TEACHING INNOVATIONS

Students from a large Australian university use Twitter to identify difficult course concepts to review during face-to-face lectorial sessions

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Abstract

Engaging undergraduate students in large classes is a constant challenge for many lecturers, as student participation and engagement can be limited. This is a concern since there is a positive correlation between increased engagement and student success. The lack of student feedback on content delivery prevents lecturers from identifying topics that would benefit students if reviewed. Implementing novel methods to engage the students in course content and create ways by which they can inform the lecturer of the difficult concepts is needed to increase student success. In the present study, we investigated the use of Twitter as a scalable approach to enhance engagement with course content and peer-to-peer interaction in a large course. In this pilot study, students were instructed to tweet the difficult concepts identified from content delivered by videos. A software program automatically collected and parsed the tweets to extract summary statistics on the most common difficult concepts, and the lecturer used the information to prepare face-to-face (F2F) lectorial sessions. The key findings of the study were 1) the uptake of Twitter (i.e., registration on the platform) was similar to the proportion of students who participated in F2F lectorials, 2) students reviewed content soon after delivery to tweet difficult concepts to lecturer, 3) Twitter increased engagement with lecturers, 4) the difficult concepts were similar to previous years, yet the automated gathering of Twitter data was more efficient and time saving for the lecturer, and 5) students found the lectorial review sessions very valuable.

flipped teaching; large lecture; lectorials; student engagement; Twitter discussions

INTRODUCTION

Engaging students in large classes (n > 100) is a constant challenge for many lecturers (17, 26, 29, 33, 37). For most higher education institutions, course delivery modes vary from using face-to-face (F2F) lectures, live streaming, video recording, and lecture slides posted in a learning management system (LMS), yet one commonality among delivery modes is that student attendance and participation is often not required, and typically, less than 100% (15, 21, 22). This reduced student engagement is concerning, since a correlation between student success and increased engagement, in the form of class attendance, has been demonstrated (17, 29). There is also a strong positive relationship between class attendance and higher grades in undergraduate courses (5). The goal of all lecturers is to present the difficult material in a way that students can engage, understand, and identify the difficult concepts that they need to review before exam time (24). With the combination of low attendance and lack of student engagement, lecturers are often frustrated, as they are unaware of any difficulty that students may be having in understanding the course concepts until course exams provide that information.

Novel methods of engaging the students in course content and ways for the students to inform the lecturer of the concepts that they need to review must be implemented to increase student success. Many current lecturers began teaching using the traditional lecture model, and it is acknowledged that adopting new modes of teaching can be difficult (30). However, there should be no hesitation to evolve teaching methods; today’s students embrace technology, and its use in the classroom has been shown to increase student engagement and improve faculty satisfaction (17).

The use of Flipped Teaching (FT) has been shown to increase student engagement and promote knowledge retention (1, 9, 18). Replacing traditional, large F2F lectures with several videos per week as part of the FT mode has been shown to boost student engagement and exam performance (21). The partial FT model, where a portion of the class uses FT, has also been shown to be more effective in teaching advanced physiology students when compared with students in the traditional F2F lecture-format section (10).

For the reasons outlined above, the partial FT model was integrated into the first 4 wk of the 12-wk pharmacology of therapeutics course. During those first 4 wk of the semester,
students were provided with several short videos on the course content to replace 2 h of F2F lectures per week. During that time period and throughout the remainder of the semester, the class met for a 1-h F2F lectorial session to review the difficult concepts that the students identified in the videos. In a traditional lecture, the unidirectional flow of information is from instructor to students, with often little interaction between them. Lectorials as the name suggests is a blend of lecture and tutorial format. Lectorials have been effective in reviewing difficult concepts, and students rate them highly because they allow for greater engagement in content and help to improve student understanding of difficult concepts (11, 35). There are many versions of a lectorial format. In our work, the lectorial format used interactive discussion specifically focused on the difficult concepts that were identified by the students.

For many years, discussion boards have been used to enhance interaction and student engagement. Although discussion boards are a valuable resource there is not an easy way to efficiently download student comments, and so the student video concept form (SVCF) was developed. In previous offerings of the course, during the FT portion, students watched videos and completed the SVCF, in which they identified the concepts that they wanted to review in the lectorial sessions. This was done on a weekly basis with students submitting the SVCF at the end of each week, after which the lecturer collated the data, identified the difficult concepts by using a word cloud to visualize how frequently the various concepts appeared in the SVCFs, and then prepared and delivered the lectorial session on the most frequently occurring difficult concepts the following week. Collation of the data was time-consuming for the lecturer of this large class. To more efficiently collect the information provided by the students and allow the lecturer more time to prepare the lectorial, the SVCF was replaced with Twitter discussions. Twitter has been used in many different ways in higher education, from tweeting articles related to course content (7) to discussing the first year common book (16) and continuing class discussions outside of class (15). Implementing Twitter in large, first-year classes for discussions on academic and cocurricular activities has been found to increase student engagement and grades (16). The use of Twitter has also been shown to establish a course-learning community (27), and this is particularly relevant since students in large classes often feel isolated. Requiring students in large classes to participate in Twitter has been linked to an increase in collaboration, engagement, and student success when compared with students’ voluntary participation (15).

Twitter has been effective in engaging undergraduate students from small classes (<20 students) in robust small-group asynchronous discussions (3 or 4 students/group) to discuss course content. Students prefer it to F2F discussions because they have time to reflect before responding, student interaction is increased, and these asynchronous discussions fit into their busy schedules (8, 12, 14, 20). This small group discussion model has been effective with small classes; therefore, the next logical step is to implement the model in a larger class (n = 145) with discussion groups of 8–10 students. Both the FT and Twitter discussions were integrated by instructing students to tweet the difficult concepts from the videos. Student tweets were then collected and used by the lecturer to prepare the lectorial.

The secondary goal of the project was to increase engagement of students with their classmates and lecturers, as higher engagement has been shown to benefit the students’ overall learning achievement (4, 16). Placing students in groups increases student-student interactions, and the likelihood that peer-to-peer mentoring will occur increases. Peer-to-peer mentoring and interactions with lecturers, both formal and informal, have both been shown to increase student engagement and retention in STEM majors, especially in underrepresented groups and first-generation students (23, 31, 36). Asynchronous online discussions are effective as they expand the opportunities for students to discuss course content with classmates and lecturers outside the restrictions of the classroom (34). In this pilot study, we combine partial FT with small-group Twitter discussions to engage students in course content and provide a vehicle for them to identify difficult concepts for review in lectorial sessions.

#### METHODS

Participants (n = 145) were second-year undergraduate students enrolled in an ONPS2493 Pharmacology of Therapeutics-I class during the first semester of the 2020 academic year at a large Australian public university. The students were pharmacy majors (120/145, 83%) and pharmacology majors (25/145, 17%).

**Partial FT Model**

Students met face-to-face (F2F) for the first-class meeting to review the syllabus and course expectations and were provided with an explanation of FT. During the subsequent 3 wk of the course, FT was implemented in place of F2F lectures and students were assigned 5 or 6 videos per course topic (Treatment of: Hypertension I, Hypertension II, Coronary Artery Disease and Lipid Disorders, Heart Failure, and Arrhythmias) each week to view. After viewing the videos, students were instructed to identify the course concepts that they found the most difficult, selecting those topics for review during the weekly lectorial.

**Replacing SVCF with Twitter Discussions**

In previous offerings of the course, students completed a SVCF in which they were asked to identify at least three concepts that they had the most difficulty understanding. The SVCF was uploaded into Canvas, the learning management system, in the week before the delivery of the lectorial. Although this process was effective in collecting the difficult concepts reported by the students, it was very labor intensive for the lecturer; each form had to be downloaded from Canvas, and each concept was pasted into PowerPoint, which was then used to generate a word cloud, where the size of each word indicated its relative frequency of occurrence in the SVCFs. All these tasks took on average 5 min per student SVCF. The top three or four identified concepts were chosen and the 1-h lectorial session was prepared. For this current offering of the course, the SVCFs were replaced with
Twitter discussions that involved students weekly tweeting the concepts they found difficult.

**Use of Twitter**

To facilitate the successful use of Twitter, before the first day of class, each student was e-mailed a randomly generated alphanumeric Twitter username (25), put into a group of 8–10 students, and assigned a group hashtag e.g., #ONPS2493GRP1. They were also e-mailed a YouTube video (https://www.youtube.com/watch?v=ElDqVL0GxsQ) with instructions on how to download the Twitter app onto their phone and sign up for an account. During the first class meeting that was held F2F, the format for the course tweets was projected to the class, and it was emphasized that their group hashtag and the usernames of their lecturers @BSCIProf and @ProfBadoer should be included in all tweets.

To manage the potentially large volume of tweets produced by the 145 students in the class, a Python script was developed to automate the collection, processing, and analysis of the students’ tweets (Fig. 1). The script ran automatically each week on a university server to collect the students’ tweets through the Twitter REST API. Tweets were identified by querying the API using the assigned group hashtags described above. The software then automatically filtered the collected tweets to remove any tweets posted by course lecturers or any tweets that fell outside the relevant date range of Sunday through midnight Friday each week. After filtering, the software automatically parsed the tweets using the Python Natural Language Toolkit (or NLTK). Parsing the tweets consisted of four steps:
1. Tokenizing the tweets (i.e., extracting each word, or sequence of characters, that occurred in each tweet).
2. Converting each token to lowercase.
3. Removing stop words (content-free words such as “the”, “and”, “or”, and so on), URLs, hashtags, images, videos, and emojis.
4. Counting the set of relevant tokens that occurred most often in the current week’s tweets.

The software then used the parsed tweet data to automatically generate a word cloud in which the size of the given word in the cloud represented that word’s relative frequency of occurrence in relation to the other words in the Tweets. The word cloud provided an efficient way to identify the topics that the greatest proportion of students wanted to review. Finally, the software emailed the generated word cloud to the course lecturer, and the lecturer chose the three or four most common concepts from the word cloud and developed the lectorial. The software was very efficient; on average, it took less than a minute each week to collect and process the tweets, generate the word cloud, and e-mail it to the course lecturer. This process was in stark contrast to the previous method that took ~5 min per student to process their SVCF.

**Survey Distribution and Collection**

A hard-copy presurvey and consent form were distributed to students at the end of the first F2F class meeting; then the surveys were completed and collected. The presurvey was also placed in the course Canvas site to provide the opportunity for students who did not attend the first-class meeting to complete the survey.

![Figure 1. Comparison of steps and time spent using student video concept form (SVCF) vs. Tweet-collecting program. Comparison of previous approach (left) and current approach (right). Darker colors indicate a larger commitment of (instructor/student) time. Uncolored boxes indicate steps that are automated and require no commitment of instructor or student time.](http://advan.physiology.org)
In the original study design, students would complete a hard-copy postsurvey in the 5th week of the semester at the lectorial. Prior to that lectorial, the university announced that because of the COVID-19 pandemic, all classes would move online the following week. Following this announcement, the course attendance for the 5th week lectorial was sparse, so limited postsurvey questionnaires (31) were completed. A Qualtrics survey was created, and the link was sent to the class via Canvas to provide the opportunity for the students to complete the postsurvey online. The survey was available for 3 wk, and the lecturer sent reminders to complete the survey, yet only two more students completed the postsurvey for a total of 33 postsurveys.

This protocol was approved as exempt by the University of New Hampshire Institutional Review Board IRB #6331. The Science, Engineering & Health College Human Ethics Advisory Network (or CHEAN) of RMIT University approved this protocol as low risk (protocol no.02–20/22637). Funding was provided by the American Physiological Society 2019 Teaching Career Enhancement Award.

RESULTS

The class enrollment was 145 students; only 84, or 58%, of the class attended the first-class meeting and of those 67, or 46%, of the class completed the presurvey. Another way of illustrating this information is to state that of the students who attended the first class (n = 84), 80% of them (n = 67) completed the presurvey.

Presurvey

The demographics of the students who completed the presurvey were 42% male, 57% female, and 0% other. The majority, 49%, were >21 yr old, with the remaining 33% = 20 yr and 16% = 21 yr. The most common type of social media used by students was FaceBook, at 79%; followed by Instagram, at 69%; Snapchat, at 55%; WhatsApp, at 30%; Twitter, at 13%; and Pinterest, at 4%. Most of the students, 97%, had never used Twitter for coursework. The students were asked to describe their confidence level using Twitter, and only 12% were confident, with 3% very confident, and 6% extremely confident. Most of the class, 48%, expressed they were not confident, and 25% were somewhat confident using Twitter (Fig. 2).

Postsurvey Results

A total of 33 students filled out the postsurveys. Of those that completed the postsurvey, 13 or 39% reported that they participated in the Twitter discussions. For those students who did not participate, the most common reason cited for not participating was “No good reason” (five responses) and “Did not want to” (five responses).

Twitter Discussions

The rationale behind placing students in small groups on Twitter was to facilitate small group discussions on course content and provide a venue for peer-to-peer learning. The lecturers were tagged on each tweet, so there would be more engagement with them than in the large lecture class. To determine the level of participation in class discussions before the Twitter implementation, students were asked how often they participated in F2F class discussions. Almost half of the respondents, 44%, reported they participated a few times per semester, 21% reported once per week, 22% more than once per class, 9% once per class, and 4% never. The respondents who stated never or a few times per semester were then asked the reason for their low participation. They stated: I need time to process the information, 22%; I am shy, 13%; my English skills are not strong, 4.5%; I don’t want people to judge me, 7%; and I understand everything and do not have a question, 1%.

Twitter Responses

Out of total enrollment (n = 145), 40% of the class signed up for a Twitter account, and 21% of the total class tweeted. Thus, over half of the students (53%) who signed up for Twitter actually participated in the Twitter discussions. The first week had the highest number of students tweeting difficult course concepts that they wanted to review in the lectorial: week 1 = 18%, week 2 = 5.5%, and week 3 = 9%. This was a drop in participation compared with the previous year’s completion of SVCFs in week 1 = 45%, week 2 = 39%, and week 3 = 26%. The difficult concepts identified were nearly identical when comparing Twitter versus SVCF groups (Table 1).

Use of Twitter Engaged Students in Course Content

Students agreed (54% agreed, 15% strongly agreed) that knowing they would have to tweet difficult concepts made them review. Participating in Twitter discussions helped them better understand difficult concepts (69% agreed, 15% strongly agreed) and reduce the number of concepts for further review (54% agreed). They felt the Twitter discussions increased their engagement with lecturers (50% agreed, 17% strongly agreed) but not classmates (23% disagreed, 8% strongly disagreed) (Table 2).

Lectorial Sessions

All of the students who completed the postsurvey attended the lectorials. Most of the students (64.7%) attended all three sessions and 23.5% attended two of the three sessions. The students who attended found the lectorials valuable, at 38.2%, or extremely valuable, at 47.1% (Fig. 3).
**DISCUSSION**

The use of the Twitter platform as a mechanism of increasing student engagement has been successfully used in small class environments (8, 12, 14). However, the use of this social media platform for coursework in the large class environment has not been used to identify difficult concepts of lectures delivered in a FT mode. In the present study, we sought to examine the use of Twitter to increase student engagement with course content, peers, and lecturers. The key findings of the study were 1) the uptake of Twitter (i.e., registration on the platform) was similar to the proportion of students who participated in lectorials; 2) students reviewed course content soon after delivery to tweet difficult concepts by the deadline; 3) Twitter increased student engagement with lecturers; 4) the difficult concepts tweeted were similar to previous years when a more labor-intensive process was used; the automated gathering of tweet data was more efficient and time saving for the lecturer; and 5) students found the lectorial review sessions very valuable.

### Table 1. Students identify difficult concepts using SVCF vs. Twitter

| Flipped Class | Video Topics                        | % Class Completing SVCF | % Class Tweeting | Difficult Concepts Identified by SVCF Group | Difficult Concepts Identified by Twitter Group |
|---------------|------------------------------------|-------------------------|------------------|--------------------------------------------|-----------------------------------------------|
| Week 1        | Hypertension I                      | 45                      | 18               | Diuretics                                  | Arterial baroreceptor reflex                   |
|               | Hypertension II                     |                         |                  | Arterial baroreceptor reflex reflex         |                                               |
|               |                                    |                         |                  | RAAS                                       |                                               |
|               |                                    |                         |                  | Water reabsorption                         |                                               |
|               |                                    |                         |                  | Cholesterol transport and drug treatment of hypercholesterolemia |                                               |
|               |                                    |                         |                  | Angina treatment                            |                                               |
|               |                                    |                         |                  | Cardiac glycosides                          |                                               |
|               |                                    |                         |                  | Treatment of arrhythmia                     |                                               |
| Week 2        | Coronary Artery Disease and Lipid Disorders | 39                      | 6                | Cholesterol transport and drug treatment of hypercholesterolemia |                                               |
|               |                                    |                         |                  | Angina treatment                            |                                               |
|               |                                    |                         |                  | Cardiac glycosides                          |                                               |
|               |                                    |                         |                  | Treatment of arrhythmia                     |                                               |
| Week 3        | Heart Failure and Arrhythmias       | 26                      | 9                | Diuretics                                  | Arterial baroreceptor reflex                   |
|               |                                    |                         |                  | Arterial baroreceptor reflex reflex         |                                               |
|               |                                    |                         |                  | RAAS                                       |                                               |
|               |                                    |                         |                  | Water reabsorption                         |                                               |
|               |                                    |                         |                  | Cholesterol transport and drug treatment of hypercholesterolemia |                                               |
|               |                                    |                         |                  | Angina treatment                            |                                               |
|               |                                    |                         |                  | Cardiac glycosides                          |                                               |
|               |                                    |                         |                  | Treatment of arrhythmia                     |                                               |

The two to four most common difficult concepts identified by the students were selected from the word clouds that were generated from the student video concept form (SVCF) and Tweets.

### Table 2. Postsurvey responses by Twitter users

| Postsurvey Statements and Questions                                                                 | Strongly Disagree | Disagree | Neither Agree Nor Disagree | Agree | Strongly Agree |
|---------------------------------------------------------------------------------------------------|-------------------|----------|---------------------------|-------|---------------|
| Knowing I would have to tweet which concepts I found difficult made me review the material more carefully. | 0                 | 0        | 31%                       | 54%   | 15%           |
| Participating in the Twitter (discussions) helped me to better understand some difficult concepts. | 0                 | 0        | 16%                       | 69%   | 15%           |
| Participating in the Twitter (discussions) reduced the number of concepts I needed to review again. | 0                 | 8%       | 38%                       | 54%   | 0             |
| Did you feel the use of Twitter increased your engagement with classmates?                     | 8%                | 23%      | 54%                       | 15%   | 0             |
| Did you feel the use of Twitter increased your engagement with the content?                    | 0                 | 0        | 31%                       | 61%   | 8%            |
| Did you feel the use of Twitter increased your engagement with your lecturers?                  | 0                 | 17%      | 17%                       | 50%   | 17%           |

The postsurvey responses were provided by the students who used Twitter.

The Uptake of, and Participation in, Twitter

Approximately 40% of students in the class registered for Twitter, and about half of those participated in the Twitter discussions. Although this number seems low, only 58% of the class attended the first class session, and this is the likely pool of students from which the Twitter participants were self-selected. For the students who participated in the Twitter discussions, the discussions were beneficial in several ways; the results in Table 2 reflect these benefits. The students stated that using Twitter made them review the material more carefully because they knew that they would have to tweet the difficult concepts. Eighty-four percent of these participants found that using Twitter helped them to understand the difficult concepts and, as a result, 54% of the participants reported that participating in the Twitter discussions reduced the number of concepts they needed to review again. This is an important benefit, as students are not waiting until just before an exam to go back and review the material. When students review their notes soon after material is presented, they are providing themselves with an additional learning trial and, thus, improve...
USE OF TWITTER TO IDENTIFY DIFFICULT CONCEPTS FOR REVIEW

Figure 3. Students found lectorials valuable. Students overwhelmingly found that the lectorials that they attended were valuable. Answers were collected from the postsurvey (n = 34).

their recall of important information (2). Knowing the Twitter discussions ended on Fridays at midnight made the students review soon after the material was available, and this helped them identify the difficult concepts that they needed to focus on to achieve understanding of the concepts.

Engagement with Lecturers and Peers with the use of Twitter

The secondary goal of the study was to use Twitter to increase engagement of the students with their classmates and encourage peer-to-peer learning. The data indicate that most of the students felt that using Twitter did not achieve this goal, whereas only a small proportion of students (16%) felt that the use of Twitter increased their engagements with classmates. For each group of 8–10 students, there were only 1–3 students who tweeted. In contrast, the students who tweeted most (67%) did feel the use of Twitter increased their engagement with their lecturers. This is a very positive outcome, as students in large classes often feel isolated and anonymous to their lecturers, and Twitter helped form a learning community (27).

Engagement with Twitter vs. SVCF

The engagement with Twitter compared with completing the SVCF yielded ~2.5–6 times less participation in the Twitter discussions when compared with the SCVF. The SVCF was more popular, probably because students were more comfortable with the method compared with the Twitter platform. However, despite this low engagement with Twitter, the use of the tool was effective in identifying the difficult concepts, and the results were nearly identical to the previous year when the SVCFs captured that information (Table 1). This result is very encouraging because it demonstrates that using Twitter can be a very effective tool for students to report the difficult course concepts to their lecturer. Using the Twitter model was much more efficient for the lecturer than the use of SVCFs, as the tweets were automatically downloaded each week and a word cloud that highlighted the most tweeted concepts was generated automatically (Fig. 1). This program’s efficiency allowed the lecturer more time to create the content for the lectorial, and it scales much more effectively to large class settings, where the time spent by the lecturer to download and process the SVCFs becomes prohibitive.

Our primary goal of this project was to use Twitter as a tool for students to tweet the difficult concepts in the FT portion of the course. The assumption was that students would have to review the material soon after delivery to be able to identify the difficult concepts and, thereby, narrow down the number of concepts that would be the focus of the lectorial. However, to fully engage the class and make the Twitter discussions more inclusive, there needs to be a higher level of student participation. In the presurvey, students stated that their confidence in using Twitter was low, and this could be directly correlated with the small percentage of students who had previously used Twitter. This lack of confidence and experience with Twitter does not mean that the tool cannot be effective. In fact, the most common reasons for not participating in the Twitter discussions were reported to I did not want to, and no good reason. Surely both reasons can be resolved in the future to increase participation.

In previous studies, only a small percentage of the class had used Twitter, as was observed in the present study, and yet the tool was successful in engaging students in robust discussions on course content (8, 12, 14). One major difference in this present study was that the Twitter discussions were not required and did not earn course credit, whereas in the previous studies, the Twitter discussions were a course assignment that earned students points toward their final grade. In such instances, student participation in the Twitter discussions were found to be higher (89–100%) than that observed for the F2F class discussions (80–100%) (8, 12). Since participation in class discussions using Twitter has been shown to be higher than F2F discussions and student engagement exceeded the minimum requirement for all discussions (12), this tool can work and will be more effective if credit or points are assigned.

The Lectorial Sessions were Very Valuable

Unlike traditional lectures, lectorials, first developed in Australian universities, are more interactive and have been successful in increasing student engagement with difficult content (3, 11, 32). The lectorial sessions were held to review the difficult concepts identified by the tweets focused by the word cloud. Of the respondents to the postsurvey, 88% attended at least two of the three sessions. The data clearly demonstrate that 87% (48% agree and 39% strongly agree) of the respondents valued the lectorial sessions. Effectively designed review sessions, like these lectorials, are highly rated by students for their usefulness in reviewing difficult content (35).

Limitations and Next Steps

The conversion rate of students who signed up for Twitter and then tweeted was less than we had hoped. Engagement is linked to positive outcomes for students that include higher grades, critical thinking skills, integration of information, and persistence (19). Increasing student attendance and engagement is a common challenge for lecturers that teach large classes. For this study, of the 145 enrolled students, 60% attended the first class meeting and 48% of total students...
completed the presurvey. A total of 40% signed up for Twitter, and participation varied each week with 18% participating in week 1, 5.5% participating in week 2 and 9% participating in week 3. Ensuring that the students who signed up to participate on Twitter continue to follow through each week is an important goal to make this model more inclusive.

The most common reasons why students did not participate were I did not want to, and no good reason, and these reasons could be the cause of low participation. Although the number of students participating in the Twitter discussions was sufficient for this pilot study, requiring students to participate and making the Twitter discussions an assessable assignment, with associated course credit for completion of the weekly assignment, might increase participation and effectiveness of this model. Both assigning credit for Twitter discussions and requiring participation has been effective in improving student outcomes (7, 15). Providing clear guidelines for what defines full participation in the discussion for complete credit is also needed to achieve the maximum benefit for the students. Furthermore, the completion of homework assignments has been demonstrated to be a predictor of academic success (29). Thus, we feel that requiring participation in the Twitter discussions and awarding course credit would increase participation and may have long-term benefits to students, including academic success.

The secondary goal of the project was to increase engagement of students with their classmates, and this goal was not achieved. The primary course lecturer encouraged peer-to-peer learning, but it did not occur, and, thus, students did not feel the use of Twitter increased their engagement with their classmates (Table 2). Previous courses that divided the class into small discussion groups of three to four students per group had been successful in increasing peer-to-peer engagement (8, 12, 14). Using technology has been shown to increase student engagement (17, 28), and Twitter, in particular, has been found to support learning beyond the classroom (6, 8). Therefore, we anticipated the group size of 8–10 students in each Twitter discussion group would be appropriate for robust discussions. Unfortunately, this did not eventuate, and perhaps the group size was too large. Additionally, another major difference in past successes was that those small group discussions were required and were credited toward the course grade. A positive correlation between students that complete their homework and academic performance has been reported (29). Assigning the Twitter discussions as homework with a small number of points would increase the likelihood of higher participation, more engagement with classmates, and, potentially, more learning.

A positive outcome of note was that students overwhelmingly agreed that the use of Twitter increased their engagement with their lecturers (Table 2). This is very important, as students often feel isolated in large classes and have little contact with their lecturers. Twitter has been used in large classes in the past, but the focus of our project was to engage students specifically on the content that needed to be reviewed F2F in lectorials. This appeared to have been useful in this regard, as the students agreed they were more engaged in the course content (Table 2). Twitter was successfully used to engage students with their lecturers and course content, which are both defined by Chickering and Gamson (4), as good practices in undergraduate education.

The conversion of the students who signed up for a Twitter account and then did not tweet needs further investigation. Students were reminded via Canvas messages, and each group was sent a tweet using their group hashtag as well. Yet in previous studies, few students have used Twitter before class assignments (8, 12). The most engaged students participated on Twitter, completed the postsurvey, attended all the lectorials, and agreed they were valuable. Overall, this suggests that there been greater participation in Twitter discussions and overall engagement, it would have benefited the rest of the class and that participation in Twitter discussions needs to be required.

Future offerings of this course will continue with the partial FT model, as well as Twitter discussions, in which students identify difficult concepts to focus on during the F2F lectorial review sessions.

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**DISCLOSURES**

No conflicts of interest, financial or otherwise, are declared by the authors.

**AUTHOR CONTRIBUTIONS**

P.A.H., J.A.J. and E.B. conceived and designed research; P.A.H., J.A.J. and E.B. performed experiments; P.A.H., J.A.J. and E.B. analyzed data; P.A.H., J.A.J. and E.B. interpreted results of experiments; P.A.H. and J.A.J. prepared figures; P.A.H. drafted manuscript; P.A.H., J.A.J. and E.B. edited and revised manuscript; P.A.H., J.A.J. and E.B. approved final version of manuscript.

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