RESEARCH ARTICLE

Student perceptions and academic performance in a remote flipped classroom

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Abstract

Objective: To identify the components of a flipped classroom that may need to be adjusted for remote learning and to compare academic performance between remote and in-person flipped classrooms.   **Methods:** After implementing a remote flipped classroom in therapeutics classes in an integrated organ system block in 2020, the authors surveyed students on their perceptions of it and compared the median percent score of therapeutics questions on two summative assessments between students who took the block in person in 2019 and remotely in 2020.   **Results:** Reducing the amount of pre-class work was the most frequent feedback. Fewer than half felt that breakout room sessions enhanced their learning. The Cohort 2020 had significantly lower median percent scores on therapeutics questions than the Cohort 2019.   **Conclusions:** Delivery of pre-class materials and arrangements of student interactions in-class were identified as components for adjustments in a remote flipped classroom. Given the lower academic performance, additional support should be provided.

Introduction

The Flipped classroom is defined as 'a pedagogical approach in which basic concepts are provided to students for pre-class learning so that class time can apply and build upon those basic concepts' (Pesky *et al*., 2017). In this learner-centred approach, active learning strategies are utilised during class time after some content is offloaded as pre-class work (Pesky *et al*., 2017). Compared with a lecture-based pedagogic approach, flipped classroom has been shown to improve student learning in didactic settings in healthcare professions education including pharmacy education (Pierce *et al*., 2012; Rui *et al*., 2017; Hew & Lo, 2018; Kugler, Gogineni & Garavalia, 2018; Goh & Ong, 2019; Yang *et al*., 2020).

The format of flipped classrooms can be flexible but all flipped classroom models should have two key compo-

nents: pre-class offloaded content and active learning activities during class. Content is asynchronously delivered to students in a variety of formats prior to the class. Web-based modules, captured videos of lecture, podcasts, and eBooks are common formats used to deliver the content, although it is unclear which method is most conducive to student learning (Han & Klien, 2019). In addition, pre-class assessments may be administered to ensure that students study the content and are ready for active learning activities during the class (Wong *et al*., 2014; Woodruff *et al*., 2014). The goal of active learning activities is to help students apply pre-class content and learn new knowledge by engaging them in activities. This goal may be achieved through problem and case-based learning where students are provided with problems or patient cases to apply the pre-class content individually and/or as

a small group (McLaughlin *et al.*, 2014; Persky & Dupuis, 2014; Wong *et al.*, 2014; Woodruff *et al.*, 2014; Han *et al.*, 2019).

The COVID19 pandemic, which started in 2020, has changed pharmacy education. It has forced didactic pharmacy education, which was traditionally delivered as in-person classes, to become remote learning due to the risk of infection. As a result, content is delivered mainly via a video conferencing programme. One of the most commonly used video conferencing programmes is Zoom (Camargo *et al.*, 2020). This programme is popular because it offers many useful features that may simulate an in-person class experience. It allows the instructor to share his or her computer screen while verbally explaining the learning material such as lecture slides. In addition, its breakout room feature can partition students into virtual small groups where they can engage in active learning activities. These features of Zoom may allow instructors to continue pedagogic approaches that they have been using for in-person classes, such as the flipped classroom model. Since pre-class learning materials have already been asynchronously and remotely delivered for in-person flipped classrooms, these materials may not need to be changed other than updates on new information for remote flipped classrooms (Garcia-Vedrenne *et al.*, 2020). Furthermore, the breakout room feature of Zoom may function as a remote proxy for the small group active learning strategies used during in-person flipped classes.

Although Zoom allows instructors to implement flipped classrooms remotely, there may be components of in-person flipped classrooms that need to be adjusted for more effective and efficient learning. Also, even if a flipped classroom may be implemented remotely, it is unknown how students would perceive it for their learning. Finally, remote flipped classrooms may have different impact on students' academic performance compared with in-person flipped classrooms. Therefore, the objectives of this study were:

1)   to identify components of an in-person flipped classroom that may require adjustments for a remote flipped classroom;

2)   evaluate pharmacy students on their perceptions of a remote flipped classroom; and

3)   to compare academic performance between two classes, one with an in-person flipped classroom and the other with a remote flipped classroom.

Methods

This study was declared to be exempt from full review by the University of California, San Francisco (UCSF) Institutional Review Board.

The Cardiovascular Sciences & Therapeutics course

The Doctor of Pharmacy programme at UCSF is a three-year professional degree programme with the first two years focusing mainly on didactic education and the final year on experiential training. The Cardiovascular Sciences & Therapeutics course has been offered to the first year Doctor of Pharmacy students as their first integrated organ system course since 2018. It covers four disease states (i.e. ischemic heart disease, dyslipidemia, heart failure, and arrhythmia) and integrates relevant content in anatomy, pathophysiology, pharmaceutical chemistry, pharmacology, research design, statistics, and therapeutics by carefully sequencing the topics and content as well as utilising an anchoring patient case and team teaching. This 11.5-unit course is required for all students enrolled in the Doctor of Pharmacy programme and runs for nine weeks. In 2020, the entire course was delivered remotely, utilising Zoom due to the COVID19 pandemic. Except for small group facilitators, the course content and instructors were identical between 2019 and 2020. Small group facilitators, who mostly consist of pharmacy practice residents, lead small group sessions separate from large group sessions. There were 128 and 123 students enrolled in the course in 2019 and 2020, respectively. Student performance was evaluated with two summative exams.

Design and implementation of online flipped classroom

Since its inception in 2018, the course has utilised the flipped classroom model to teach its therapeutics content, which consists of a total of eight classes. In this model, students are required to watch pre-class lecture videos and to complete an online quiz prior to each class. On average, there were 2.1 modular pre-class videos per class, each of which lasted approximately 17 minutes. The average durations of pre-class videos per class and per class hour were 35 minutes and 18 minutes, respectively. Scripts for all of the pre-class video lectures, except for one on the topic of chronic stable heart failure, were provided to students. Each online pre-class quiz was designed based on the pre-class lecture to assess students' readiness for in-class patient discussion and consisted of five to ten multiple choice questions. Students were allowed to make as many attempts as they wanted until they were able to achieve 80% of the total score or

the closure of the quiz. The answers were released after the quiz was closed. Both pre-class lecture videos and quizzes were made available to students for at least three days prior to the class session.

The in-class patient discussion had two parts. The first part was a lecture summary and quiz review, and lasted about 20 minutes. In this part, the instructor highlighted key points of the pre-class lecture by providing and discussing charts, algorithms, or tables that summarised pre-class materials. In addition, the instructor reviewed quiz questions that many students had missed. The second part was a patient case discussion, which, depending on the topic, lasted 40-150 minutes. The patient case contained two to fifteen guiding questions, which were designed to help students solve therapeutics problems in the case. During the second part, students reported back and discussed their group answers in a large group setting after working on the patient case and guiding questions with their small groups.

The overall structure and process of the flipped classroom model that was described above was maintained in 2020. No pre-class lecture videos were changed. Of the total of 50 pre-class quiz questions, only four (8.0%) were changed. In addition, the number of students per in-class small group was four to five with a total of 25 small groups, identical to those in the in-person flipped classroom model. Given the online delivery of the course, however, a few adjustments to the authors flipped classroom model were made. First, the number of guiding questions in the in-class patient case was reduced due to additional time needed to transition between Zoom breakout rooms and large group sessions. Prior to the start of the course, a student, who took the course in 2018, and the course director reviewed all the guiding questions and deter-mined questions that did not need to be discussed in class based on the importance and coverage of the content in other components of the course (e.g., pre-class quizzes, small group sessions). This reduced a total number of the guiding questions by 16.2%. Those questions not dis-cussed in class were still included in the patient cases as self-study questions, and answer keys to all guiding and self-study questions were provided to students after each therapeutic class. Second, while students had been assigned to one small group and were required to work with the assigned small group in all of the therapeutics classes throughout the course, in the in-person flipped classroom students worked with different small groups in 2020 because it was not logistically feasible to have students work with one small group throughout the course due to the requirement to generate and use 25 zoom links. Instead, the automatic

group assignments function on Zoom was utilised. There were one to five breakout room sessions within a therapeutics class depending on the length of the class. Although students had their small group assign-ments changed between therapeutics classes, they worked within the same small group for the multiple breakout room sessions that took place within a single therapeutics class. Third, two senior Doctor of Pharmacy students and one pharmacy practice resident were recruited as teaching assistants for in-class sessions. In the in-person flipped classroom, the instructor circulated small groups to answer any questions groups may have while students were working on guiding questions with their groups. Since it was almost im-practical for a single instructor to circulate between 25 breakout rooms online, the teaching assistants for the in-class sessions were added so that small groups could have their questions answered in a timely manner. Finally, a Smartsheet in which students could indicate that they had a question during a breakout room session was created and made available to students, instructors, and teaching assistants so that students' questions could be answered in a timely manner.

Other changes to the course made in 2020

Due to the move of the date of summative assessments from a Friday to a Monday per the school policy based on students' feedback, the coverage of topics on Summative Assessment 1 was expanded in 2020; acute decompensat-ed heart failure, which was covered only on Summative Assessment 2 in 2019, was covered on Summative Assess-ment 1 in 2020. This was reflected by the two additional questions added to summative Assessment 1 in 2020.

The number of guiding questions in patient cases that were discussed in ten small group sessions was reduced by 28.7% to accommodate to the online delivery of the course. The questions not discussed in class were included in patient cases as self-study questions, and answer keys to all questions including self-study questions were released to students after each session.

A total of 12 practice cases and answer keys were made available to students as self-study in 2020 whereas only seven practice cases and answer keys were provided in 2019. In addition, the course director offered four optional practice case review sessions after Summative Assessment 1 in 2020. Approximately, 20 students attended each optional session.

Written summative assessments

In 2019 and 2020, there were two summative assessments. In both years, the assessments were identical except for two new questions added to Summative Assessment 1 in 2020. Summative Assessment 1 had 24 and 26 questions in 2019 and 2020, respectively, whereas Summative Assessment 2 had 25 questions in both years. In Summative Assessment 1, there were ten short answer questions and 14 multiple choice questions in 2019. The two new questions added in 2020 were one short answer and one multiple choice questions. Summative Assessment 2 consisted of 11 short answer and 14 multiple choice questions. Of the 24 questions on Summative Assessment 1 that were utilised in both years, seven questions (29.2%) were about therapeutics, whereas 14 questions (56.0%) on Summative Assessment 2 were related to therapeutics.

Each question on a summative assessment was graded as a full pass, borderline pass, or no pass. For a full pass, one point was awarded. For a borderline pass and no pass, 0.5 and 0 points were awarded, respectively. As a result, the maximum total score achievable was identical to the number of questions on a summative assessment. The student's total score of a summative assessment was the sum of all of the points.

The percentage score of therapeutics questions on a summative assessment was calculated with the following formula:

Percentage score of therapeutics questions = the student's score on all of the therapeutics questions x 100 / the number of therapeutics questions on a summative assessment

The average percent therapeutics score was calculated by taking the mean of percent score of therapeutics questions on both summative assessments.

Post-course survey

A survey invitation was sent to all of the 123 students who took the Cardiovascular Sciences & Therapeutics course in 2020 via Qualtrics after the completion of the course. The survey largely consisted of four sections:

1) pre-class learning materials including quizzes;

2) in-class patient case discussion;

3) technical aspects of the remote flipped classroom; and

4) overall experience with the remote flipped classroom.

Students were asked to rate their perceptions of components of each section, primarily using a Likert scale of 'Strongly Agree, Agree, Neutral, Disagree, and Strongly Disagree'. In addition, students' past experience with flipped classrooms and their preference between remote flipped classroom method and live lectures were asked about. Students also had the opportunity on the survey to provide feedback or suggestions for the improvement of the remote flipped classroom. The survey consisted of 17 questions and remained open for two weeks after completion of the course in December 2020. After the initial invitation to participate in the survey, reminder emails were sent to students every week while the survey was open.

Statistical analysis

Descriptive statistics to determine frequency distributions, percentage distributions, means, standard deviations, and inclusive ranges were used as appropriate. To identify variables that may predict students' preference for remote flipped classroom versus live lecture, a multivariable logistic regression analysis was performed. In this analysis, survey responses with 5-point Likert scale were collapsed to three levels (strongly agree/agree; neutral; disagree/ strongly disagree). The students' preference was treated as the dependent variable, and response to each question in the survey as well as percentage scores of therapeutics questions on both summative assessments as independent variables. To evaluate an association between the percentage score of therapeutics questions and survey responses, a linear regression analysis was performed with the average percent score of therapeutics questions on the summative assessments as the dependent variable, and survey responses including those with three levels as the independent variables.

The percentage score of therapeutics questions as well as the total exam scores were compared between students who took the course in 2019 (Cohort 2019) and in 2020 (Cohort 2020) by using the Wilcoxon rank sum test. STATA 16 (STATA Corp LLC, College Station, TX, USA) and SAS (version 9.4, SAS Institute, Carry, NC, USA) were used. A *p*-value < 0.05 was considered as statistically significant.

Results

Of 123 students enrolled, 113 responded (Response rate: 91.8%). Table I summarises the results of the survey. More than 60% of the respondents reported that they had had previous experience with a flipped classroom. Over 75% of

Table I: The results from the survey

Questions	Yes			No	
Past experience with flipped classroom	70 (62.0)			43 (38.1)	
	Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**
Review pre-class lecture material enhanced understanding of pre-class materials.	52 (46.0)	45 (39.8)	9 (8.0)	5 (4.4)	2 (1.8)
Review of quiz questions enhanced understanding of pre-class materials.	48 (42.5)	41 (36.3)	19 (16.8)	2 (1.8)	3 (2.7)
Time to review pre-class lecture material and quiz was adequate.	32 (28.3)	42 (37.2)	18 (15.9)	18 (15.9)	3 (2.7)
In-class cases and questions helped me apply.	81 (71.7)	25 (22.1)	4 (3.5)	2 (1.8)	1 (0.9)
The number of case questions was adequate.	23 (20.4)	58 (51.3)	19 (16.8)	12 (10.6)	1 (0.9)
Breakout room sessions enhanced my learning.	12 (10.6)	36 (31.9)	38 (33.6)	20 (17.7)	7 (6.2)
The number of breakout room sessions per class was adequate.	9 (8.0)	57 (50.4)	24 (21.2)	20 (17.7)	3 (2.7)
The number of students in a breakout room was adequate.	19 (16.8)	67 (59.3)	19 (16.8)	7 (6.2)	1 (0.9)
The amount of time to work with peer in a breakout room was adequate.	11 (9.7)	39 (35.0)	35 (31.0)	21 (18.6)	7 (6.2)
The access to the instructor during breakout room sessions was adequate.	27 (23.9)	28 (24.8)	38 (33.6)	17 (15.0)	3 (2.7)
Large group discussion enhanced my understanding.	51 (45.1)	50 (44.3)	10 (8.9)	2 (1.8)	0 (0)
The level of technical support was adequate.	19 (17.0)	48 (42.9)	39 (34.8)	6 (5.4)	0 (0)
Flipped classroom enhanced my understanding.	22 (19.6)	58 (51.8)	20 (17.9)	12 (10.7)	0 (0)
	Flipped classroom			**Live lecture**	
Which approach do you prefer?	70 (62.5)			42 (37.5)	

the respondents agreed or strongly agreed that it was useful to review the pre-class materials during the first part of the in-class activities. However, more than one third of the respondents did not agree or strongly agree that the time for reviewing pre-class materials was adequate. Over 70% of the respondents agreed or strongly agreed that cases and questions helped them apply knowledge and the number of case questions was adequate, suggesting that the reduction in the number of guiding questions may have been effective. On the other hand, students' perceptions of the structure and design of breakout rooms appears to be mixed; while more than half of the respondents agreed or strongly agreed that the number of breakout rooms per session and the number of students per breakout room were adequate, less than half of them agreed or strongly agreed with their effectiveness in learning, adequacy of the time allocated for breakout room sessions, and accessibility to the instructor(s). This was in contrast to the large group discussion, where approximately 90% of the respondents agreed or strongly agreed that it was effective for their learning.

Finally, whilst over 70% agreed or strongly agreed that remote flipped classroom enhanced their learning, only about 62% preferred remote flipped classroom over remote live lecture.

Technical aspects of remote flipped classroom

The two most common technical issues reported by the respondents were internet connection issues (64.6%) and Zoom lagging or freezing (63.7%). Approximately 60% of the respondents agreed or strongly agreed that the level of technical support provided by the school was adequate.

Students' feedback on the remote flipped classroom model

The three most common pieces of feedback on the remote flipped classroom model were related to pre-class materials. Approximately 20% of the respondents suggested reducing pre-class materials by moving some materials to live lecture. Also, 13.3% suggested limiting the length of the entire pre-class lecture videos per class to 20-30 minutes in total. In addition, 13.3% suggested continuing to provide scripts of pre-class video lectures. Other suggestions included continuing to provide summary charts, algorithms, or tables of the pre-class materials (10.7%), increasing the in-class time to review pre-class materials including quizzes (8.9%), allotting more time for large group discussion (5.4%), and assigning more students to each breakout room (4.5%).

Table II: Survey responses associated with students' preference for flipped classroom

Survey questions	Odds ratio	95% CI	*p*-value
Experience with the flipped class-room	7.08	1.24 – 40.49	0.03
In-class cases helped	3.79	0.80 – 17.90	0.09
Large group discussion enhanced learning	0.16	0.03 – 0.82	0.03
Flipped classroom enhanced under-standing	19.95	4.36 – 91.24	<0.01
Percentage score on the therapeutic questions on summative Assess-ment 2	1.05	0.98 – 1.13	0.07

CI: confidence interval. All survey response variables with a *p*-value < 0.1 are included in the table.

Association of preference for remote flipped classroom with other survey responses

In the multivariable logistic regression analysis, three variables were statistically significantly associated with students' preference for remote flipped classroom over remote live lectures: previous experience with flipped classroom, belief of large group discussion enhancing learning, and agreement that a flipped classroom enhances learning (Table II). While belief that large group discussion enhances learning decreased the likelihood of preference for remote flipped classroom by 84.0%, past experience with flipped classroom and agreement that a flipped classroom enhances learning increased the likelihood by at least seven folds.

Association of the average percentage score of therapeutics questions with survey responses

In a multivariable linear regression analysis where all of the survey responses were included as independent variables, only past experience with flipped classroom was statistically significantly associated with the average percentage score of therapeutics questions on both summative assessments (parameter estimate: 6.89; 95% confidence interval: 3.79-9.98; *p* = 0.007). None of the other survey responses, including preference for flipped classroom over live lecture, were associated with the average percentage score of therapeutics questions on summative assessments.

Comparison of academic performance between 2019 and 2020 student cohorts

Table III shows the comparison of median percent scores of summative assessments 1 and 2 as well as therapeutics questions on both summative assessments between

students who took the Cardiovascular Sciences and Therapeutics course in 2019 and 2020. Cohort 2020 had a 16.7% lower median percentage score on therapeutics questions on Summative Assessment 1 than Cohort 2019. Although this gap was reduced to 8.1% on Summative Assessment 2, Cohort 2020 still had a significantly lower median percentage score than Cohort 2019. When compared with performance on the entire assessments, Cohort 2020 also had significantly lower median percentage scores than Cohort 2019; Cohort 2020 had 10.8% and 3.5% lower median percent scores on summative assessments 1 and 2, respectively.

Table III: Comparison of median test scores between Cohorts 2019 and 2020

	Cohort		
Item	2019	2020	*p*-value
Therapeutics questions on summative Assessment 1	85.7 (71.4, 92.9)	71.4 (57.1, 78.6)	<0.0001
Therapeutics questions on summative Assessment 2	89.3 (78.6, 92.9)	82.1 (71.4, 89.3)	<0.0001
Summative Assessment 1 total	77.1 (66.7, 85.4)	68.8 (56.3, 77.0)	<0.0001
Summative Assessment 2 total	85.0 (76.0, 90.0)	82.0 (68.0, 88.0)	0.0064

Data expressed as Median(Interquartile Range)

Discussion

In this study, the authors have the following three main findings: 1) Pharmacy students generally preferred flipped classroom over live lecture even in a remote learning setting. However, there are components of the flipped classroom that may need to be adjusted. Specifically, the amount of pre-class materials may need to be reduced and the time allocated to highlight key points of the pre-class material during the class may need to be increased. In addition, increasing the time for breakout room sessions and, if logistically feasible, keeping the same small groups throughout the course may be considered to improve effectiveness in learning. 2) Students' past experience with flipped classroom predicts the likelihood of students' preference of remote flipped classroom over live lecture. Also, students' past experience with flipped classroom method was positively associated with academic performance (i.e., average percentage scores on the therapeutics questions on both summative assessments). 3) The student cohort with a remote flipped classroom had lower academic performance than the cohort with an in-person flipped classroom even though both cohorts were provided with the almost identical content and flipped classroom format. To the authors

knowledge, this is the first study reporting students' perceptions of a remote flipped classroom as well as its effect on students' academic performance compared with an in-person flipped classroom in didactic pharmacy education.

In this study, the amount of pre-class lecture videos was identified as one of the components of flipped classroom that may need to be adjusted even though the average duration of pre-class videos per class hour was 18 minutes. In addition, the average duration of a pre-class video module was approximately 17 minutes, consistent with the best practice for developing pre-class videos for flipped classroom (Persky & McLaughlin, 2017; Garcia-Vedrenne *et al*., 2020). Also, the average total length of pre-class videos – 35 minutes – was similar to that of a published remote flipped classroom model utilised in an analytical chemistry course where the total duration of pre-class videos was up to 75 minutes per week (Heiss & Oxley, 2021). Moreover, the authors own pre-class lecture videos have been successfully used in the last two iterations of the course. Despite this, students seemed to feel that the length of pre-class lecture videos should be shortened in this study. This may be due to so called 'Zoom fatigue' (Wiederhold *et al*., 2020; Chawla *et al*., 2021). Since all of the courses were delivered online, students had to watch a computer screen for six to eight hours a day, causing them to feel tired of prolonged screen-viewing. When pre-class materials are additionally delivered online, this will prolong the time they are required to watch a computer screen, exacerbating 'Zoom fatigue'. This fatigue may have decreased efficiency in learning because students seemed to want to extend the time to review pre-class materials by the instructor in the first part of this flipped classroom model. These findings suggest that when all of the courses are delivered online, pre-class materials may need to be delivered in a different format such as books, and/or the total length of pre-class lecture videos may need to be shortened (e.g. less than 20-30 minutes). In addition, it should be considered to extend the in-class review time for pre-class materials to help students be ready for case discussion.

Considering the setup of Zoom breakout rooms, the authors reduced the number of guiding questions related to the patient case discussion, added one to two additional instructors per session, and had instructors circulate breakout rooms. However, these adjustments did not seem to be sufficient; less than half of the respondents reported effectiveness in learning, the adequacy of the time allocated for breakout room sessions, and the accessibility to the instructor(s) during breakout sessions. One major limitation of the Zoom

breakout room feature is that students cannot easily ask instructors for help with questions once partitioned off, and instructors may find it difficult to efficiently circulate between the breakout rooms. Even though students could indicate that they had a question during breakout room sessions by accessing the Smartsheet the authors had created, they rarely used the Smartsheet, possibly because they had to take additional steps to access to it instead of simply raising a hand. The success of small group sessions in flipped classroom largely depends on how well students come prepared (Han *et al*., 2019). If students did not fully understand materials of pre-class lecture videos due to Zoom fatigue, they may need more time to look up pre-class materials to answer guiding questions and may not contribute to the learning of their group members during breakout sessions. Therefore, educators should consider reducing the amount of pre-class materials and extending the time to review pre-class materials before breakout room sessions in a remote learning setting. In addition, it may be helpful to recruit additional instructors to circulate and facilitate breakout rooms. If recruiting additional instructors is not feasible, reducing the number of breakout rooms may be considered. Also, if feasible, keeping the same small group throughout all flipped classroom sessions may increase students' engagement and learning. Finally, a team-based learning approach may be utilised because it has been shown to increase students' engagement in a remote flipped classroom model (Cross, Robinson & Todd, 2020).

It is interesting to note that past experience with a flipped classroom model, instead of preference for remote flipped classroom over live lecture, was associated with students' academic performance. In this study, approximately 40% of the respondents reported that they had no experience with flipped classroom. Students who had been exposed to a flipped classroom previously may have known how to approach this type of learning experience regardless of whether or not they liked a flipped classroom. Given that the Cardiovascular Sciences & Therapeutics course was the second course in the entire Doctor of Pharmacy programme, past experience with flipped classroom may have helped students adjust their study approaches more quickly. These findings suggest that it is important to provide students with detailed guidance on study approaches in courses utilising a flipped classroom during the orientation to the programme and/or course.

Previous studies have reported conflicting results on students' academic performance before and during the COVID19 pandemic (Kim *et al*., 2020; Foo, Cheung, & Chu, 2021; Jaap *et al*., 2021; Prigoff, Hunter, & Nowygrod, 2021; Seifert *et al*., 2021). In studies conducted in the United

States of America and the United Kingdom, mean scores of medical students on an applied knowledge test and clinical skills exam were comparable before and during the COVID19 pandemic (Jaap *et al*., 2021; Prigoff, Hunter, & Nowygrod, 2021). In contrast, medical students' mean scores on didactic course exams, problem-based learning exams, and comparative self-assessments were significantly reduced during the COVID19 pandemic (Kim *et al*., 2020; Foo, Cheung, & Chu, 2021; Seifert *et al*., 2021). In this study, Cohort 2020, who received only online instructions, showed inferior academic performance compared with Cohort 2019 who received in-person instructions, despite no major changes to the course content and instructors. Although the gap in the level of academic performance became narrower on summative Assessment 2, it persisted even after Cohort 2020 received additional support such as extra practice cases as well as optional classes with the course director. Although the student populations evaluated between this study and previous studies are different, it remains concerning that remote learning due to the COVID19 pandemic may negatively affect pharmacy students' academic performance. In a remote learning setting, students may need to be provided with additional academic supports such as tutoring and more frequent office hours.

There are some limitations to this study. First, students may not have received sufficient support during breakout room sessions because the number of instructors, including teaching assistants per in-class session (i.e., two to three), may be too small compared with the number of breakout rooms. Given the limited resources available, however, it was almost impractical to have more than three instructors for a session. Second, the number of therapeutics questions on summative assessments, particularly the first assessment, was small. Even if the number was relatively small, the authors were able to observe a significant difference in the mean percentage score. Third, the authors utilised a historical control to compare academic performance between remote and in-person flipped classrooms due to feasibility issues. Finally, the authors did not survey Cohort 2019 about their perceptions of the flipped classroom model and cannot exclude a possibility that these findings may apply to both in-person and remote flipped classrooms.

Conclusion

Remote flipped classroom was generally preferred over remote live lecture by students. Given that all of the courses are delivered remotely, however, pharmacy educators should consider making adjustments to reduce screen-viewing time and to increase student interactions during virtual small group sessions when implementing a remote flipped classroom. Since past experience with flipped classroom was associated with increased academic performance and remote learning may result in decreased academic performance, pharmacy educators should also consider providing students with detailed guidance on study approaches for a flipped classroom as well as additional academic support such as tutors.

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Conflict of Interest

The authors declare no conflict of interest.

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