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First-Semester Organic Chemistry During COVID-19: Prioritizing Group Work, Flexibility, and Student Engagement

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First-Semester Organic Chemistry During COVID-19: Prioritizing Group Work, Flexibility, and Student Engagement

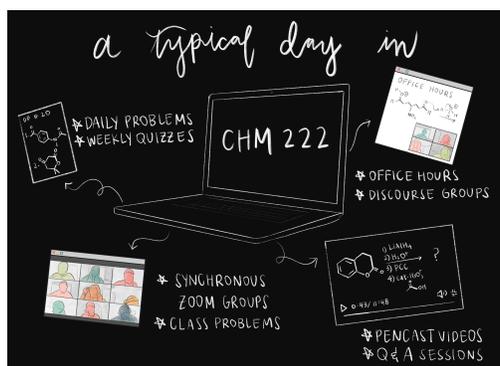
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5 ABSTRACT

Our first-semester organic chemistry class focused on structured group work to enable active learning in class. When Smith College switched to online learning after spring break, the class was adapted to fit into an online learning model while retaining active learning. Using feedback from students, we implemented two tracks, one focused on independent work and one focused on group work. Using 10 Zoom's breakout rooms, we were able to simulate the full class and small group experiences of our in-person class with the help of student learning assistants to facilitate group learning. Slack was introduced for class questions and communications. Student feedback was positive overall and indicated that their perceptions about group work improved over the semester. In the case of in-person classes in the fall, this method might be preferable to a class in which social distancing hampers 15 student-to-student discussion.

GRAPHICAL ABSTRACT



KEYWORDS

Second-year undergraduate, organic chemistry, collaborative/cooperative learning, distance learning, 20 student-centered learning.

INTRODUCTION

The core organizing principle for the design of our first-semester organic chemistry class in the spring of 2020 was to maximize student interactions and facilitate small group work inside and

outside of regular class time.^{1,2} We used a newly renovated, flat-floor, active learning space that would
25 accommodate our 80 students. Two undergraduate learning assistants were ready to assist in
developing a productive learning environment. We used the Comprehensive Assessment of Team
Member Effectiveness (CATME) program³ to sort students into 14 groups of 5-6 students and monitor
their weekly progress.^{4,5} We had all students participating in weekly discussion groups outside of
class, and high attendance in optional question-and-answer (Q&A) sessions and evening tutoring
30 sessions with peer tutors. All was going well until we were told not to return to campus after spring
break in March.

Over the extended, two-week spring break, we had to figure out how (and if) we could transition a
class built around synchronous, in-person, small-group learning to an online class. Our provost
encouraged the faculty to do two important things: 1) construct a new syllabus to reflect the new
35 reality of the course, and 2) focus on replicating the key essence of the course while being open to
introducing less content. He also encouraged faculty to be maximally flexible with respect to deadlines
and expectations.

As we looked to pivot to online instruction, another key decision was to ask students for their
opinions about shifting to a remote learning environment. From our inquiry, we found that many
40 students wanted to continue working with their groups. We also learned that a minority of the class
would be unable to participate in our synchronous sessions due to familial/work obligations, personal
preference, or time zone differences. Students encouraged us to communicate regularly and provide as
much guidance and structure as possible. They also wanted to be held regularly accountable for their
understanding to provide motivation for learning. Furthermore, we had the added challenge of our 80-
45 student class growing to 120 with the addition of the other section of first-semester organic chemistry.

NEW COURSE STRUCTURE

Our new syllabus⁶ reflected the reality that we could no longer require attendance at synchronous
meetings; however, we incorporated course structures that encouraged students to learn consistently.
To address the different needs of our students, we adopted a new model with two different tracks
50 through the course and removed any participation-based grade from the second half of the class.
Track 1 was an individual track where students opted out of attending the Monday, Wednesday,

Friday synchronous group problem solving sessions. Track 2 was a collaborative track where students agreed to participate in the synchronous group sessions. Track 2 served to maintain the essence of our course by enabling students to learn from each other in small groups during synchronous meetings. We were able to retain this option by using Zoom⁷ breakout rooms during our remote class sessions.

Approximately 75% of the students chose the group track. Similar to the first half of the class, we had daily office hours and two weekly Q&A sessions (all on Zoom) available to everyone. We continued with our weekly discussion groups, though they were no longer required. We also implemented weekly online multiple-choice quizzes focused on the material discussed that week. Points were awarded for completing the problem sets (due every Monday, Wednesday, and Friday), four multiple-choice online quizzes, and two traditional exams (Table 1).

Table 1. Point breakdowns of the course before and after COVID-19.⁸

| Course component | Original plan | First half | Second half | Overall |
|-----------------------------|---------------|------------|----------------|---------|
| In-class problems | 75 | 35 | 0 ^a | 35 |
| Weekly discussion group | 75 | 40 | 0 ^a | 40 |
| Problem sets | 100 | 50 | 70 | 120 |
| Take-home quizzes (75 each) | 150 | 75 | – ^b | 75 |
| Online quizzes (20 each) | – | – | 80 | 80 |
| Exams (150 each) | 300 | 150 | – | 150 |
| Exams (100 each) | – | – | 200 | 200 |
| Final exam | 150 | – | – | – |
| Total | 850 | 350 | 350 | 700 |

^aIn-class problems and weekly discussion groups were still part of the class, but no participation points were awarded for them in the second half of the semester. ^bDashes indicate that the course component did not exist in the given part of the semester.

In addition to updating the syllabus, we had to modify the type and nature of some course assignments. Consistent with the first half of the course, collaboration was encouraged for the problem sets, but was not allowed for quizzes and exams. The problem sets continued exactly as in the first part of the course, while the weekly online quizzes were a new element. The motivation for the quizzes was to provide students with a low-pressure summative assessment to ensure they were learning the material.

70 We provided two attempts to complete the quiz⁹ and started by averaging the grades of the two attempts. Prompted by student feedback, we made the quiz grade based on the best score of the two attempts for the final two quizzes. All quizzes and exams were untimed, open-book, and open-note, with resources on our course page available (other internet resources were prohibited), relying on Smith's Honor Code¹⁰ to help enforce academic integrity. For all quiz and exam questions, we wrote new questions and did not
75 rely on test banks, book questions, or previous questions from our classes. We thought this was essential to prevent the ability to google answers to questions. The two exams were similar to the exams given on campus with a variety of traditional organic reaction questions: predict the products, complete the synthesis, draw the mechanism, correct the mistakes, complete the reaction scheme, etc.¹¹ Students completed the exam and sent back an electronic copy that we graded using tablets.

80 We knew that constant communication with the class was critical when switching from in-person to online. We sent emails with longer updates and explanations usually about three times a week through our course management software (Moodle). For more spontaneous communications and to solicit student questions, we adopted the use of Slack.¹² This proved to be a popular and efficient means of communication within the class. Slack enabled communication between the entire class, small groups,
85 or individuals. Each group of students that worked together during the synchronous group time had their own Slack channel to encourage group community. We also used Slack to post a daily "to do" list to keep students on track,¹³ which proved to be incredibly popular. Importantly, the students embraced the "#questions" channel, which was an open channel that the entire class could use to post questions that instructors or students could answer. This was particularly helpful for our track 1 students who did not
90 have class time to ask their questions. Additionally, Slack enabled back-channel communication for the instructors and learning assistants during the synchronous group sessions which was especially important when we were in different breakout groups and not able to communicate with each other through Zoom.

CLASS LAYOUT

95 After moving to remote instruction, we had two teaching blocks available to us from our original schedule (one for each class section): Monday, Wednesday, Friday from 8:00-9:15 AM and 11:00 AM-12:15 PM. We decided to hold our synchronous sessions in a 45-minute portion of these blocks

thinking that 75 minutes is too long for regular Zoom interactions. The remaining 30 minutes were for the students to view additional resources including videos^{14,15} and tablet screen recordings¹⁶ that served to introduce material that would have happened during the in-person, on-campus class.¹⁷ We had around 50 students (9 groups) in the 8:30-9:15 session and around 40 students (7 groups) in the 11:30-12:15 session. Groups were established prior to beginning remote instruction, carrying over from our in-person groups when possible. We were impressed that student attendance stayed relatively steady over the 6 weeks of remote instruction. We postulate that feeling accountable to other members of their group played a key part in keeping attendance high.

The structure of these sessions followed a set outline. After a brief opening welcome, groups were sorted into pre-set Zoom breakout rooms to discuss the problems due that day. We returned to the large group for comments on common questions or mistakes, then went back to the breakout rooms to attempt new group problems.¹⁸ A critical component for the full class and small groups was a tablet with a stylus to enable screen sharing and effective structural drawing. Many groups had students with this capability. Groups lacking a student with a tablet were much less efficient and relied on the whiteboard capability in Zoom for drawing.

The key to enabling productive group discussion was having a teaching team to support small group learning. Our teaching team consisted of two faculty members along with undergraduate learning assistants (3 students were hired for the 8:00 AM class and 2 students for the 11:00 AM class). This enabled us to assign each learning assistant to 2 groups (5-6 students per group), leaving the 2 faculty members to cover 3 groups. We rotated groups each day so that the instructors regularly saw each group. This format worked very well to foster group interaction and improve student understanding. Without the number and quality of student learning assistants, this would have been far less effective. Reflecting on the synchronous group sessions, they were one of the success stories of the course.

Because our synchronous class time was used for group work (and not all students attended the synchronous class time), we needed alternative methods for content delivery. We found that making our own videos or tablet screen recordings¹⁶ was an effective replacement for introducing material in class. We also used tablet screen recordings to provide answers to all daily problems, class problems,

quizzes, and exams to help offset some of the hesitation to ask questions on Zoom. Additionally, we generated static PDFs of the screen recording from Notability¹⁹ so students could choose the format that best suited their needs.

Several key components of the course became less popular once we went to remote instruction. Weekly discussion groups went from mandatory to voluntary, so some level of reduced attendance was expected. However, this drop was steady over the 6-week period resulting in much smaller sessions at the end of the course. Office hours and Q&A sessions saw similar drops in attendance as did our evening tutoring sessions led by our undergraduate tutors. Notably, students who used these learning resources reported that they were effective and promoted their understanding. However, the impact of being off campus clearly resulted in fewer students attending these sessions.

FACULTY REFLECTION

Overall, we believe the 6-week remote instruction period went well. Many students learned the key concepts of the course and a sizable number achieved at a very high level. Several components introduced for distance learning were so successful that we will continue to use them in future semesters, whether in person or remote. Slack will become a key tool for our future communications with students. We will continue to make more tablet screen recordings so they can see the problem-solving process. We also found that many students were reluctant to ask questions during class time on Zoom. One method that encouraged questions from students was the “Chat” function on Zoom. Students could type their question and whichever instructor was not talking would act as a moderator and would verbally interrupt the other instructor and ask the question on behalf of the student. This seemed to take away some of the intimidation factor of asking questions on Zoom, and we saw an increase in questions of this type towards the end of the semester.

After analyzing the grades from both sections of the class we noticed an interesting trend of which students self-selected for the independent track. Students in section 1 (our original class, using structured group work from the beginning) that picked the independent track tended to have a slightly lower overall grade than students that picked the group track (Table 2). This could be attributed to several factors, including feeling that the group work wasn't working, scheduling concerns, or personal reasons unrelated to class. Unfortunately, over the course of the second half of the semester this grade

discrepancy widened and, at the end of the class, track 1 had an average grade of 79% compared to track 2 that had an average of 85%. With the students in section 2 (run as an interactive lecture in the first-half of the semester by a different instructor where group work was a smaller, less formal part of the class), we saw this trend reverse. In the first half of the semester, students that would end up choosing the independent track in the second part of the class had an average overall grade that was 10 percentage points higher than the students that would choose the group track. This grade gap in section 2 continued into the second half of the class with students in track 1 earning an average of 88% compared to the track 2 students at 79%. These results could indicate that high-achieving students with prior group experience in the class tend to choose the group track (as evidenced by section 1) whereas high-achieving students without group work experience elect for the independent track. However, more research would need to be done to identify if this outcome is significant.

Table 2. Grade outcomes.

| Section | First half average grades ^a (%) | | | Second half average grades (%) | | | Overall average grades (%) | | |
|---------------------------|--|---------|------------|--------------------------------|---------|------------|----------------------------|---------|------------|
| | Track 1 | Track 2 | Full class | Track 1 | Track 2 | Full class | Track 1 | Track 2 | Full class |
| Section 1 ^b | 83 | 87 | 86 | 74 | 83 | 82 | 79 | 85 | 84 |
| Section 2 ^c | 94 | 84 | 87 | 88 | 79 | 82 | 91 | 81 | 84 |
| Sections 1+2 ^d | 88 | 86 | 87 | 80 | 82 | 81 | 84 | 84 | 84 |

^aFor the first half of the class Section 1 and 2 were separate classes and there was no choice of independent or group work. These are the averages of the first half grades based on which learning group students chose in the second half. ^bTrack 1 students n = 13, track 2 students n = 66. ^cTrack 1 students n = 11, track 2 students n = 23. ^dTrack 1 students n = 24, track 2 students n = 89, entire class n = 113.

We continue to believe in active learning and the importance of small group work.¹ Some students still resist active engagement in these settings even as we introduce them to research findings highlighting the benefit of group work versus lecture.²⁰ Using Zoom to switch between a large group and breakout rooms proved effective to enable full class and small group interactions without an in-person classroom. Thinking ahead to options for the fall, this online format may be the best option for active learning. If face masks and social distancing of six feet are required when together in classrooms, many of us might prefer to conduct active learning classes using Zoom. Ensuring that at

least one student has a tablet and a stylus, perhaps provided by our institution, in each group will
175 help standardize visual communication across all groups.

STUDENT FEEDBACK

A critical part of our course design was to solicit student feedback regularly. Overall, students
seemed happy with the structure of the course. We surveyed students before moving to remote
instruction and weekly for the first two weeks after moving online. Their initial suggestions led us to
180 establish independent and group tracks for online learning and incorporate low-stakes weekly quizzes
to keep students on task. Once online learning had begun, we learned that they liked the variety of
options to communicate with the instructors. We also adjusted the grading method of the weekly
quizzes and opened the breakout rooms on Zoom 30 minutes early before the synchronous session
started for those groups that wanted more time to collaborate on their problem sets.

185 To pinpoint which aspects of the course students found most useful, we sent a survey after the
end of the semester asking them to rank the class learning resources (Figure 1). They highly valued
the synchronous sessions and the ability to work with their peers in breakout rooms with 47 students
marking synchronous class time as important or very important in their learning. Students also
regarded the daily problems and tablet screen recordings as integral to their learning.

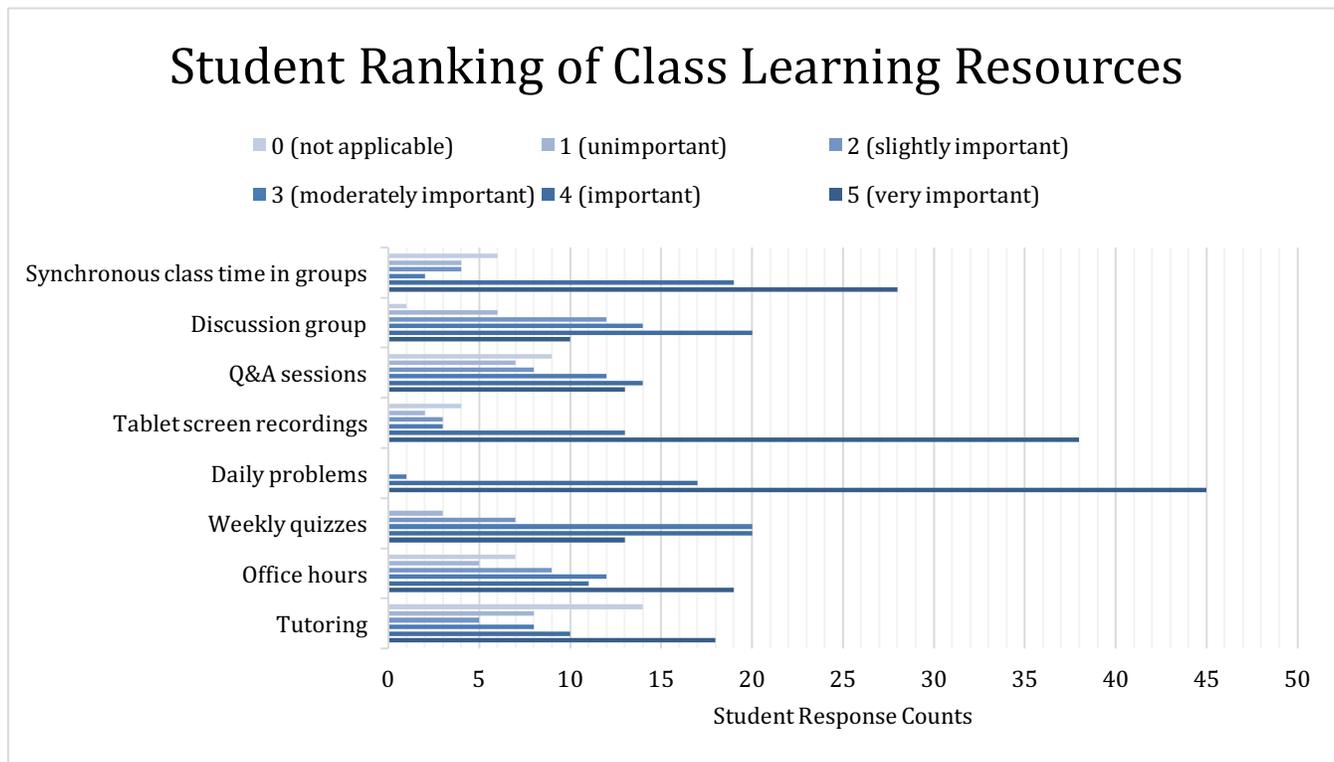


Figure 1. Class learning resources ranked in terms of importance by students (n = 63).

Prior to COVID-19 we had planned on looking at students' perceptions about group work before and after a class where group work was a core value of learning. To do this we asked students to respond to a survey before they were put into groups at the beginning of the class. We sent the same survey after the semester was over. Analyzing the before and after group work questions, students became more comfortable with group work, believed more strongly that group work helps to improve understanding, stated that group work helps them feel more welcome in class, and felt that group work was a good use of class time (Table 3). Representative student comments about group work included, "My group was a source of support and encouragement for my learning. My group was integral to my learning.", "Group work really helped me to solidify my learning and also identify what I needed to improve by collaborating with my peers.", "Group work was really, really great when people participated, but became frustrating when it was communicated that some people were not participating and there wasn't a way to deal with that.", "Group work helped keep me going through rough spots in the remote learning part of our class since I wanted to be there for my team.", and "I found it helpful to explain my understanding to my

group mates. It solidified my confidence with the material. When we were confused, we could work together instead of getting frustrated alone.”

Table 3. Student perceptions about group work.

| Group work statements | Beginning of semester ^a | End of semester ^b |
|--|------------------------------------|------------------------------|
| | Avg (% 4/5) ^c | Avg (% 4/5) ^c |
| I am comfortable working in groups. | 3.65 (59) | 4.07 (86) |
| I believe group work helps to improve understanding. | 3.66 (62) | 4.23 (80) |
| Group work helps me feel welcome in class. | 3.47 (51) | 4.02 (73) |
| Group work is a good use of class time. | 3.22 (41) | 3.98 (77) |

^an = 68. ^bn = 44. ^cThe percent of students selecting 4 or 5. 1 = strongly disagree, 5 = strongly agree.

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Student comments about learning remotely echoed familiar themes including, it “requires a lot of self-discipline and a good at-home environment”, it “takes a lot more organization and motivation to succeed”, “you really need to be able to teach yourself, far easier to fall through the cracks than in person”, and “it’s really difficult to stay engaged...and I find all the online assignments much more overwhelming”. It was also interesting to see that student attitudes ranged from “it is more difficult to concentrate at home” to “remote learning is convenient and really accessible”.

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CONCLUSIONS

When we set out to prepare for this semester, we had planned on incorporating consistent group work into the first semester of organic chemistry. In reality, we ended up testing many new ideas as we endeavored to keep synchronous group work as the core of our class during the transition to online learning. Despite the initial misgivings of both the students and the instructors, we feel confident that we provided a rigorous first semester of organic chemistry for our students. The key to this success started with communication with the students to learn exactly what they needed from us and the class. This led us to introducing two different tracks (one with synchronous group work and one without) to help accommodate our students’ new lives. We also put trust in the students that they would follow the Honor Code and take responsibility for their own learning as we helped them navigate changes in time zones, home lives, and work situations. To this end, we made all exams, quizzes, and assignments untimed, open-note and open-book. We also incorporated different content delivery methods to avoid lecturing on Zoom where interacting with large numbers of students can be difficult. In addition, we were fortunate to have excellent student support in the form of peer tutors and in-class learning

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assistants. Though this semester did not proceed as we had expected, it turned out to be an amazing learning experience for both students and instructors.

ASSOCIATED CONTENT

Supporting Information

235 The Supporting Information is available on the ACS Publications website at DOI:

Supplementary materials including syllabi, exams, and samples of a quiz, daily problems, “to do” lists, and in-class problems and answers (PDF)

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⁷Zoom <https://zoom.us/> (accessed June 2020)

⁸ The lab portion of the course is integrated into the class (not separate course credit).

Although work for the lab portion of the course changed after going remote, the points awarded for the lab were kept at 150 points total for the first and second parts of the course. Points from the lab were used when calculating final grades for students, but they are not included in any of our analyses for this paper.

⁹ Multiple choice quizzes were administered using Moodle, our course management software.

¹⁰ A partial excerpt from the Honor Code section of Smith's Student Handbook reads: Smith College expects all students to be honest and committed to the principles of academic and intellectual integrity in their preparation and submission of course work and examinations. All submitted work of any kind must be the original work of the student who must cite all the sources used in its preparation.

¹¹ For examples of problem sets, quizzes, and exams, please see the Supporting Information.

¹² <https://slack.com/> (accessed June 2020)

¹³ For examples of "to do" lists, please see the Supporting Information.

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