For full credit, a student had to participate in multiple questions and all of the questions on the worksheet had to be answered. Thus if a student did not participate for a week, the remaining students in the group were still responsible for completing the worksheet for full credit. The students were informed of this requirement at the start of the semester.

Results

Student Engagement

Student engagement in the small-group discussions was difficult to quantify during in-person instruction. Unengaged or naturally quiet students often have limited interaction with their group or fail to make meaningful contributions to the discussion. While the instructor attempted to engage these students in the discussion, fostering consistent participation during in-person was not always feasible. The instructor had difficulty deciding if a student should receive their full participation points for their given efforts. However, the virtual environment improved this by tracking student contribution to the final

document as quantifiable evidence of contribution. Naturally quiet students may find it easier to type their responses to the questions rather than speak them and can thus contribute their thoughts to the discussion without additional anxiety. For students who are otherwise nervous sharing their thoughts without having time to process them ahead of time, accessing the worksheet ahead of a group meeting allowed students to gather their thoughts before having to discuss them with a broader group. Finally, this format allows groups to meet when students are at their prime. The instructor had previously observed that the 8 am time slot assigned to this course hampered student discussion during the first 20-30 minutes of the class due to the early hour and some students having a laboratory/course the previous night. Allowing groups to meet outside of the designated times provided an opportunity for students to approach the material when their minds are already active, improving their engagement with the material and thoughtful consideration of the discussion questions posed.

However, this environment is not without some disadvantages. For groups deciding to meet outside of the designated class period, the availability of the instructor to hear ongoing group discussions and engage in conversation with the group is limited. When groups become “stuck” on a question in a real-time setting, the instructor can ask leading questions to guide students to the correct answer or line of thinking. The lack of real-time facilitation was observed to stunt student’s critical thinking as they often spent more time trying to locate an answer directly from the course textbook or an outside source rather than critically considering the question at hand, an aspect that being in class without accessing reference materials forces students to achieve. Comments made by the instructor upon reviewing the student answers was a substitute for this, but an imperfect one as there was no guarantee that feedback was revisited by the student in a meaningful way.

Additionally, there is often an element of “eavesdropping” that occurs between groups in a classroom environment where one group may listen in on another group’s conversation with the instructor or amongst themselves and gain a piece of information they needed to continue their work. As the group worksheets are not shared among the entire class, there is not a clear way to replicate this aspect of in-class discussion using the Google Doc format. Also if a question proved problematic for all the groups, the students do not know that a concept was difficult for the whole class, which can create a feeling of isolation in their misunderstanding when the misunderstanding was universal. Problematic questions were addressed with the addition of mid-module videos as needed.

Soft Skill Development

While not a formal learning objective for this course, increasing communication skills in developing scientists was one that is highlighted in a POGIL-model classroom. Articulating thoughts orally and in writing is a foundational skill that students will need throughout their continued college education and beyond. One advantage of the Google Doc platform over the in-person classroom was that students are forced to write their answer to each question. In the classroom setting, they might discuss a question, agree on an answer, and move on without actually writing the answer in their notes for future reference, limiting their practice of articulating answers clearly. Since the record of their discussion in the Google Doc platform was their written response, students were required to summarize their discussions in succinct answers reflecting their group's discussion. Additionally, any feedback provided by the instructor was also present in writing for future reference and study. One disadvantage of the online environment is that students may write answers without actually discussing the answer with their group, limiting their opportunity to practice expressing their understanding orally. Outside course responsibilities and conflicting schedules required groups to meet asynchronously periodically, but the instructor encouraged students to read and comment on other group members' answers.

Methodology Robustness

With much uncertainty concerning delivery format for courses and the looming possibility that future semesters could be transitioned to fully online delivery, course designs have to be robust and easily transferable between multiple learning environments. Small group discussions employing Google Doc worksheets could easily be adapted for in-person learning by having students work on the worksheet recording their answers in real-time using a laptop, but instructors have to emphasize the requirement for every student to act as a recorder on a worksheet. For HyFlex models where half of the class is in person while half the class meets remotely, a group could meet via a video conferencing platform with half its members in the classroom and the other half attending virtually. The instructor could still serve as facilitator, group-to-group "eavesdropping" could still occur and much of the authenticity of the group discussion format could be preserved. In any case, should a quick transition to a fully virtual environment be necessary for school closure due to illness, inclement weather or other unforeseen issue, the platform for accessing and recording group discussions would be preserved with minimal downtime in the course. While the advantages are strong and led this instructor to embrace this mode of teaching, this method of iterative written feedback on group worksheets is time intensive. To achieve the full effect of discussion between students and instructor, feedback must be provided in a timely manner

and is typically required multiple times before assigning a grade for the worksheet. If the group completed their worksheet close to the due date, the instructor has to choose whether or not to provide feedback. With the Fall 2020 section, the instructor decided not to provide feedback if the students started the worksheet the afternoon of the deadline as the students had several days to begin the assignment. This technique can be labor-intensive and may be most easily achieved in courses with small class sizes (<40 students) or through the use of a teaching assistant to help monitor the discussions. While for face-to-face courses, the instructor would review the worksheets in class and outside of class, feedback using the Google Doc required an average of 30 minutes per group each week.

Discussion and Conclusion

The current protocols surrounding in-person class meetings (social distancing) due to COVID-19 can make POGIL-style classroom small group discussions difficult to achieve. While there are many options for virtual platforms for discussion (9-11), the user friendliness, widespread availability, and editing capabilities of Google Docs provided advantages in preserving small group discussion in a remote learning classroom. While maintaining the development of communication skills, the instructor observed more widespread and consistent participation in group discussions in an online environment as students were able to exhibit more flexibility in the scheduling of these activities to suit the needs of the group members. These interactions are similar to the discussions that Wenzel examines with an Analytical Chemistry course (9) where he served as a facilitator. The first author facilitated students' discussions/answers by commenting on groups' Google Doc throughout the week. Although spurring students into higher-level problem-solving skills remains a challenge in this method, the ability to provide iterative formative feedback and the robustness of the Google Doc group discussion format across the variety of instruction modes now implemented in classes are strong advantages that make this an effective method for facilitating small group discussions in a virtual classroom.

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