



## Original Research Article

# A Potential Package for Organic Chemistry Remote Teaching

Ashok Khanal\*

Department of Chemistry and Biochemistry, University of the Incarnate Word, San Antonio, United States

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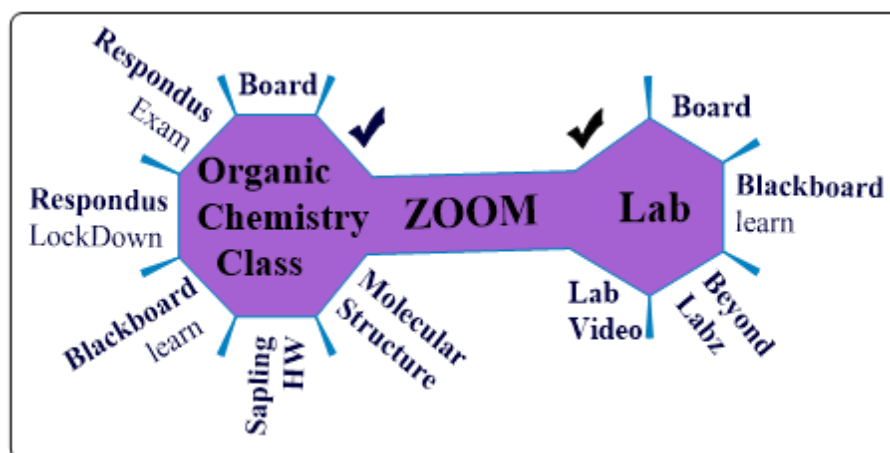
Remote teaching

Synchronous teaching

## ABSTRACT

The pandemic has brought both challenges and opportunities to all universities across the globe. Every challenge will open the door for new opportunities. As the world was fighting against the global pandemic, all universities were transitioned online over a short period without any prior preparation. Over time as an instructor, I shape myself for combating the situation. Utilizing Zoom, whiteboard, molecular model, videos, ChemDraw, Respondus, LockDown Browser, blackboard, mandated attendance, interactive class, and office hour, this instructor was able to facilitate the learning process compatible with the face-to-face model. Laboratory was the blend of lab manuals, lab videos, and simulation experiments. Prelab, quiz, and report were prepared based on the lab manual and lab video. Similarly, simulation experiments were conducted for each lab via Beyond Labz which helped to connect the lecture with the techniques of the laboratory. In fall 2020, a survey was conducted on sixty students representing different organic chemistry lectures (CHEM 2311) and laboratories (CHEM 2111) at the University of the Incarnate Word, San Antonio, Texas. The outcome of the survey revealed that live synchronous with mandated attendance and office hour fulfills the expectations of the students as well as the standards of the course. This instructor's perspective also aligned with the outcome of the students' thoughts. The preferred response for live synchronous is almost half of the total so it is equally beneficial, provides full expectation, and almost as effective as face to face.

## GRAPHICAL ABSTRACT



\* Corresponding author: Ashok Khanal

✉ E-mail: [khanal@uiwtx.edu](mailto:khanal@uiwtx.edu)

☎ Tel number: 210-841-7498

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## **Introduction**

Online classes are conducted over the Internet through different learning management systems without face-to-face interaction between the student and the instructor. For the last twenty years, it has been collecting its popularity so fast. Due to its flexibility, affordability, variety of academic opportunities as well as enrollment facilities for distant learners from diverse geographical places, it became the center of attraction. Online classes can be conducted in two formats, synchronous and asynchronous. If students and instructors follow their calendars appropriately, they need to meet at the stated day and time outlined in the syllabus. Choosing synchronous guarantees that. In contrast, selecting asynchronous states that there are no set meeting days or times.

Teaching organic chemistry itself is a very challenging job even in a face-to-face format. The online transition made it even more challenging in terms of delivery, students' interest, motivation, and understanding. However, over time, instructors are upgrading themselves to overcome the shortcomings and move forward. At the same time, organic chemistry became one of the most popular classes at the University of California, Los Angeles. According to the author, instructors can make it possible by making students feel connected to the class, supporting them, providing opportunities to do amazing things like organic chemistry music videos, and various online resources created in partnerships with students [1]. There is no doubt that most would love a face-to-face setting, but instructors did not have any options other than choosing online during the pandemic situation. With a sudden move in the middle of the spring semester, initially, a combination of synchronous and asynchronous was found to be more effective. One of the exit surveys conducted in SUNY Plattsburgh reported, the majority of the student (64%) preferred face-to-face [2]. This

survey was conducted during spring 2020 and students who participated in the survey were in face-to-face class until March. In addition, both students and instructors were not prepared enough for the abrupt transition. During the abrupt transition due to the pandemic, as many as 36% of students were inclined to online is a clear indication that if instructors and students prepared well in advance, more students will be attracted by online teaching.

After trying live synchronous, and asynchronous with different teaching methodologies in spring and summer 2020, the instructor's perspective, as well as students' thoughts, were inclined towards live synchronous would be more effective. However, at that moment, the author did not have any specific survey or data to support this hypothesis. In fall 2020, the author conducted the survey and evaluated the live synchronous mode of online organic chemistry classes and laboratories at the University of the Incarnate Word. Survey strongly supports live synchronous organic classes and laboratories are the better options and could be the potential alternative package for organic chemistry teaching.

Similar research was conducted for small undergraduate chemistry classes by Naval Academy Instructors. Though the authors in that work surveyed chemistry faculty exclusively for undergraduate science courses and their conclusion 'Synchronous instruction is preferred' aligned with my specific survey for organic chemistry classes and laboratories [3]. The authors talked about mandatory attendance in the introduction which is good support for synchronous instruction.

For the organic chemistry laboratory, Wesleyan University tried a different approach to run the lab to fit the circumstances. Apart from scientific writing, presentation, and critical thinking skills, they provided one project from a published paper [4]. Though they did a great job to continue organic laboratory, it does not answer

the uniformity of the organic laboratory throughout the nation. The University of the Incarnate Word, chemistry, and Biochemistry department utilized the blended organic laboratory for distant students. The laboratory was a blend of lab manuals, lab videos, and simulation experiments. Around half of the students' preferred blended setting is a clear indicator that we can deliver and conduct the lab with similar expectations with face to face. Similar research was conducted at the University of Michigan, Dearborn [5] for remote lab using techniques like manuals, videos, Beyond Labz. They believed these strategies will be adapted in the future. But they do not have direct data for face to face versus live synchronous in terms of student's choices. Though the virtual laboratory has limitations like there is no direct supervision, the student is not aware of the laboratory hazards, but it will be useful for developing countries that cannot afford laboratory facilities and sophisticated lab equipment because of financial problems [6].

The motivational goals/aims for organic chemistry distance learning are

1. It is very useful, effective, especially where the physical class and laboratories cannot be developed due to the dearth of funding and actual practices.
2. It is appropriate, effective, and cheap for the universities of developing countries where physical facilities are difficult to get.
3. It will cover a large audience.
4. It will have more impact if we are hit by another type of emergencies in the future.
5. More importantly, it covers all the standards of the course and fulfills the expectations of students as well as instructors.

## Methods and Discussion

Sixty students from organic chemistry classes (CHEM-2311) and labs (CHEM2111) representing different sections participated in

this survey. The lecture and laboratory class sizes were twenty and fourteen students, respectively. A live interactive synchronous ZOOM lecture was conducted. The lecture was made more effective utilizing a whiteboard, three-dimensional molecular model, videos, mandated attendance, and office hours. All exams were prepared in Respondus, conducted over lockdown browser via blackboard. Proctoring was performed by evaluating their activities in the Lockdown Browser. For the organic lab, the same strategies were applied for the meeting. Students used their first hour for the prelab and the quiz adopted from the lab manual and videos. Then, a brief lecture was delivered in the corresponding lab. After that, students were responsible to run an experiment on Beyond Labz. They were evaluated in the lab video and Beyond Labz experiment once they completed the post video and Beyond Labz questionnaire. Finally, a lab report was prepared for each lab based on manuals and lab videos. All the course components and methods applied are summarized in Table 1. After completing all the requirements for the lecture and lab discussed in Table 1, the instructor evaluated whether live synchronous is sufficient enough to fulfill their need, criteria, and expectations about the course. Surprisingly, the outcome aligned with instructor expectations.

### *Class attendance and participation*

Class attendance/participation is an important factor in the learning process. If the instructor can make students speak up during the class, the whole class can be benefited from the addressed response. By evaluating their question type, the instructor can figure out their understanding and accordingly prepare the pace for upcoming classes. Consistent class attendance greatly correlates with good academic performance [7]. This reference convinced me that class attendance/participation is an important factor

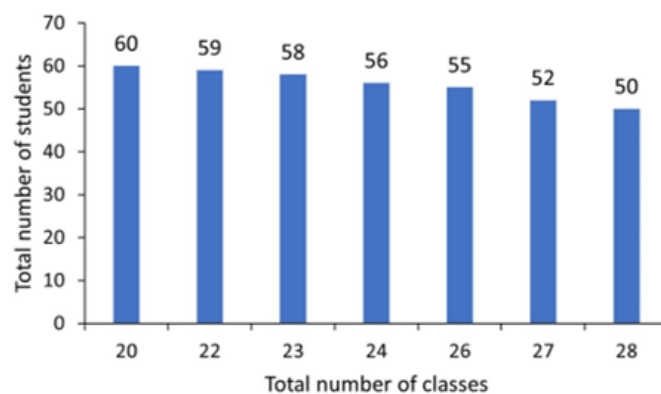
for academic performance. Class attendance was encouraged by providing points and monitored by roll call at the end of each class. Interestingly, it became a great technique to attract all students during class. Real-time recording of class attendance is shown in Figure 1. A total of 28 total classes.

(1.25 h each) was included. According to the real-time attendance, which is revealed in Figure 1, out of 60 students, 50 students attended all classes and all students attended at least 20 classes.

Besides, in the separate survey, 75% of students considered class attendance/ participation is beneficial (Table S1).

**Table 1.** Summary of course components and worked out methods

Entry	Course components	Method Applied	Applied to
1	Class	Live synchronous via ZOOM	Lecture and Lab
2	Class Attendance	Roll call at the end of class	Lecture and Lab
3	Interactive class	By asking/breakout room	Lecture and Lab
4	Use of molecular model	By showing if necessary	Lecture and Lab
5	Expectation from instructor	By asking anonymous way	Lecture and Lab
6	Reposting live lecture on bb	Once the live lecture is done	Lecture
7	Chalkboard	By using smartpen	Lecture and Lab
8	Structure drawing	With ChemDraw & smartpen	Lecture and lab
9	All course materials	By posting on bb	Lecture and lab
10	Exam mentoring	Via LockDown Browser	Lecture
11	Homework	Via Sapling	Lecture
12	Office hour	Via zoom	Lecture and Lab
13	Lab video and lab manual	By posting on the bb course	Lab
14	Simulation Experiment	Via Beyond Labz	Lab
15	All Lab writing and exam	Via bb submission window	Lab



**Figure 1.** Real-time attendance of 60 students in 28 classes

#### *Use of different three-dimensional model and video*

Drawing or explaining a three-dimensional model on a two-dimensional board/screen is difficult and time-consuming. Three-dimensional compounds are best viewed with the help of a molecular model. Students can understand the

orientations of each atom in three-dimensional compounds. The use of molecular models during online organic chemistry lectures makes a huge difference in explaining how and why chemical phenomena occur [8]. The instructor uses Organic Chemistry Molecular Models and Videos during the class for visualizing the three-

dimensional structure of the molecule. In addition, instructor demonstrated converting a two-dimensional structure drawn in ChemDraw to a three-dimensional structure. This idea reflected vividly in the survey, out of 55 students, 47 (87%) considered molecular model and videos are very helpful (Table S2).

#### Interactive live session

The beauty of live synchronous is the instructor enjoys the questions, interactions, and immediate feedback from the students. Interaction during class helps to understand whether the students are following the lecture or not. Furthermore, it can provide the taste of a face-to-face setting. In an interactive live session, both students and the instructors are more involved in the learning process, gain more information, and become more satisfied [9]. The interactive session was made more effective by using the ZOOM breakout room. The activities conducted in the breakout rooms are

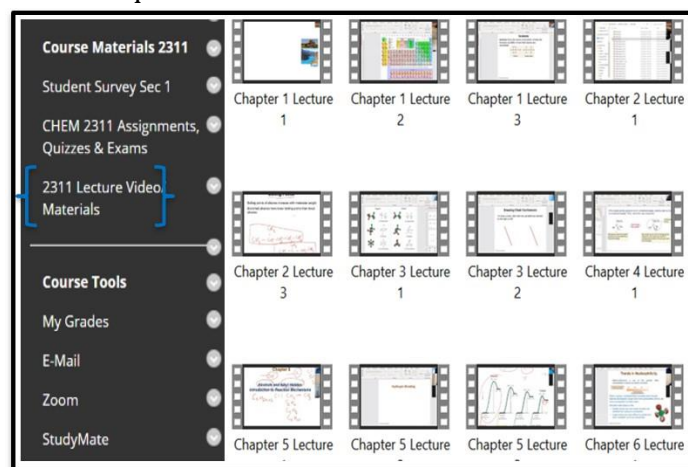
1. Provide an assignment for each group and monitor their activities one by one.
2. Assigning roles for each individual.
3. Based on their role, the individual is responsible to explain to the class.

The survey in this study also supports the idea. Out of 55 students, 35 (around 64%) preferred the interactive lecture with a question in the

breakout room vs just delivering the lecture (Table S3)

#### Reposting live lecture on blackboard once the lecture completed

The nature of the students varies, only a few students concentrate enough throughout the class to catch the pace of the lecture. Besides, different factors can interrupt the class like internet connection, electronic gadgets, family/friends gathering, personal reasons, etc. If the instructor reposted the same lecture on Blackboard (Figure 2), they would review and make sure at their convenience. If the recorded lecture is posted, the students will have the option to hear them being explained again. Also, an instructor can get information about students who go through the videos, how many times have watched, how long they watched. Detailed data about student interaction with video content gives instructors greater insight into the effectiveness of the lecture content. Most students expressed they would like lectures available online [10]. Surprisingly, in this survey out of 54 students, 52(97.3%) preferred reposting recorded lecture once class was over (Table S4)



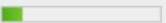

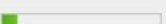

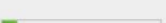



**Figure 2.** Reposting live lecture in the blackboard immediately after the lecture

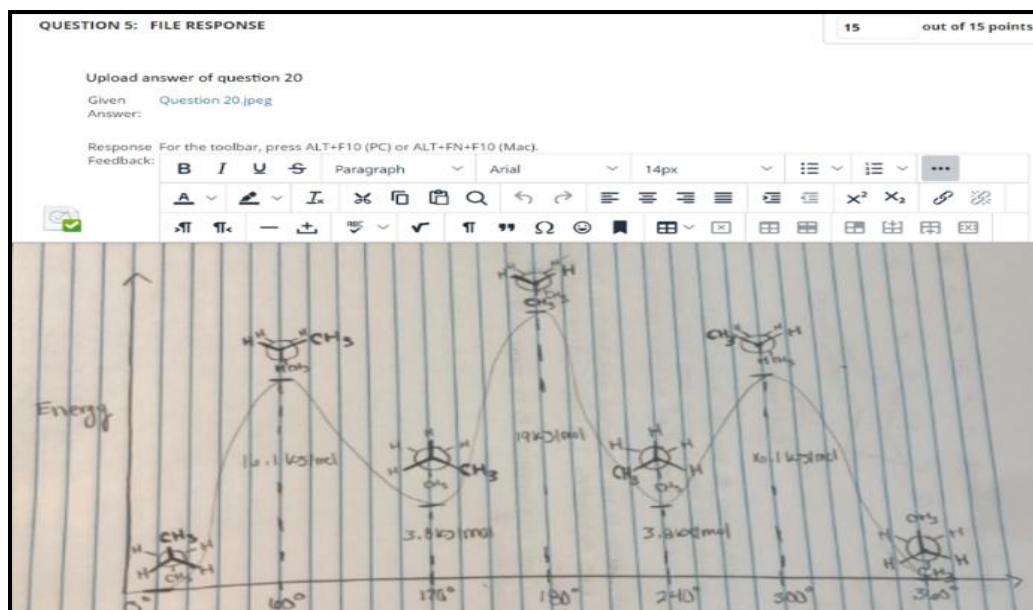
### Exam mentoring

If there is any type of cheating during the test, then the instructor fails to excel in the integrity of the exam. There are different forms of cheating including online cheating, peer/instructor resources cheating, and cheating during the test. The purpose of proctored exams is to stop cheating and validate the integrity of the exam. Maintaining academic honesty is the most important thing, so there should be effective online proctoring for online classes. Online proctoring can be administered by conducting the exam in a fixed time, preventing them to save and complete later, having a different set of exams for different sections, and watching their activities [11]. The instructor considered two ways for online proctoring, ZOOM, and Respondus lockdown browser. Using the ZOOM can watch/record the real-time video to monitor their activities like face to face. Instructors are responsible to monitor their surroundings, table, and the wall before the exam. The university of the incarnate word has an inbound Respondus Lockdown Browser on the blackboard. As its

name indicate, it can prevent students to use other browsers, from copying and pasting, printing, or accessing other applications during the exam. If Respondus LockDown Browser is used, students will not be able to take the test with a standard web browser. The instructor chose the Respondus lockdown Brower as it automatically saves the exam video. If the system finds any suspicious activities, then it's flagged (Figure 3a) on the percentage which makes it easy for the instructor to review the video and make a decision. After the quiz or exam is complete, an instructor can review all the details. There is one small drawback to this software that does not allow students to upload file response questions (Figure 3b). In this case, the instructor made it possible by asking students to upload the file as soon as they exit from the lockdown browser and that can be checked. In the survey, out of 54 students, 27 (50%) students preferred for lockdown browser, and another 27 students (50%) preferred for live zoom exam (Table S5).

Review Priority		Date	Score	Duration
HIGH		28 Oct 2020 @ 3:24PM	160.00	125.2
LOW		28 Oct 2020 @ 3:14PM	118.00	75.9
LOW		28 Oct 2020 @ 2:39PM	123.00	64.5
LOW		28 Oct 2020 @ 1:19PM	119.00	50.1
LOW		28 Oct 2020 @ 3:23PM	170.00	43.8
LOW		28 Oct 2020 @ 3:14PM	137.00	125.0
LOW		28 Oct 2020 @ 1:25PM	125.00	95.4
LOW		29 Oct 2020 @ 3:03PM	153.00	60.4

**Figure 3a.** Proctored videos of individuals from Respondus LockDown Browser showing review priorities based on flagged to track cheating



**Figure 3b.** File response answer uploaded by students immediately after exiting from the lockdown Browser

### Homework

Homework/assignment helps the student to improve memory, critical thinking, and intellectual abilities. In this course, Sapling online homework was introduced. Sapling is an online homework system. Sapling Learning online homework system allows the instructor to assign key concepts that help students to learn. Question types include multiple-choice, free-response, labeling, and ranking, along with hints and feedback to help students answer and learn from mistakes. *Richards-Babb et. al* [12] surveyed the student perception of online homework for learning organic chemistry. According to them, online homework helped students to improve their learning by improving their study habits. Moreover, students expressed a positive attitude toward online homework. On this basis, the instructor asked students whether Sapling's online homework system is aligned with our course materials or not. The majority of students agreed. In the survey, out of 55 students, 50 (91%) students agreed that online sapling homework is aligned with the chapter materials and beneficial (Table S6).

### Office hour

A one-on-one meeting is considered as one of the effective and best ways to solve the problem as well as to make a personal connection. If students have any questions, they can come in and ask. Instructors have the opportunity to know the student better, motivate them, and ask how the course is going during that office hour. The instructor holds the synchronous zoom office hour as well as an open-door virtual office (for those who were unable to make synchronous zoom) from the beginning. It connects the students and the instructor besides the lecture. It is more flexible as both the students and the instructors have the choices to the time [13]. When the instructor ran a survey, almost all students considered ZOOM office hour is very helpful. In the survey, out of 55 students, 54 (98.2%) students agreed with it (Table S7).

### Students expectation from instructor

Anonymous students' feedback (Figure S1) was collected to address their expectations for this online class randomly. Though they addressed

specifically the instructor in their comment, the instructor summarized some of them as a teaching tool. They preferred the instructor who is always readily available, willing to help, and does the prompt response to the questions. The instructor's dedication and enthusiasm about the material have facilitated learning and understanding of the material. The instructor should be very understanding and enjoys teaching. Students think having a professor who loves teaching and is excited every day when they come to class helps them learn better. The instructor should also dumb all concepts down for students so that everyone can understand the concepts. The instructor should help student learning and make the subject matter easy to understand by explaining the concepts thoroughly and providing examples to help visualize concepts. And they appreciate that the instructor records lectures to later post on class Blackboard, this helps them go back to points they do not fully understand while studying or doing homework.

#### *Lab manuals and videos*

Though the student's used simulation experiments for all labs, the instructor encouraged them to use lab manual and video to complete all lab requirements like preparation of prelab, quiz, post video questionnaires, and the lab report. This is because the instructor was shaping them to complete the lab in a real lab setting. In the survey, out of 54 students, 35 (65%) students agreed for keeping a notebook that is similar to the face-to-face setting by using the lab manual is a good idea (Table S8). In addition, 38 (70%) students considered taking data from the video lab for the lab report is useful (Table S9)

#### *Simulation experiment*

The simulation experiment provides virtual experimentation during an online session. The

simulation experiment is not only designed for the experiment by simulation it also provides information about laboratory technique and the potential safety. Students have the opportunity to characterize the target by using Nuclear Magnetic Resonance (NMR) and Infrared Spectroscopy (IR). For the simulation experiment, Beyond Labz was used. Beyond Labz provides sophisticated and realistic laboratory simulations for chemistry, organic chemistry, biology, and physics education, based on a Science SDK (Software Development Toolkit) built up over 20 years of research. Their philosophy is that students should be placed in educational environments where they are free to make decisions and experience the resulting consequences. The instructor believes students learn science best by doing real science, and that a combination of real and virtual labs provides students a richer learning experience where they are freed from the constraints of time, safety, and cost [14]. The simulation lab is the pool that connects lecture and lab effectively and it is a robust platform for practical knowledge other than cookbook learning [15]. In this survey, out of 54 students, 38 (70%) students agreed that the Beyond Labz experiment aligns with the lab experiment (Table S10).

Students conducted a series of following activities for executing each laboratory experiment. 1. *PreLab*: Before each experiment, students are required to submit the prelab. PreLab was prepared by using the lab manuals. 2. *Lab Quiz*: Lab quizzes were available for the first 30 minutes of the lab time. Questions were adapted from lab manuals and lab videos. After submission, they were responsible to run the experiments via Beyond Labz. 3. *Lab Video*: Students compare the video procedure to the one they prepared in their PreLab. Students were provided with Post-lab questions for each video. 4. *Execute the experiment*: Each experiment was executed by simulation via Beyond Labz then they are required to complete the associated



exercise for each experiment. 5. *Report*: Students completed their lab reports following WICKED lab writing. WICKED is designed to give students electronic resources and assessments that will better prepare them for writing in upper-division labs and post-graduate curricula.

## Outcome

### Lecture

By considering the above-explained teaching methods/styles supported by the student's responses, the instructor summarized more crucial information based on student responses. First of all, around 80% of students have a preference for live synchronous over asynchronous (Table 2). Besides, around 80% of

students agreed that the lecture provided the right amount of theoretical and practical experience (Table 2). The more exciting thing and important outcome of this survey is around 33% of students considered live synchronous organic lecture model is equally aligned with face-to-face in terms of delivery (Table 2). Around 15% considered live synchronous organic lecture model is better aligned than face to face in terms of delivery (Table 2). The responses for (a) live synchronously is equally aligned with face to face plus (b) live synchronously is better aligned than face to face, which is almost half of the total. So, a live synchronous organic lecture model with the above-mentioned teaching style can be the next alternative for organic chemistry teaching.

**Table 2.** Student survey on teaching mode. 1. Live synchronous versus asynchronous 2. Effectiveness of live synchronous lectures based on providing the right amount of theoretical and practical experiences. 3. Direct comparison of live synchronous with face to face

Response questions	Options		
For an online organic lecture, which one you prefer, live synchronous, or asynchronous? (Total responses= 55)	Live Synchronous Responses = 44 80%		Asynchronous Responses = 11 20 %
Do you think the class provided the right amount of theoretical and practical experience? (Total responses = 54)	Yes Responses = 43 79.6%		No Responses = 11 20.4%
How do you Compare live synchronous organic lecture model align with F2F in terms of delivery? (Total responses = 54)	LS = F2F Responses = 18 32.7%	LS > F2F Responses = 8 14.5 %	F2F > LS Responses = 29 52.7 %
LS = Live Synchronous, F2F = Face to Face			

### Laboratory

By introducing a blending lab, which was the combination of the lab manual, lab video, simulation experiment, the Instructor was able to provide an effective laboratory package. About 30% of students considered the blended lab is as the same as face to face and around 19%

considered as it is superior to face to face (Table 3). The responses for (a) blended lab is the same as face to face plus (b) blended lab is better than face to face, is almost half of the total like for organic lecture. It is a clear indication that we can use this model in the future to run an effective virtual lab.

**Table 3.** Direct comparison of the live blended lab with a face-to-face lab**How do you compare the blended lab (Beyond Labz, video lab, and lab manuals) with the F2F lab? Total responses = 54**

Blending = F2F Responses = 16 Percentage = 29.6%	Blending > F2F Responses = 10 Percentage = 18.5%	F2F > Blending Responses = 28 Percentage = 51.9%
F2F = Face to Face		

**Conclusions**

Teaching organic chemistry online is a difficult and challenging job. During this pandemic era, a lot of online teaching styles, methods, and software have been experimented with. This study discussed the effectiveness of the live synchronous class and laboratory. Based on the student's feedback live synchronous class is equally beneficial, provides full expectation, and almost as effective as face-to-face. Live synchronous lecture was conducted over ZOOM and is supported by attendance, interaction, reposting lecture after the class, using molecular model, whiteboard, and providing sufficient office hours. All exams were proctored by using the Respondus LockDown Browser. The same level of satisfaction was reflected in the laboratory setting as well. The lab was blended with lab manuals, lab videos, and simulation experiments. This lecture and laboratory package will be the potential future alternatives in the field of remote organic chemistry teaching. Also, the blended lab is more economical so in the future, it will be useful for those who cannot afford laboratory facilities and sophisticated lab equipment.

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**Disclosure statement**

No potential conflict of interest was reported by the author.

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