

Content delivery models influence class preparation, study habits, and preferences

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Abstract

Objective: To examine the change in reported levels of class preparation, preferences, study habits and to assess correlation between these and changes in examination scores as students progressed through a course series with different content delivery methods.

Methods: The authors surveyed students regarding pre-class preparation, participation in in-class activities, preferences for class activities, and study habits. Spearman's coefficient was used to assess a correlation between survey variables and examinations scores.

Results: Ninety-two students completed all surveys (response rate: 80.7%). The proportion of students reporting pre-class preparation and in-class participation was significantly higher in courses employing a flipped classroom model. About 90% indicated that the content delivery in the flipped model had a positive influence on their study habits. The level of class preparation and participation was not significantly correlated with a change in examination scores.

Conclusions: Content delivery models may be associated with reported level of preparation, study habits, and preferences.

Keywords: *Flipped Classroom, Pharmacy Education, Lectures*

Introduction

In pharmacy education, one-way lectures have been the primary content delivery model for large group instruction (Islam, Khan & Talukder, 2016). This approach is an efficient way to provide factual information to a large number of students in a short amount of time but it allows only minimal opportunity to engage during the class. Because engagement via active learning approaches has been demonstrated to increase student performance in science topics, methods such as the "flipped classroom" approach have been introduced (Freeman *et al.*, 2014). The flipped classroom method is defined as "the delivery of core content to students independently before class, often using electronic technology, with class time devoted to applying the core content in facilitated group discussions" (Prober & Khan, 2013). This approach is seeing increasing use in pharmacy education and is preferred over the traditional lecture model by students in several studies (Pierce & Fox, 2012; McLaughlin *et al.*, 2014; Wong *et al.*, 2014; Khanova *et al.*, 2015a; 2015b; Armour, Schneid & Brandl, 2016; Koo *et al.*, 2016; Rotellar & Cain, 2016; White *et al.*, *in press*).

In both the traditional and flipped models, pre-class preparation is important for maximising learning during the class. In traditional lecture, pre-class expectations typically include required readings. In addition to these, the flipped classroom model often requires students to

review pre-recorded materials prior to class. To ensure that students complete the pre-class assignments, both models can use assessments such as online quizzes to help the student gauge readiness. Of note, the success of the flipped classroom model depends, to an even larger extent, on student completion of the pre-class preparation activities, because the in-class activities are designed specifically to build on, but not repeat, the preparatory work (Tolks *et al.*, 2016).

Despite this importance, not all students complete pre-class assignments even in the flipped classroom model. In a study of dental students, mean response to queries about whether students had read the required readings were uniformly low and not statistically significantly different between traditional and flipped models (Bohaty *et al.*, 2016). Still, the content delivery model may influence not only preparation but also other study habits such as the timing of study and the formation of groups for study.

Within pharmacy curricula, variability in content delivery can mean that not all courses use the same instructional model. In this case, the sequencing of the models and the persistence of what students learn from specific models could be important because it may also influence their class preparation, preferences, and study habits. Understanding such changes after the introduction of a flipped delivery model may help provide students with guidance for successful completion of a course. To date,

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however, few studies have examined how traditional lecture versus flipped classroom model impacts the development and persistence of specific study habits.

The Doctor of Pharmacy curriculum at the University of California, San Francisco (UCSF) offers a required Therapeutics series consisting of four courses spanning years two and three of the programme. Although these courses share educational goals differentiated only by therapeutic area, they differ substantially in their content delivery models. Therapeutics I uses mostly traditional lecture with a few classes with a flipped model, Therapeutics II uses a flipped classroom model for the entire course, Therapeutics III uses the traditional lecture model, and about two-thirds of Therapeutics IV (not included in these analyses) uses a flipped model. We hypothesised that these changes in the content delivery model may influence student preparation, study habits, preferences, and performance as they progress through the series. Therefore, the objectives of this study are 1) to examine the change in reported levels of class preparation, preferences, and study habits from Therapeutics I through Therapeutics III by surveying a cohort of students and 2) to assess a correlation and an association between these variables and examination score changes in Therapeutics courses.

Methods

This prospective study was determined to be exempted from full review by the UCSF Institutional Review Board.

Description of the courses

Therapeutics I

Therapeutics I, a four-unit course, covers treatment and management of diseases related to the endocrine system, lungs, liver, and kidneys. It consists of four hours of large group instruction and one and a half hours of small group instruction each week. Of the nine large group instruction sessions, seven are traditional lectures and two flipped classroom. Prior to each flipped classroom session, students are instructed to watch pre-recorded lectures developed using Articulate® software. Before all classes, at least one required reading is assigned for class preparation. Although there are five graded quizzes throughout the course, these are designed as post-session assessments, covering student knowledge of topics as discussed during class. The focus of in-class activities is application and problem-solving, although the format is not consistent and students do not work consistently in specific groups.

Therapeutics II

Therapeutics II, a six-unit course, covers treatment and management of common cardiovascular diseases such as hypertension, coronary artery disease, heart failure, and

atrial fibrillation. It consists of four - five hours of large group instruction and two hours of small group instruction per week. The large group instruction follows a standard format consistently across the course. Prior to each large group session, students are instructed to watch pre-recorded lectures developed using Articulate® software and to complete one - two required readings. In addition, students are assigned to complete an online graded quiz with ten multiple choice questions. The in-class large group instruction always consists of two parts - lecture summary and patient case discussion. During the lecture summary, which runs about 20 minutes, the instructor reinforces key concepts in the pre-recorded lecture, answers questions regarding the lecture, and reviews quiz questions. The patient case discussion focuses on application and problem-solving. The cases contain five - ten guiding questions designed to help students address the cases. In class, students work on these questions within assigned small groups. The instructor invites students randomly to provide their group responses, clarifies misunderstandings, and resolves any issues.

Therapeutics III

Therapeutics III, a six unit-course, covers primarily the treatment and management of psychiatric disorders such as depression, bipolar disorder, and schizophrenia. It consists of six hours of large group and one and a half hours of small group instruction each week.

The format of all of the large group instruction sessions is traditional lecture supported by PowerPoint® slides. Students are assigned one - three required readings prior to each class. There are seven weekly online graded quizzes, each of which consists of five multiple choice questions, to assess class preparation.

Table I: Comparison of Therapeutics courses.

| Item | Therapeutics I | Therapeutics II | Therapeutics III |
|--------------------------------|-----------------|--|------------------|
| Class format | Mixed | Flipped | Lecture |
| Pre-recorded lecture | Narrated slides | Narrated slides | Not applicable |
| Pre-class assessment | No | Yes (before each class) | Yes (weekly) |
| Structure of flipped class | Unstructured | Structured: 1- lecture summary and quiz review 2- patient discussion | Not applicable |
| Number of written examinations | 2 | 2 | 2 |

Survey

We surveyed students three times: after the end of Therapeutics I, II and III. We emailed students an invitation for participating in the online surveys which were deployed via the Qualtrics™ client. Each survey contained six identical items scored using a five-level scale (Appendix A). These were designed to assess the frequency of pre-class preparation, participation in in-class activities, and preference for class activities focusing on application and problem-solving. The second and third surveys contained three additional items - 1) what changes in study habits the flipped classroom model of Therapeutics II may have influenced; 2) whether the changes in the study habits were maintained in Therapeutics III; and 3) how likely pre-class preparation would be completed without a graded quiz. The surveys were open for 7-36 days depending on the gap between the courses. Students were reminded to complete the survey up to five times. The surveys were not anonymous; however, students were assured that the responses would be de-identified before access by the principal investigator.

Examination scores and grades

Each course had both written midterm and final examinations. These examinations had a total of 100 points and scores were scaled based on performance. We calculated the sum of scores of the written midterm and final examinations in each course. We calculated the difference of the sum of the examination scores between Therapeutics I and II as well as between Therapeutics III and II.

Statistical analysis

We used descriptive statistics to determine frequency distribution, percentage distributions, means and standard deviations, and inclusive ranges as evidenced by the data. To compare the frequency of class preparation, level of participation in class activities, and preference for class activities focusing on application and problem-solving, we used the McNemar's test. We considered students' responses to survey items on the percent of time to complete required reading and the percent of time to review in-class activities before class as indicators of the level of class preparation. In each item, we assigned a value of 1 to < 10%, 2 to 10-40%, 3 to 40-60%, 4 to 60-90% and 5 to >90%. We summed each student's responses to these items in each course. We treated the difference between the courses as the change in the level of class preparation. Since Therapeutics III did not have pre-recorded lectures, we did not include this item when calculating the difference in the level of class preparation between Therapeutics III and II.

We also evaluated students' level of participation with the examination score change by using Spearman's correlation coefficient. For this evaluation, we assigned a value of 1 to < 10%, 2 to 10-40%, 3 to 40-60%, 4 to 60-90% and 5 to >90% for student's responses to the survey item on the percent of time they participated and engaged in discussion during class.

In addition, we used a mixed effect linear regression analysis to model the examination score as the dependent variable, with the percent of time to complete required reading, the percent of time to review in-class activities before class, the reported level of class participation, and therapeutics courses as independent variables, accounting for within-subject variability. We treated all of the independent variables as fixed variables and the intercept as a random variable. In this analysis, we used the Akaike information criterion to select a model fit the data best. We did not include the percent of time to complete the pre-recorded lecture in the model because Therapeutics III did not have a pre-recorded lecture.

Finally, we compared mean Therapeutics III examination score between those who responded to positive, negative and no influence by using the Kruskal-Wallis test. Since Therapeutics II had only 2 students who responded as no influence, we collapsed those responding as no and negative influence, and compared mean Therapeutics II examination score between those who had positive influence and who did not by using the Wilcoxon rank sum test.

We used SAS 9.3 (SAS Institute, Cary, NC, USA) and considered a *p*-value <0.05 as statistically significant.

Results

Survey responses

A total of 119 students were enrolled across the three courses. Of the 113 students who agreed to participate in the study, 102 completed the first survey (90.3%), 101 the second survey (89.4%), and 105 the third survey (92.9%). Ninety-two students completed all three surveys (80.7%).

Table II shows the changes of study habit and preference over time. There was a statistically significantly higher percentage of students who reported to have completed required readings prior to class and participating and engaging in discussion during class in Therapeutics II as compared with Therapeutics I. However, these percentages were significantly decreased in Therapeutics III compared with Therapeutics II. In addition, the percentage of students who worked with a study group to prepare for a class was significantly lower in Therapeutics III than in Therapeutics II. Neither item was statistically significantly different between Therapeutics III and I.

The percentage of students who reported preferring in-class activities focusing on application and problem-solving over lectures was statistically higher in Therapeutics II than in Therapeutics I. However, it was not significantly different between Therapeutics II and III.

Since both Therapeutics I and II had pre-recorded lectures, students were surveyed on whether they watched assigned pre-recorded lectures prior to class (Table II). The percent of students who completed this assignment was significantly higher in Therapeutics II than in Therapeutics I.

Table II: Changes in the class preparation and preference over time

| Item | Therapeutics I (n=102) | Therapeutics II (n=101) | Therapeutics III (n=105) | p-value | | |
|---|---------------------------|----------------------------|-----------------------------|----------|------------|-----------|
| | | | | I vs. II | II vs. III | I vs. III |
| <i>Percentage of the required readings completed before class</i> | | | | <0.0001 | 0.0012 | 0.059 |
| < 10% | 40 (39.2) | 14 (13.9) | 34 (32.4) | | | |
| 10-40% | 38 (37.3) | 17 (16.8) | 29 (27.6) | | | |
| 40-60% | 11 (10.8) | 27 (26.7) | 15 (14.3) | | | |
| 60-90% | 10 (9.8) | 23 (22.7) | 18 (17.1) | | | |
| >90% | 3 (2.9) | 20 (19.8) | 9 (8.6) | | | |
| <i>Percentage of pre-recorded lectures watched prior to class*</i> | | | | 0.02 | | |
| < 10% | 4 (3.9) | 1 (1.0) | | | | |
| 10-40% | 7 (6.9) | 0 (0) | | | | |
| 40-60% | 9 (8.8) | 1 (1.0) | | | | |
| 60-90% | 21 (20.6) | 14 (13.8) | | | | |
| >90% | 61 (59.8) | 85 (84.2) | | | | |
| <i>Percentage of the in-class activities reviewed before class</i> | | | | 0.053 | 0.098 | 0.47 |
| < 10% | 29 (28.4) | 17 (16.8) | 31 (29.5) | | | |
| 10-40% | 27 (26.5) | 26 (25.7) | 21 (20.0) | | | |
| 40-60% | 13 (12.8) | 15 (14.9) | 20 (19.0) | | | |
| 60-90% | 17 (16.7) | 18 (17.8) | 21 (20.0) | | | |
| >90% | 16 (15.7) | 25 (24.8) | 12 (11.4) | | | |
| <i>Percentage of time working with group to prepare for a class†</i> | | | | 0.12 | 0.0015 | 0.39 |
| < 10% | 35 (34.3) | 17 (16.8) | 38 (36.2) | | | |
| 10-40% | 29 (28.4) | 31 (30.7) | 28 (26.7) | | | |
| 40-60% | 25 (24.5) | 30 (29.7) | 26 (24.8) | | | |
| 60-90% | 10 (9.8) | 12 (11.9) | 8 (7.6) | | | |
| >90% | 3 (2.9) | 11 (10.9) | 5 (4.8) | | | |
| <i>Without a graded quiz, percentage of the time to study pre-recorded lectures and required readings before each class</i> | | | | | 0.0005 | |
| < 10% | | 14 (13.9) | 46 (43.8) | | | |
| 10-40% | | 20 (19.8) | 27 (25.7) | | | |
| 40-60% | | 24 (23.8) | 15 (14.3) | | | |
| 60-90% | | 20 (19.8) | 5 (5.7) | | | |
| >90% | | 23 (22.8) | 11 (10.5) | | | |
| <i>Percentage of the time to participating and engaging in discussion during class</i> | | | | <0.0001 | 0.0002 | 0.38 |
| < 10% | 21 (20.6) | 3 (3.0) | 25 (23.8) | | | |
| 10-40% | 26 (25.5) | 14 (13.9) | 21 (20.0) | | | |
| 40-60% | 20 (19.6) | 12 (12.9) | 23 (21.9) | | | |
| 60-90% | 26 (25.5) | 33 (32.7) | 20 (19.0) | | | |
| >90% | 9 (8.8) | 38 (37.6) | 16 (15.2) | | | |
| <i>During class, I prefer activities focusing on application and problem-solving over lectures</i> | | | | 0.0011 | 0.65 | 0.0002 |
| Strongly disagree | 4 (3.9) | 1 (1.0) | 3 (2.9) | | | |
| Disagree | 11 (10.8) | 4 (4.0) | 5 (4.8) | | | |
| Neutral | 36 (35.3) | 19 (18.8) | 23 (21.9) | | | |
| Agree | 37 (36.3) | 37 (36.6) | 28 (26.7) | | | |
| Strongly agree | 14 (13.7) | 40 (39.6) | 46 (43.8) | | | |

Data are expressed as number (%). I vs. II: n = 93; II vs. III: n = 95; I vs. III: n = 99

*: Therapeutics III did not have a pre-recorded lecture. n = 95.

†: Therapeutics I did not have a weekly quiz. n = 95

Both Therapeutics II and III had quizzes assessing students' preparation for a class. After Therapeutics III, the percentage of students who responded that they would have completed the pre-class assignments without a graded quiz was significantly reduced compared with after Therapeutics II (Table II).

Table III shows changes in student study habits over time. Of the changes in study habits during Therapeutics II, studying learning materials before each class and keeping on top of learning materials were reported most frequently. About 90% of students felt that the content delivery format in Therapeutics II had made a positive influence on their study habits. During Therapeutics III, about 25% of students maintained study habits that they had established previously. Although studying learning materials before each class was the top change, about 20% of students responded that they did not study until a few days before the examination. In addition, about half of the students felt that the content delivery format negatively influenced their study habits.

Table III: Influence of a flipped classroom model on study habits.

| Item | Therapeutics II (n=101) | Therapeutics III (n=105) | p-value |
|--|----------------------------|-----------------------------|---------|
| Changes to your study habits the content delivery format made | | | |
| No change at all | 1 | 25 | |
| Form a study group | 2 | 13 | |
| Study learning materials before each class | 46 | 24 | |
| Review in-class activities before each class | 2 | 8 | |
| Keep me on top of learning materials/Did not study a few days before the examination | 42 | 20 | |
| Other | 8 | 14 | |
| Influence of the content delivery format on study habits | | | <0.0001 |
| No influence | 9 (9.0) | 25 (23.8) | |
| Positive influence | 90 (89.1) | 31 (29.5) | |
| Negative influence | 2 (2.0) | 49 (46.7) | |

Correlation and association of level of class preparation and participation with the examination score change

The mean examination scores in Therapeutics I, II, and III were 80.0 (± 8.7), 83.0 (± 8.6), and 84.9 (± 7.3), respectively. The level of class preparation was not significantly correlated with the exam score change between Therapeutics II and I or between Therapeutics III and II ($p=0.70$ and 0.85 , respectively). In addition, there was no significant correlation of the level of class participation with the grade change between Therapeutics

II and I as well as between Therapeutics III and II ($p=0.39$ and 0.11 , respectively). In the mixed effect linear regression analysis, only the therapeutics course was statistically significantly associated with the examination score (parameter estimate: 2.47; $p<0.0001$); the other variables indicating levels of class preparation and participation were not statistically significant.

The median scores of Therapeutics II examination scores in students with positive influence and those with no or negative influence were 84.7 (range: 56.0-97.8) and 75.3 (range: 68.0-94.0) and this difference was not statistically significantly different ($p=0.36$). The median scores of Therapeutics III were 84.2 (range: 70.4-100.0), 84.2 (range: 74.6-97.0), and 86.1 (range: 66.7-97.5) in students with positive, no, and negative influence, respectively. There was no statistically significant difference in the median score between the groups ($p=0.75$).

Discussion

In this study, the authors found that the content delivery model was associated with reported levels of class preparation and preference as well as with study habits in the Therapeutics course series. When Therapeutics II, with a structured flipped classroom model for the entire course, was compared with Therapeutics I, with mostly traditional lectures, a significantly larger proportion of students reported completing required readings and pre-recorded lectures prior to class. When Therapeutics III, with traditional lectures, was compared with Therapeutics II, the proportion of students who reported completion of required readings prior to class was significantly decreased. In addition, the proportion of students reporting preparation for a class with a study group was significantly reduced.

In response to the structured flipped classroom model in Therapeutics II, almost all of the students made changes to their study habits. The two most common changes were studying learning materials before each class and keeping on top of learning materials. These findings are in line with a previous study reporting that successful students in a flipped classroom model viewed online learning materials in a timely manner (Gross *et al.*, 2015). In this study, about 90% of students felt that the flipped classroom model made a positive influence on their study habits. In contrast, only about 30% of students felt that the traditional delivery model in Therapeutics III made a positive influence. Instead, more than 45% of students felt it made a negative influence on their study habits. Although about 25% maintained study habits they had in Therapeutics II, the majority made changes to their study habits in Therapeutics III with studying learning materials before each class being the most common change. Interestingly, 20 students responded that they did not study until a few days before the examination, suggesting some students may not keep on top of learning materials in the traditional lecture model. Overall, these data suggest that the majority of students

adjust their study habits according to the content delivery model of the course. This is an interesting finding given that the vast majority of students in this Pharm.D. programme have at least four years of undergraduate experience, which could have shaped students' study habits. The main influence of a structured flipped classroom model on study habits may be studying learning materials before each class and keeping students on top of learning materials. Since these changes were overwhelmingly received as positive by students, these data may be used to support the implementation of a flipped classroom model when students and/or faculty are skeptical or even resistant to this change.

In this study, the proportion of students who responded that they would study required readings and pre-recorded lecture without a graded quiz was significantly decreased in Therapeutics III compared with Therapeutics II. These data may suggest that the content delivery model may influence students' motivation for class preparation. Although these findings are in contrast to a previous report suggesting that, even in flipped classroom, students may complete pre-class assignments due to pre-class assessments, others have indicated that the flipped classroom may make students feel more responsible for their own learning as compared with the traditional lecture model (Koo *et al.*, 2016; Green & Schlairet, 2017). Since the structured flipped classroom model requires students to engage in activities during class, students may feel greater need to be prepared for these activities as to avoid embarrassment. This contrasts with the traditional delivery model where students may not possess this level of motivation since they passively receive information from the lecturer for the majority of the class time. Because the traditional delivery model may not stimulate motivation for study as much as the flipped classroom model, a graded quiz may become more important as a way to enforce completion of pre-class assignments. These data suggest that educators should consider a graded pre-class assessments if they rely on the traditional content delivery model.

The authors also found that the content delivery model was associated with reported level of participation in class activities. Compared with Therapeutics I, the percent of students who reported participating and engaging in in-class discussion was significantly increased in Therapeutics II. In Therapeutics III, however, the percent was decreased to a level that was not significantly different from that of Therapeutics I. In contrast to Therapeutics I and III, students were given time to solve problems with their small group in class in Therapeutics II and this in-class structure seemed to increase the reported level of class participation. These findings are consistent with previous studies reporting that flipped classroom enhances engagement and participation during class (Gilboy, Heinerichs & Pazzaglia, 2015; Park & Howell, 2015). Compared with Therapeutics I, the proportion of students who reported preferring activities focusing on application and problem-solving over lecture was significantly increased in Therapeutics II. Interestingly, this changed was

maintained in Therapeutics III even though the course used the traditional lecture model. These data suggest that the influence of a structured flipped classroom model on students' preference for class activities focusing on application and problem-solving over lecture may persist even after the course format changes. These data also suggest that when designing a curriculum, educators should include in-class activities focusing on application and problem-solving even in a course with the traditional lecture model, particularly, if the course is offered after a course with a structured flipped classroom model.

In this study, the authors did not find a significant correlation or association of the change in the level of class preparation and preference with the change in written examination grades. There may be multiple explanations for this finding. First, regardless of class preparation and preparation, students may have prepared well for written examinations in order to achieve a good academic grade. Second, as students progressed through the Therapeutics course series, they may have become more proficient in resolving therapeutic problems. Indeed, the mean examination scores increased from 80.0 in Therapeutics I to 84.9 in Therapeutics III in our study. Also, with these high median scores, it may not be feasible to observe an effect of any intervention. Third, since the testing content, format of written examinations, and level of difficulty differed by each course, it may be more difficult to detect an association. Given the difference in the in-class focus between flipped classroom and traditional lecture (*i.e.*, problem-solving vs. providing information), the focus of the assessment on the examination may differ. This change in the assessment focus on the examination may make it difficult to compare examination score between the courses with different content delivery models (White *et al.*, 2016).

There are several methodological limitations in this study. First, including a concurrent control group was impractical in the study. Second, the three surveys did not have a completely identical questionnaire due to the difference in the course structure, precluding evaluating changes in the response to a certain item over time. Thirdly, although the authors used a time-series design (*i.e.*, traditional lecture model as repetitive exposure), the authors may not have been able to fully control the effect of maturation on the results. Finally, the authors did not include the Therapeutics IV course in the study because there was a different study of flipped classroom methodologies planned for that course.

In conclusion, the results show that the content delivery model used within a course is associated with reported level of preparation, study habits, and preferences. Further, the structured flipped classroom model appears to enhance class preparation and have a positive influence on study habits overall. Some, but not all, of these positive behaviours may persist even if the model in subsequent courses is traditional lecture. This suggests within a curriculum, educators should prioritise early exposure to engaging teaching methods. For educators

teaching with more traditional methods; however, strategies such as graded pre-class assessments and in-class activities focusing on application and problem-solving may be helpful in achieving similar goals.

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References

- Armour, C., Schneid, S.D. & Brandl, K. (2016). Writing on the board as students' preferred teaching modality in a physiology course. *Advances in Physiology Education*, **40**(2), 229-233.
- Bohaty, B.S., Redford, G.J. & Gadbury-Amyot, C.C. (2016). Flipping the Classroom: Assessment of Strategies to Promote Student-Centered, Self-Directed Learning in a Dental School Course in Pediatric Dentistry. *Journal of Dental Education*, **80**(11), 1319-1327.
- Freeman, S., Eddy, S.L., McDonough, M., Smith, M.K., Okoroafor, N., Jordt, H. & Wenderoth, M.P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences of the United States of America*, **111**(23), 8410-8415.
- Green, R.D. & Schlairet, M.C. (2017). Moving toward heutagogical learning: Illuminating undergraduate nursing students' experiences in a flipped classroom. *Nurse Education Today*, **49**, 122-128.
- Gilboy, M.B., Heinerichs, S. & Pazzaglia, G. (2015). Enhancing student engagement using the flipped classroom. *Journal of Nutrition Education and Behavior*, **47**(1), 109-114.
- Gross, D., Pietri, E.S., Anderson, G., Moyano-Camihort, K. & Graham, M.J. (2015). Increased Preclass Preparation Underlies Student Outcome Improvement in the Flipped Classroom. *CBE life Science Education*, **14**(4), ar36.
- Islam, M.A., Khan, S.A. & Talukder, R.M. (2016). Status of physiology education in US Doctor of Pharmacy programs. *Advances in Physiology Education*, **40**(4), 501-508.
- Khanova, J., McLaughlin, J.E., Rhoney, D.H., Roth, M.T. & Harris, S. (2015a). Student Perceptions of a Flipped Pharmacotherapy Course. *American Journal of Pharmaceutical Education*, **79**, 140.
- Khanova, J., Roth, M.T., Rodgers, J.E. & McLaughlin, J.E. (2015b). Student experiences across multiple flipped courses in a single curriculum. *Medical Education*, **49**(10), 1038-1048.
- Koo, C.L., Demps, E.L., Farris, C., Bowman, J.D., Panahi, L. & Boyle, P. (2016). Impact of Flipped Classroom Design on Student Performance and Perceptions in a Pharmacotherapy Course. *American Journal of Pharmaceutical Education*, **80**(2), 33.
- McLaughlin, J.E., Roth, M.T., Glatt, D.M., Gharkholonarehe, N., Davidson, C.A., Griffin, L.M., Esserman, D.A. & Mumper, R.J. (2014). The flipped classroom: a course redesign to foster learning and engagement in a health professions school. *Academic Medicine*, **89**(2), 236-243.
- Park, S.E. & Howell, T.H. (2015). Implementation of a flipped classroom educational model in a predoctoral dental course. *Journal of Dental Education*, **79**(5), 563-570.
- Pierce, R. & Fox J. (2012). Vodcasts and active-learning exercises in a "flipped classroom" model of a renal pharmacotherapy module. *American Journal of Pharmaceutical Education*, **76**(9), 196.
- Prober, C.G. & Khan, S. (2013). Medical education reimaged: a call to action. *Academic Medicine*, **88**(10), 1407-1410.
- Rotellar, C. & Cain, J. (2016). Research, Perspectives, and Recommendations on Implementing the Flipped Classroom. *American Journal of Pharmaceutical Education*, **80**(2), 34.
- Tolks, D., Schafer, C., Raupach, T., Kruse, L., Sarikas, A., Gerhardt-Szep, S., Kllauer, G., Lemos, M., Fischer, M.R., Eichner, B., Sostmann, K. & Hege, I. (2016). An Introduction to the Inverted/Flipped Classroom Model in Education and Advanced Training in Medicine and in the Healthcare Professions. *GMS Journal of Medical Education*, **33**(3), Doc46.
- White, P.J., Larson, I., Styles, K., Yuriev, E., Evans, D.R., Rangachari, P.K., Short, J.L., Exintaris, B., Malone, D.T., Davie, B., Eise, N., McNamara, K. & Naidu, S. (2016). Adopting an active learning approach to teaching in a research-intensive higher education context transformed staff teaching attitudes and behaviours. *Higher Education Research and Development*, **35**(3), 619-633.
- White, P.J., Naidu, S., Yuriev, E., Short, J.L., McLaughlin, J.E. & Larson, I.C. (in press). Student engagement with a flipped classroom teaching design affects pharmacology examination performance in a manner dependent on question type. *American Journal of Pharmaceutical Education*.
- Wong, T.H., Ip, E.J., Lopes, I. & Rajagopalan, V. (2014). Pharmacy students' performance and perceptions in a flipped teaching pilot on cardiac arrhythmias. *American Journal of Pharmaceutical Education*, **78**(10), 185.

Appendix A**Survey 1**

The following questions refer to your experience with the courses during the 2016 winter quarter.

1. In the last winter quarter, approximately what percent of the required readings did you complete prior to class?

- Less than 10% (1)
- 10-40% (2)
- 40-60% (3)
- 60-90% (4)
- Greater than 90% (5)

2. In the last winter quarter, approximately what percent of the assigned pre-recorded lectures did you watch prior to class?

- Less than 10% (1)
- 10-40% (2)
- 40-60% (3)
- 60-90% (4)
- Greater than 90% (5)

3. In the last winter quarter, approximately what percent of in-class activities (e.g., patient cases) did you review prior to class?

- Less than 10% (1)
- 10-40% (2)
- 40-60% (3)
- 60-90% (4)
- Greater than 90% (5)

4. In the last winter quarter, approximately what percent did you work with your study group to prepare for a class?

- Less than 10% of the time (1)
- 10-40% of the time (2)
- 40-60% of the time (3)
- 60-90% of the time (4)
- Greater than 90% of the time (5)

5. In the last winter quarter, approximately what percent did you participate and engage in discussion during class?

- Less than 10% of the time (1)
- 10-40% of the time (2)
- 40-60% of the time (3)
- 60-90% of the time (4)
- Greater than 90% of the time (5)

6. During class, I prefer activities focusing on application and problem-solving (e.g., patient case discussion) over lectures.

- Strongly disagree (1)
- Disagree (2)
- Not sure (3)
- Agree (4)
- Strongly agree (5)

Survey 2

The following questions refer to your experience with CP121 2016 Therapeutics.

1. Approximately what percent of the assigned required readings did you complete prior to class?

- Less than 10% (1)
- 10-40% (2)
- 40-60% (3)
- 60-90% (4)
- Greater than 90% of the time (5)

2. Approximately what percent of the assigned pre-recorded lectures did you watch prior to class?

- Less than 10% (1)
- 10-40% (2)
- 40-60% (3)
- 60-90% (4)
- Greater than 90% (5)

3. Approximately what percent of the in-class activities (e.g., patient case) did you review prior to class?

- Less than 10% (1)
- 10-40% (2)
- 40-60% (3)
- 60-90% (4)
- Greater than 90% (5)

4. Approximately what percent of the time did you work with your study group to prepare for a class?

- Less than 10% of the time (1)
- 10-40% of the time (2)
- 40-60% of the time (3)
- 60-90% of the time (4)
- Greater than 90% of the time (5)

5. Without a graded online quiz, how often would you have studied pre-recorded lectures and assigned required readings prior to class?

- Less than 10% of the time (1)
- 10-40% of the time (2)
- 40-60% of the time (3)
- 60-90% of the time (4)
- Greater than 90% of the time (5)

6. Approximately what percent of the time did you participate and engage in discussion during class?

- Less than 10% of the time (1)
- 10-40% of the time (2)
- 40-60% of the time (3)
- 60-90% of the time (4)
- Greater than 90% of the time (5)

7. During class, I prefer activities focusing on application and problem-solving (e.g., patient case discussion) over lectures.

- Strongly disagree (1)
- Disagree (2)
- Neutral (3)
- Agree (4)
- Strongly agree (5)

8. What changes did the flipped classroom model in CP121 make to your study habits? Check all that apply.

- No change at all. (1)
- It made me form a study group with my classmates. (2)
- It made me study learning materials (*i.e.*, readings, pre-recorded lecture) before each class. (3)
- It made me review in-class patient cases before each class. (4)
- It kept me on top of learning materials. (5)
- Other (please specify in the space below): (6) _____

9. How did the flipped classroom model in CP121 influence your study habits?

- It did not influence my study habits. (1)
- It influenced my study habits positively. (2)
- It influenced my study habits negatively. (3)

Survey 3

The following questions refer to your experience with CP130 2016 Therapeutics.

1. Approximately what percent of the assigned required readings did you complete prior to class?

- Less than 10% (1)
- 10-40% (2)
- 40-60% (3)
- 60-90% (4)
- Greater than 90% of the time (5)

2. Approximately what percent of the in-class activities (e.g., patient case) did you review prior to class?

- Less than 10% (1)
- 10-40% (2)
- 40-60% (3)
- 60-90% (4)
- Greater than 90% (5)

3. Approximately what percent of the time did you work with your study group to prepare for a class?

- Less than 10% of the time (1)
- 10-40% of the time (2)
- 40-60% of the time (3)
- 60-90% of the time (4)
- Greater than 90% of the time (5)

4. Without a graded online quiz, how often would you have studied pre-recorded lectures and assigned required readings prior to class?

- Less than 10% of the time (1)
- 10-40% of the time (2)
- 40-60% of the time (3)
- 60-90% of the time (4)
- Greater than 90% of the time (5)

5. Approximately what percent of the time did you participate and engage in discussion during class?

- Less than 10% of the time (1)
- 10-40% of the time (2)
- 40-60% of the time (3)
- 60-90% of the time (4)
- Greater than 90% of the time (5)

6. During class, I prefer activities focusing on application and problem-solving (e.g., patient case discussion) over lectures.

- Strongly disagree (1)
- Disagree (2)
- Neutral (3)
- Agree (4)
- Strongly agree (5)

7. Compared with your study habits for CP121 Therapeutics in Spring Quarter, what changes did you make to study for CP131 Therapeutics? Check all that apply.

- I made no change at all. (1)
- I formed a study group with my classmates. (2)
- I studied study learning materials (*i.e.*, readings) before each class. (3)
- I reviewed in-class patient cases before each class. (4)
- I did not study until a few days before the examination. (5)
- Other (please specify in the space below): (6) _____

8. How did the delivery of content model mainly as a lecture format in CP130 influence your study habits you had for CP121 in spring?

- It did not influence my study habits. (1)
- It influenced my study habits positively. (2)
- It influenced my study habits negatively. (3)