

Strategies for enhancing remote student engagement through active learning

B. Jill Venton¹ · Rebecca R. Pompano¹

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The abrupt shift to remote teaching and learning in spring 2020 has given rise to some natural “experiments” in how best to engage students remotely. Many faculty are wondering how best to engage their students and help them learn in this setting. In this short article, we present the experiences and lessons learned at the Department of Chemistry at the University of Virginia. Active learning has been far more successful at engaging students than traditional lectures delivered online. We have had success with structured, live problem-solving sessions after students watch a pre-recorded lecture, a strategy that many traditional faculty are willing and able to adopt. More fully active learning classes have also been highly successful in the virtual format, consisting of a nearly fully synchronous series of virtual lessons and activities that provide lots of opportunities for students to grapple together with the material. We share practical tips and tricks, advantages, and limitations to active learning in the remote setting, and encourage instructors and departments to consider making this type of learning a priority.

In spring 2020, University of Virginia went remote at spring break due to the coronavirus pandemic, similar to other universities. In the Department of Chemistry, we observed markedly varied student reactions to remote learning across courses, and even across sections of the same course. In one section of General Chemistry, where students had a traditional, lecture-based class for 3 h a week, 9 of 300 students stopped engaging in the remote class, measured by mandatory clicker questions in lecture (note a few students also increased

participation remotely). Meanwhile, in another 500-student section of General Chemistry, where students had one 75-min lecture and one 75-min active learning session with assigned groups each week, every student continued to participate fully in active learning. From informal conversations with students at the time, we concluded that being accountable to a group kept them coming back; they knew they would be missed if they did not show up. But crucial questions remained: how do you implement active learning in an online only class and would it continue to keep students engaged?

This article is a description of teaching experiences at University of Virginia that used active learning to promote student engagement during the pandemic. It is written from two perspectives: first, Prof. Jill Venton, who is an analytical chemist and also department chair; she has had the experience of helping many colleagues transition their classes online. Second, Assistant Prof. Rebecca Pompano, an analytical chemist, has successfully transitioned her active learning graduate and undergraduate classes online during this pandemic. We acknowledge that much of our evidence in support of active learning and student engagement is anecdotal; like most people, we have not had time to do full-scale rigorous assessments or collect proper student feedback on the ideas. However, others have begun reporting similar ideas [1–4] and the experience of many faculty shows that implementing active learning is an effective method to enhance student engagement in a remote chemistry course.

This contribution is part of a series featuring teaching analytical science during the pandemic in order to support instructors in preparing their courses.

✉ B. Jill Venton
jventon@virginia.edu

¹ Department of Chemistry, University of Virginia, Charlottesville, VA 22901, USA

Flipping the classroom: try active learning instead of Q&A

“Flipping” the classroom has been around for some time but many professors had never tried it [5]. However, in the coronavirus age, many professors were encouraged to record lectures and allow students to view them anytime. But what to do with those class periods? Many professors chose to make

them like office hours, doing Q&A sessions. An informal survey of faculty in our department has shown that those Q&A sessions are very poorly attended (i.e., only 10–20% of students logged in), and that when students do attend, they do not talk, seeming hesitant to either answer or ask questions in front of the whole class. Oftentimes, students do not know how to formulate questions on new material and may not yet know what they grasp and what they do not understand [6].

In contrast, some professors with recorded lectures are filling their class periods with small active learning exercises. Dividing the students into small groups and giving them a problem to work on first, followed by a recap with the whole class, leads to higher student attendance, more student engagement, and more discussion. Our organic chemists find most students show up for their active learning group discussions, far more than for a standard Q&A with the professor or teaching assistant (TA). Adding an active learning component to a class where the lectures are pre-recorded actually takes little planning effort: just a few problems need to be designed per class to get students going. Questions from exams from prior years, from homework assignments, and from textbooks are all good fodder for this type of active learning session.

Migrating an active learning class online: design principles

Some faculty had already adopted active learning prior to the pandemic, and were faced with how best to retain the sense of community and the academic value of the exercises in a remote setting. Here, we share Prof. Pompano's experience in migrating a graduate course, Bioanalytical Methods, and an upper-level undergraduate course, Analytical Chemistry, to remote learning:

Prior to the pandemic, these courses relied heavily on in-class, group activities instead of lecturing. Especially in the undergraduate course, I rarely lectured for more than 20 min at a time, and even then it was peppered with questions for the class. Longer group activities were structured around printed worksheets, which every student completed and kept as a study guide. The activity, along with the subsequent few minutes in which I went over the issues and sticking points, was the sole mode in which many concepts were taught. This led students to take the activities seriously, since there would not be a subsequent lecture to learn the material a different way. Many such activities are available for adoption in the ASDL website, which is a fantastic resource for faculty

teaching analytical or general chemistry [7] (<http://community.asdlib.org/activelearningmaterials/>).

Fully remote, or hybrid in-person/remote? Consider the approach to group work

Our university gave professors the choice of remote or in-person learning (particularly for small classes), but required all in-person classes to have a remote option. Leaving aside the technological requirements to facilitate simultaneous remote/in-person learning, we considered how active learning would play out during an in-person, physically distanced class session. Students sitting 6–10 ft (1.8 to 3 m) apart may be comfortable if the instructor lectures at the board or uses “clicker” questions, but working collaboratively in physically distanced groups of 3–5 people might be challenging, given that you would have to project loudly to be heard and you would not be able to easily see one another's work. Other faculty have had students in distanced, in-person classrooms successfully make use of Zoom to talk within their groups, but this might defeat the purpose of being in person. My own choice was to go fully remote, with daily use of breakout rooms in Zoom for small group work, which facilitates face-to-face group work.

Synchronous or asynchronous

With an emphasis on group work interspersed with short lectures and feedback from the instructor, it was clear that the course should be fully synchronous. Fortunately, the time slot worked even for students attending from other time zones. Students appreciated the synchronous meetings. After spring 2020, one anonymous student wrote, “I really missed being able to have in person discussion... I am SO glad we still had live meeting times, though, as those were all very helpful and the worksheets and presentations were great.” To conserve time, the worksheet, or learning guide, was posted in advance to the online course management system for each student to download prior to class. I also held my normal amount of office hours virtually, with similar turnout as in prior years.

How to deliver lectures

Just like in-person teaching, each instructor needs to find a style of remote teaching that works for them. In person, I do not typically lecture from PowerPoint slides, but rather write notes on the board as I go. Therefore, for short synchronous bits of lecture, I settled on using a Zoom whiteboard or sharing a writable screen (e.g., Microsoft OneNote). Because analytical lecture notes typically include the full gamut of concepts written in words, chemical equations, and drawn schematics

of instruments, I find it essential to have access to both a digital pen and a keyboard. Other faculty have also had success in setting up a camera or laptop to film them as they write on a real whiteboard. For longer lectures (15–25 min), I now pre-record a video and post it to YouTube for students to watch prior to class.

Typical class format with active learning in groups

For most class sessions, students submit a short, easy pre-class assignment that orients them to the day's topic. Each 75-min session starts with a verbal recap of what we covered so far in the unit and a short (2–15 min) introduction to the day's topic. We then move directly into the day's activity, with students placed into Zoom Breakout Rooms of 3–5 people (see note below). I move myself and a TA from room to room to check in on their progress, answer their questions, and prompt deeper thinking. If the entire class is struggling with a concept, I call them all back to the main room and go over it before putting them back in their rooms again. The transitions are slow, so it is important to minimize the back-and-forth (see below). I call them back together 5–10 min before the end of class to wrap up the activity and answer any last questions.

Engaging the breakout rooms

I usually have 6–8 rooms for 35 students and spend a few minutes per room, which means that I do not always reach every group for every activity. I have never had a problem with students not working on the activity in the breakout rooms, despite these being unmonitored most of the time. Instead, when I appear in their room (with no notice), I find students grappling with the concepts and trying to learn. Far more students choose to turn on their videos in the breakout rooms than in the main room, and though some students stay quiet just as in an in-person class, the engagement overall is high.

Student feedback

Student responses to the virtual group work have been overwhelmingly positive. One student wrote anonymously, "I think that this semester is just really hard for me (along with everyone else - including professors) in that I really struggle with online classes. Given the overarching struggle of that format, I still really love how we do breakout rooms and I appreciate the activities in class each day." Students who described themselves as shy

reported feeling more comfortable to speak in the breakout rooms than in the main room. Others commented that the breakout rooms give them a chance to get to know other classmates, which is otherwise challenging during the pandemic. Students like that the professor or TA join their breakout room occasionally to answer questions, and emphasize that they do prefer to recap the activity and the "right answers" at the end of class in the main room.

Practical advice for implementing online active learning

Here are some of the practical tips and advice we have learned from our experience and from our colleagues.

It's okay to give up pre-set groups

One of the difficulties of Zoom is how to set groups for breakout rooms, which have to be preloaded and then are inflexible. Prof. Pompano decided in her medium-sized (35 person) analytical class to let Zoom divide the people into breakout rooms randomly each time rather than worry about set groups. In the long term, the students see each other often enough that they get used to the people in the class, but it may take longer in the beginning of the semester to get students used to the active learning format this way.

Set teams in Zoom

A colleague of ours pointed out to us that a mid-Fall 2020 Zoom update now makes it possible for a professor to name breakout rooms and then let students choose the breakout room to go to. Therefore, if groups have set names, students can select and take themselves there without needing the professor to assign them. This could work especially well if there is some student choice in an assignment, for instance if they picked different analytical techniques to solve a homework problem they could go to rooms by technique to discuss!

Microsoft Teams does set groups well

Our general chemistry colleagues really wanted to keep set groups to build community among their students, and so they switched from Zoom to Microsoft Teams this semester. Each active learning group (or lab group) is then a channel in Teams and the instructors can move back and forth between the Teams to facilitate discussion. Teams also archives materials so the students have it all in one place, so they used Teams

instead of course management software to post announcements, assignments, and videos.

Transitions are slow, so have fewer (or none) of them

In an active learning classroom, an instructor might flip back and forth between group work and whole-class lecture or discussion four or five times per session. In Zoom and other platforms, transitions back to the main group are slow and awkward. Therefore, we find that longer active learning sessions often work better, with fewer transitions back to the whole group. This can be facilitated by adding short written explanations (no more than a few sentences) at an appropriate point in the active learning worksheet.

Record the live session and make it available to students after class

Prof. Pompano reports that after not offering recordings for the first half of the semester, many students voiced concern that they could not keep up with their notes in the virtual format. Perhaps surprisingly, she found that making recordings available did not significantly diminish attendance, again suggesting that students value the interactions and the group work. Recordings made by the instructor should be “paused” during group work time, to avoid extended blank video, because the breakout rooms are not included in the recording. Some institutions may have legal restrictions on posting videos for privacy reasons if they contain students, so check your institution’s rules.

Benefits and challenges of engaging students with active learning

We find many advantages of active learning in student engagement and also some challenges. In this final section, we address these and give an outlook on active learning in our new, online classroom mode.

Benefits

Students are more likely to come to class and participate

Students vote with their attendance, and remote classes with an active learning component are better attended than remote lectures. The students find the group work valuable, and do not want to let their community down.

Students talk and turn on their cameras more in small groups

Like many institutions, we are encouraged not to require students to turn on cameras for equity reasons. In a large group setting, we tend to see a lot of cameras off, but in the small group breakout rooms, students tend to choose to put their camera on when they can, and engage more with peers [8].

Students engage more with the material in active learning

One of the greatest benefits of active learning is that students have to struggle with the material, but get peer feedback and support. Even online, students are grappling together with the material and collaborating to answer challenging questions. Thus, we still see a deeper understanding of material after an active learning session.

Active learning helps with equity issues

Led by Prof. Linda Columbus, our general chemistry classes started implementing active learning to address equity issues of higher failure and withdrawal rates among first-generation students and underrepresented minorities [9–11]. In the classroom, active learning helped eliminate those gaps by boosting achievement of vulnerable groups. While we do not have full data on student performance yet for our remote classes, we do see fewer withdrawals in classes with active learning and the anecdotal evidence says the peer support of an active learning group is still helping with retention of first-generation students and underrepresented minorities. Challenges to connecting to synchronous classes remain for marginalized students, and universities should provide important support [12].

Challenges

Active learning requires synchronous participation

While there has been a trend in the pandemic in not requiring students to participate at given times, a completely asynchronous format is not conducive to traditional active learning. However, it is possible that groups could meet together at times they choose outside the class time, to better align with different time zones, for example [13, 14]. It is also possible they could work together asynchronously with a discussion board style format, although that is likely to be less engaging than talking in a small group format.

Activities take longer remotely than they did in person

Anecdotally, activities take 10–50% longer when offered remotely. This differential is likely driven by the instructor being able to engage with only one group at a time, by not being able to provide clarification quickly to the whole class, and by

the technological challenge for students to draw schematics, graphs, etc., electronically on a shared screen.

Students (and parents) still do not think they are learning as much One common complaint with active learning is that the students do not feel that they are learning or that the professor is teaching them anything [15]. This challenge still exists online. As chair, Prof. Venton regularly receives complaints that the professor only posts lectures online and has the students work in groups during class, so they must not actually be teaching. Honestly, these complaints aren't that much different than the ones we receive about active learning when classes are in person. One irony is that most faculty are finding that remote teaching takes *more* preparation and effort than in-person teaching. Research shows that students learn more in active learning classes, and in fact perform better on assessments, but still feel they learned less [10, 15]. Consistent reminders to students about the vast scientific evidence in support of active learning, both in the syllabus and in comments during class, may help alleviate these concerns.

Final conclusions

The past year has been an incredible challenge for higher education and has truly “shaken up” all of our educational practices. However, our faculty have risen to the occasion to translate their best practices of learning into a remote environment. We find that students are more engaged in classes where active learning is a main component. All of our general chemistry classes have switched to the active learning format, and they report students enjoy the exercises with their groups and show up for synchronous class sessions with high attendance. One of Prof. Pompano's analytical students sums it up nicely: “I really appreciate the in-class assignments since it's much easier to stay engaged compared to a typical lecture.” With remote classes continuing at least in the short-term, our department at University of Virginia is shifting resources (such as graduate and undergraduate teaching assistants) to facilitate active learning wherever we can because of how it promotes student engagement. The pandemic has shown us the value of active learning even in remote classes, and perhaps this push towards active learning during the pandemic will continue to help us expand

implementation when we return to more “normal” in-person classroom experiences.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflicts of interest.

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B. Jill Venton is Professor and Chair of the Department of Chemistry at the University of Virginia. She is also affiliated with the Neuroscience Graduate Program and Brain Institute. Her research interests are in developing new electrochemical and separations techniques for measurements of neurotransmitters in tissue.



Rebecca R. Pompano is Assistant Professor in the Departments of Chemistry and Biomedical Engineering at the University of Virginia, and a member of the Beirne B. Carter Center for Immunology Research. She completed a BS at the University of Richmond in 2005, a PhD in chemistry in 2011 at the University of Chicago, and postdoctoral studies in the University of Chicago Department of Surgery. Her research interests center on devel-

oping cutting edge microscale tools and chemical methods to unravel the complexity of the immune response. Current NIH-funded projects include developing hybrids of lymph node tissue and microfluidics to model inflammation, and establishing a spatially organized organ-on-chip model of a lymph node. In recognition of her work, she received an Individual Biomedical Research Award from The Hartwell Foundation, the national Starter Grant Award from the Society of Analytical Chemists of Pittsburgh, a *Lab on a Chip* Emerging Investigator designation, the Rising Star award from the Cellular and Molecular Bioengineering Special Interest Group, and an inaugural University of Virginia Research Excellence Award. In addition to research, she is active in advancing active learning formats in the analytical chemistry classroom, advocating for continued funding for education and biomedical research on Capitol Hill, and in building inclusive environments for STEM research.