Designing Virtual Chemistry Experiments using Microsoft Forms

Anna Beatriz Galang, Melanie Snow, Pasquale Benvenuto and Kris Kim
Department of Physical and Environmental Sciences
UNIVERSITY OF TORONTO SCARBOROUGH

Introduction

Chemistry educators around the world have had to introduce innovative approaches for engaging students through virtual chemistry laboratory exercises, both out of necessity and to complement traditional in-person learning. As new methods are explored, instructors strive to offer experiences that are engaging and accessible and that foster skills transferable to in-person laboratories. Here, we introduce a method for designing virtual laboratory exercises using existing survey platforms, namely Microsoft Forms and Google Forms. Overall, this approach offers a platform for designing interactive and accessible virtual laboratory exercises.

These survey platforms serve the following unique functionalities:

- **offers instructors the ability to integrate media content** (e.g., videos and images) **and questions** which allow instructors to scaffold experiments with targeted inquiries.
- **encourage students to make decisions by the incorporation of branching points** where the outcome(s) of the experiment can vary based on the selections chosen by students.

Designing a Virtual Experiment

The design of these virtual lab exercises, as illustrated in Figure 1, involved four phases: **(1)** testing the in-person experiments, **(2)** storyboarding, **(3)** media production, and **(4)** building the exercise in the survey platform.

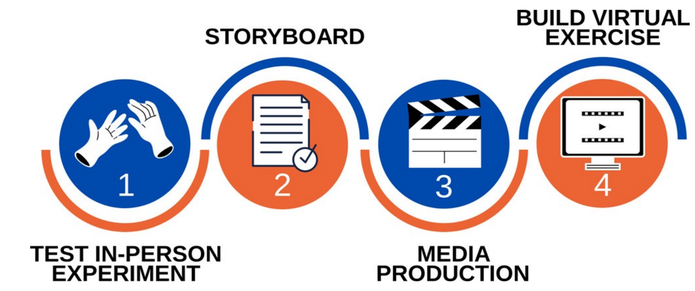


Figure 1: The Four Phases of Designing and Developing Forms-based virtual exercises

(1) Prior to filming, experiments were first selected, tested, and optimized. Testing experiments provided opportunities assess the applicability of the experiment in a virtual format, while also identifying potential places where questions and branching points could be integrated.

(2) Once an experiment was tested, its experimental procedure optimized, and branching points selected, storyboards were developed to organize and guide the collection of media content.

(3) After the storyboard was prepared, media content was collected to integrate into the survey platform. A combination of photos, film, and technical illustrations were collected and edited using a video editing software. Narrations were added to videos to highlight specific procedures.

(4) All media content, questions, and branching points were organized onto Microsoft Forms as prescribed by the storyboard. Virtual exercises were tested by several users to ensure that media content flowed in the correct order and that branching points were organized appropriately. Once finalized, the Forms exercise was embedded within Quercus for students to complete asynchronously.

Virtual Chemistry Experiments

At UTSC, the majority of chemistry courses were delivered virtually between May 2020 and August 2021. During this period, seven exercises were designed and tested using Microsoft Forms across two courses: (1) an introductory general chemistry course (enrolment of ~150) and (2) an introductory analytical chemistry course (enrolment of ~110). Below we highlight the benefits of using this platform for virtual labs.

INTEGRATING GUIDED QUESTIONS

When performing experiments in-person, students are regularly encouraged to question experimental procedures and to make note of relevant observations with the support of TAs, Lab Technicians, and/or Lab Instructors. To emulate these discussions, videos/images were uploaded and coupled with guided questions to promote active participation among students as they visualize each step of an experiment.

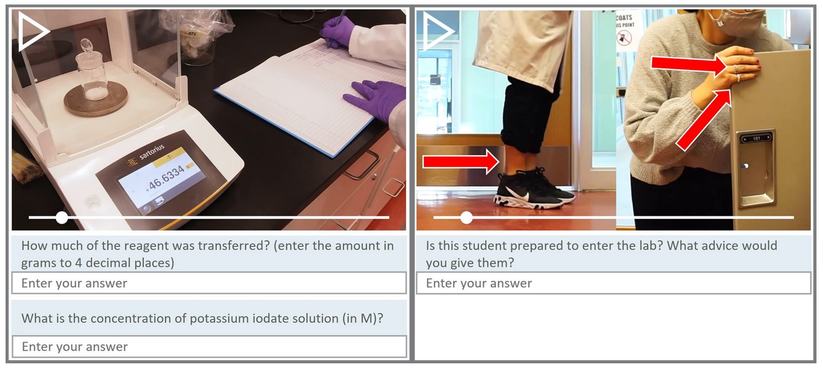


Figure 2: Integrating guided questions after each video clip helps scaffold calculations required for an experiment (such as calculating concentrations of standard solutions) while also encouraging students to strengthen record-keeping skills in their lab notebooks (left). Videos can also be designed to exhibit poor or incorrect lab practices with questions that encourage students to consider methods for improvement (right).

ENABLING DECISION MAKING

Another functionality of Microsoft Forms is the ability to "branch", which allows the instructor to redirect students to different sections within the form depending on their answers to multiple-choice style questions. This tool was used to encourage active learning by providing students an opportunity to make decisions that have a direct impact on experimental outcomes, similar to what they would experience in-person.

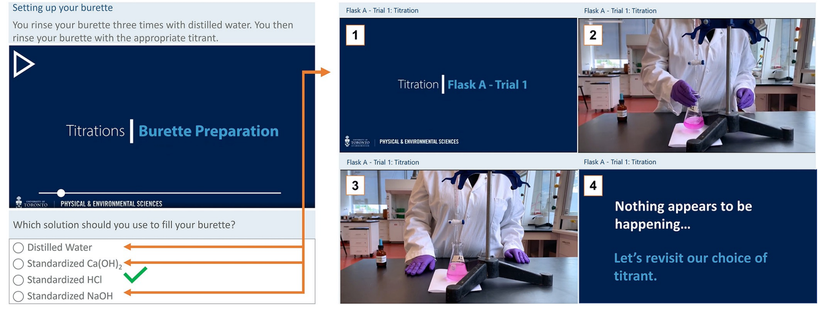


Figure 3: Encouraging self-directed decision-making during a virtual exercise. Students must select the appropriate solution to fill their burette with for the titration. If an incorrect solution is selected (indicated by the orange arrows), students will engage with a series of videos depicting the titration being performed using the incorrect titrant. After attempting the titration, students will realize an end point is never achieved and are encouraged to reflect on previous decisions.

Student Feedback

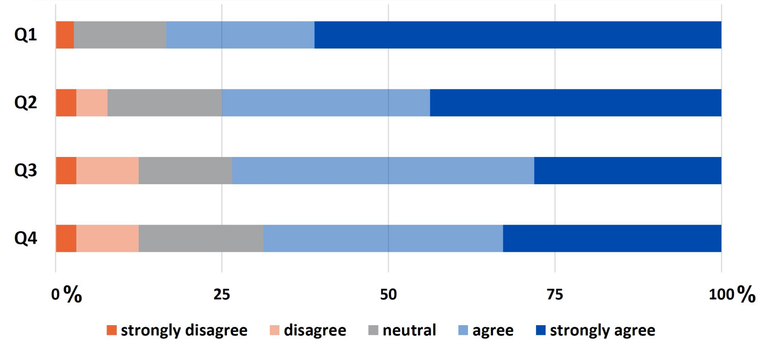
Anonymous surveys were administered to obtain student feedback on their experience participating in the Forms-based exercises. Surveys were a combination of open-ended questions to gather qualitative feedback and Likert-scale type questions.

(Q1) The Microsoft Forms-based experiments were more engaging than other types of virtual experiments

(Q2) Having to make decisions during the video experiment encouraged me to prepare more thoroughly and understand the procedure

(Q3) Having completed the Microsoft Forms-based labs, I feel confident in performing a titration when I am able to return to the lab

(Q4) Having completed the Microsoft Forms-based labs, I feel confident in preparing samples and solutions when I am able to return to the lab



Below are some qualitative comments student had about their experience with the Forms-based labs:

"I enjoyed being able to see people perform the procedures and ***I also liked being able to make decisions/figure out what went wrong in the experiment***."

"Usually, I'm looking for online examples to show me what to do (and I know most students do this) but I didn't have to do that for this class and was able to ***figure out everything on my own, with the extra guidance and the MS forms questions***."

"... the choices we did during the lab could affect how we progressed. Things such as selecting the wrong chemical and continuing until realizing a problem occurred like in real life. ***Learning from mistakes is sometimes better than just watching the successful version***."

Future Work

While the virtual exercises described here were developed and delivered out of necessity, there is potential for their continued application to complement in-person laboratories as institutions progress toward a new, post-pandemic normal. Given the versatility, educational value, and ease of implementation, we plan to continue utilizing Forms-based exercises to complement traditional in-person teaching and learning. For example, we anticipate the utility of these resources in circumstances where students may not be able to fully participate due to accessibility related challenges or as a pre-laboratory exercises to help students feel visualize the experiment in advance of performing it in-person.

Acknowledgements

This work was supported by the Department of Physical and Environmental Sciences at the University of Toronto Scarborough. I would like to express my sincere gratitude and appreciation to Dr. Kris Kim for supervising this project. Many thanks to Melanie Snow, Pasquale Benvenuto and Tony Adamo for their technical help. I would like to thank Chai Chen for support with filming the footage for the laboratory videos.