

## REVIEW

### Pre-Class Learning Methods for Flipped Classrooms

Emily Han, PharmD, Kristin C. Klein, PharmD

University of Michigan College of Pharmacy, Ann Arbor, Michigan

Submitted December 18, 2017; accepted August 1, 2018; published February 2019.

**Objective.** To review the types of pre-class learning modalities used in flipped classrooms (FC) and team-based learning (TBL) and determine best practices.

**Findings.** Forty-eight articles were included. Reading materials or video lectures were used most often as the primary modality to deliver the pre-class learning. Students favored assignments that have clear objectives, provide guidance, are guided, and are brief.

**Summary.** This study describes how pharmacy schools and colleges are implementing FC into their curricula and the types of pre-class learning that are being developed and assigned with the implementation. More research should be done in comparing the impact of different types of pre-class material on learning outcomes, such as knowledge retention. This is especially important in FC settings because the in-class learning and higher order activities are built upon having a good foundational knowledge, which comes from the pre-class learning.

**Keywords:** team-based learning, flipped classroom, pre-class, pre-work

## INTRODUCTION

Over the past two decades, there has been a major shift in the college classroom. The traditional, lecture-based pedagogy has evolved to a “flipped classroom” (FC) paradigm that shifts foundational learning from inside to outside of the classroom. Additionally, “team-based learning” (TBL) is a type of FC that adopts a small-group oriented, collaborative, and interactive learning approach.<sup>1</sup> In the traditional model, new concepts are introduced to the students during class by an instructor-led lecture. Then, students are assigned homework outside of the classroom to apply the newly acquired material. In FC, students are held accountable for their own learning through completion of a pre-class learning assignment that covers the lower levels of cognition, according to Bloom’s revised taxonomy (recall of facts and basic concepts).<sup>2</sup> Instead of the classroom serving as the first time when students are introduced to a topic, classroom time in FC allows for higher order cognition (application, analysis, evaluation, and creation). With this approach, what was once thought of as homework is moved into classroom time. This allows the classroom to serve as an active learning environment where students can work through more complex cases with the added benefit of learning from peers and receiving direct guid-

ance from instructors. The growth of this new pedagogical approach is multifactorial. Whether it was the need to keep this generation of learners better engaged or feedback from employers wanting college graduates to have human interaction and problem-solving skills, a lot of data has emerged on the adoption of FC not only in undergraduate courses but also in graduate and professional education. There are a variety of different approaches to implementing an FC, however the application of TBL as outlined by Michaelsen and colleagues is commonly referenced and modeled, especially within the health sciences.<sup>1</sup> The sequence of activities for TBL follows the general pattern of FC, beginning with pre-class preparation by the student. Then, the in-class portion begins with a readiness assessment based on the pre-class assignment. Once the initial assessment is complete, students work in groups on problems ranging in complexity, followed by a review of key points, and a final graded problem to solve. In this model, knowledge acquisition occurs outside of the classroom before the scheduled class session and the learning assessments are moved into the classroom time.

Studies have shown that FC improved student performance on assessment scores, in addition to receiving positive student and faculty feedback.<sup>3-5</sup> Reviews have been published highlighting best practices for implementing FC and TBL.<sup>3-5</sup> However, there is a gap of knowledge regarding the specific types of pre-class assignment modalities and whether they influence student performance and perceptions of the FC approach. FC relies heavily on pre-class learning material to deliver the foundational

---

**Corresponding Author:** Kristin C. Klein, University of Michigan College of Pharmacy, 428 Church St., Ann Arbor, MI 48109. Tel: 734-936-6945. E-mail: kriklein@med.umich.edu

knowledge for students. Therefore, the goal of this review is to explore what pre-work modalities have been used in various implementations of FC and whether there is an impact observed on student learning based on the different platforms.

## METHODS

A review exploring the literature on the pre-class learning materials assigned in FC and TBL courses was conducted. To identify studies that were relevant to this review, the authors first defined FC and TBL to include the assignment of preparatory work before class and active learning in the classroom to build upon foundational knowledge. The authors searched PubMed and EMBASE databases in October 2017 for articles meeting the following inclusion criteria: the article detailed the pre-work modality assigned; the article presented data evaluating the FC or TBL approach, whether it was on learning outcomes and/or student perceptions; and full texts of the articles were accessible. The abstracts of all articles derived from initial searches were read and articles that fit the selection criteria were included to be read in full. When an article included multiple types of pre-class learning, the data were included under the type of pre-class learning that was most strongly associated with outcomes.

## RESULTS

The initial search yielded 97 original candidate articles, but after abstract review, 48 articles remained eligible for inclusion. Common reasons for article exclusion were the type of pre-class learning was not specified and in-classroom active learning was not provided. After reading the full articles, seven additional studies were excluded for reasons including lack of specific pre-class learning specification and lack of evaluation of the implementation of the FC or TBL. As a result, 41 articles were

selected for inclusion in this review. Most of the reports were in undergraduate science courses or health professions with the number of studies from each discipline displayed in Figure 1. Figure 2 illustrates the number of articles that mentioned each type of pre-class learning modalities used in the literature.

## Reading Assignments

*Textbook Readings.* Twenty-seven of the articles used reading assignments as the delivery platform for pre-class learning when implementing FC.<sup>6-33</sup> Eight of these studies with reading assignments used textbook readings, more specifically, as the only type of pre-class learning.<sup>6,7,11,12,21,28,31,32</sup>

Burgess and colleagues looked at the effects on knowledge acquisition and retention and also student perception after the implementation of TBL in a medical anatomy course.<sup>6</sup> Forty-two senior medical students were split into teams of five to six students and were assigned pre-class reading from the anatomy course manual for each day. In-class dissection practical examinations were held, and the primary outcome measured was the acquisition of knowledge as measured by standardized practical assessments. These assessments, each with a maximum score of 20, were administered pre-course (baseline knowledge), mid-course, end-course, and post-course. Statistical analyses compared the pre-course scores with the latter assessment scores as a marker of acquisition and retention of knowledge. The median post-course assessment score significantly improved compared to the pre-course assessment score (19.5/20 vs 9/20,  $p < .001$ ) showing that the course contributed to an increase in knowledge in this subject. Additionally, 71% ( $n = 20/28$ ) of the students who completed a questionnaire at the end of the course believed the completion of the prescribed pre-class readings assisted in their in-class learning and group work.

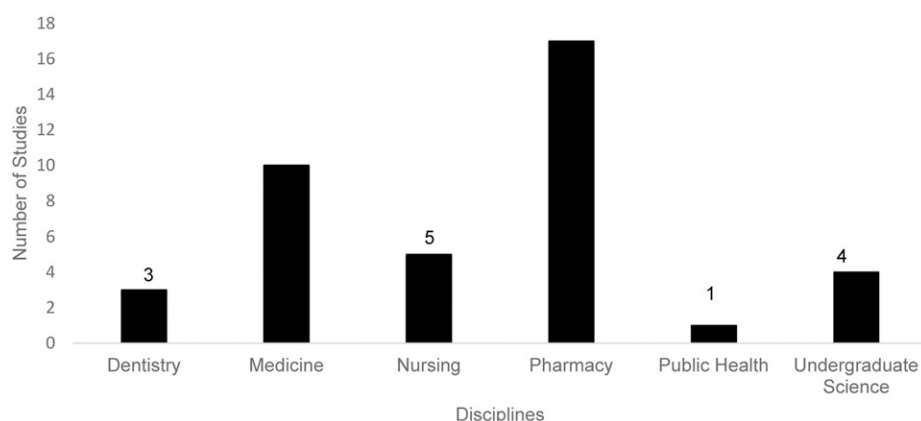


Figure 1. Disciplines Describing Pre-Class Learning with Flipped Classrooms.

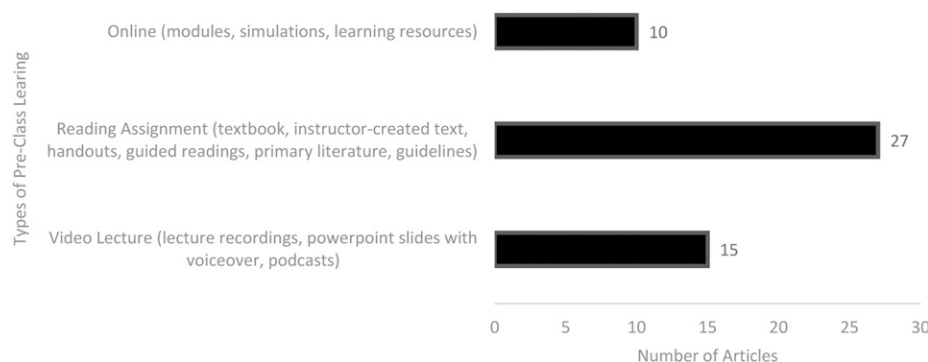


Figure 2. Types of Pre-Class Learning.

Despite the small sample size, this study showed that textbook pre-readings may be an effective modality of delivering foundational knowledge to prepare for TBL sessions.

In another study, Burgess and colleagues reported results from the implementation of TBL in year 1 of a problem-based learning (PBL) medical program.<sup>7</sup> They identified that PBL, although the traditional form of teaching within medical education, was resource intensive, requiring more tutors-to-student ratio. Therefore, the authors studied the efficacy of TBL in 20 first year medical students, due to the advantages that TBL offers in retaining the small group teaching and learning environment without the large requirement of tutors. The students completed four weeks of cardiology PBL in groups of 10, where one student facilitated a 1.5-hour PBL and one tutor facilitated a 1.5-hour PBL per week. Two iterations of PBL were then converted to TBL format. The same PBL groups of 10 students each were then combined to form one TBL class, divided into four teams of five students. The TBL sessions were 1.5 hours each in duration with one session held each week. There were assigned pre-class readings before the TBL session. The specific TBL sessions included individual readiness assurance tests (IRAT), team readiness assurance tests (TRAT), immediate feedback from the supervisor who went through each question, and a problem-solving activity. Finally, a questionnaire was distributed to all participants immediately following the first two cardiology PBL sessions and immediately following the first two cardiology TBL sessions to evaluate students' perceptions of the course's key performance measures. There was a significant improvement in students' IRAT scores from week 1 to week 2 of the TBL sessions ( $p=.004$ ). Students rated all aspects of the TBL process between three and five (1=strongly disagree, 5=strongly agree), including team members' completion of the pre-class reading assignments. A positive viewpoint of the TBL implementation was that students felt "being forced to do pre-reading/pre-study made

[them] feel more confident during the TBL session." The students found the IRATs and TRATs difficult but motivating and engaging, and also liked the immediate feedback they received in the TBL sessions versus the PBL sessions. However, in the survey results describing the worst features of TBL, 32% ( $n=6/19$ ) of the students felt that more specific pre-class reading material was needed. Limitations of the study include the small sample size and that only two iterations of TBL were analyzed.

McMullen and colleagues and Saunders and colleagues had similar feedback from nursing students and medical residents when implementing FC or TBL.<sup>28,34</sup> While the students in both studies considered the pre-class readings to be useful in preparation for the class session, common suggestions were to have fewer, more specific readings and not to provide excessive readings. The study by McMullen and colleagues was in a residency training program for 44 psychiatry residents. The course was a didactic module that was converted to a TBL module. The residents were given objectives and pre-session readings, administered RATs, and given application activities. After the final session, residents were asked to complete a questionnaire about their experiences of TBL. Twenty-nine of the 44 residents responded to the survey, and 100% of them agreed or strongly agreed that TBL had improved their knowledge of addiction psychiatry and improved their clinical skills. However, there was feedback that other professional and personal demands competed with the demands of the reading assignments and therefore, the readings were not always completed. Other studies that implemented reading assignments as the primary pre-class learning similarly showed positive feedback from students on their learning and perception of FC or TBL implementation.<sup>11,12,31,32</sup>

**Guided Readings.** Some of the studies with assigned pre-class readings deviated from traditional textbook readings and provided some sort of handout or worksheet, instructor-developed texts, or other reading guides as the preparatory learning material.<sup>17,23-25,27,33</sup> Lieu and colleagues

investigated the effect of reading guides provided along with readings versus textbook readings alone on examination performance and motivation to complete the pre-class assignment in an undergraduate introductory biology course.<sup>17</sup> This was explored based on the theory that students usually do not read textbook assignments and that they may be more engaged in the required reading if a reading guide was created. The reading guides ranged from two to five pages in length and consisted of defining terms, explaining concepts, making tables and drawings, and/or answering in-chapter textbook questions. Students were directed to read or skip specific pages, sections, figures, or tables as necessary. The completion of the reading guide was not required and was posted on the course website at least one week before the class day. Results from this study showed that >80% of students completed the reading guides before class and additionally, there was a significantly positive correlation between full completion of the pre-class reading guide and examination performance. This highlights that the reading guides proved to be a motivation for students to get through the assigned readings and had a positive correlation with examination performance.

A study examined the effectiveness of TBL on nursing students' perceived teamwork and academic performance at a university in South Korea.<sup>24</sup> It was a prospective, pre- and post-test design that enrolled a sample of 72 second-year nursing students. All students received written material on a double-sided sheet of paper that summarized the learning outcomes of the class topic one week prior to class. The total time required for this pre-class preparation method was approximately 30-45 minutes. After administering IRATs and TRATs, the instructor gave immediate feedback. Results showed significant improvements in the mean scores of students' perceived teamwork. While the study focused on the benefit of TBL in building team-efficacy and team-interpersonal skills, an additional finding was that IRAT scores correlated significantly with student performance on the examination. This shows the importance of pre-class preparation and self-directed learning to build a solid foundation of knowledge for students to learn the material.

Persky and colleagues reported on the implementation of a modified TBL in a physiology course for pharmacy students.<sup>36</sup> The pre-class assignments were instructor-developed readings that summarized major concepts from the course textbooks. They were <16 pages in length with an average word count of 5,300 per reading assignment, including learning objectives, graphs, tables, and figures. Sometimes review articles and primary literature served as additional resources, when appropriate. When these modalities were included as part of the TBL format, there were significant increases in scores for basic foundational and applied questions, and positive student survey results

compared to the traditional lecture format. Regarding the type of pre-class reading assignment, 85% of students agreed with having a strong preference for abridged pre-class assignments and instructor-developed notes compared with entire book chapters.

Another FC implementation with similar student perceptions on pre-class reading assignments was from a study by Veeramani and colleagues for first year medical students in a neuroanatomy course.<sup>33</sup> Web source study aids related to neuroanatomy, neuropathology modules, and relevant clinical neuroanatomy textbooks were provided as the pre-class learning component. Students were divided into five groups and pre- and post-tests were designed to test the declared learning objectives of the session. Student perception was also evaluated regarding the model of teaching and learning. Out of 130 students who answered the survey, 92% felt that a worksheet with questions provided prior to class enabled better understanding of the subject. Additionally, 87% felt that web sources with references promoted greater interest to read as compared to didactic lectures.

Two studies looked more specifically at the effects of the quality and quantity of reading materials assigned to students as pre-class learning.<sup>18,25</sup> McDonnell and colleagues conducted a study in an undergraduate biology course and looked at the difference in student performance between a group of students that was assigned pre-class reading with new terminology ("jargon"), versus a second group that was exposed to concepts first without the jargon. "Jargon" was defined as technical vocabulary terms used in science that are not always intuitive to a novice. The two groups performed the same on the multiple-choice assessment questions; however, the group that had the reading without the jargon had 1.5 times and 2.5 times more correct arguments on the free-response questions about concepts. Persky and colleagues looked at the impact of instructor-developed reading material on the amount of time spent preparing for the TBL session in an FC pharmacokinetics and physiology course for pharmacy students.<sup>25</sup> They found that self-reported study time was positively correlated with word count, the number of tables and figures, and overall page length. However, the students' self-reported study time was about four times greater than the time predicted by simple word count. These two studies show that there may be many factors influencing the type and quantity of pre-reading assignments. This can have effects on student performance, as well as time spent on the material, and therefore should be considered when developing pre-work material.

The limitation of these studies was the lack of direct correlation between the type of pre-work and learning outcomes. However, when these reading guides were



used as part of the TBL format, it proved to be an acceptable learning modality that motivated students to complete the pre-work assignment, and ultimately had a positive correlation with examination performance. Therefore, summarized and concise guides as pre-class material may be a good way to prepare students for FC courses.

**Primary Literature/Guidelines.** Chokshi and colleagues used primary literature as the sole source of pre-class learning for a medical resident workshop on teaching that implemented the FC approach.<sup>8</sup> This was an intensive one-day curriculum that included four one-hour workshops. Prior to each workshop, articles were prescribed as preparatory learning. Pre- and post-workshop objective structured teaching examinations (OSTEs) and attitudinal and self-efficacy teaching questionnaires were used by the authors to evaluate the curriculum. Resident mean performance showed statistically significant short-term improvement on all three core skills taught in the workshops: giving feedback, teaching a skill, and orienting a learner. Resident ratings also indicated positive attitudes of themselves as more effective teachers after the training. This shows a successful implementation of primary literature used as pre-class learning material to this group of medical residents in providing foundational knowledge. The rest of the studies that assigned readings from primary literature or guidelines did so as supplementary to other types of pre-class learning materials.<sup>9,16,23,30,35,36</sup>

In an antimicrobial stewardship elective for pharmacy students, Gauthier and colleagues assigned readings from peer-reviewed publications and from relevant sections of the Infectious Diseases Society of America/Society for Healthcare Epidemiology of America (IDSA/SHEA) guidelines.<sup>9</sup> This was supplemental to a pre-recorded 30-45 minute didactic lecture as pre-class preparation. On a post-course survey, students' perceived ability to define, identify, participate in, and appraise literature of antimicrobial stewardship was significantly enhanced after the completion of the course ( $p < .001$ ), showing a positive influence of primary literature and guidelines as supplemental pre-class learning material. In a study on the FC approach for teaching emergency medicine medical staff, Tan and colleagues used a variety of pre-class learning materials including readings, podcasts, videos, clinical guidelines, notes, websites, blog posts, and manuscripts.<sup>30</sup> In the final survey on the perceived utility of the learning materials, the clinical guidelines and research articles received a median rating of four out of five (1 = not useful at all; 5 = extremely useful), similar to the ratings for videos and podcasts. These all ranked higher in utility than original research studies, case reports, and medical textbook readings

which, all received a median rating of three. Comments about the pre-reading included that it "encourages us to review and keep up-to-date with current med literature, an important part of continuing medical education." However, barriers to completing pre-session learnings, regardless of modality, were similar to findings from other studies, and included work and family commitments, perceived lack of time, examination preparation, and high volume of learning materials. Similar sentiments were observed in a study by O'Connor and colleagues in a pharmacy self-care course.<sup>23</sup> The delivery of pre-class learning consisted of primary literature, as well as chapters from the course textbook, with study guides provided. The readings were typically between 15 and 35 pages per class session. Although students achieved significantly better academic grades with this new small-group course format, compared to the previous large lecture-based class, students suggested shortening the pre-class reading assignments.

Again, limitations of these studies include the use of student perception rather than a direct measure on student performance. Also, when academic grades were measured as an outcome, it was difficult to conclude whether the improvement was attributed to the new small-group course format or the pre-class learning assignment.

### **Video Lectures**

The second most prevalent modality of pre-class material, following readings, was recorded video lectures. Fifteen of the studies used some sort of video to deliver the preparatory learning including recorded lectures, voice-over Microsoft PowerPoint (Redmond, WA) recordings, Khan Academy (Mountain View, CA)-style recorded slides with digital inking, and podcasts.<sup>9,10,16,20,22,30,36-43</sup> Video lectures seem to be an acceptable modality of pre-class learning delivery based on positive student perceptions on student performance following implementation of FC. Most of the video lectures were less than 60 minutes and some were broken down into even shorter segments. The videos that were greater than 60 minutes were generally negatively received. Benefits perceived by students to the video recordings were that the materials were often more succinct and that there is the ability to pause, rewind, and re-watch the lectures. Some of the negative experiences included videos that were too lengthy or took longer than predicted by the professor due to difficulty of the material, technical difficulty accessing the videos, redundancy from the pre-class recording and in-class teachings, and getting twice the amount of materials when completely new materials were introduced in class but were not mentioned in the video lecture.

In two pathophysiology and therapeutics course modules on viral hepatitis and clinical pharmacokinetics

of aminoglycosides for pharmacy students, Woodruff and colleagues implemented interactive e-lectures, electronic lectures available online, with use of screencasting and embedded assessment questions that ranged from 11 to 45 minutes as pre-class preparation.<sup>44</sup> Screencasting is a type of e-lecture that incorporates digital recording of computer screen actions with audio narration, eg, PowerPoint slides with voice-over. These e-lectures allowed students to stop, restart, replay, and skip sections. Assessment questions were embedded within the lectures to provide students immediate feedback on their understanding of the material. The primary objective of the study was to compare students' test performance before and after the creation of these course modules using the advanced screencasting with embedded assessments. Secondary analysis included performance on test questions categorized based on Bloom's taxonomy, student satisfaction with the use of e-lecture technology, and the amount of time spent completing the e-lectures. Before the implementation of the e-lecture pre-class preparation, this class was taught with pre-class reading assignments designed to take 1 to 2 hours to complete. To encourage completion of the pre-class readings, unannounced quizzes were given during the class session. The average score on examination questions was 91% in 2013 and 87% in 2012 ( $p < .001$ ) showing that students performed significantly better with the implementation of the e-lecture pre-class learning materials. Students also showed a preference for the e-lectures over traditional reading assignments on survey questionnaires. Suggestions for improvement were to have the e-lectures shorter in length or provide a series of shorter clips. As with many of the other studies using electronic platforms, there were students who faced technical difficulties while trying to access the e-lectures.

In a study that implemented FC in a renal pharmacotherapy module to assess the impact on pharmacy students' performance and attitudes, lecture content in the form of vodcasts were provided for students to review prior to the in-class activity. Vodcasts were course lectures that were originally performed live in the previous year (2011) and made available for viewing on Apple iTunes U (Cupertino, CA) platform. A comparison was conducted of student performance on final examination questions between 2011, when students attended the traditional lecture, and 2012, when the vodcasts were implemented as pre-class preparation. Summed examination scores in 2012 were higher with a mean and standard deviation (SD) of 81.6 (4.4) and a range of 43-100 than in 2011, which had a mean and SD of 77.7 (4.7) and a range of 43-100. Ninety-six percent of the students either agreed or strongly agreed that viewing the pre-recorded lectures prior to class was important, and 90% of students agreed

that the instructor made meaningful connections between topics in the pre-class preparation and in-class activity.<sup>43</sup>

It is notable that in several of these studies, the benefit of aligning the pre-class and in-class learning objectives was emphasized as contributors to successful FC implementation. For example, Lichvar and colleagues evaluated the integration of a virtual patient activity in a required pharmacy therapeutics course already using an FC teaching format. Although this study was evaluating the implementation of a virtual patient activity compared to written cases, a notable difference between the two cohorts was that the authors presented learning objectives to the students who experienced the pre-class video lecture and in-class virtual patient case, but not to students who received written cases. The median examination scores were higher in the group that received the virtual patient case and learning objectives than the group that only received a written patient case.<sup>38</sup> Although this study was not a direct comparison on the effect of learning objectives and focused more on the in-class virtual patient case, 68% of the students perceived that the in-class activity helped apply the knowledge gained in the pre-class video lecture. Part of the positive student perception may have to do with the fact that through the learning objectives that were created along with the virtual patient case, students clearly understood how the in-class and pre-class learning materials correlated and the importance of completing the pre-class work. A limitation of this study was the inability to correlate the aligned learning objectives as the single contributing factor leading to the improvement in scores due to the many other existing variables.

Limitations to these studies were that they mostly measured the various pre-class learning materials and student perception rather than performance. Due to this limitation, it is difficult to say that video pre-class learning materials itself has a positive impact on student performance. However, across many of the studies, students reportedly had positive perceptions to this modality of pre-class preparation. Therefore, videos may help students to be engaged and motivated to complete the materials prior to in-class assignments.

### Other Materials

Eleven of the studies in this literature review used alternative methods to reading assignments or video lectures for pre-class learning.<sup>13,16,19,26,30,36,40,44-47</sup> In a course for graduate students taking public health, Galway and colleagues integrated an FC using NextGenU.<sup>46</sup> NextGenU is an online resource of courses that includes learning resources, peer activities, discussion forums, and quizzes. This, in addition to journal articles, videos, and websites from reputable sources were all used as pre-class

learning material. The mean examination scores between the traditional lecture versus NextGenU/FC classes were similar; however, students rated the NextGenU and FC setting more highly as a positive learning experience with an increase in self-perceived knowledge. Khanova and colleagues implemented FC in a psychiatry/neurology pharmacotherapy course for third-year pharmacy students using interactive, text-based online modules with a series of linked webpages, interactive assessments, and discussion forums as pre-class preparation.<sup>46</sup> Pre- and post-course surveys were administered to examine student perceptions of their learning experiences with the FC. Contrary to the positive perceptions in the study by Galway and colleagues, only 28% of participants agreed or strongly agreed that the pre-class modules enhanced learning. However, 59% of students agreed or strongly agreed that the assessment questions embedded within the online modules enhanced learning. The online modules were valued as a comprehensive resource and reference, but students were concerned that the modules contained too much information and required too much time to read. Students' suggestions for improvement included: reducing the length of the online material and modules, having clearer direction as to what material was essential versus supplemental, having professors develop study guides or drug tables, having video lectures as an alternative to text-based modules, and starting each class with an instructor-led review of key concepts and allowing students to ask questions. Another study by Khanova and colleagues implemented an online interactive module with e-textbook readings as pre-class preparation in multiple FC courses in a single pharmacy curriculum.<sup>36</sup> The most notable comment regarding the online module was that students found it difficult to learn from materials that were described to be full of errors and confusing words. Therefore, students expressed an expectation that pre-class learning materials should be "carefully crafted" and "made specifically for the flipped classroom."

Another study that demonstrated that students care about the quality of the online, pre-class learning material was by Saunders and colleagues, who implemented FC in

a nursing program.<sup>47</sup> Students were assigned multimedia e-learning resources. Students appreciated and found useful the quality of the online content, interactive tutorials, and online quizzes. Common suggestions were to incorporate more e-learning resources. Across many of these studies, students seemed to appreciate the use of assessment questions and quizzes through the online modules.

As with other modalities of pre-class learning, most of the studies measured student perception rather than performance making it difficult to know the direct implication of these pre-class learning materials on knowledge acquisition and retention. However, students do give helpful feedback and ways to improve the materials to fit their learning style. Also, when a certain pre-class learning method is received positively, it may be a good motivator for students to complete the pre-class learning as assigned.

## DISCUSSION

In general, the studies in this review were limited by a lack of data regarding learning outcomes and reliance on students' perceptions of the benefits of the pre-class learning activity. Based on the available literature, the authors have drafted a list of "best practices" to approach pre-class learning materials for FC approaches (Table 1).

*Align learning objectives.* It is important to align the objectives of the pre-class learning materials with the in-class learning assignments. This bridges the gap between the independent study materials with their application in class. As mentioned previously, several studies demonstrated the benefit for students in aligning learning objectives and making meaningful connections between pre-class and in-class learning. Although there is no direct comparison, when there were FC implementations with well-aligned learning objectives or instructors that made connections between the pre-class and in-class activities, students' perceptions and median examination scores were higher, and student feedback reflected an understanding of the importance of completing the pre-class activities.<sup>38</sup> Aligning the objectives not only bridges the information from pre-class learning to application for

Table 1. Best Practices for Pre-Class Learning Materials

Align pre-class learning materials with learning objectives
Avoid replicating material from pre-class learning during in-class learning
Provide specific guidance for pre-class learning materials
Be conscientious of preparation time and other demands on students' time (eg, other courses, work, family, etc.)
Include assessments within pre-class learning materials
Allow time at the beginning of class for students' questions and summary of key concepts
Hold students accountable for pre-class preparation
Provide access to pre-class learning materials in a timely fashion

students, it also shows them the importance of completing the pre-class learning material to have the foundational knowledge to build upon for the in-class activities.

*Avoid redundancies and double-lecturing.* Ensure that the in-class activities build upon the pre-class learning but are not a replication of the pre-work. Students have voiced concern when there are redundancies, and that may decrease motivation to complete the pre-class learning if the material will be re-taught in the in-class session.<sup>36</sup> It is also important not to teach completely new materials during the in-class activities, which may give students the impression they are receiving “double lectures” between the pre-learning and in-class materials.

*Provide specific direction or guide for pre-class assignments.* Many of the studies looking at FC showed that students appreciate, and therefore may gain more, from directed pre-class learning assignments. Whether it is an instructor-created text for readings, objectives, or even a study guide worksheet, it is a common theme that students need and appreciate more guidance and direction in their pre-class learning assignments.<sup>7,17,20,46,47</sup> A study directly comparing the use of reading guides versus traditional textbook reading alone found that the reading guides motivated and helped students get through assigned readings, which had a positive correlation with examination performance.<sup>17</sup>

*Be conscientious of the time it may take students to get through the pre-class materials.* Studies have shown that current methods of predicting the time it takes students to get through readings and recorded video lectures are not accurate and that preparation time is usually underestimated.<sup>25,36</sup> Therefore, it may take more than just looking at word count for readings and length of the video for recordings. While it is not possible to predict the preparation time for each student, it is important to get student feedback and to adjust accordingly. It is also important to consider other outside time commitments, including other FC courses students are taking simultaneously, which may compete for time and result in fewer students completing the pre-class learning. Steps must be taken when implementing FC to ensure students have adequate time to complete the preparatory materials and that the assignments are an acceptable length.

*Include assessments within the pre-class learnings.* Several of the studies included assessments throughout the pre-class material and students had positive perceptions regarding that approach.<sup>19,39,46,47</sup> This is a way of providing immediate feedback to students and to help clarify key points within the material. Immediate feedback could be given through online quizzes or even by posting an answer key to study guide materials after students have been given an adequate amount of time to complete them individually.

*Begin each class with a highlight of key concepts from the pre-class material, as well as time for questions*

*from students.* The studies where instructors began the class with key concepts from the preparatory materials and allowed for questions were positively received.<sup>23</sup> Studies without that framework resulted in student comments requesting an instructor-led time in the beginning of class to review key concepts.<sup>46</sup> Depending on the discipline and topic, it may be difficult for students to pick up on all of the key points through pre-class preparation alone, and there may be many questions that will arise. Therefore, tackling the gaps in the foundational knowledge prior to building on that foundation in the in-class portion may be beneficial to student learning.

*Keep students accountable for the pre-class activities.* Many of the studies included in-class quizzes or assessments that kept students accountable for the pre-class learning. These were also positively received by the students as a motivational factor to complete the preparatory work. From the literature review, it seemed the only method of assessment that was negatively received was when pharmacy students in an antimicrobial stewardship elective were required to do a pre-class writing component.<sup>9</sup> Instead of writing materials and submissions, quiz-type assessments may be better received by learners.

*Provide access to the pre-class learning materials in a timely manner.* Several of the studies in the literature review provided the pre-class learning material at least a week before the FC session.<sup>11,17,19,24,41,45</sup> It is good practice to give enough time for students to pace their self-directed learning and be able to plan for other commitments. The minimum amount of time pre-class material was provided to students in this literature review was two days prior to the class session, however, it is recommended that materials be provided to students at least one week in advance.<sup>10,29,42</sup>

## CONCLUSION

There have been numerous studies recently on the implementation of FC approaches with various results on student performance, student perceptions, and faculty perceptions. While there is data supporting this type of learning style, there is little data on the types of pre-class learning as it correlates to student performance. The limitations from many of these studies is that the outcome measured was student perception of the pre-class learning rather than a comparison of the pre-class learning modality on student performance. There is a need for future studies directly comparing different pre-class preparation methods and whether that has an impact on learning outcomes in FC courses. Future studies could be conducted to assess student performance on examination and other assessments using a prospective design where students enrolled in separate sections of a course are provided with different types of pre-class preparation (eg, readings vs videos).



Currently, there is not a strong correlation supporting a single type of pre-class learning. Regardless of type of pre-work, it is important to keep these overall best practices in mind to help keep students engaged and motivated, and to comprehend the foundational knowledge from the assigned pre-class materials.

## REFERENCES

1. Krathwohl DR. A revision of Bloom's taxonomy: an overview. *Theory Pract.* 2002;41(4):212-218.
2. Michaelsen L, Bauman Knight A, Fink LD. *Team-based Learning*. Westport, CT: Greenwood Publishing Group, Inc.; 2002.
3. Bernard JS. The flipped classroom: fertile ground for nursing education research. *Int J Nurs Educ Scholarsh.* 2015;12(1):99-109.
4. Persky AM, McLaughlin JE. The flipped classroom – from theory to practice in health professional education. *Am J Pharm Educ.* 2017;81(6):Article 118.
5. Ramnanan CJ, Pound LD. Advances in medical education and practice: student perceptions of the flipped classroom. *Adv Med Educ Pract.* 2017;8:63-73.
6. Burgess AW, Ramsey-Stewart G, May J, Mellis C. Team-based learning methods in teaching topographical anatomy by dissection. *ANZ J Surg.* 2012;82(6):457-460.
7. Burgess A, Ayton T, Mellis C. Implementation of team-based learning in year 1 of a PBL based medical program: a pilot study. *BMC Med Educ.* 2016;16(1):49.
8. Chokshi BD, Schumacher HK, Reese K, et al. A "resident-as-teacher" curriculum using a flipped classroom approach. *Acad Med.* 2017;92(4):511-514.
9. Gauthier TP, Sherman EM, Unger NR. An elective course on antimicrobial stewardship. *Am J Pharm Educ.* 2015;79(10):Article 157.
10. Gopalan C, Klann MC. The effect of flipped teaching combined with modified team-based learning on student performance in physiology. *Adv Physiol Educ.* 2017;41(3):363-367.
11. Haj-Ali R, Al Quran F. Team-based learning in a preclinical removable denture prosthesis module in a United Arab Emirates dental school. *J Dent Educ.* 2013;77(3):351-357.
12. Inuwa IM. Perceptions and attitudes of first-year medical students on a modified team-based learning (TBL) strategy in anatomy. *Sultan Qaboos Univ Med J.* 2012;12(3):336-343.
13. Keegan RD, Oliver MC, Stanfill TJ, et al. Use of a mobile device simulation as a preclass active learning exercise. *J Nurs Educ.* 2016;55(1):56-59.
14. Khanova J, Roth MT, Rodgers JE, McLaughlin JE. Student experiences across multiple flipped courses in a single curriculum. *Med Educ.* 2015;49(10):1038-1048.
15. Kolluru S, Roesch DM, Akhtar de la Fuente A. A multi-instructor, team-based, active-learning exercise to integrate basic and clinical sciences content. *Am J Pharm Educ.* 2012;76(2):Article 33.
16. Letassy NA, Fugate SE, Medina MS, Stroup JS, Britton ML. Using team-based learning in an endocrine module taught across two campuses. *Am J Pharm Educ.* 2008;72(5):Article 103.
17. Lieu R, Wong A, Asefirad A, Shaffer JF. Improving exam performance in introductory biology through the use of preclass reading guides. *CBE Life Sci Educ.* 2017;16(3):1-10.
18. McDonnell L, Barker MK, Wieman C. Concepts first, jargon second improves student articulation of understanding. *Biochem Mol Biol Educ.* 2016;44(1):12-19.
19. McLaughlin JE, Rhoney DH. Comparison of an interactive e-learning preparatory tool and a conventional downloadable handout used within a flipped neurologic pharmacotherapy lecture. *Curr Pharm Teach Learn.* 2015;7(1):12-19.
20. McLaughlin JE, Roth MT, Glatt DM, et al. The flipped classroom. *Acad Med.* 2014;89(2):236-243.
21. McMullen I, Cartledge J, Finch E, Levine R, Iversen A. How we implemented team-based learning for postgraduate doctors. *Med Teach.* 2014;36(3):191-195.
22. Munson A, Pierce R. Flipping content to improve student examination performance in a pharmacogenomics course. *Am J Pharm Educ.* 2015;79(7):Article 103.
23. Ferreri SP, O'Connor SK. Redesign of a large lecture course into a small-group learning course. *Am J Pharm Educ.* 2013;77(1):Article 13.
24. Park HR, Kim CJ, Park JW, Park E. Effects of team-based learning on perceived teamwork and academic performance in a health assessment subject. *Collegian.* 2015;22(3):299-305.
25. Persky AM, Hogg A. Influence of reading material characteristics on study time for pre-class quizzes in a flipped classroom. *Am J Pharm Educ.* 2017;81(6):Article 103.
26. Persky AM. The impact of team-based learning on a foundational pharmacokinetics course. *Am J Pharm Educ.* 2012;76(2):Article 31.
27. Persky AM, Pollack GM. A modified team-based learning physiology course. *Am J Pharm Educ.* 2011;75(10):Article 204.
28. Saunders A, Green R, Cross M. Making the most of person-centred education by integrating flipped and simulated teaching: an exploratory study. *Nurse Educ Pract.* 2017;27:71-77.
29. Moravec M, Williams A, Aguilar-Roca N, O'Dowd DK. Learn before lecture: a strategy that improves learning outcomes in a large introductory biology class. *CBE Life Sci Educ.* 2010;9(4):473-481.
30. Tan E, Brainard A, Larkin GL. Acceptability of the flipped classroom approach for in-house teaching in emergency medicine. *Emerg Med Australas.* 2015;27(5):453-459.
31. Vasan NS, DeFouw DO, Compton S. A survey of student perceptions of team-based learning in anatomy curriculum: Favorable views unrelated to grades. *Anat Sci Educ.* 2009;2(4):150-155.
32. Vasan NS, DeFouw DO, Holland BK. Modified use of team-based learning for effective delivery of medical gross anatomy and embryology. *Anat Sci Educ.* 2008;1(1):3-9.
33. Veeramani R, Madhugiri VS, Chand P. Perception of MBBS students to "flipped class room" approach in neuroanatomy module. *Anat Cell Biol.* 2015;48(2):138-143.
34. McMullen I, Cartledge J, Finch E, Levine R, Iversen A. How we implemented team-based learning for postgraduate doctors. *Med Teach.* 2014;36(3):191-195.
35. Persky AM, Pollack GM. A modified team-based learning physiology course. *Am J Pharm Educ.* 2011;75(10):Article 204.
36. Khanova J, Roth MT, Rodgers JE, McLaughlin JE. Student experiences across multiple flipped courses in a single curriculum. *Med Educ.* 2015;49(10):1038-1048.
37. Hanson J. Surveying the experiences and perceptions of undergraduate nursing students of a flipped classroom approach to increase understanding of drug science and its application to clinical practice. *Nurse Educ Pract.* 2016;16(1):79-85.
38. Lichvar AB, Hedges A, Benedict NJ, Donihi AC. Combination of a flipped classroom format and a virtual patient case to enhance active learning in a required therapeutics course. *Am J Pharm Educ.* 2016;80(10):Article 175.
39. Liebert CA, Mazer L, Bereksy Merrell S, Lin DT, Lau JN. Student perceptions of a simulation-based flipped classroom for the

surgery clerkship: A mixed-methods study. *Surg (United States)*. 2016;160(3):591-598.

40. Park SE, Howell TH. Implementation of a flipped classroom educational model in a predoctoral dental course. *J Dent Educ*. 2015;79(5):563-570.

41. Varthis S, Anderson OR. Students' perceptions of a blended learning experience in dental education. *Eur J Dent Educ*. 2016; (November):e35-e41.

42. Wong TH, Ip EJ, Lopes I, Rajagopalan V. Pharmacy students' performance and perceptions in a flipped teaching pilot on cardiac arrhythmias. *Am J Pharm Educ*. 2014;78(10):Article 185.

43. Pierce R, Fox J. Vodcasts and active-learning exercises in a "flipped classroom" model of a renal pharmacotherapy module. *Am J Pharm Educ*. 2012;76(10):Article 196.

44. Galway LP, Corbett KK, Takaro TK, Tairyan K, Frank E. A novel integration of online and flipped classroom instructional models in public health higher education. *BMC Med Educ*. 2014; 14(1):181.

45. Khanova J, McLaughlin JE, Rhoney DH, Roth MT, Harris S. Student perceptions of a flipped pharmacotherapy course. *Am J Pharm Educ*. 2015;79(9):Article 140.

46. Saunders A, Green R, Cross M. Making the most of person-centred education by integrating flipped and simulated teaching: an exploratory study. *Nurse Educ Pract*. 2017;27:71-77.

47. Woodruff AE, Jensen M, Loeffler W, Avery L. Advanced screencasting with embedded assessments in pathophysiology and therapeutics course modules. *Am J Pharm Educ*. 2014;78(6): Article 128.